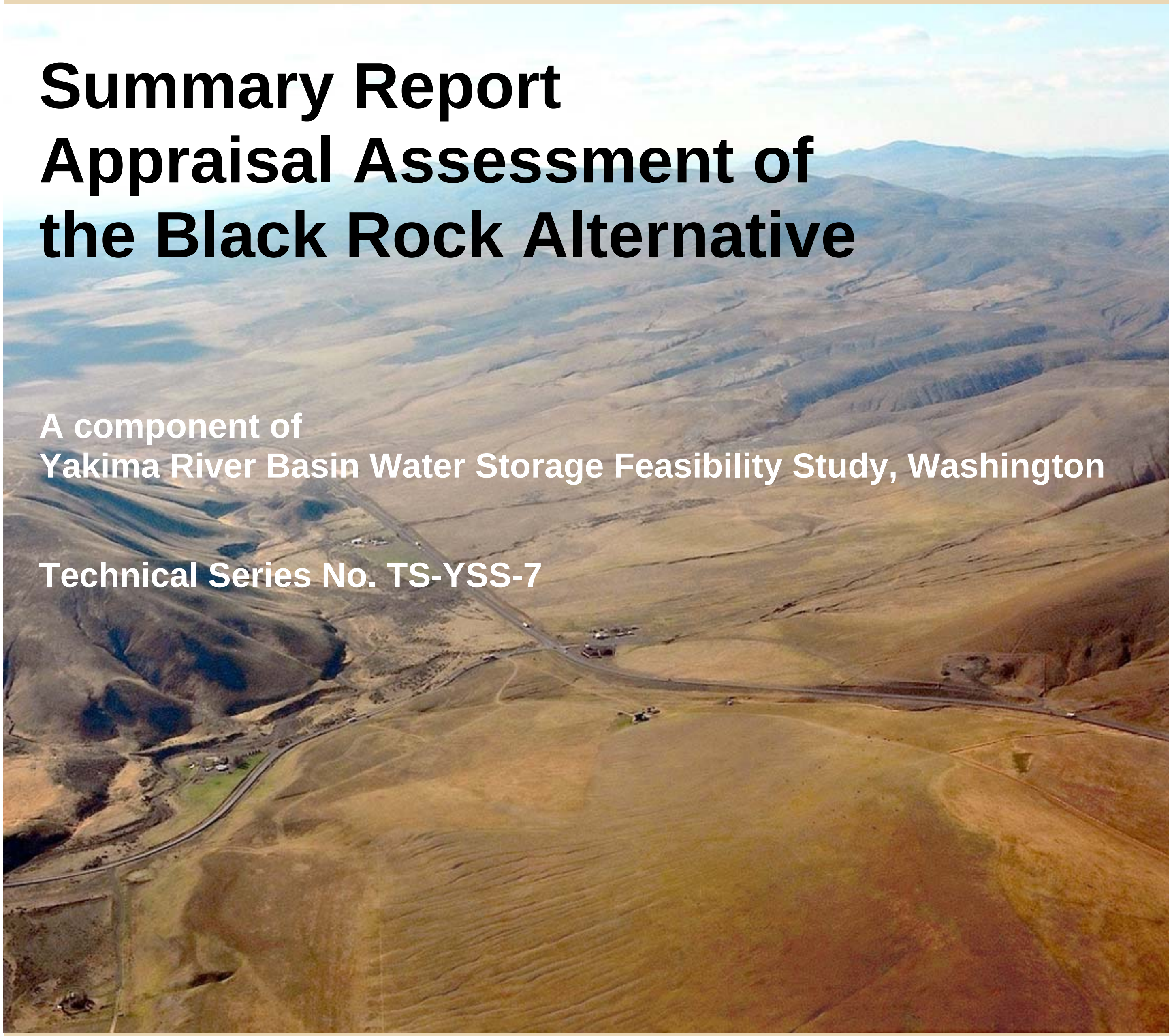
RECLAMATION

Managing Water in the West



Summary Report Appraisal Assessment of the Black Rock Alternative

A component of
Yakima River Basin Water Storage Feasibility Study, Washington

Technical Series No. TS-YSS-7

Black Rock Valley

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region

December 2004

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

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

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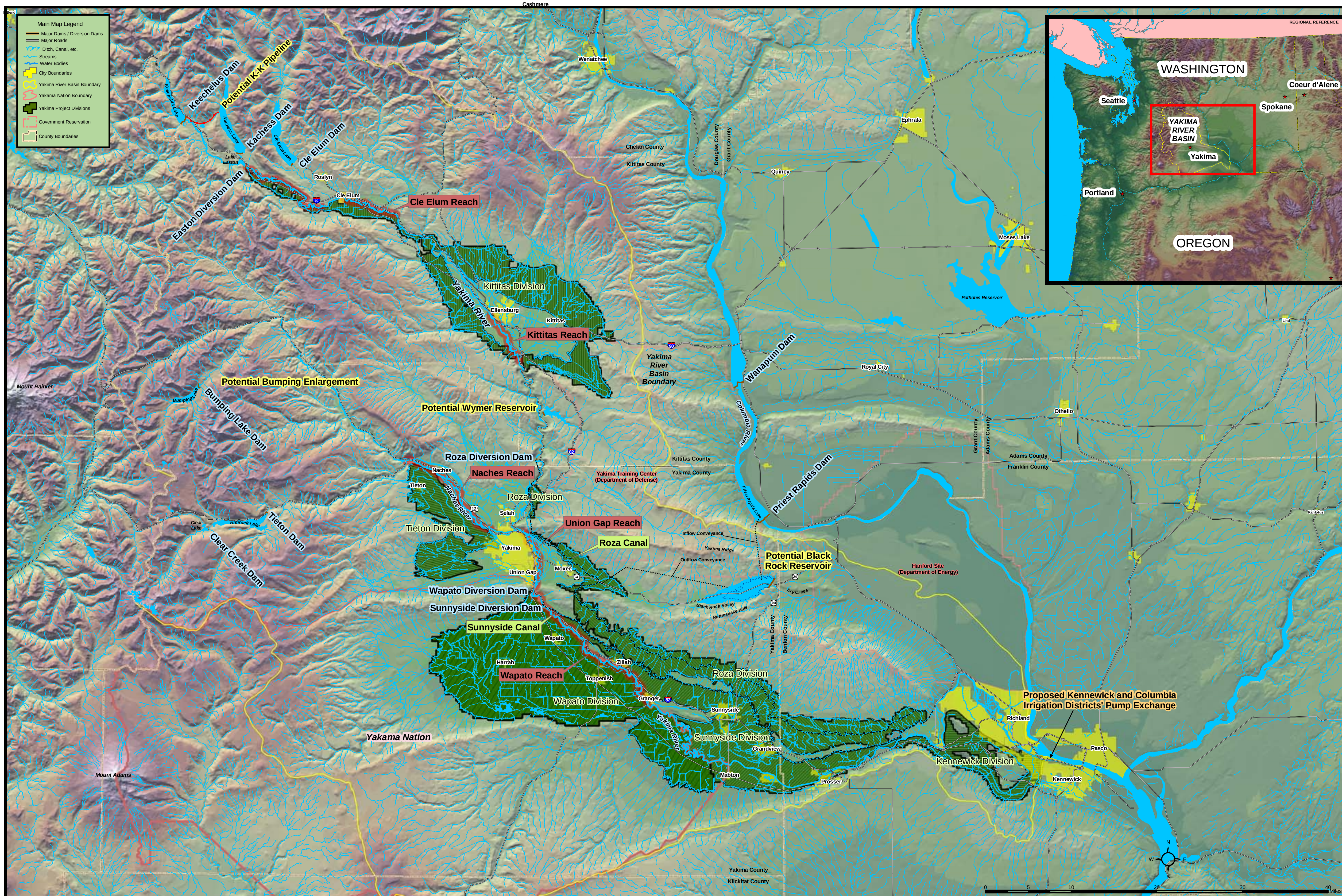
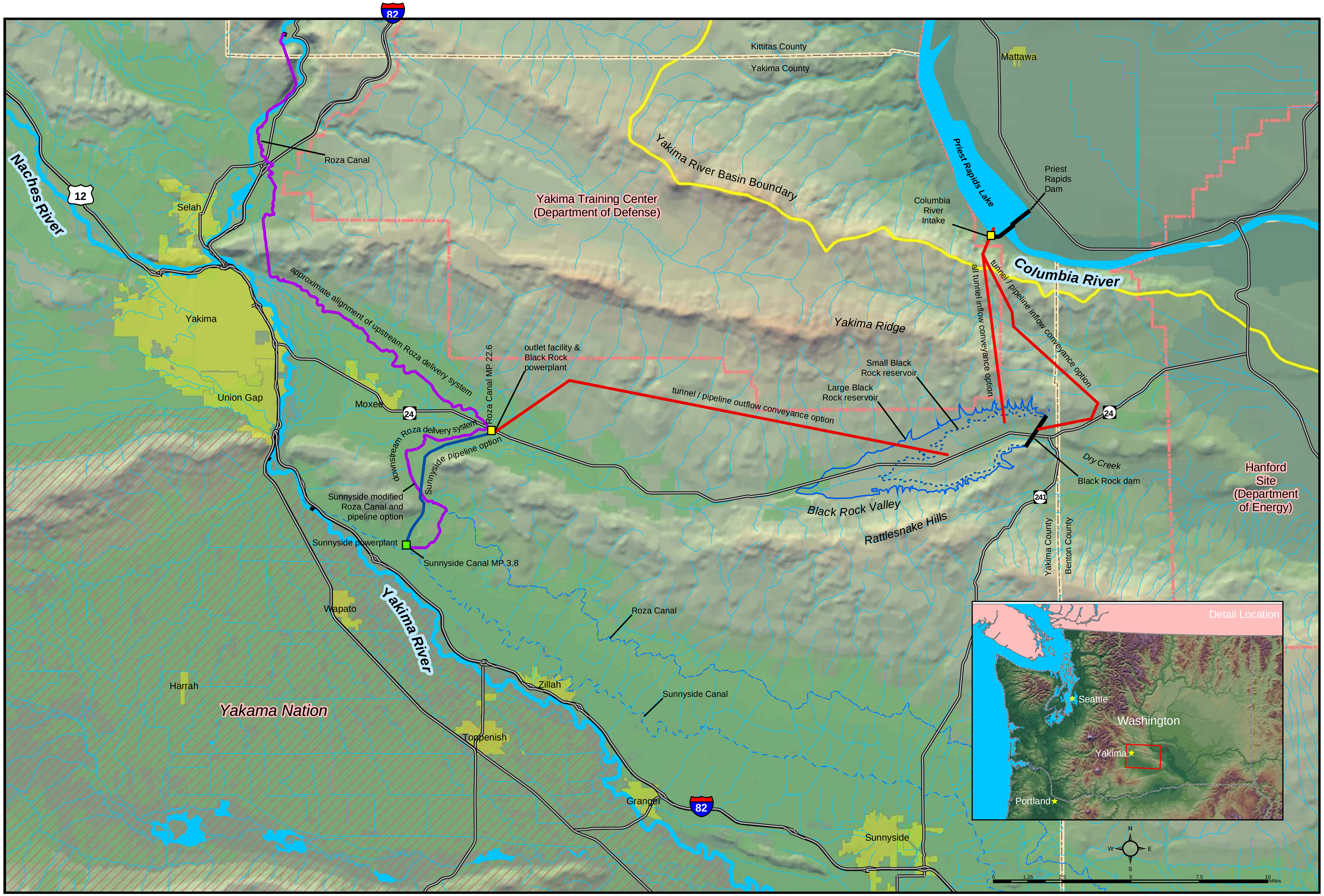


Frontispiece A. Yakima River Basin Water Storage Feasibility Study overview map



Frontispiece B. Overview of the preliminary Black Rock alternative configurations

APPRAISAL ASSSESSMENT OF THE BLACK ROCK ALTERNATIVE
A COMPONENT OF
YAKIMA RIVER BASIN WATER STORAGE FEASIBILITY STUDY

Executive Summary

Further Consultations

This appraisal assessment is limited to certain engineering and technical aspects of the potential Black Rock alternative. Furthermore, the information available at this time is necessarily preliminary, has been developed only to an appraisal level of detail, and is therefore subject to change if this alternative is investigated further in the course of the Yakima River Basin Storage Feasibility Study (Storage Study). Finally, economic, financial, environmental, cultural, and social evaluations of the Black Rock alternative have not yet been conducted, and this appraisal assessment offers no conclusions in this regard.

The policy of the Bureau of Reclamation (Reclamation) requires non-Federal parties to share the costs of financing feasibility studies and the eventual construction of Federal reclamation projects. In light of this policy, the preliminary cost estimates presented in this Summary Report, and current Federal budgetary constraints, Reclamation is not reaching a decision at this time as to whether the Black Rock alternative will be carried forward into the next phase of the Storage Study or dropped from further consideration. Rather, Reclamation will consult with the State of Washington (which is cost sharing in the Storage Study), the Yakama Nation, the potential water exchange participants, project proponents, and other interested parties before making a decision in this regard. It is anticipated that a decision will be reached by the fall of 2005.

If the Congress provides further funding for the Storage Study, all technically viable alternatives would be compared and an alternative(s) selected for further analyses in the feasibility phase. (Whether the Columbia River-Yakima River water exchange concept in the form of the Black Rock alternative is included will depend upon whether Reclamation, after these additional consultations, decides to carry that alternative forward into the plan formulation phase of the Storage Study.) The selected alternative(s) would then be subject to detailed evaluation in the feasibility phase in terms of engineering, economic, and environmental considerations, and cultural and social acceptability. This feasibility phase would be the last phase of the Storage Study. Preparation of the Feasibility Report/Environmental Impact Statement would be a part of this final phase.

Preliminary Conclusion on Technical Viability

Reclamation concludes that, based on current information, a potential Columbia River-Yakima River water exchange by means of the Black Rock alternative appears to be technically viable. Reclamation also concludes that a potential water exchange could meet the purposes of the

Yakima River Basin Water Storage Feasibility Study (Storage Study). These conclusions are based on Reclamation's assessment of the following:

- potential participants who may be willing to exchange water;
- availability of Columbia River water in excess of seasonal instream flow targets;
- Washington State water appropriation statutes and exchange participants' water rights and water service contracts;
- damsite and reservoir basin geologic and hydrogeology characteristics; and
- potential facility options and preliminary plans to divert, store, and deliver exchange water
- exchanging Columbia River water for some Yakima River water currently diverted for use in the lower Yakima Valley will significantly improve the reliability of the Yakima River basin's water supply.

Background

In February 2003, Congress authorized the Secretary of the Interior, acting through Reclamation, to conduct the Storage Study. The Storage Study is an ongoing evaluation of options for additional water storage facilities to improve water supplies for the Yakima River basin. It investigates the potential for in-basin storage opportunities (such as Bumping Lake enlargement, a new Wymer dam and reservoir, and a Keechelus to Kachess pipeline) as well as a potential transbasin diversion from the Columbia River (the Black Rock alternative).

One purpose of the Storage Study is to develop additional stored water and manage it to improve anadromous fish habitat. To this end, the water supply goal is to restore the flow regime of the Yakima and Naches Rivers to some semblance of the natural (unregulated) hydrograph. A second purpose is to improve the reliability of the Yakima Project water supply to provide not less than 70 percent supply for junior (proratable) water rights in dry years. Another purpose is to meet growth demand for municipal water supply.

Because the Federal authorization includes the provisions, "…with emphasis on the feasibility of storage of Columbia River water in the potential Black Rock Reservoir ….," and because the State of Washington appropriated $4 million in the 2003 legislative session, also instructing that initial study emphasis be on the Black Rock alternative, the appraisal assessment of the Black Rock alternative (Assessment) was undertaken as an early component of the Storage Study. This Assessment focuses on the technical viability of the Black Rock alternative and the potential of a water exchange to meet the Storage Study purposes.

Summary Report

The *Summary Report, Appraisal Assessment of the Black Rock Alternative* (Summary Report) merges into a single document the information and findings of numerous technical reports prepared for this Assessment. The Summary Report also identifies some technical issues involved with the Black Rock alternative that will need to be addressed, and it sets the framework for further analyses. The individual Reclamation reports will be published as a part of a technical series on the Storage Study website http://www.usbr.gov/pn/programs/storage_study/index.html at, or near, the time the Summary Report is released.

The Summary Report does not quantify annual benefits that may be realized from a potential Black Rock alternative. Work on estimating unit benefit values has begun, but final estimates and the annual benefits have yet to be determined. As a consequence, a benefit-cost analysis has not been prepared, and this Summary Report does not address whether the Black Rock alternative is economically justified. Likewise, a cost allocation to reimbursable and nonreimbursable project purposes has not been made, and an analysis of the ability to repay the reimbursable costs has yet to be done. Further, environmental, social, and cultural impacts have yet to be evaluated.

Black Rock Alternative

The Black Rock alternative concept is to pump water from the Columbia River, when available in excess of current instream flow targets, for storage in a Black Rock reservoir. Stored water would be released to an outflow conveyance system running to the west to the lower Yakima Valley and provided to some lower Yakima Valley irrigation entities situated to receive exchange water into their existing, or modified, distribution systems. The Yakima River water currently used by the potential participating exchange irrigation entities would not be diverted by those entities (and is referred to in this report as freed-up Yakima River water) and would instead be used to meet the Storage Study goals. Other Yakima Valley irrigators with junior proratable water rights, but not physically located to receive exchange water from the Black Rock alternative, would also benefit in dry years by receiving a portion of the freed-up Yakima River water.

A basic requirement of the Black Rock alternative is that a sufficient number of lower Yakima Valley irrigation entities are willing to participate in a water exchange. The following five entities [whose April through October senior (nonproratable) and junior irrigation water rights total 869,000 acre-feet] are identified as potential water exchange participants: Roza and Sunnyside Divisions; and the Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts.

A water exchange with these five irrigation entities could free up about 869,000 acre-feet of Yakima River water in wet and average water supply years for instream flow purposes. In dry years such as 1994 and 2001, this exchange could only free up about 552,000 acre-feet of water, 248,000 acre-feet to firm up the supply of junior irrigation water right holders (those not physically located to receive exchange water) to not less than 70 percent of their rights, and to provide about 304,000 acre-feet for instream flows. The municipal water supply of 30,000 acre-feet would also have to be provided in dry years. Exchange participants' junior irrigation water rights would also be firmed up to not less than a 70-percent supply from Black Rock reservoir. This appears to be the maximum exchange possible.

The Black Rock alternative would involve numerous facilities that could be configured in different ways. This Assessment considered multiple options of the following major facilities between the Columbia River and the intersection of State Highway 24 and Roza Canal mile post (MP) 22.6:

- Two inflow conveyance system options: an all tunnel option and a tunnel/pipeline option, extending from the intake pumping plant discharge to a Black Rock reservoir.
- Three dam options:
  - a rockfill embankment dam that relies on an upstream concrete face as the impervious element,
  - a rockfill embankment dam with an earthen central core of relatively impervious soils,
  - a roller compacted concrete dam made of no-slump concrete placed by earth-moving equipment and compacted by vibrating rollers.
- Two Black Rock powerplant options (a 1,500-cfs, 38-MW powerplant and a 900-cfs, 23-MW powerplant) at the Black Rock outlet facility located adjacent to Roza Canal MP 22.6.

In addition, delivery system options were developed to convey exchange water upstream from Roza Canal MP 22.6 to Roza Division's service area and to the Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts, and downstream from Roza Canal MP 22.6 to Sunnyside Division's Sunnyside Canal. Roza Division's service area downstream from Roza Canal MP 22.6 can be provided exchange water without constructing new delivery systems.

Three preliminary project configurations of major facilities to pump, store, and deliver Columbia River water to Roza Canal MP 22.6 are:

- A large reservoir pump only option includes a fish screened intake from Priest Rapids Lake, a 3,500-cfs pumping plant to lift water to Black Rock Valley, a dam to store 1,300,000 acre-feet of active storage in a Black Rock reservoir, a 2,500-cfs reservoir outflow conveyance system, and powerplants at points of discharge.
- A large reservoir pump/generation option is similar to the large reservoir pump only option, except it includes a multilevel intake to selectively withdraw water from a Black Rock reservoir for a 3,500-cfs powerplant to generate electricity, and a 3,500-cfs tailrace channel to return water back to Priest Rapids Lake.
- A small reservoir pump only option includes a fish screened intake from Priest Rapids Lake, a 6,000-cfs pumping plant to lift water to Black Rock Valley, a dam to store 800,000 acre-feet of active storage in a Black Rock reservoir, a 2,500-cfs reservoir outflow conveyance system, and powerplants at points of discharge.

Table ES-1 shows the characteristics of these three preliminary Black Rock configurations.

Table ES-1. Summary of major facilities for three preliminary Black Rock alternative configurations

OPTIONS →	LARGE RESERVOIR		SMALL RESERVOIR
	PUMP ONLY	PUMP/ GENERATION	PUMP ONLY
FACILITIES			
Priest Rapids Lake intake and fish screen			
design flow capacity	3,500 cfs		6,000 cfs
intake location	on right bank of Priest Rapids Lake		
Priest Rapids plant	pumping	pump/generation	pumping
design flow capacity	3,500 cfs		6,000 cfs
500-cfs, two-stage spiral case pumps	three		n.a.
1,000-cfs, two-stage spiral case pumps	two		six
turbines	n.a.	two 1,750-cfs turbines with 150-MW generators	n.a.
Inflow conveyance system			
design flow capacity	3,500 cfs		6,000 cfs
conveyance type	all tunnel		
inlet/outlet structure	n.a.	multi-level screened	n.a.
Black Rock dam			
location	original Washington Infrastructure Services' damsite		
concrete face rockfill embankment dam			
crest elevation	1790.0 feet		1722.0 feet
structural height	760 feet		692 feet
crest width	40 feet		
central core rockfill embankment dam			
crest elevation	1785.0 feet		1717.0 feet
structural height	755 feet		687 feet
crest width	40 feet		
spillway	none		
low-level outlet works:	upstream steel-lined concrete conduit, downstream buried steel pipe, and two jet flow gates in left abutment		
Black Rock reservoir			
maximum water surface elevation	1778.0 feet		1712.0 feet
active storage capacity	1,300,000 acre-feet		800,000 acre-feet
elevation top of active storage	1775.0 feet		1707.0 feet
inactive storage capacity	157,610 acre-feet		
elevation top of inactive storage	1500.0 feet		
State Highway 24 relocation	relocated south of Black Rock reservoir in Rattlesnake Hills		
Outflow conveyance system			
design flow capacity	2,500 cfs		
intake structure	single-level screened		
conveyance type	tunnel/pipeline		
Black Rock outlet facility			
location	adjacent to Roza Canal MP 22.6		
pump delivery	all water through powerplant to Roza Canal		
	1,500-cfs Black Rock powerplant – 38 MW		
pressure delivery	upstream bifurcation to pressurized pipeline		
	900-cfs Black Rock powerplant – 23 MW		
Sunnyside powerplant and bypass			
powerplant capacity	900 cfs – 15 to 29.5 MW		

Technical Issues Needing Further Analyses

There are two technical issues regarding the Black Rock alternative that require further investigation. The results of these investigations could affect the technical viability, cost, and acceptability of the Black Rock alternative.

Seismicity

The initial assessment indicates the Black Rock damsite lies in an area of relatively high earthquake potential. Preliminary seismic hazard analysis suggests a level of ground shaking that might be associated with the occurrence of magnitude 6 to 7+ earthquakes relatively near the site. Because of its proximity to the site, the Black Rock Valley fault appears to be the largest contributor to such an occurrence. While the Black Rock Valley fault has not been studied in sufficient detail to define its activity, it is assumed at this stage of study that the fault may be capable of large-magnitude earthquake. However, Reclamation has determined it is possible to design a potential Black Rock dam that would withstand earthquakes of these magnitudes. Further investigations of the Black Rock Valley fault and the Yakima Fold Belt are needed to guide future engineering design decisions.

Reservoir Basin and Reservoir Rim Leakage

The Pomona Basalt, intercepted at 145 feet deep, appears to be a hydraulic barrier to downward seepage, at least at the site of the initial hydrologic testing. However, if vertical joints and fractures exist in the Pomona Basalt elsewhere in the proposed reservoir basin, significant leakage from the reservoir could occur. Should reservoir leakage reach the geologic units that underlie the Pomona Basalt, there could be significant regional effects on the groundwater system. Future investigations would include hydrologic testing within the reservoir basin to substantiate the hydrologic conditions within the Pomona Basalt and working with the Pacific Northwest National Laboratory to estimate potential leakage and the impact to the Hanford Site. Further investigations are required to characterize the leakage potential of geologic units around the reservoir site.

In addition, current information indicates permeable geologic units may be exposed or covered only by a thin soil layer on the dam abutments and reservoir rim. Depending on the structure and fracturing of these units, significant reservoir leakage could occur. Exploratory drilling is required along the reservoir rim to determine the geologic structure of potential leakage areas. Based on data available to date, it should be possible to accommodate the potential reservoir leakage by various means.

Project Costs

Appraisal-level field construction cost estimates were prepared as a part of this Assessment solely for screening potential facility options and developing preliminary configurations of the Black Rock alternative. These appraisal-level field construction cost estimates are based on available, but limited, data and preliminary designs and drawings and professional assumptions.

Field costs are not the total cost necessary to complete a project. Field construction costs are limited to the costs of construction contracts and do not include costs such as preparing final engineering designs and specifications, land acquisition, regulatory compliance and permitting activities, environmental mitigation and monitoring, and construction contract administration and management. Thus, total estimated project costs, which have yet to be prepared, would be substantially in excess of estimated field construction costs.

Appraisal-level field construction costs of major facilities to divert, store, and deliver Columbia River water to Roza Canal MP 22.6 are estimated at about $2.5 to 2.7 billion (June 2004 price levels). Appraisal-level field construction costs to build new facilities or modify existing facilities to deliver exchange water from this point to participants' current facilities are estimated at up to $270 million, depending on the type of delivery system and amount of a water exchange. Therefore, field construction costs are estimated at about $2.8 to $3 billion.

As a rule of thumb in the industry, the additional costs (for preparing final engineering designs and specifications, land acquisition, regulatory compliance and permitting activities, environmental mitigation and monitoring, and construction contract administration and management) are typically estimated to be from 20 to 35 percent of the field construction costs. Based on current information, these appraisal-level field construction cost estimates, and industry-wide, accepted cost estimating methodology, standards, and practices, it is reasonable to anticipate the total construction cost of the Black Rock alternative could be from $3.5 to $4 billion.

A more refined cost estimate cannot be provided at this preliminary stage of the study. Furthermore, it is highly likely that this cost estimate will change if the Black Rock alternative is investigated in greater detail.

Additional data should be collected prior to refining potential concepts and project configurations. Value engineering methods of analysis should be applied to identify needs, major cost components, and to reduce overall costs. Value engineering is a problem-solving methodology that examines potential component features of a potential project to determine pertinent functions, governing criteria, and associated costs. Other proposals would then be developed that either meet the necessary requirements at lower costs or that increase the long-term value.

Other Issues to be Addressed

Economic, financial, environmental, cultural, and social aspects have not been addressed in this Assessment. Further investigations and analyses needed to identify and evaluate these issues would be addressed in the next phase of the Storage Study.

In summary, the geologic foundation and hydrologic conditions related to potential reservoir leakage are technical issues requiring further investigations and analyses to guide and refine engineering design decisions. These activities would be addressed in the next phase of the Storage Study. Refined field construction costs and total project costs would be estimated if the Black Rock alternative is investigated in greater detail in the next phase of the Storage Study. It is highly likely this will result in cost estimates different from the preliminary estimates presented in this Summary Report.

Glossary and Acronyms

• 1945 Judgment	the Consent Judgment [*in Kittitas Reclamation District v. Sunnyside Valley Irrigation District* (Civil 21, E. Dist. Wash., 1945)]
• *Acquavella* case	a Yakima River basin water adjudication court case in Yakima County Superior Court
• active capacity	the reservoir capacity or quantity of water which lies above the inactive reservoir capacity and is normally usable for storage and regulation of reservoir inflow to meet established reservoir operating requirements
• antecedent flood	a flood or series of floods assumed to occur prior to the occurrence of an inflow flood used to design a specific dam
• anticline	a geologic fold that is convex upward
• alternate damsite	upstream alignment explored by Reclamation
• appraisal-level design	designs based on limited analyses, available design data, and professional assumptions but of sufficient detail to provide satisfactory quantities and preliminary field cost estimates
• Assessment	the gathering and appraisal-level assessment of the data and information contained in this Summary Report
• average water supply year	a water supply in the Yakima River basin between 2,250,000 and 3,250,000 acre-feet
• Benton Board	Board of Benton County Commissioners
• Black Rock outlet facility	a potential facility to divert water at the downstream end of an outflow conveyance system into potential or existing Roza and Sunnyside Divisions' delivery system facilities; this facility would include a bifurcation works and a Black Rock powerplant
• Black Rock powerplant	a potential powerplant near Roza Canal MP 22.6 at the potential Black Rock outlet facility
• BPA	Bonneville Power Administration
• CBP	Columbia Basin Project
• cfs	flow rate in cubic feet per second

• delivery systems	the potential canal, pipeline, or tunnel systems that would deliver water from the potential Black Rock outlet facility to the existing or modified Roza and Sunnyside Divisions' canal systems for delivery to Yakima Project lands
• dry year	a water supply in the Yakima River basin less than 2,250,000 acre-feet
• Ecology	Washington Department of Ecology
• ESA	Endangered Species Act
• ethnographic	relating to the branch of anthropology that deals historically with the origin and filiation of races and cultures
• FCRPS	Federal Columbia River Power System
• flow targets	instream flow targets as established in the December 2000 FCRPS Biological Opinion [4] and retained in the 2004 FCRPS Biological Opinion [5], and flow objectives for nonlisted salmon downstream from Priest Rapids Dam at Vernita Bar
• freed-up Yakima River water	the Yakima River water currently used by potential exchange participants that would not be diverted by those participants, but would instead be used for instream flow, dry-year proratable irrigation water rights, and future municipal supply needs
• fry	the life stage of fish between the egg and fingerling stages
• Grant PUD	Grant County Public Utility District
• Hanford Reach	the Columbia River reach extending from 15 miles upstream from the mouth of the Yakima River to Priest Rapids Dam
• heavy load hours	periods of highest electricity use, from 6 a.m. to 10 p.m., Monday through Saturday
• hydraulic grade line	the surface or profile of water flowing out of hydraulic gradient; the slope of the hydraulic grade line is under pressure; the hydraulic grade line is the actual level to which water would rise in a small vertical tube connected to the pipe
• hydraulic gradient	the slope of the surface of open or underground water

• Hyd-Sim	the BPA computer model used as the hydrologic basis for the 2000 Biological Opinion [4]; it includes the significant United States Federal and non-Federal dams and the major Canadian projects on the main stem Columbia River and its major tributaries
• inactive capacity	the reservoir capacity or quantity of water which lies beneath the active reservoir capacity and is normally unavailable for withdrawal because of operating agreements or physical constraints
• inflow conveyance	the system and facilities that would transport water from the potential Columbia River intake to a Black Rock reservoir
• in-lieu exchange	a potential Columbia River diversion used by lower Yakima Valley irrigation entities in lieu of existing Yakima River diversion
• kWh	kilowatt-hour
• light load hours	periods of low electricity use, from 10 p.m. to 6 a.m., Monday through Saturday and all day Sunday
• liquefaction	a loss of material strength during earthquake shaking that can result in large areas of slope failure or settlement of the ground surface
• Ma	million annum; million years
• maximum section	maximum cross-sectional area of a dam embankment
• MP	mile post – refers to locations on the Roza Canal with MP 0.0 being at Roza Diversion Dam
• MW	megawatt
• natural flow	river flow that originates from a source other than reservoir storage
• NOAA Fisheries	the National Oceanic and Atmospheric Administration, National Marine Fisheries Service
• nonprorated water rights	pre-Yakima Project senior water rights related to natural flows that are served first and cannot be reduced until all the proratable rights are regulated to zero
• original damsite	farthest downstream alignment explored by Washington Infrastructure Services, Inc.
• outflow conveyance	the potential system and facilities that would release water stored in a Black Rock reservoir and convey it to a downstream Black Rock outlet facility

• overburden	a thick deposit of sediments overlying bedrock
• PHA	Peak Horizontal Acceleration; a measure of very high frequency earthquake ground motions
• plinth	a concrete pedestal or footing located beneath the base of a dam's concrete face
• Priest Rapids intake	a potential intake facility on the right bank of Priest Rapids Lake about 3,600 feet upstream from Priest Rapids Dam that would pump Columbia River water to a potential Black Rock reservoir; one of the three intake options includes a Priest Rapids pump/generation plant
• Priest Rapids pump/generation plant	a potential combined pump/generation plant incorporated in the potential Priest Rapids intake facility that would permit Columbia River water stored in a Black Rock reservoir to return to the Columbia River to generate power
• prorated water rights	newer junior water rights related to storage water that, in water short years, receive less than their full right on a prorated basis
• PSHA	Probabilistic Seismic Hazard Assessment; a technique that provides an assessment of the annual levels of earthquake ground motions that the site might experience based on the rates of seismic activity and fault movements in the region surrounding the site
• RCC	roller compacted concrete – no-slump concrete placed by earth-moving equipment and compacted by vibrating rollers in horizontal lifts up to 12 inches thick
• RCW	Revised Codes of Washington; State laws
• Reclamation	U.S. Department of the Interior, Bureau of Reclamation
• redd	the nest that a spawning female salmon digs in gravel to deposit her eggs
• Reserved works	facilities operated and maintained by Reclamation
• RM	river mile – refers to locations on either the Yakima River or the Columbia River
• Roza Division	a division of Yakima Project comprised of Roza Irrigation District
• Roza Powerplant	the existing powerplant located at Roza Canal MP 11
• Roza-Selah lands	those irrigated lands upstream from the inlet of Roza Canal tunnel No. 3

• SH	State Highway
• storage facilities	a potential Black Rock dam and related facilities that would impound in a Black Rock reservoir the Columbia River water received via an inflow conveyance system
• Storage Study	Yakima River Basin Water Storage Feasibility Study; a multi-year evaluation of the viability and acceptability of several storage augmentation alternatives, including a potential water exchange, for the benefit of fish, irrigation, and municipal water supply within the Yakima River basin
• storage water	water that has been stored and purposefully released
• Summary Report	*Summary Report - Appraisal Assessment of the Black Rock Alternative - A component of Yakima River Basin Water Storage Feasibility Study, Washington*
• Sunnyside Division	a division of Yakima Project comprised of Sunnyside Valley Irrigation District and eight other irrigation districts, companies, and cities
• Sunnyside powerplant	a potential new powerplant at Sunnyside Canal MP 3.83
• tailrace	the body of water immediately downstream from a powerplant or pumping plant that regulates fluctuating discharges from the plant
• total capacity	the total reservoir capacity or quantity of water which can be impounded in the reservoir below the maximum water surface elevation
• transferred works	facilities owned by Reclamation, but operated and maintained by an irrigation district or other entity
• Treaty	Columbia River Treaty
• UCAO	Reclamation's Upper Columbia Area Office
• USGS	U.S. Department of the Interior, Geological Survey
• value engineering	an organized team effort directed at analyzing the functions of processes, systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality, and safety
• WAC	Washington Administrative Code; State rules and regulations
• WDFW	Washington Department of Fish and Wildlife

- wet year — a water supply in the Yakima River basin greater than 3,250,000 acre-feet
- WIS — Washington Infrastructure Services, Inc. – the contractor Benton County, Washington, commissioned to study the technical feasibility and approximate cost of a Black Rock alternative
- Work Group — Biology Technical Work Group; consists of technical representatives from NOAA Fisheries, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, the Yakama Nation, Yakima Basin Joint Board, Yakima Sub-Basin Fish and Wildlife Planning, and Reclamation's Upper Columbia Area Office and Technical Service Center
- Yak-RW — Yakima Project RiverWare model; is a daily time step reservoir and river operation computer model of the Yakima Project created with the RiverWare software

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Appendices

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Figures

1.0 Introduction

1.1 Storage Study

The Yakima River Basin Water Storage Feasibility Study (Storage Study) is an ongoing evaluation of how to provide additional stored water for the benefit of fish, irrigation, and municipal water supply within the Yakima River basin. This may be achieved (as shown on frontispiece A) by constructing new facilities to impound Yakima River basin waters or by importing water from the Columbia River for exchange with irrigation entities willing to forego all or part of their current Yakima River diversions. Prior investigations have identified a potential alternative for importing Columbia River water to the Yakima River basin. Because importing Columbia River water would involve the construction of a major offstream storage reservoir in Black Rock Valley, it has been termed the Black Rock alternative.

1.1.1 Authorization and Purpose

Congress directed the Secretary of the Interior, acting through the Bureau of Reclamation (Reclamation), to conduct a feasibility study of options for additional water storage for the Yakima River basin. Section 214 of the Act of February 20, 2003, (Public Law 108-7) contains this authorization and includes the provision "… with emphasis on the feasibility of storage of Columbia River water in the potential Black Rock Reservoir and the benefit of additional storage to endangered and threatened fish, irrigated agriculture, and municipal water supply."

Reclamation initiated the Storage Study in May 2003. As guided by the authorization, the Storage Study will identify and examine the viability and acceptability of various potential storage alternatives.

A purpose of the Storage Study is to develop additional stored water and manage it in a manner to improve anadromous fish habitat. To this end, the water supply goal is to restore the flow regime of the Yakima and Naches Rivers to some semblance of the natural (unregulated) hydrograph. The process being used in the Storage Study for achieving this goal is to: (1) define potential "blocks" of Yakima River water that may be made available through an exchange, and (2) assess how such blocks could be shaped, by spill and regulation, to most closely mimic the historic flow regime of an unregulated Yakima River system.

Another purpose of the Storage Study is to improve the reliability of the Yakima Project water supply for junior (proratable) water rights in dry years. Current Yakima Project legal, contractual, and operational parameters provide that when there is a deficiency in the available water supply to meet recognized water rights, senior (nonproratable) water rights are served first and shortages are assessed against junior (proratable) water rights. In the dry years of 1994 and 2001, this resulted in a 37 percent water supply being available for proratable water rights. A water supply goal of providing not less than 70 percent supply for proratable rights in dry years has historically been used in the Yakima River basin for planning purposes. This goal is being used for all Yakima Project proratable irrigation water rights.

A further purpose of the Storage Study is to meet growth demand for municipal water supply. Future population growth in the Yakima River basin will increase the need for municipal water supply. A water exchange could meet this need.

1.1.2 State of Washington Participation

State support for the Storage Study was provided in the 2003 Legislative session. The capital budget included a $4 million appropriation for the Washington Department of Ecology (Ecology) with the provision the funds "… are provided solely for expenditure under a contract between the department of ecology and the United States bureau of reclamation for the development of plans, engineering, and financing reports and other preconstruction activities associated with the development of water storage projects in the Yakima river basin, consistent with the Yakima river basin water enhancement project, P.L. 103-434. The initial water storage feasibility study shall be for the Black Rock reservoir project."

Reclamation and Ecology entered into a Memorandum of Agreement for Cost Sharing on November 14, 2003. This agreement complies with Reclamation's framework for general principles and administration of cost sharing for the Storage Study.

1.1.3 Process

Reclamation's Upper Columbia Area Office in Yakima, Washington, is managing and directing the Storage Study. A Plan of Study was prepared and published September 2003 and is available on the Storage Study website at http://www.usbr.gov/pn/programs/storage_study/index.html. For management purposes, the Storage Study is a four-phase, multi-year process culminating with the Storage Study Feasibility Report/Environmental Impact Statement, which will be the document used by Reclamation and the Secretary of the Interior to decide whether to seek congressional authorization for construction of any Storage Study alternative(s).

1.2 Black Rock Alternative Assessment

Mindful of the directives, Reclamation placed priority on study activities related to the Black Rock alternative. The appraisal assessment of the Black Rock alternative (Assessment), a component of the Storage Study, was undertaken to provide further information on a water exchange, to assist in understanding the major features of the alternative, potential effects, and to help guide future Storage Study activities.

The primary objectives of the Assessment are to determine whether a Columbia River-Yakima River water exchange by means of the Black Rock alternative is technically viable, whether it would meet the goals of the Storage Study, and whether it should be carried forward as an element of the Storage Study.

This Assessment addresses such questions as the potential of water delivery and the willingness of water exchange participants, the availability of Columbia River water to exchange, water rights and contractual matters associated with a potential exchange, geologic and hydrogeology site characteristics, potential facility options, and possible conceptual plans to divert, store, and deliver exchange water. It addresses the question of what a water exchange may physically accomplish in improving the availability and reliability of the Yakima River basin water supply to meet the Storage Study purposes. This Assessment also identifies some primary issues involved with the Black Rock alternative that will need to be addressed, and it sets the framework for further analyses.

However, this Assessment does not quantify annual benefits that may be realized from the Black Rock alternative. Work on estimating benefit unit values has begun, but final estimates, and the annual benefits, have yet to be determined. As a consequence, a benefit-cost analyses has not yet been prepared, and this Summary Report does not address whether the Black Rock alternative is economically justified. Likewise, a cost allocation to reimbursable and nonreimbursable project purposes has not been made and an analysis of the ability to repay the reimbursable costs has not been made. Further, environmental and cultural impacts have not been determined, and the public acceptability of the Black Rock alternative has yet to be determined.

1.3 Assessment Summary Report

Reclamation prepared a series of technical reports documenting the Assessment work conducted to date and the primary findings. Details of the concepts, assumptions, technical standards, and analysis applied to the Black Rock alternative components are in the technical reports. This *Summary Report Appraisal Assessment of the Black Rock Alternative* (Summary Report) consolidates information from the individual technical reports into a summary of the work conducted and the primary findings. The individual Reclamation reports will be published as part of a technical series on the Storage Study website at, or near, the time the Summary Report is released.

This Summary Report completes the Assessment and most activities of the second phase (pre-plan formulation) of the Storage Study. Because this Assessment includes some of the September 2003 Plan of Study phase 3 plan formulation activities associated with the Black Rock alternative, future work on these activities would be significantly reduced.

2.0 Black Rock Alternative

2.1 Defining the Alternative

Reclamation has conducted a number of studies in the past seeking solutions to recurring water supply shortages in the Yakima River basin. As to additional storage opportunities, the studies have focused on potential sites within the Yakima River basin.

Prompted by severe water supply shortages in the 1990s and economic studies of the negative impacts of such shortages, a renewed local effort emerged to seek additional water supply. This local initiative had its roots in a July 30, 2001, resolution adopted by the Board of Benton County Commissioners (Benton Board). The resolution authorized: (1) a program for examining opportunities internal to the Yakima River basin for enhancing water flows and external through importation of Columbia River water, and (2) the expenditure of $500,000 for related studies. This program was called the Yakima River Storage Enhancement Initiative.

The Benton Board placed initial emphasis on the study of a reservoir site located east of the city of Yakima, near the intersection of State Highways (SH) 24 and 241 and at the east end of Black Rock Valley on Dry Creek (see frontispiece A). The alternative, as conceptually described in an April 1993 paper prepared by the State Department of Natural Resources [1], would store water pumped from the Columbia River for transfer to the Yakima River basin.

In the fall of 2001, the Benton Board engaged Washington Infrastructure Services, Inc. (WIS) to study the technical feasibility and approximate cost of a Black Rock reservoir project. The project would withdraw water from the Columbia River at or near Priest Rapids Dam, pump it to a new, large storage reservoir in Black Rock Valley, and convey it from the reservoir to a junction with Roza Canal in the lower Yakima River basin. No attempt was made to determine the manner or cost of further distribution of water beyond that point.

WIS analyzed two project sizes and reported findings in a May 2002 report [2]. The larger project would consist of a 4,000-cfs pump-turbine facility taking water from Priest Rapids Lake for transmission to a Black Rock reservoir. A concrete face rockfill dam would store a total capacity of 1.7 million acre-feet of water in the reservoir. The reservoir outflow system would be sized for 2,000-cfs delivery to Roza Canal with an energy recovery plant (hydrogenerator) at the canal. Annually, approximately 500,000 acre-feet would be available at this point during the irrigation season.

The smaller WIS project is a potential 2,000-cfs pumping plant on the Columbia River downstream from Priest Rapids Dam, conveying water to a Black Rock reservoir. A concrete face rockfill dam would create a total reservoir capacity of 860,000-acre-feet. The outflow system would be sized to deliver 1,000 cfs to Roza Canal in conjunction with a hydrogeneration plant.

WIS emphasized that their study does not address issues such as water rights, financial capabilities to construct the project, fisheries issues, environmental mitigation, or geotechnical matters that can only be determined via field investigations. Instead, the study concentrates on the technical and cost aspects for moving Columbia River water via a Black Rock reservoir to the Yakima River basin. In this context, WIS identified no fatal flaws in project feasibility.

Based substantially on the Benton Board/WIS work, in February 2003, Congress authorized the Storage Study, which Reclamation is now conducting.

2.2 Water Exchange Concept

The water exchange concept is to replace, or exchange, Yakima River irrigation water with Columbia River water. This exchange would allow the Yakima River irrigation water to be used for instream flows, dry-year irrigated agriculture, and municipal water supply.

To accomplish this exchange, the Black Rock alternative would pump water from the Columbia River upstream from Priest Rapids Dam (when the flows are in excess of current instream flow targets) for storage in a Black Rock reservoir. The stored water would be conveyed west to Yakima Valley irrigation entities that are situated to receive the Columbia River water into their existing, or modified, distribution facilities. These irrigation entities would not divert Yakima River water for irrigation, thus freeing up the Yakima River water for allotment to other uses. Chapter 3.0 describes the irrigation entities and the amount of water potentially available in the exchange.

A water exchange alternative could respond to the stated congressional intent to provide additional water supply in the Yakima River basin for anadromous fish, existing irrigated agriculture, and future municipal water supply. Study objectives are to fully allocate freed-up Yakima River water to instream flows and municipal water supply in Yakima River basin in full water supply years when there would be no irrigation proration. In dry years, the Yakima River allocation would include water for those irrigation entities subject to proration. The extent that the Storage Study goals could be met would depend on the amount of exchange water made available and the allocation policies determined through the feasibility study process.

3.0 Yakima-Columbia River Water Exchange

3.1 Amount of Potential Water Exchange

A primary consideration as to the viability of a Columbia River water importation alternative is whether existing irrigation water users are so situated and willing to receive Columbia River water in lieu of diverting from the Yakima River. The amount or extent of exchange water that could be secured from willing participants in the lower Yakima Valley is critical in addressing the viability of the Black Rock alternative. Consequently, initial activities of this Assessment are to:

- Identify irrigation entities that may be willing to exchange water.
- Determine the amount of a water exchange.

The foregoing is necessary to define the quantity of imported water that could be exchanged and the configuration of the Black Rock alternative facilities necessary to transport such water from the Columbia River to potential exchange participants. This process requires the development of preliminary appraisal-level plans of how to deliver exchange water to their existing systems and the estimated costs of such systems.

3.1.1 Potential Water Exchange Participants

Potential water exchange participants were identified using the following general criteria:

- The general proximity of existing water delivery facilities to permit gravity delivery from a Black Rock reservoir.
- A willingness of irrigation entities to explore the possibility of a water exchange.
- The classes (nonproratable and proratable) of the irrigation entities' water rights.
- An ongoing or proposed water conservation program designed to reduce surface return flows to the Yakima River.

Applying the above criteria, the following irrigation entities have been identified as potential water exchange participants: Roza Division (Roza Irrigation District); Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts; and the Sunnyside Division (Sunnyside Valley Irrigation District and eight other irrigation districts, companies, and cities that comprise this division). These entities have expressed their willingness to explore water exchange possibilities. No agreements have been made or negotiated for these entities to make the water exchange.

3.1.2 Existing Water Delivery Systems of Potential Water Exchange Participants

Figure 3-1 shows the location of the main canals of the potential water exchange participants and the relationship to the Black Rock alternative water supply. Roza Canal (with its headworks on the Yakima River at Roza Diversion Dam at river mile (RM) 127.9 about 11 miles upstream from the confluence of the Naches River) serves the Roza Division. The canal extends for 95 miles parallel to and north of the Yakima River through the eastern portion of the middle and lower valley areas of the Yakima Project. The canal conveys water for irrigation to about 72,000 irrigable acres (figure 3-2) within the Roza Irrigation District and for hydroelectric generation at Reclamation's Roza Powerplant. The terminus of Roza Canal is in the vicinity of Benton City in the lower valley.

Selah-Moxee Irrigation District's primary diversion is from the Yakima River near Pomona (RM 123.6). The Selah-Moxee Canal runs parallel to and downslope from Roza Canal and ends in the southeast side of Moxee Valley. Selah-Moxee Irrigation District serves irrigation water to about 5,800 acres. In 1997, the Moxee Ditch Company and the Moxee-Hubbard Irrigation Company, with a total service area of about 2,000 acres, merged into the Selah-Moxee Irrigation District. The Moxee-Hubbard Canal diverts off the Yakima River at RM 116. The Moxee Ditch diverts off the Moxee-Hubbard Canal downstream from the Moxee-Hubbard Canal headworks. The Moxee Ditch and the Moxee-Hubbard Canal run parallel to and downslope of Roza Canal and Selah-Moxee Canal, also ending in Moxee Valley.

Union Gap Irrigation District's Yakima River diversion (RM 114.9) is downstream from the Naches River confluence. The Union Gap Canal runs parallel to and downslope of the above canals through Moxee Valley, then continues in pipeline and flume through the Union Gap. As it nears Sunnyside Diversion Dam, the Union Gap Canal swings upslope of Sunnyside Canal, which it parallels, ending in the vicinity of Zillah. The Union Gap Canal serves about 1,700 acres in Moxee Valley and another 2,950 acres in lower Yakima Valley.

The Sunnyside Division diverts from the Yakima River about 12.5 miles downstream from the confluence of the Naches River at Sunnyside Diversion Dam (RM 103.8) into the 60-mile-long Sunnyside Canal. This canal is on the northeast side of the Yakima River downslope from and parallel to Roza Canal. The terminus of Sunnyside Canal is near Benton City in the lower valley. Some 100,000 irrigable acres lie within the Sunnyside Division.

The Sunnyside Division is comprised of nine irrigation districts and companies, and cities. A January 3, 1945, contract with Reclamation established a Board of Control that oversees the operation and maintenance activities for Sunnyside Canal and joint-use ancillary facilities. The Sunnyside Valley Irrigation District, on behalf of the Board of Control, operates and maintains the joint-use facilities. Reclamation transferred operation and maintenance of Sunnyside Diversion Dam to the Board of Control in June 1959.

Part of the Sunnyside Valley Irrigation District and Grandview Irrigation District service areas, which are members of the Sunnyside Division, are upslope from Sunnyside Canal. A combination of hydroturbine and electric pumps lift water from the canal to serve these lands. All other lands within these two districts lie downslope from the canal and receive gravity service.

These existing main conveyance facilities are located so that Columbia River water stored in a Black Rock reservoir could be conveyed by gravity through an outflow conveyance system that would intersect Roza Canal mile post (MP) 22.6 at the SH 24 crossing. From this point, water could be transported by new or modified delivery systems for use by potential water exchange participants. A brief summary of existing facilities and the peak irrigation demands upstream and downstream from Roza Canal MP 22.6 follows.

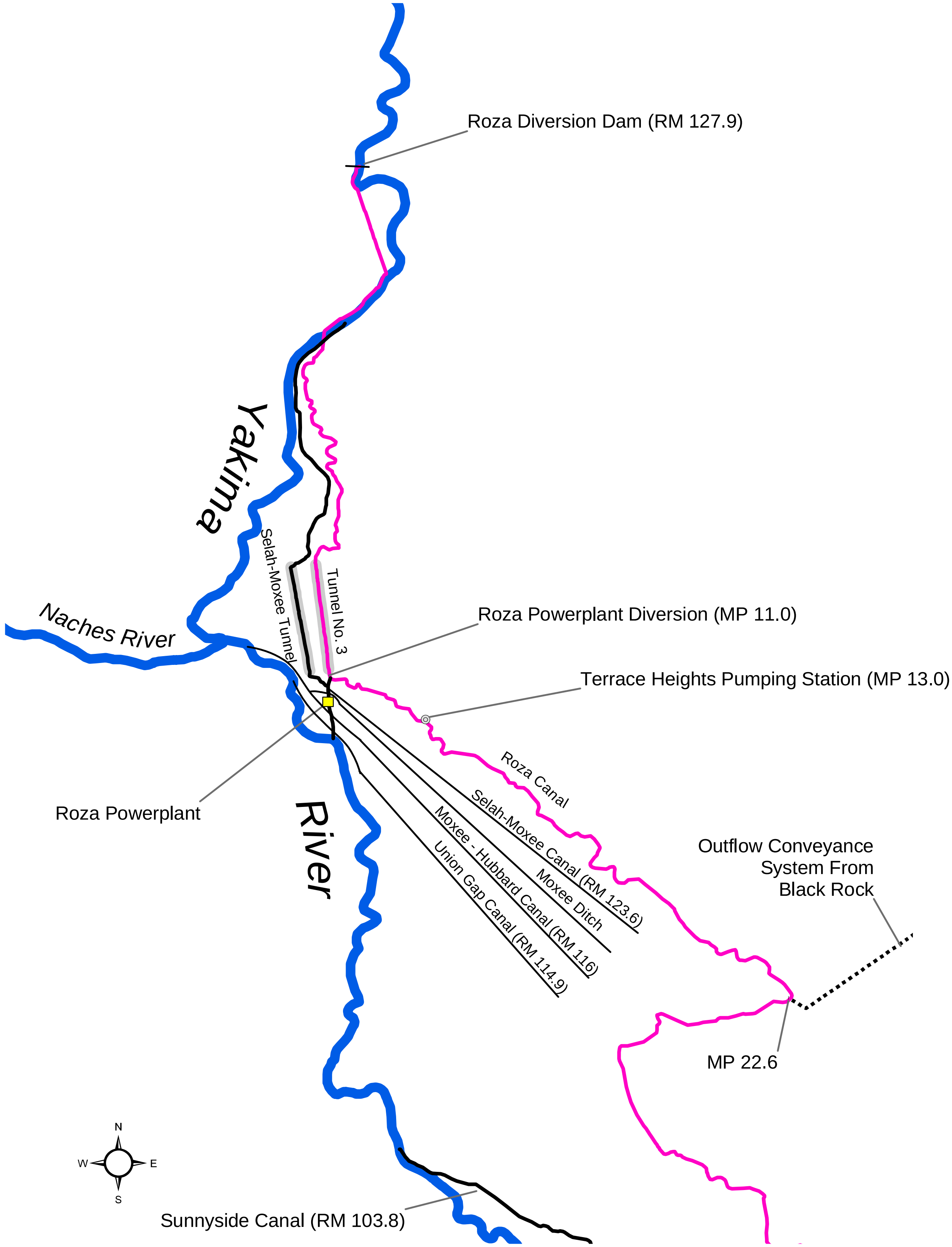


Figure 3-1. Schematic of potential water exchange participants' existing irrigation systems, diversion points (in parenthesis), and connection to the Black Rock alternative

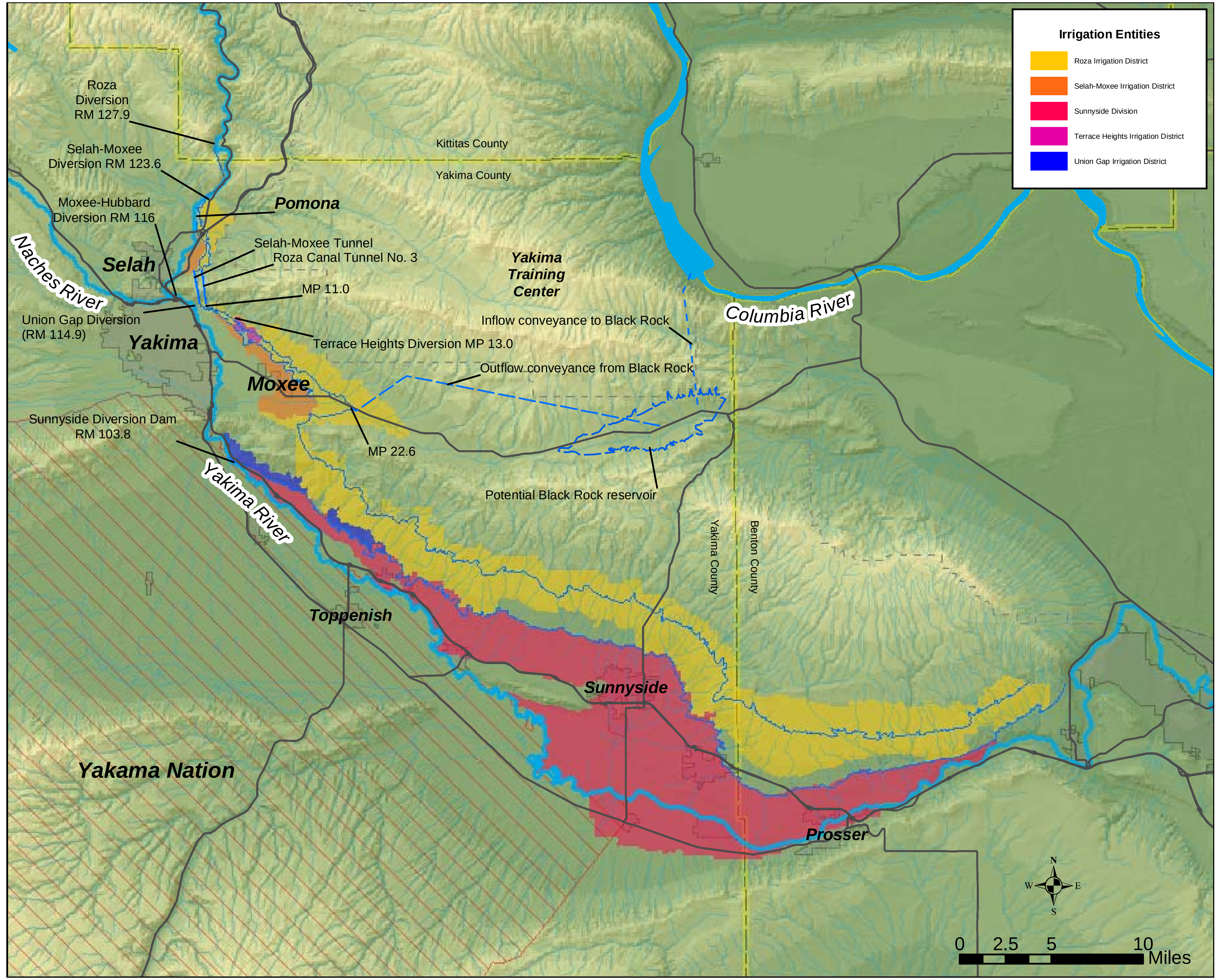


Figure 3-2. Irrigated lands of potential water exchange participants

3.1.2.1 Upstream From MP 22.6 - Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts

As shown on figure 3-3, the capacity of Roza Canal at its Yakima River diversion is about 2,200 cfs. Initially, the Roza Canal transports water for irrigation and hydroelectric generation. Upstream from MP 22.6, peak irrigation water demands of the Roza Irrigation District total about 215 cfs. Irrigation requirements upstream from the tunnel No. 3 inlet (MP 8.8) are about 40 cfs for the Roza-Selah lands. At MP 11.0 just downstream from the tunnel No. 3 outlet portal, a bifurcation facility diverts up to 1,020 cfs for use at the 11,250-kW Roza Powerplant. Powerplant discharge reenters the Yakima River at RM 113.3. Downstream from the bifurcation facility, Roza Canal carries water solely for irrigation purposes, and the capacity reduces to about 1,100 cfs. The peak irrigation demand from this point to MP 22.6 is about 175 cfs.

Three pumping stations, located at MP 7.2, 16.8, and 22.5, serve lands upslope from Roza Canal; downslope lands receive gravity service. In addition, Terrace Heights Irrigation District receives water at its MP 13.0 pumping station under an agreement with Roza Irrigation District.

Reclamation operates Roza Diversion Dam and the first 11 miles of Roza Canal; maintenance is a joint responsibility of Reclamation and Roza Irrigation District. Reclamation operates and maintains Roza Powerplant. Roza Irrigation District receives a credit for power generated at this plant to offset power used to run canalside pumping plants required to lift water to upslope lands. Bonneville Power Administration (BPA) markets any excess energy. Roza Irrigation District is responsible for the operation and maintenance of all of the pumping stations and laterals throughout the Roza Division.

Selah-Moxee and Union Gap Irrigation Districts' main conveyance facilities in this area are in close proximity of Roza Canal. The water rights of the two districts are for a maximum 205-cfs rate of diversion. These districts are responsible for the operation and maintenance of their respective water delivery facilities.

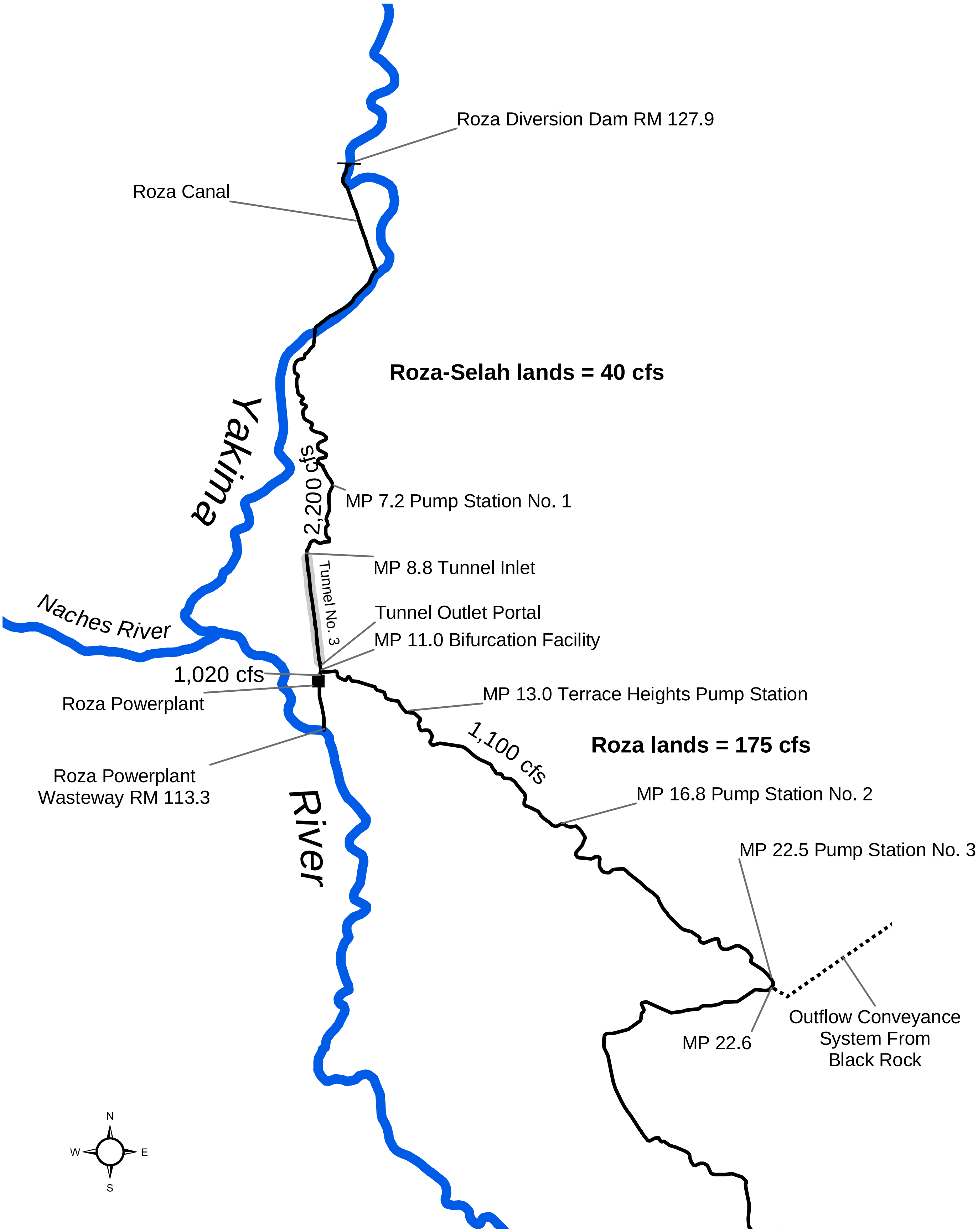


Figure 3-3. Peak Roza Canal flows and facilities upstream from MP 22.6

3.1.2.2 Downstream From MP 22.6 - Roza Irrigation District and Sunnyside Division

Roza Canal conveys Roza Irrigation District's peak irrigation demand (885 cfs) downstream from MP 22.6. In this area, 15 pumping stations serve upslope lands, and downslope lands receive gravity service.

Current appraisal-level water delivery plans provide for service to the entire Sunnyside Division either by a direct connection to the Black Rock outlet facility or through the joint use of some of Roza Irrigation District's facilities. Based on current water rights, Sunnyside Division is entitled to a maximum 1,316-cfs rate of delivery at the canal headworks. Through a Water Right Settlement Agreement reached in the *Acquavella* case, the Sunnyside Division has agreed to a reduction of its water rights to a 1,262-cfs rate of diversion by December 31, 2016.

3.1.3 Potential Exchange Participants' Water Rights

Individual water rights of the identified potential exchange participants represent their maximum water requirements and maximum water exchange potential. The water rights summarized in table 3-1 are based on Yakima River basin adjudication court documents (*Acquavella* case). These data represent the combined water rights of the five potential water exchange participants. Table 3-1 also shows a separation of these rights into proratable and nonproratable components, which are not part of the adjudication court determination, but are presented for planning purposes.

Table 3-1. Current water rights of potential water exchange participants

	Irrigation Entity[1]				
Item	Roza	Terrace Heights	Selah-Moxee[2]	Union Gap[3]	Sunnyside[4]
	(cfs)				
Maximum diversion rate	1,193	10.6	124.6	80	1,316
Applicable month	June	July	July	May	June
	(acre-feet)				
Total right	375,000	2,785	42,023	22,200	435,422
Nonproratable	0	2,206	37,742	17,558	315,836
Proratable	375,000	579	4,281	4,642	119,586

[1] All data applies to diversion at the appropriate Yakima River intake during the April through October irrigation season.

[2] Does not include: (a) the Warren Act contract right specific to lands of the Sub-A water users, and (b) any reduction in the annual use (acre-feet per year) resulting from in-lieu use of measured return flows.

[3] The adjudication court confirmed a flood water right of 1,200 acre-feet to be diverted from March 15 to May 31. No segregation of the total was made by month. This right is not included in the acre-foot tabulation.

[4] Through a Water Right Settlement Agreement filed with the Superior Court for Yakima County, the Sunnyside Division agreed to a reduction of its water rights to a 1,262-cfs rate of diversion and a 415,972-acre-foot volume by December 31, 2016.

These water rights pertain only to demand during the April through October irrigation season. Several districts hold water rights to divert March flood flow water when it is available and primarily use it to prime the water delivery systems prior to the irrigation season. These flood flows mostly spill to the Yakima River. Due to concerns about attracting Columbia River anadromous fish into the Yakima River if Columbia River water were discharged directly to the Yakima River, this assessment assumes the irrigation entities would continue to meet their nonirrigation season water requirements with Yakima River water.

Reclamation developed appraisal-level water delivery plans and related field cost estimates to determine if all or part of these water rights could be provided Columbia River exchange water. The irrigation entities received this information for comment. Section 5.8 of this Assessment presents the appraisal-level plans for two delivery concepts:

- one involving service from Roza Canal to all or a portion of Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts
- one involving full service to Sunnyside Division.

The assumptions for individual water service to the potential water exchange participants are:

- Sunnyside Division would receive irrigation water service at the current 435,422-acre-foot per year water right
- Roza Division would receive full irrigation service
- Terrace Heights and Union Gap Irrigation Districts would receive full irrigation service
- Selah-Moxee Irrigation District would receive irrigation service for 80 percent of the total water rights; the Yakima River would continue to serve the 20 percent balance.

The assumptions for service to all potential water exchange participants are:

- During Yakima River basin wet and average water supply years, the Columbia River would supply the full water right amounts.
- In Yakima River dry water supply years when the supply available for proratable water rights is greater than 70 percent, the Columbia River would supply the full nonproratable water right amounts and the same proratable supply if the exchange had not been made.
- In Yakima River dry water supply years when the supply available for proratable water rights is less than 70 percent, the Columbia River would supply the full nonproratable water right amounts and not less than 70 percent of the proratable amounts.

For illustration purposes, table 3-2 identifies the reduced Yakima River diversions that would result for both wet and average, and the most recent driest years. If these irrigation entities agree to the exchange, these reduced diversions would be the amounts of water available for other uses in the Yakima River basin: supplying water for fish habitat flows and future municipal demands, and firming up the irrigation water supply in dry years to not less than 70 percent of the proratable water rights of entities not involved in the exchange.

The years 1994 and 2001 represent the most recent dry-year condition for the Yakima River basin. Proration during these years resulted in a supply of only 37 percent of the proratable water rights. The 37 percent (551,990 acre-feet) shown in table 3-2 represents the exchange water supply that would be available in a repeat of these dry years taking into account the water rights of the water exchange participants.

Table 3-2. Reduced Yakima River water diversion resulting from a water exchange and the amounts of Yakima River water that would be available for other uses

Potential Participating Entity	Proratable	Nonproratable	Total
	April through October (acre-feet)		
Wet and Average Water Supply Years			
Sunnyside	119,586	315,836	435,422
Roza	375,000	0	375,000
Subtotal	494,586	315,836	810,422
Terrace Heights	579	2,206	2,785
Union Gap	4,642	17,558	22,200
Selah-Moxee	3,424	30,194	33,618
Subtotal	8,645	49,958	58,603
Total	503,231	365,794	869,025
Dry Water Supply Years (1994 and 2001)			
Sunnyside	44,247	315,836	360,083
Roza	138,750	0	138,750
Subtotal	182,997	315,836	498,833
Terrace Heights	214	2,206	2,420
Union Gap	1,718	17,558	19,276
Selah-Moxee	1,267	30,194	31,461
Subtotal	3,199	49,958	53,157
Total	186,196	365,794	551,990

To illustrate the exchange concept, assume:

- the irrigation entities identified in table 3-2 were fully supplied from the Columbia River,
- they would not divert from the Yakima River during April through October, and
- their Yakima River basin water rights were available for other Yakima River basin uses.

Further assume the allocation of this Yakima River water would be:

(1) solely for instream flow purposes in wet and average Yakima River basin water supply years

(2) for irrigation, municipal, and instream flow purposes in Yakima River basin dry years – The Yakima River water supply available due to the exchange would be used to provide not less than a 70-percent supply for those Yakima Project irrigation districts with proratable water rights (with total proratable water rights of 752,000 acre-feet[1]), but not physically able to participate in the water exchange, and to provide municipal supplies. Water in excess of the irrigation and municipal demands would then be used for instream flows.

[1] Two irrigation entities, the Wapato Irrigation Project (350,000 acre-feet) and the Kittitas Reclamation District (336,000 acre-feet) account for 91 percent of the 752,000-acre-foot proratable demand.

Under these assumptions, table 3-3 shows the allocation of freed-up Yakima River water available due to the exchange. It also shows that to meet the irrigation criteria of not less than 70 percent in a dry year, the other proratables need 248,000 acre-feet. The municipal water supply of 30,000 acre-feet would also have to be provided (although this is excluded from table 3-3).

Table 3-3. Allocation of freed-up Yakima River exchange water

Item	Allocation (acre-feet)
Wet and Average Water Supply Years	
Total water available	869,000
To instream flows	869,000
Dry Water Supply Years (1994 and 2001)	
Total water available	552,000
To irrigation (other proratable entities)	248,000 [a]
To instream flows	304,000 [b]

[a] Total water rights of 752,000 acre-feet x 33 percent (37 percent prorationing brought up to 70 percent = 248,000 acre-feet).

[b] Total available after irrigation allocation.

The instream flows would not be released as steady flow year round, but would be managed to simulate the unregulated hydrograph. To provide a frame of reference, a conversion of the above data (acre-feet) into a flow rate (cfs) based on a continuous flow over a 365-day period results in the following allocation to instream flow:

- Wet and average year: 1,200 cfs
- Dry year (i.e., 1994 and 2001): 420 cfs.

Findings: Exchanging Columbia River water for Yakima River water under the conditions described would create a freed-up block of Yakima River water ranging from about 869,000 acre-feet (the potential exchange participants' total water rights) in wet and average water years to 552,000 acre-feet in extremely dry years such as 1994 and 2001.

The exchange concept as presented in this Summary Report would firm up, to not less than 70 percent, the water supply of irrigation entities with proratable water rights, but not able to participate in the water exchange; it would provide water to augment instream flows and to municipal needs for future growth.

The Black Rock alternative involving an exchange with only the Roza Division would not meet the study goals. In a repeat of dry years such as 1994 and 2001, Roza Division's junior irrigation

rights of 375,000 acre-feet result in about 140,000 acre-feet of supply (see table 3-2). This is considerably short of the amount necessary to firm up the dry-year water supply of other Yakima River basin junior irrigation rights, let alone provide water for instream flows. It appears a water exchange including senior water right holders is necessary for the Storage Study goals to be realized.

3.2 Columbia River Water Exchange Supply

The March 18, 2004, *Preliminary Appraisal Assessment of Columbia River Water Availability for a Potential Black Rock Project* [3] provides the basis for discussion of the hydrologic analyses on water availability. Two conditions should be recognized when comparing data contained in the water availability assessment to data contained in this Summary Report:

- At the time Reclamation prepared the water availability assessment, an 810,422-acre-foot Columbia River water exchange for April through October was being considered only for the Roza and Sunnyside Divisions. Reclamation later identified Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts as potential exchange participants. The total water rights of all five exchange participants equals 869,000 acre-feet for April through October.
- The 840,422-acre-foot water service initially identified in the water availability assessment for the Roza and Sunnyside Divisions included both March water (30,000 acre-feet) and April through October irrigation season water (810,422 acre-feet). The majority of the March water is for priming the irrigation system and is returned to the Yakima River. Since one objective of the water exchange concept would be to not directly discharge Columbia River water to the Yakima River, March service for the Black Rock alternative is no longer under consideration. However, all discussion in this Summary Report pertaining to Columbia River pumping is based on the water availability assessment [3] and, therefore, reflects a demand including this 30,000-acre-foot March water.

3.2.1 Seasonal Instream Flow Targets

The potential Columbia River water diversion for the Black Rock alternative would be from Priest Rapids Lake, immediately upstream from the 51-mile-long Hanford Reach (the last undammed, free-flowing reach of the Columbia River in the U.S). The Black Rock alternative primarily affects the 62-mile reach of the Columbia River extending from the mouth of the Yakima River (RM 335.2) to Priest Rapids Dam (RM 397.1). The lower 11 miles of this reach contain water affected by the downstream operation of McNary Dam and are not considered free-flowing habitat. Vernita Bar, about 4 miles downstream from Priest Rapids Dam, is one of the largest spawning areas for fall Chinook salmon.

Four species of anadromous salmonids inhabit or migrate through the Hanford Reach: spring, summer, and fall Chinook salmon (*Oncorhynchus tshawyscha*); summer steelhead (*O .mykiss*); coho salmon (*O. kisutch*); and sockeye salmon (*O. nerka*). The Endangered Species Act (ESA) lists the Upper Columbia River Spring Chinook Salmon Evolutionarily Significant Unit and the Upper Columbia River Steelhead Evolutionarily Significant Unit as endangered. Only fall Chinook salmon are known to spawn and rear in the Hanford Reach. The other anadromous species migrate through as adults returning to upriver spawning areas, while smolts travel through the area on their downstream migration.

The National Oceanic and Atmospheric Administration, National Marine Fisheries Service's, (NOAA Fisheries) December 2000 Biological Opinion of operation of the Federal Columbia River Power System (FCRPS) [4] establishes seasonal instream flow targets downstream from Priest Rapids, McNary, and Bonneville Dams for ESA-listed fish. Flow targets facilitate spawning and downstream passage of juveniles, and accommodate returning adult salmon and steelhead. The November 30, 2004, NOAA Fisheries FCRPS Biological Opinion [5] retains the same instream flow targets as the 2000 Biological Opinion.

FCRPS operations accommodate other flow objectives, not part of the Biological Opinion, for nonlisted salmon downstream from Priest Rapids Dam at Vernita Bar. Table 3-4 summarizes all seasonal instream flow targets downstream from Priest Rapids Dam.

Table 3-4. Seasonal flow targets and planning dates for the main stem Columbia River

	Fall Through Spring Targets		Summer Targets	
Columbia River Location	Dates	Flow (cfs)	Dates	Flow (cfs)
at Priest Rapids Dam - transport target[a]	4/10 - 6/30	135,000	NA	NA
at Priest Rapids Dam - spawning target[b]	10/10 - 6/30	55,000	NA	NA
at McNary Dam - transport target[a]	4/10 - 6/30	220,000 - 260,000[c]	7/01 - 8/31	200,000
at Bonneville Dam - spawning target[a]	11/1 through April	125,000 - 160,000[d]	NA	NA

[a] as per 2000 FCRPS Biological Opinion [4] for listed species

[b] pertains to nonlisted species (Chinook salmon) as per Vernita Bar Agreement; would govern in October; after 4/10, the 135,000 cfs minimum governs

[c] objective varies according to water volume forecasts

[d] objective varies based on actual and forecasted water conditions

3.2.2 Water Supply in Excess of Seasonal Instream Flow Targets

The hydrologic basis for the 2000 Biological Opinion [4] is a BPA computer model (Hyd-Sim) which includes the significant United States Federal and non-Federal dams and the major Canadian projects on the main stem Columbia River and its major tributaries. This computer model contains a data set of runoff from 1929-1978 to which current operations are imposed. In this data set, the 1930s and 1940s are the controlling dry years of the Columbia River water supply. Given a set of operating parameters for each project, BPA determines the Columbia River operation that best minimizes the impact on each project and optimizes use of the water resources. Model output includes information on inflow, outflow, end-of-month reservoir elevations, power generation at each project, and monthly average flows at different target points on the river.

Table 3-5 presents the average monthly volumes of water historically available in the vicinity of Priest Rapids Dam after meeting all current downstream instream flow targets. This assessment assumes the average monthly volumes are available for diversion each day of the month.

Table 3-5. Average monthly water available for pumping in the vicinity of Priest Rapids Dam in excess of instream flow targets

(Flows above 125,000 cfs Bonnneville Dam Nov-Apr; 260,000 cfs McNary Dam Apr-Jun; 200,000 cfs McNary Dam Jul-Aug; 135,000 cfs Priest Rapids Dam Apr-Jun; 55,000 cfs at Priest Rapids Dam Sept-Oct)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr1	Apr2	May	Jun	Jul	Aug1	Aug2	Sep	Total
1929	1387	0	0	1286	0	0	0	0	0	0	0	0	0	640	3313
1930	1844	0	0	0	373	0	0	0	0	0	0	0	0	834	3050
1931	1587	0	0	0	0	0	0	0	0	0	0	0	0	1095	2683
1932	1666	0	0	0	0	2274	608	971	2552	234	216	0	0	801	9322
1933	1451	0	1537	5222	3289	0	0	0	0	5587	5137	0	0	1419	23643
1934	2858	2591	9752	13415	7578	4848	2808	927	757	0	0	0	0	729	46263
1935	1543	0	963	4611	4831	0	0	0	0	0	26	0	0	879	12853
1936	1667	0	0	0	0	123	0	0	3883	0	0	0	0	440	6114
1937	1662	0	0	0	0	0	0	0	0	0	0	0	0	530	2192
1938	1828	0	829	5977	920	3548	59	0	3644	0	0	0	0	860	17665
1939	1490	0	0	1903	0	347	0	0	0	0	0	0	0	509	4248
1940	1811	0	324	1010	177	3441	0	0	0	0	0	0	0	380	7143
1941	1470	0	1013	2094	0	0	0	0	0	0	0	0	0	637	5214
1942	1314	0	3706	5673	260	0	0	0	0	171	463	0	0	585	12174
1943	1632	0	1387	4996	3709	4074	1784	593	3516	1462	2075	0	0	512	25741
1944	1458	0	89	1731	0	0	0	0	0	0	0	0	0	734	4012
1945	1462	0	0	0	0	0	0	0	0	0	0	0	0	315	1777
1946	1690	0	231	3133	2148	4239	482	39	4457	0	857	0	0	904	18181
1947	1060	0	5174	5675	4199	4367	0	0	2363	0	236	0	0	737	23810
1948	3993	1699	2887	6072	1220	2026	81	0	4311	15620	2691	0	0	1927	42528
1949	1814	0	955	2297	1540	6525	0	695	3846	0	0	0	0	205	17877
1950	1490	0	156	3091	5026	7537	759	281	1790	7856	3747	0	0	1161	32895
1951	2294	2627	6406	9109	8943	5173	1000	1050	6410	0	1613	0	0	1416	46043
1952	3124	412	3340	4990	3232	2978	405	220	5279	0	0	0	0	513	24494
1953	1422	0	0	2958	4782	184	0	0	562	3934	1955	0	0	885	16682
1954	1747	81	2368	4107	4813	2541	685	0	3173	6281	3923	952	0	4452	35123
1955	2454	1170	2056	1044	0	0	0	0	0	7265	6264	0	0	1037	21289
1956	2271	1976	6450	10088	3284	6679	1409	2216	8067	7435	2711	0	0	875	53461
1957	1725	0	2704	3533	0	2546	1255	0	3918	5691	0	0	0	514	21885
1958	1373	0	398	3136	3955	2876	0	0	3131	1951	0	0	0	657	17477
1959	1394	1019	3747	8782	5011	2609	1175	0	1410	5052	3306	0	0	3984	37488
1960	4694	3082	4817	4475	1360	2090	2689	200	0	481	372	0	0	839	25100
1961	1623	553	964	3981	4979	3993	1372	0	389	8332	0	0	0	384	26570
1962	1401	0	59	3733	0	0	1484	626	0	0	0	0	0	517	7821
1963	1587	1047	3703	3899	2543	1211	0	0	0	0	41	0	0	1006	15038
1964	1240	0	375	3641	660	0	0	0	0	5979	4743	0	0	1657	18296
1965	2743	159	7388	10836	8165	5171	327	626	3835	1899	243	0	0	667	42059
1966	1579	223	1993	4767	0	92	683	0	0	0	698	0	0	589	10624
1967	1344	0	1184	5768	5984	650	842	0	0	7189	3661	0	0	1208	27830
1968	1593	220	2042	4925	4216	2446	0	0	0	896	2701	0	0	2291	21331
1969	2484	1528	2892	8023	4813	3118	2412	1086	6486	629	185	0	0	619	34276
1970	1454	0	530	5392	3648	497	0	0	0	1986	0	0	0	0	13506
1971	1185	0	452	7606	9358	4092	564	455	7128	4962	3308	0	0	792	39903
1972	1158	103	2025	6758	8114	13880	3228	0	6524	10616	4977	529	0	1421	59333
1973	1545	0	2564	5537	0	0	0	0	0	0	0	0	0	0	9646
1974	1300	0	4814	13853	9371	6685	1932	1477	6253	8111	7671	129	0	1513	63110
1975	1150	0	800	5056	2478	3927	0	0	2225	2737	5096	0	0	801	24270
1976	1888	2160	8488	8839	5041	3371	1637	335	4934	106	3843	1453	0	5103	47198
1977	1753	0	313	1936	0	0	0	0	0	0	0	0	0	431	4434
1978	938	0	2243	3743	1318	4746	473	0	1584	0	1131	0	0	1036	17213
Average	1773	413	2082	4574	2827	2498	603	236	2049	2449	1478	61	0	1041	22084
# of Years Water Is Available															
	50	17	41	44	35	35	30	16	27	26	29	4	0	48	

Findings: Columbia River water in excess of seasonal instream flow targets is physically available for diversion, but not during every month.

3.2.3 Water Delivery Criteria for Potential Exchange Participants

Appraisal-level water delivery designs under consideration at the time Reclamation prepared the water availability assessment [3] indicate that Columbia River water physically could be delivered to serve all of the Roza and Sunnyside Division lands in lieu of their current Yakima River diversions. The maximum flow rate required by the Divisions was assumed to be measured by the current water rights (i.e., 1,193 cfs for Roza and 1,316 cfs for Sunnyside). Therefore, the water availability assessment uses a 2,500-cfs peak water exchange requirement.

For this Assessment, a full irrigation water supply consists of the sum of all authorized nonproratable water and: (a) 100 percent of the proratable water in wet and average water years, and (b) not less than 70 percent of proratable water in Yakima River basin dry years. Table 3-6 shows the March and April through October Columbia River water supply that would need to be delivered to the Roza and Sunnyside Divisions in wet and average water years and in a repeat of the 1994 and 2001 Yakima River basin dry years. The distribution by month of the total allocation is based on the current water service contracts and the adjudication (*Acquavella* case) determinations.

Table 3-6. Columbia River water supply needs based on water rights of Roza and Sunnyside Divisions

	Division (acre-feet)		
Wet and average water years	(numbers are rounded)		
	Roza	Sunnyside	Total
April	37,500	52,160	89,660
May	56,250	72,670	128,920
June	71,250	74,370	145,620
July	71,250	76,020	147,270
August	71,250	76,020	147,270
September	45,000	56,910	101,910
October	22,500	27,260	49,760
Subtotal	375,000	435,400	810,400
March	18,000	12,000	30,000
Total	393,000	447,400	840,400
Dry years such as 1994 and 2001			
April through October	262,500[a]	399,500[b]	662,000
March	18,000	12,000	30,000

[a] 375,000 acre-feet proratable x 70 percent = 262,500 acre-feet
[b] 119,600 acre-feet proratable x 70 percent = 83,700 acre-feet + 315,800 acre-feet nonproratable = 399,500 acre-feet

The water availability assessment considers the option of pumping directly from the Columbia River to irrigation canals serving Roza and Sunnyside Divisions to meet the irrigation season demands indicated above. The maximum combined peak water right is about 2,500 cfs in June.

Table 3-7 shows the water supply that could be delivered assuming a 2,500-cfs pumping capacity and diverting only when Columbia River flows were in excess of the instream flow targets.

Table 3-7. Direct delivery water supply based on 810,400-acre-foot April - October water rights

	Maximum Supply	Average Supply	Minimum Supply
Water delivered	736,800 acre-feet	437,200 acre-feet	142,600 acre-feet
Percentage of water rights delivered	91	54	18
Percentage of water rights shortage	9	46	82

Findings: Under current assumptions, direct delivery of Columbia River water to Roza and Sunnyside Divisions without storage would not be viable due to the differences in timing of water availability and water demands.

3.2.4 Storage and Pumping Plant Capacities

Based on information contained in the WIS report [2], this Assessment uses 1,300,000 acre-feet as the maximum active reservoir capacity. Analyses of various reservoir sizes and pump capacities identifies 800,000 acre-feet as the smallest reservoir capacity that provides sufficient carryover to meet the water delivery criteria based on available Columbia River water supply.

The water surface of Black Rock reservoir would be about 1,400 feet higher than the Columbia River. Large pumps would be necessary to lift water up that distance. Reclamation's assessment [4] examines the Black Rock alternative configuration consisting of:

(1) maximum active reservoir capacity (1,300,000 acre-feet as identified in the WIS report [2]) with minimum pumping capacity (3,500 cfs), and

(2) minimum active reservoir capacity (800,000 acre-feet) with minimum pumping capacity (6,000 cfs) to fill the reservoir.

Both alternative configurations (large and small reservoirs) were designed to meet the total water requirements (840,400 acre-feet) of the Roza and Sunnyside Divisions. Pumping capacities influence the amount of critical carryover. A larger reservoir with smaller pumping capacity would require more carryover to eliminate water shortages than a smaller reservoir with larger pumping capacity.

The water availability assessment also examines the two following pump rate scenarios and various pumping durations for these scenarios:

Pump Rate Scenarios

- Pumping only during periods of low electricity use (light load hours), which is from 10 p.m. to 6 a.m., Monday through Saturday and all day Sunday.
- Pumping during both light and heavy load hours (periods of highest electricity use - 6 a.m. to 10 p.m., Monday through Saturday).

Pumping Durations

- Pumping during the 3 months of April, May, and June when the peak Columbia River runoff occurs
- Pumping during the 10 months of November through August.
- Pumping throughout all 12 months.

Findings: **As the water availability assessment [3] shows, and based on the current assumed maximum and minimum active reservoir capacities, only one pumping scenario would meet the wet- and dry-year irrigation water delivery criteria. That scenario is for year-round pumping during both light and heavy load hours when Columbia River flows are in excess of instream flow targets and there is reservoir capacity available to store water. This scenario requires a minimum 3,500-cfs pumping capacity for the 1,300,000-acre-foot active capacity reservoir and a minimum 6,000-cfs pumping capacity for the 800,000-acre-foot active capacity reservoir.**

4.0 Water Rights and Water Service Contracts

4.1 Introduction

Lower Yakima River water users take natural flows, releases of stored water, and return flows under Federal contracts, a Federal consent judgment, and State water rights. Reclamation operates the Yakima Project to deliver water from all these sources to Federal contractors, senior appropriators, and other diverters. A potential alternative for exchange of Columbia River water for current use of Yakima River water by some lower Yakima River appropriators raises questions of the best legal pathway to acquire water rights that would allow diversion of Columbia River water. The identified exchange alternative also raises concerns about potential impacts on existing water rights and water service contracts.

Reclamation allocates and delivers water to water users under the authority of Federal contracts and the Consent Judgment [in Kittitas Reclamation District v. Sunnyside Valley Irrigation District (Civil 21, E. Dist. Wash., 1945) (1945 Judgment)]. The 1945 Judgment set up a unique allocation scheme for the Yakima River basin by creating a two-tier system of water rights. Water rights associated with storage, and the May 10, 1905, Federal appropriation for the Yakima Project are generally "proratable," i.e., susceptible of pro rata reduction in times of scarcity. Pre-Yakima Project senior rights are nonproratable and cannot be interrupted or reduced until all the proratable rights are regulated to zero. Historically, there has never been a water shortage that completely curtailed diversion by proratable users.

In 1977, Reclamation formalized operating procedures that had for many years tracked the parameters laid out in the 1945 Judgment. Reclamation estimates the total water supply available for Yakima Project purposes in March of every year and forecasts the amount of proration, if any, that will apply for the coming irrigation season. Total water supply available is recalculated on a regular basis during the irrigation season and the proration percentage updated. In this way, Reclamation has institutionalized the equitable sharing of the available water supply among the competing irrigators in the basin, as the 1945 Judgment envisioned. Though a final decree in the Acquavella adjudication will set state-law-based quantities and priorities for the basin's water users, it will not completely supersede the administrative and operational aspects of the 1945 Judgment.

Water right and post-1905 contract regulation has historically been very relaxed, but that trend changed with a priority call through the Acquavella court in 2001, a year of 37 percent proration. Tighter regulation of unauthorized and out-of-priority use, and more careful management of existing water supplies are the accelerating trends. Clearer water quantifications from the Acquavella adjudication allow the newly-created State watermaster for the Yakima River basin to reduce unauthorized or out-of-priority use in all years. In June 2004, the Acquavella court entered a permanent order for curtailment of all non-Project post-1905 water rights in water short years. Groundwater and Yakima Project return flow have not been integrated into the regulatory scheme, but inevitably will come under increased scrutiny. Universal water measurement, diversion reporting, and regulation are already helping stretch available supplies within the context of existing water rights.

Both State and Federal law apply to water use in the Yakima River basin. For any given use, there is a complex interplay of Federal and State jurisdiction, management, and regulation. For the purposes of this water rights analysis, it is assumed that Reclamation's operational scheme, which is based on the 1945 Judgment, the 1855 Yakama Nation Treaty, and the Washington State law of water rights, will continue to guide water allocation decisions.

4.2 Current Status

4.2.1 Participating Irrigation Entities

Two divisions of the Yakima Project (Roza and Sunnyside) and three irrigation districts (Selah-Moxee, Terrace Heights, and Union Gap) have expressed an interest in water exchange possibilities. Chapter 3.0 describes the location and features of these entities' Yakima River water delivery systems.

4.2.2 Water Service Contracts

In general, Reclamation has executed two types of contracts in the Yakima River basin – repayment contracts and water supply contracts. Repayment contracts make up the majority of the contract-based commitments in the basin. Water supply contracts are typically Warren Act contracts, which supplement the supply of water users who depend on pre-Yakima Project natural flow water rights. In other instances (e.g., the Sunnyside Valley Irrigation District contract of 1945), the contract applies to conditions of both repayment and water supply.

The repayment contracts of the lower basin entities were originally executed in the early years of the Yakima Project. These early contracts are perpetual and not fixed-term arrangements. They have subsequently been modified and expanded, but have not been amended or renegotiated since 1951.

Except for Roza Irrigation District, the irrigation entities who might participate in a potential exchange alternative hold pre-Yakima Project natural flow rights. Limiting agreements executed in the early 1900s as a condition for Federal commitment to the Yakima Project set limits on these pre-Project water rights. Federal courts and the State Acquavella adjudication have interpreted and applied the limiting agreements as real limitations on water rights that continue to bind the signatory entities.

If the exchange alternative were to be constructed, Reclamation and the exchange participants may have to engage in a detailed review of Federal water contracts and any multi-party agreements. This review would involve a simultaneous evaluation of the participants' existing state-based water rights, Federal contract entitlements, any new appropriations from the Columbia River, and the operational parameters of the exchange alternative. For each potential exchange participant, the review would generally involve the following:

- Roza Irrigation District: repayment and water supply contract
- Sunnyside Division: repayment and water supply contract, settlement agreement
- Terrace Heights Irrigation District: two Warren Act contracts
- Selah-Moxee Irrigation District: three Warren Act contracts
- Union Gap Irrigation District: six Warren Act contracts.

4.3 Water Appropriation From the Columbia River

4.3.1 Background

The identified exchange alternative would be based on diversion of Columbia River water. Authorization for such a diversion must comply with Washington State law. Washington instituted a moratorium on new water rights from the Columbia River in 1991, shortly after Snake River sockeye salmon were listed under ESA. In 1997, Washington lifted the moratorium with revisions to Chapter 173-563 WAC. The revisions mandated an evaluation of impacts on fish and existing water rights in consultation with Federal agencies and Indian tribes.

Since that time, Washington has launched a new program, the Columbia River Initiative, to evaluate and apportion available Columbia River water resources. That program is expected to result in rulemaking to establish a new water management program for the Columbia River.

4.3.2 Columbia River Initiative

In September 2004, Governor Gary Locke announced that the effort to adopt new rules under the Columbia River Initiative was being suspended. Instead, the Governor's office will develop recommendations for consideration by the 2005 Legislature. The recommendations are to include both proposed legislation and draft rules. State water policy for securing a new water right from the Columbia River, and the use of that right for a potential exchange alternative, could be affected by further legislative action.

4.3.3 Diversion Authorization Approaches

Several approaches have been identified for acquiring State authorization to divert and store Columbia River water for benefit of the Black Rock alternative. The following discussion identifies some strengths and weaknesses of each approach.

4.3.3.1 Application Under State Water Code

RCW 90.03.250 through -.340 deals with new appropriations of public water. To make a new appropriation, Reclamation would file an application with Ecology to appropriate public water. This application would carry the priority date of the withdrawal notice[2], a point of diversion at

[2] See section 4.3.5 for a discussion of the operative Washington process for Federal water appropriations.

Priest Rapids Dam, and a place of use in the Yakima River basin. To maintain the maximum flexibility for the exchange water, the United States would assert multiple purposes of use – irrigation, power, municipal and industrial use, fish, wildlife, and recreation. The claimed quantity would depend on the final design and operation scheme of the preferred exchange alternative.

Another section of the water code, RCW 90.03.370, describes the water appropriation procedure for storage reservoirs. Under the statute and WAC 508-12-260 and -270, a reservoir permit is required to construct a barrier across a stream, channel, or water course that would retain a portion of the annual runoff for beneficial use. Ecology may authorize reservoirs to be filled more than once per year or more than once per season of use to ensure that existing storage capacity was effectively and efficiently used.

Assuming a reservoir permit is required, such permit would be considered the primary right. Application(s) for secondary permit could also be filed for withdrawal of the stored water for off-site beneficial use. The secondary permit(s) would name the reservoir as the source of supply. The existing water rights of the exchange participants could be amended to include the reservoir as an additional source of supply. However, this statutory and conceptual framework does not make the actual appropriation from the Columbia River easier or more certain.

A new State appropriation under any of the above processes would face three significant hurdles. There is a slow queue of pending applications for Washington water rights, a functional moratorium on new diversions from the Columbia River, and a NOAA Fisheries bucket-for-bucket flow replacement policy for Columbia River withdrawals that occur during flow target periods.

While these hurdles are not fatal flaws, they would be significant challenges. Ecology may expedite processing of applications when the proposed use is nonconsumptive and if approval would substantially enhance or protect the quality of the natural environment. The functional moratorium is linked to the direction of the Columbia River Initiative program.

4.3.3.2 Columbia Basin Project Withdrawal and Transfer

Through a May 16, 1938, filing with the State pursuant to RCW 90.40.030, the United States gave notice of its intent to develop the Columbia Basin Project (CBP). Columbia River water sufficient for this purpose was withdrawn from appropriation. Water rights for existing power development and the first half of the irrigation project have been perfected. The withdrawal continues in effect for water to benefit the second half of the irrigation development.

The concept of moving a part of the CBP withdrawal to the Black Rock exchange alternative presents several challenges. The most obvious is that there would not be enough water for the second half of the CBP. Another obstacle would be the specific purpose and place of use detailed in the notice of intent. CBP entities have, in the past, suggested a quid pro quo where some water is transferred to Yakima River basin users in return for new service areas on the CBP.

Washington water law does not allow transfer of unperfected rights. RCW 90.03.380 limits transfers to water rights that have been applied to beneficial use. Water rights that have been granted a certificate, and, in some cases, permitted water rights can be transferred. It is unlikely that the CBP withdrawal could be changed to a new point of diversion and place of use under State law.

4.3.3.3 In-Lieu Exchange

The concept of exchanging Columbia River water for Yakima River water currently used by lower Yakima Valley irrigation entities has been applied by Reclamation at the Umatilla Project in Oregon. The strategy in Umatilla was to allow diversion of Columbia River water under a new appropriation for fish passage purposes in the Umatilla River. As the Columbia River water was diverted into the Umatilla Project, it was routed to irrigation uses, while the existing supply native to the Umatilla basin was designated to assist fish in the lower Umatilla River. Oregon's legislature had to craft a statute to allow the exchange (See Oregon Revised Statutes 540.533 to 540.537), but over time, it has proved to be a worthwhile and workable arrangement.

The main advantage of an in-lieu exchange is that it would avoid some of the State processes associated with a new appropriation and treat the new diversion as an additional point of diversion. Assuming the in-lieu exchange were based on a model similar to the Umatilla Project, the new Columbia River diversion could carry a December 28, 2004, priority date, but a purpose of use limited to fish and wildlife. Individual participants in the Black Rock alternative could execute agreements to make their Yakima River supplies available for instream flow, with certain limitations and the possibility of reversion in an emergency.

Washington's transfer statute, RCW 90.03.380, sets out the process for transfers and changes to water rights. Ecology has historically interpreted the statute to preclude diversion of new and hydrologically unrelated sources under color of existing water rights. However, recent Supreme Court rulings may be interpreted to more generally allow changes of water rights between hydrologically unrelated sources. As long as there was no impairment to other water rights, including State-adopted minimum instream flows, these exchanges may be permissible. Nevertheless, new State legislation similar to Oregon's may be necessary.

Diversion at Priest Rapids Lake would require tapping a new source of water – the Columbia River. Therefore, Washington law, as currently interpreted by Ecology, would not allow an exchange alternative diversion from the Columbia River under color of the Yakima Project water rights unless the Yakima River rights were subordinated to existing Columbia River rights in the reach from Priest Rapids to the McNary pool. Also, Ecology is likely to further condition the Columbia River point of diversion by limiting it to the supply available to the original Yakima River rights. This defeats one of the central purposes of the Black Rock alternative – augmentation of supply in low-water years.

4.3.3.4 Modify Existing Rights

Reclamation and the exchange participants could apply for a modification to the existing Yakima Project water rights to include a new, additional point of diversion on the Columbia River. This approach would be very similar to an in-lieu exchange, and has most of the same benefits and difficulties. A water right change to include a new point of diversion under RCW 90.03.380 would be a more simple approach that would not require new legislation. However, the underlying water right could not be expanded or enhanced in the process. Water right changes that enhance or expand the underlying right are generally prohibited under Washington law.

Adding a point of diversion on the Columbia River would have problems. Ecology has not, as a historical rule, allowed existing water rights to add points of diversion that tap hydrologically discrete water sources. The rationale is that the new diversion would diminish the new source and impermissibly affect water rights on that system. If there were water rights dependent on the new source, any new impact should be authorized by a new, junior water right. In special circumstances, Ecology has allowed changes in source under existing rights; however the new and old sources in those special cases were closely related both geographically and temporally.

4.3.4 Comparison of Approaches

Table 4-1 presents a brief subjective comparison of the approaches described above. All have the common basis that the United States (Reclamation) would be the initiating entity and that applications must be filed with Ecology under State law. The indicated viability ranking for securing State approval in a timely manner assumes current legal and political conditions. Regardless of their indicated viability, all approaches should receive further evaluation.

Table 4-1. Approaches for acquiring State authorization to divert Columbia River water

Approach	Initiating Entity	Priority Based on a Withdrawal	Application to State Required	State Legislation Required	Existing Rights Amended	Potential for Controversy	Viability Ranking *
RCW 90.03 Application(s)	United States	Possibly	Yes	No	No	Medium	2
Columbia Basin Project Transfer	United States	Yes	Yes - for changes	Possibly	Possibly	High	4
In-Lieu Exchange	United States and Districts	Possibly	Yes	Yes	No	Low	1
Modify Existing Yakima River Basin Rights	United States and Districts	Yes	Yes – for changes	No	Yes	High	3

*Sequential ranking with 1 being the most viable.

4.3.5 December 2004 Notice of Withdrawal Made

Section 8 of the 1902 Reclamation Act directs Reclamation to acquire new water rights under prevailing state water law. The United States has a unique status under Washington law. The Washington legislature in 1905 enacted RCW 90.40 to facilitate construction of the Yakima Project and other Reclamation projects in Washington. This statute allows the withdrawal of public waters from appropriation upon request of the Secretary of the Interior.

Under RCW 90.40, the United States would notify Washington that it intends to make examinations or surveys for the use of specified waters of the Columbia River. Said waters are then not subject to appropriation by others for a period of 1 year. If the United States certifies in writing within the 1-year period that the alternative contemplated in the notice appears to be viable and investigations will be made in detail, the waters would continue to be withdrawn from appropriation for 3 years and such further time as the State may grant by extension.

On December 28, 2004, Reclamation filed the requisite notice with the Washington Department of Ecology and Department of Natural Resources. Reclamation filed the notice for an exchange alternative as a preliminary measure to secure a 2004 priority date for any new water rights that the alternative might require. The withdrawal is not an application to appropriate water, however. At some point in the alternative development, if construction is authorized, funded, and certain, the United States would file an application to appropriate public water under the RCW 90.03 water code process, "such appropriation to be made, maintained, and perfected in the same manner and to the same extent as though such appropriation had been made by a private person, corporation, or association . . ." RCW 90.40.030. If an application were filed, it would relate back to the initial notice by the United States.

4.4 Water Rights

A primary concern of the irrigation districts that might participate in a water exchange alternative is that their existing water rights for appropriation of Yakima River water not be jeopardized or compromised. The United States holds the State water rights of the Sunnyside and Roza Divisions on their behalf. For Union Gap, Selah-Moxee, and Terrace Heights Irrigation Districts, the United States holds the title to the Warren Act contract water rights. Whether a proposed exchange would require a change in State water rights for these two divisions and three districts would depend heavily on how the exchange alternative would legally affect its withdrawals from the Columbia River system.

4.4.1 Relinquishment

Relinquishment for nonuse could become an issue if the Yakima River water supply were not consistently put to a beneficial use as a result of the exchange. Even if the exchange were carefully monitored, the State relinquishment statutes RCW 90.14.130 through -.180 would require use within a 5-year window to avoid forfeiture. The application of the relinquishment statute could be completely avoided if the exchange cited fish and wildlife as the beneficial use for the Columbia River diversion and existing Yakima River supplies.

The potential for relinquishment of both Yakima River water and Columbia River water under State law will need to be resolved if an exchange alternative goes forward. These issues would become clearer as the United States begins to resolve its case-in-chief in Acquavella, as the adjudication of all the United States' beneficial uses in the Yakima River basin, and as the operational parameters for the exchange alternative are refined.

4.4.2 Priority Date

A key question is whether a water exchange would require a different priority date and changes to other elements of the existing State water rights. The priority date would be intimately tied to the source – the Columbia River – and the theory under which the new diversion would be authorized. Regardless of the exchange water's priority, it is possible that a priority call on the Columbia River could curtail water use from that source. Nor is priority the only criterion for Columbia River diversion interruptions. While earlier priority would be desirable, the Columbia River system faces supply challenges that may translate to State- or Federal-based regulation of diversions for the exchange program.

If the exchange participants were sure that they could shift back to the Yakima River source in the event the Columbia River source were interrupted, then the priority date and some risks associated with the new supply would no longer be an issue. The exchange participants would be in the same position they are today. To effect this backup plan, the exchanged Yakima River water could assume the status of standby or reserve supply for these entities, a position that could be advantageous for relinquishment analysis.

Priority date is a poor proxy for the actual risk of curtailment of Columbia River water. More relevant is the size of the storage facility, the flexibility of the diversion schedule, and the ability to shift to the Yakima River source in a shortage situation.

4.4.3 Source/Point of Diversion

Source of water is an element of a State water right. Because of jurisdictional limitations, all Acquavella-confirmed rights, both for Reclamation and for the potential exchange entities, have the Yakima River and its tributaries as the source of water.

For the Black Rock alternative, source would be an issue primarily for the United States' water rights. Reclamation, from the earliest days of the Yakima Project, has managed the basin's storage system as an integrated whole. Individual contractors and divisions of the Yakima Project do not own storage space or have contractual rights to particular storage facilities. Assuming the Black Rock storage facility would be fully integrated into the Yakima Project storage system, the water rights of the individual end users would need little, if any modification.

For the five potential exchange participants, the confirmed points of diversion would be their headworks on the Yakima River. The delivery points identified in this Summary Report for the exchange water would not be on the Yakima River, but at points along the various entities' canals. These delivery points would not be points of diversion in the normal sense. There is no clear State law requirement to document these delivery points in State water rights.

If, as discussed above, the Columbia River withdrawals were authorized as separate primary water rights distinct from the secondary water rights of the end users, there would probably be no requirement to modify the end users' water rights to include the Columbia River source or point of diversion. A simple cross reference or note in the water rights would be sufficient. The Columbia River water rights would be separate, and additive to each exchange participants'

Yakima River rights. Each entity would have additional water rights confirmed in the name of the United States on their behalf. No significant modifications to Yakima River rights would be required.

4.5 Water Service Contracts

The potential exchange participants are firmly opposed to reopening, renegotiating, amending, or superseding their current contracts. Their primary concerns are that new or amended contracts would require National Environmental Policy Act clearance and compliance with the Reclamation Reform Act and the Endangered Species Act, and would introduce current standard Reclamation contract provisions that would be less favorable to their interests.

Therefore, an underlying assumption is that Reclamation would avoid, to the extent possible, any changes to their Federal contracts. New agreements or memoranda of understanding, however, may be necessary to affect the actual exchange of water.

Findings: If a new appropriation is necessary for the exchange alternative, it must comply with Washington State law. Substantial legal issues will have to be addressed before diversions could be made. Current obstacles are the unknowns surrounding State water policy on the Columbia River, the State administrative process, and the consultation and mitigation requirements of State and Federal law. Legal authorization of the potential exchange alternative would take time.

The United States has filed a notice of withdrawal with Washington. This notice is not a water right application, or an indication of the identified exchange alternative's viability. The withdrawal is a preliminary step that reserves a 2004 priority date if the identified alternative were constructed.

5.0 Black Rock Alternative Facilities

5.1 Options Considered

Reclamation's engineering evaluation of appraisal-level designs and field cost estimates of the Black Rock alternative identifies the following preliminary options for facilities to pump, store, and deliver Columbia River water to potential water exchange participants in the lower Yakima River basin:

- a Columbia River intake facility with pumping only and pump/generation,
- an all tunnel inflow conveyance and a tunnel/pipeline inflow conveyance,
- a large and a small storage dam,
- three dam types,
- a large and a small reservoir size,
- highway and utility relocations,
- a tunnel/pipeline outflow conveyance with a single-level intake,
- pump and pressure outlet facilities for irrigation delivery, both with a new Black Rock powerplant,
- several irrigation delivery system plans to convey Columbia River water to potential water exchange participants,
- a new powerplant at Sunnyside Canal.

This chapter gives a summary of site characteristics followed by a brief overview of each of the above preliminary options. Figure 5-1 provides a general layout of these facilities, and table 5-1 summarizes the major features of three preliminary Black Rock alternative configurations. Three Storage Study technical series reports present further design and field cost estimate information:

- *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates, Technical Series No. TS-YSS-2* [6]
- *Appraisal Assessment of the Black Rock Alternative Delivery System for Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts, Technical Series No. TS-YSS-3* [7]
- *Appraisal Assessment of the Black Rock Alternative Delivery System for Sunnyside Division, Technical Series No. TS-YSS-4* [8]

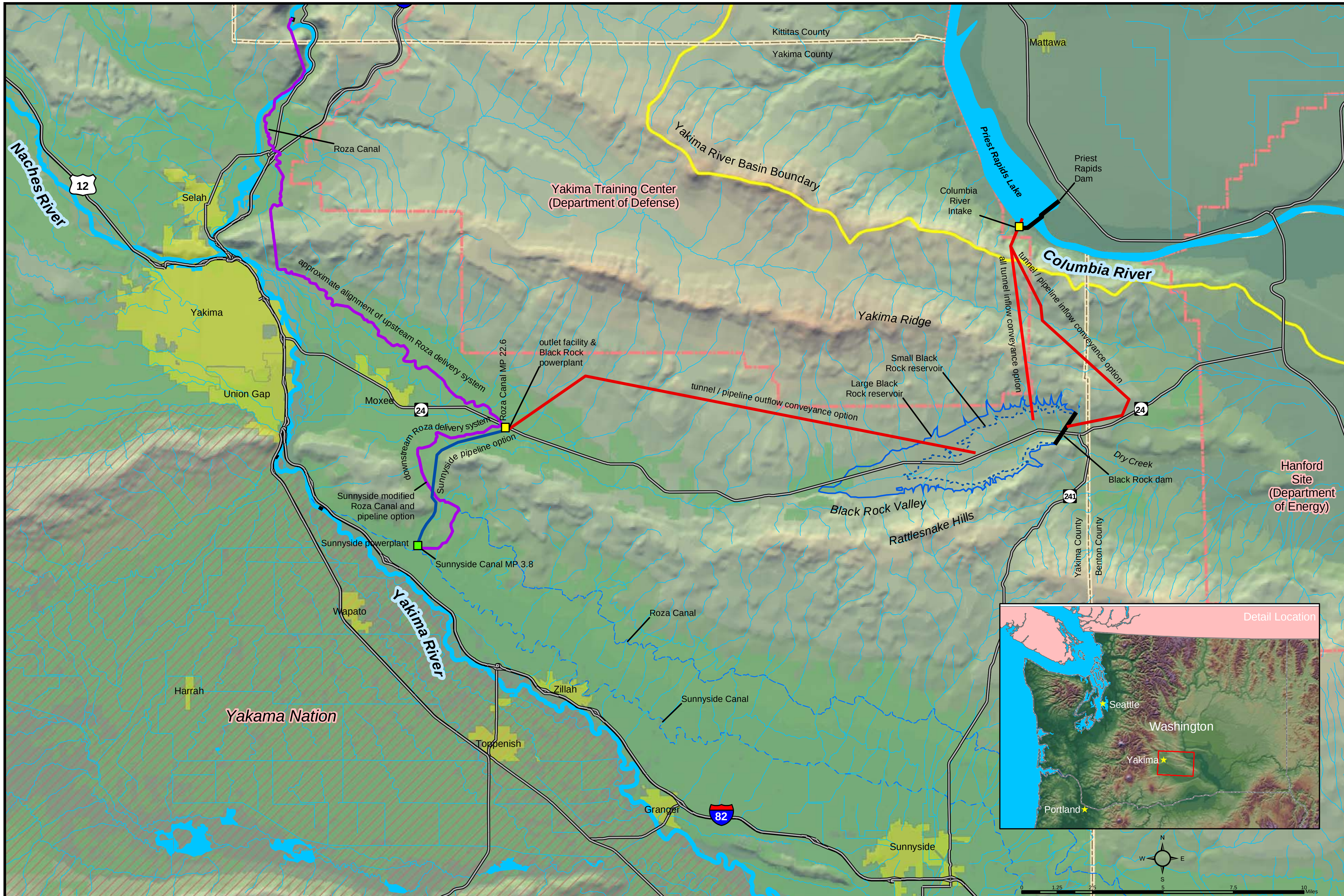


Figure 5-1. Schematic of the Black Rock alternative facility options

Table 5-1. Summary of major facilities for three preliminary Black Rock alternative configurations

OPTIONS →	LARGE RESERVOIR		SMALL RESERVOIR PUMP ONLY
	PUMP ONLY	PUMP/ GENERATION	
FACILITIES			
Priest Rapids Lake intake and fish screen			
design flow capacity	3,500 cfs		6,000 cfs
intake location	on right bank of Priest Rapids Lake		
normal Priest Rapids Lake operating water surface elevation range	481.5 to 488.0 feet		
separate tailrace channel to Priest Rapids Lake	n.a.	yes	n.a.
Priest Rapids plant	pumping	pump/generation	pumping
design flow capacity	3,500 cfs		6,000 cfs
500-cfs, two-stage spiral case pumps	three		n.a.
1,000-cfs, two-stage spiral case pumps	two		six
power design flow capacity	n.a.	3,500 cfs	n.a.
turbines	n.a.	two 1,750-cfs Francis turbines with 150-MW generators	n.a.
Inflow conveyance system			
design flow capacity	3,500 cfs		6,000 cfs
conveyance type	all tunnel		
	tunnel/pipeline	n.a.	
inlet/outlet structure	n.a.	multi-level fish screened	n.a.
Black Rock dam			
location	original Washington Infrastructure Services' damsite		
concrete face rockfill embankment dam			
crest elevation	1790.0-foot		1722.0-foot
structural height	760-foot		692-foot
crest width	40-foot		
slope	upstream and downstream 1.5:1		
central core rockfill embankment dam			
crest elevation	1785.0-foot		1717.0-foot
structural height	755-foot		687-foot
crest width	40-foot		
slope	upstream 1.75:1; downstream 1.5:1		
roller compacted concrete dam			
crest elevation	1781.0-foot		1715.0-foot
structural height	751-foot		685-foot
crest width	20-foot		
slope	upstream vertical; downstream 0.75:1		
spillway	none (See explanation in section 5.6.8.)		
low-level outlet works:			
rockfill embankment dam	upstream steel-lined concrete conduit, downstream buried steel pipe, and two jet flow gates in left abutment		
roller compacted concrete dam	fixed wheel gate, buried steel pipe, and two jet flow gates in upstream face of the dam near right abutment		

<table>
<tr><td rowspan="2">OPTIONS →</td><td colspan="2">LARGE RESERVOIR</td><td rowspan="2">SMALL RESERVOIR PUMP ONLY</td></tr>
<tr><td>PUMP ONLY</td><td>PUMP/ GENERATION</td></tr>
<tr><td colspan="4">FACILITIES</td></tr>
<tr><td colspan="4">Black Rock reservoir</td></tr>
<tr><td>maximum water surface elevation</td><td colspan="2">1778.0 feet</td><td>1712.0 feet</td></tr>
<tr><td>active storage capacity</td><td colspan="2">1,300,000 acre-feet</td><td>800,000 acre-feet</td></tr>
<tr><td>elevation top of active storage</td><td colspan="2">1775.0 feet</td><td>1707.0 feet</td></tr>
<tr><td>inactive storage capacity</td><td colspan="3">157,610 acre-feet</td></tr>
<tr><td>elevation top of inactive storage</td><td colspan="3">1500.0 feet</td></tr>
<tr><td>low-level outlet</td><td colspan="3">depends on dam type</td></tr>
<tr><td colspan="4">Highway and utility relocations</td></tr>
<tr><td>State Highway 24</td><td colspan="3">relocated south of Black Rock reservoir in Rattlesnake Hills</td></tr>
<tr><td>a buried fiber optic line and two overhead transmission lines</td><td colspan="3">relocated along the realigned State Highway 24</td></tr>
<tr><td colspan="4">Outflow conveyance system</td></tr>
<tr><td>design flow capacity</td><td colspan="3">2,500 cfs</td></tr>
<tr><td>intake structure</td><td colspan="3">single-level fish screened</td></tr>
<tr><td>conveyance type</td><td colspan="3">tunnel/pipeline</td></tr>
<tr><td colspan="4">Black Rock outlet facility</td></tr>
<tr><td>location</td><td colspan="3">adjacent to Roza Canal MP 22.6</td></tr>
<tr><td rowspan="2">pump delivery</td><td colspan="3">all water through the powerplant and bypass into Roza Canal</td></tr>
<tr><td colspan="3">1,500-cfs capacity powerplant</td></tr>
<tr><td rowspan="2">pressure delivery</td><td colspan="3">upstream bifurcation to pressurized pipeline delivery system</td></tr>
<tr><td colspan="3">900-cfs capacity powerplant</td></tr>
<tr><td>powerplant bypass design flow capacity</td><td colspan="3">2,500 cfs</td></tr>
<tr><td colspan="4">Sunnyside powerplant and bypass</td></tr>
<tr><td>powerplant capacity</td><td colspan="3">900 cfs</td></tr>
<tr><td>powerplant bypass design flow capacity</td><td colspan="3">1,250 cfs</td></tr>
</table>

5.2 Level of Detail

This chapter summarizes the engineering evaluation of appraisal-level designs of the primary components of the Black Rock alternative. The engineering evaluation is based on available design data from past WIS and Reclamation work and from more recent work as documented in the Assessment technical series reports listed in chapter 10.0.

Preliminary identification and sizing of the Black Rock alternative facilities are based on the water exchange, engineering judgment, limited analyses, available design data, and professional assumptions. Accordingly, the preliminary identification and sizing of facilities for the Black Rock alternative set forth in this Assessment will undoubtedly change if more detailed, feasibility-level analyses are done to refine these designs.

5.3 Site Characteristics

5.3.1 Topography

Reclamation and Aerometrics, Inc., developed aerial photogrammetry in August 2003 at approximately a 1:10,000 scale. The aerial photogrammetry covers the potential Columbia River intake area, Black Rock reservoir site, Black Rock outlet area, and most areas in between. These data were then used to generate grids, 2-foot contours, and orthophotos. Existing USGS 7.5-minute quad maps with 20-foot-contour intervals provided topographic information for locations outside the coverage area, including a small portion of the outflow conveyance system between the Black Rock reservoir site and Roza Canal and the Roza and Sunnyside delivery systems.

5.3.2 Geology

The *Appraisal Assessment of Geology at a Potential Black Rock Damsite* [9] report and Columbia Geotechnical Associates, Inc., investigations [10] document Reclamation's geologic investigations at an alternate Black Rock damsite and builds upon earlier work conducted by WIS for Benton County [2 and 11] at the original damsite. A brief geologic summary of the potential Black Rock site follows.

5.3.2.1 Regional Geology

The Black Rock site lies in the northwest-central portion of a large area covered by basalt flood lava referred to as the Columbia Plateau, which covers extensive portions of eastern Washington, northern Oregon, and western Idaho. The sequence of lava flows reaches thicknesses in excess of 10,000 feet and is known as the Columbia River Basalt Group. Beneath the alternative site, the lava flows form the foundation bedrock for the Black Rock damsite. Individual lava flows average about 100 feet thick and extend to a depth of at least 600 feet in test drilling completed to date at the damsite. The time periods between individual eruptions range from hundreds to tens of thousands of years, allowing for the deposition of sediments between lava flows. These sediments include sand and gravel bars laid down by the ancestral Columbia River and finer grained silt and clay layers that were deposited in shallow lakes formed by temporary damming of the Columbia River by the lava flows. These sediment layers are collectively known as the Ellensburg Formation.

Following the onset of the eruptive activity, the western portion of the Columbia Plateau was subjected to north-south compression that folded the flat-lying lava flows and sediment layers into a series of generally east-west trending ridges and valleys known as the Yakima Fold Belt. These ridges are typically asymmetrical in that the south slope is gently inclined while the north ridge slope is steeply folded. Low-angle thrust faults are present at the base of the steeply folded north slopes in each of the Yakima Fold Belt ridges. Landslides frequently are present in the Yakima Fold Belt and often occur on the steep north slopes where sliding happens in weaker layers of the Ellensburg Formation sediments that are sandwiched between the more rigid lava flows. This configuration exists at the Columbia River intake area, along the inflow conveyance system (both of which are bound by or within Umtanum Ridge), and at the Black Rock damsite (which lies between the Yakima Ridge on the north and Horsethief Mountain/Rattlesnake Hills ridge on the south).

The volcanic bedrock is overlain by sedimentary layers derived from ancient river and lake systems and volcanic eruptions in the Cascade Range. These sediments are known as the Ringold Formation. More recent wind-blown silt and alluvial deposits overlie the Ringold Formation sediments. The Ringold Formation materials form the upper foundation at the Black Rock damsite and are expected to provide a firm foundation capable of supporting a large dam. The recent alluvial and wind-blown deposits would likely be removed prior to dam construction.

5.3.2.2 Geology of Columbia River Intake and Inflow Conveyance Areas

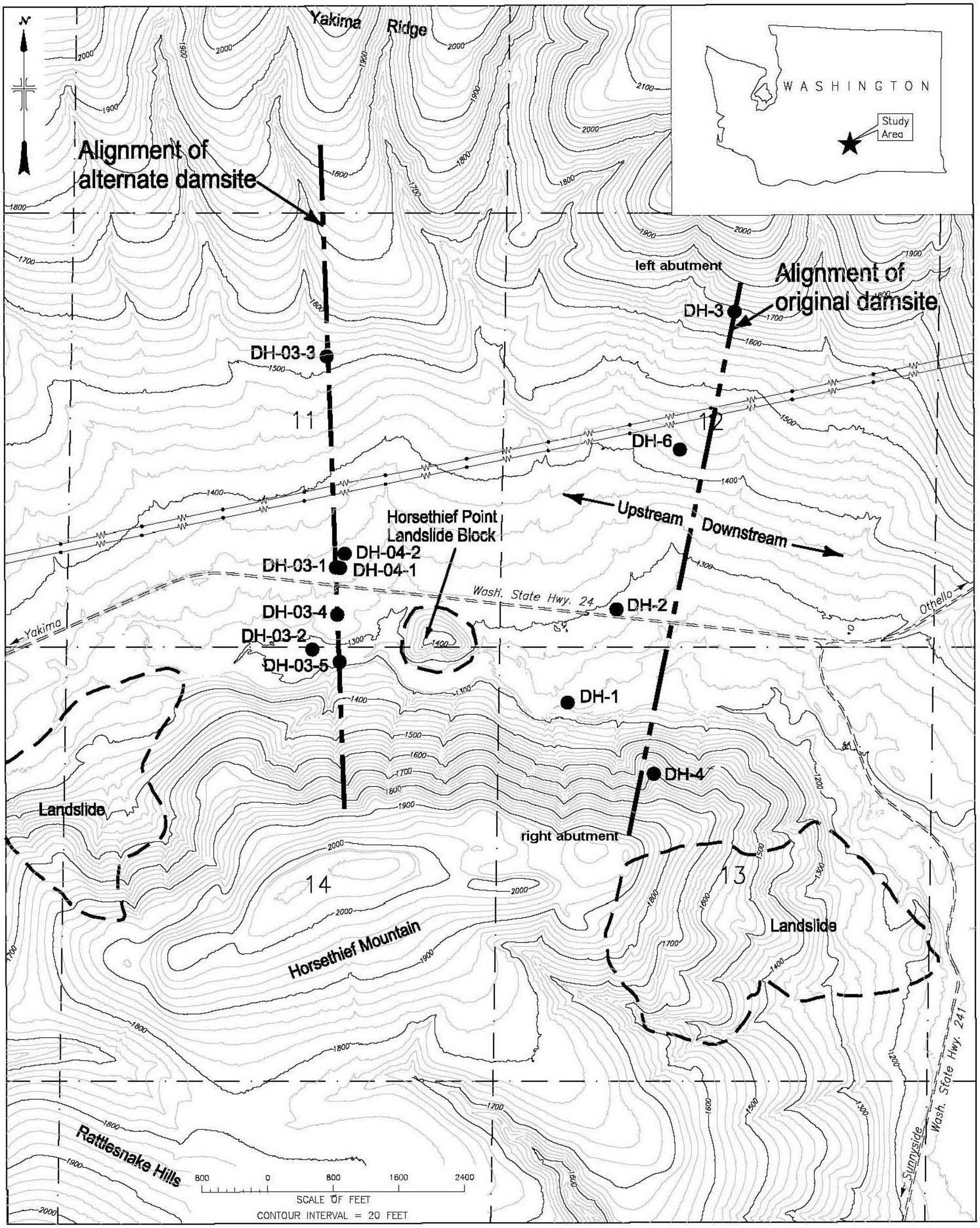
Information that the Grant County Public Utility District (Grant PUD) used to design and construct Priest Rapids Dam provides the primary basis for geologic conditions at the intake area (adjacent to Priest Rapids Lake) and along the inflow conveyance system. The intake and pumping plant structure likely would be founded on either Priest Rapids Basalt of the Columbia River Basalt Group or on terrace deposits laid down by the Columbia River. The pumping plant would likely be located in an area with less than 20 feet of unconsolidated terrace gravel lying above the Priest Rapids Basalt. If the basalt is dense and not highly fractured, excavation for the pumping plant likely would need relatively minor water control.

The inflow tunnel would penetrate Umtanum and Yakima Ridges, which are composed of folded and faulted Columbia River basalt flows layered with Ellensburg Formation sediments. The north slope of Umtanum Ridge at the nearby Priest Rapids Dam is overturned and dips to the north. An upper fault (Buck thrust) and a lower fault (Umtanum fault) define the overturned flows on the north side of the fold. Landslides exist along the steep, overturned north slope of Umtanum Ridge.

5.3.2.3 Geology of Black Rock Damsite

The geology of the Black Rock damsite was developed from 2003 WIS investigations [11] at the original damsite. Reclamation performed additional investigations [9] in 2003 and 2004 at a potential alternate damsite that the 2002 WIS report [2] identified about 1 mile west or upstream from the original site. Figure 5-2 shows the locations of the two damsites and the exploratory drill holes to date at each site. Both damsites and the reservoir site are underlain by the same geologic units: Recent wind-blown silt and alluvial deposits, Ringold Formation deposits, and Columbia River basalts with interbedded Ellensburg Formation sediments. The geologic and engineering properties of the shallow and deep foundation materials are similar at both damsites.

Figure 5-2. Locations of the two Black Rock damsites and exploratory drill holes



Tables 5-2 and 5-3 identify the depth of drilling in the exploratory holes and the depths at which bedrock was encountered.

Table 5-2. Summary of test drilling WIS performed at original Black Rock damsite

Hole Number	Location	Hole Depth (feet)	Depth to Bedrock (feet)
DH-1	maximum section near upstream toe	236.0	215.5
DH-2	left of maximum section near upstream toe	230.0	156.6
DH-3	left abutment	250.0	0.8
DH-4	right abutment	115.0	10.3
DH-5	hole was cancelled	-	-
DH-6	left abutment near upstream toe	150.1	11.6

Table 5-3. Summary of test drilling Reclamation performed at alternate Black Rock damsite

Hole Number	Location	Hole Depth (feet)	Depth to Bedrock (feet)
DH-03-1	left of maximum section	169.6	146.9
DH-03-2	maximum section	73.9	*
DH-03-3	left abutment	99.0	87.0
DH-03-4	maximum section	105.5	*
DH-03-5	maximum section	106.6	*
DH-04-1	left of maximum section	562.3	145.3
DH-04-2	left of maximum section	530.0	144.0
* Bedrock was not encountered in drill holes DH-03-2, DH-03-4, or DH-03-5.			

Figure 5-3 is a generalized geologic section that identifies the geologic units and where they occur in the alternate Black Rock damsite area. Figure 5-4 identifies the vertical depths and thicknesses of the geologic members present in the alternate Black Rock damsite area.

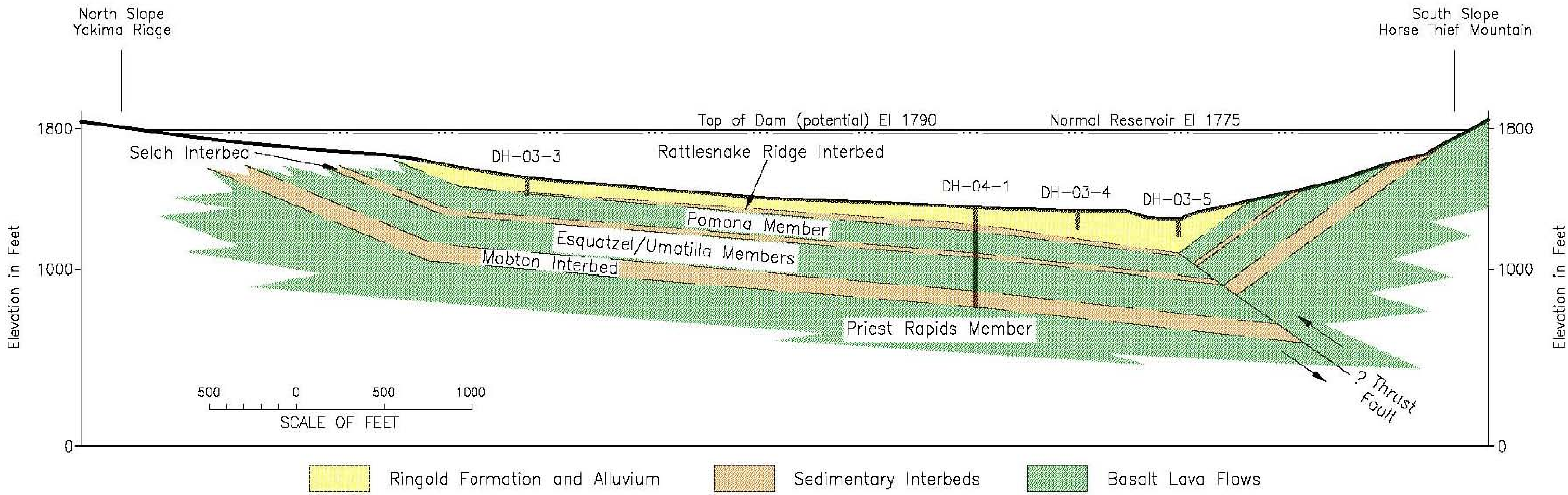


Figure 5-3. Generalized geologic section through the alternate Black Rock damsite

Period	Epoch	Group	Formation	Member (*)	Age (Ma)	Thickness (ft)	Symbol	Depth (ft)
Quaternary	Recent Pleistocene		Loess/Alluvium		0.05–0.1	31.7		31.7
Tertiary	Pliocene		Ringold		3.4–8.5	58.8		90.5
	Miocene	Columbia River Basalt Group	Saddle Mountains Basalt	Rattlesnake Ridge		28.0		118.5
				Pomona (peperite)	12	136.3		145.3
				Pomona (basalt)				254.8
				Selah		24.6		279.4
				Esquatzel	13	187.6		
				Umatilla				467.0
				Mabton		88.8		555.8
			Wanapum Basalt	Priest Rapids	14.5	>6.5		562.3

Bottom of Hole

Ringold Formation and Alluvium — Ellensburg Formation Sedimentary Interbeds — Columbia River Basalt Group Lava Flows

Figure 5-4. Stratigraphic section of geologic units in drill hole DH-04-1

Geologic explorations by both WIS and Reclamation confirm the presence of a thick deposit of sediments (overburden) overlying the basalt bedrock. Drilling indicates the overburden in Black Rock Valley is thicker than 200 feet near the base of the right dam abutment near Horsethief Mountain and may average more than 100 feet thick across the right center portion of the valley. Although the overburden includes some wind-blown silt and recent stream deposits, most appears to consist of the Ringold Formation. Based on the limited explorations, the Ringold Formation appears to be a highly variable deposit, consisting mainly of basalt gravels and cobbles in a sand matrix, but also including numerous layers of sand, silt, and clay. These varying materials range from poorly to well consolidated and from soft to hard. Portions of the Ringold Formation, particularly the deeper layers, are a dense, hard deposit of gravels and cobbles. This type of material is expected to be a firm, nonliquefiable foundation capable of supporting a large dam, although some type of cutoff to bedrock may be needed to minimize seepage.

The deep foundation at the damsite is composed of volcanic rocks of the Columbia River Basalt Group which are interbedded with sediments of the Ellensburg Formation. Individual basalt flows are up to 100 feet thick. The bedrock consists of a number of basalt flows with sedimentary interbeds sandwiched between them. Core samples obtained from test drilling indicate that some of the basalt flows plowed into the previously deposited sediments and rafted the older sediments onto the top of the new flow or mixed the sediments within the basalt (locally termed peperite). Zones of higher permeability generally exist at the top or bottom of flows due to shearing and intermixing during deposition, or from differences in how the flows cooled. The rock quality could vary significantly within flows or between flows.

The extent and causes of potential landslides in the Black Rock site need to be established. Landslides in the Yakima Fold Belt generally form on sloping limbs of the anticlines, due to failure of the lower strength sedimentary interbeds. The primary areas where these conditions exist include Horsethief Mountain (south abutment of the Black Rock damsite), and potentially along the south rim of the Black Rock reservoir area.

Several potential landslides have been identified on the Horsethief Mountain anticline (see figure 5-2 for locations). One landslide is located on the north slope of the ridge upstream from the alternate damsite. Horsethief Point is a prominent butte that projects from the valley floor upstream from the original damsite. This point appears to be a buried remnant of a landslide block that has moved off Horsethief Mountain. The third slide area is downstream from the damsite on the east slope of Horsethief Mountain near SH 241.

Additional investigations are needed to evaluate the potential impacts of a reservoir located on the landslide areas. These investigations would include identifying the sites, evaluating the impacts associated with the highway relocation along the south rim of the reservoir, evaluating the slope stability at the damsite during and after construction of the dam and appurtenant structures, and evaluating the reservoir rim stability during reservoir operation.

Excavating the dam's foundation down to solid bedrock may require removal of approximately 200 feet of overburden material. Further geologic investigations of the varying bedrock composition and quality would provide a better understanding of bedrock characteristics, foundation conditions, and the amount of material to remove beneath the dam. These investigations may find that complete excavation of the Ringold Formation down to the top of bedrock across the entire footprint of the dam would be required, if unsuitable layers of soft material were found at depth.

5.3.2.4 Geology Along Outflow Conveyance System and at Black Rock Powerplant and Delivery System Areas

Reclamation's geologic investigations of the Black Rock alternative have concentrated initially on the alternate damsite location. The geology of the potential outflow conveyance system, the Black Rock powerplant area, and the delivery system areas to the west of the damsite is poorly known. Further geologic investigations are needed to provide a better understanding of bedrock characteristics, foundation conditions, and groundwater conditions at these sites.

Findings: The original damsite identified by WIS is preferable to the alternate site investigated by Reclamation.

The deeper layers of the Ringold Formation are a dense, hard deposit of gravels and cobbles. This type of material may be expected to be a firm, nonliquefiable foundation capable of supporting a large dam, although some type of cutoff to solid bedrock may be required on the upstream portions of the dam. Or, complete excavation to bedrock may be necessary beneath the entire footprint of the dam, requiring the removal of approximately 200 feet of overburden material.

Further investigations are needed to determine whether a Black Rock reservoir could cause currently stable beds of three ancient landslides identified on Horsethief Mountain ridge to become saturated and start moving.

Further investigations are needed to determine whether three ancient landslides identified on Horsethief Mountain ridge could impact the realigned highway.

5.3.3 Groundwater

The *Appraisal Assessment of Hydrogeology at a Potential Black Rock Damsite* [12] report documents Reclamation's hydrogeologic investigations. A brief summary of the Black Rock damsite follows.

The Columbia River basalts and interbedded sedimentary units that underlie the Black Rock dam and reservoir site comprise the framework for the groundwater flow system. The primary water-bearing zones are generally limited to the tops of the basalt flows and within coarse-grained layers of the sedimentary interbeds. Groundwater can flow horizontally or vertically, in response to head differences and the hydraulic properties of the geologic materials. Hydraulic conductivity is a measure of the ability of water to flow through a unit and is generally reported in feet per day. The flow tops have relatively high horizontal hydraulic conductivity. The dense flow interiors have very low horizontal conductivity, but contain vertical joints and fractures that, if not filled with secondary minerals, could accommodate vertical groundwater movement. Structural folds and faults may impede groundwater flow or act as vertical flow pathways.

Hydraulic properties of the unsaturated zone above the water table are important at the Black Rock site since the differences within and between the distinctive unsaturated materials in the reservoir basin would result in variable downward migration and horizontal flow of infiltrated water. Alternating layers of fine-grained and coarse-grained sediments create conditions that tend to enhance horizontal spreading. At the alternate damsite, the unsaturated zone includes all of the overburden sediments and the upper-most basalt member, the Pomona Basalt. Though these units are currently dry, they would become saturated from reservoir leakage if the Black Rock alternative were built.

Hydrologic testing of a borehole (DH-04-02) located at the alternate damsite was conducted from April to June 2004. The purpose was to determine hydraulic properties of selected hydrogeologic units, identify hydraulic boundaries, and assess the capacity for vertical communication (leakage) between units. In addition, groundwater samples were collected for hydrochemical and isotopic analyses, and hydraulic head information was studied to determine hydraulic relationships between the units at this location. These studies were part of the initial assessment phase for characterizing the Black Rock Valley hydrogeology and assessing the potential impact that seepage from a reservoir could have on local and adjacent groundwater conditions.

Five unsaturated zones and two groundwater zones were successfully characterized in DH-04-02 using a suite of hydrologic test methods and analyses. Hydraulic conductivity values range from 0.04 to 2.8 feet per day in the unsaturated zones and 0.03 to 2.69 feet per day in the groundwater zones. These values fall within the lower range reported for the Hanford Site for comparable hydrogeologic units [13]. Groundwater samples collected at DH-04-02 have similar characteristics and chemistry as those within the Ellensburg Formation/Saddle Mountains Basalt at the Hanford Site and surrounding Pasco basin [13]. The groundwater samples from DH-04-02 appear to be relatively young and not altered by a long residence time within the groundwater flow system. Hydrologic testing at DH-04-02 did not identify any faults or discontinuities within about 300 feet of the borehole.

During the current investigations, no unconfined or perched water table conditions were found. In DH-04-02, the first groundwater was encountered at the bottom of the Pomona Basalt and top of the Selah sedimentary interbed, at about 254 feet below ground surface. The water level rose in the well to about 194 feet.

The Pomona Basalt appears to be a hydraulic barrier to vertical downward leakage, at least at the site of these investigations. The Pomona Basalt flow interior may inhibit large quantities of vertical leakage. Additional Pomona Basalt characterization is needed to confirm that it is a vertical hydraulic barrier and to verify the hydrologic characteristics of the unit across the entire reservoir basin. Where the basalt flow tops and interbeds are exposed or thinly covered by sediments on the adjacent ridges, large amounts of reservoir leakage could still occur.

The Selah interbed is underlain by the Esquatzel and Umatilla Basalts, which in turn are underlain by the Mabton sedimentary interbed. Based on testing responses, leakage appears to be pervasive through these basalts, and the two sedimentary interbeds are hydraulically connected.

Total leakage from a Black Rock reservoir would vary depending on the hydraulic gradients and operations of the reservoir, the final design selected for the dam foundation (whether the overburden were completely or only partially removed beneath the dam), and many other conditions. Further investigations would assess the potential for reservoir seepage into the abutments and the variability of hydraulic characteristics within the hydrogeologic units that underlie the reservoir and damsite.

5.3.3.1 Capability of Reservoir Basin to Retain Stored Water

Findings: No unconfined or perched water table conditions were found. Groundwater was first encountered at a depth of about 254 feet in the Selah interbed at the bottom of the Pomona Basalt.

The Pomona Basalt appears to be a hydraulic barrier that may inhibit vertical leakage in the reservoir basin.

Significant amounts of reservoir leakage could occur where the basalt flow tops and interbeds (i.e., Selah and Esquatzel/Umatilla) are exposed or thinly covered by sediments on the adjacent ridges if the exposure area would be within the reservoir pool.

5.3.3.2 Movement of Groundwater

Findings: Vertical leakage appears to be pervasive between the Selah interbed, the Esquatzel and Umatilla Basalts, and the Mabton interbed. These units are hydraulically connected and constitute a single groundwater flow system.

Groundwater samples appear to have similar characteristics and chemistry as those within the Ellensburg Formation/Saddle Mountains Basalt at the Hanford Site and surrounding Pasco basin. The groundwater samples appear to be relatively young

and not altered by a long residence time within the groundwater flow system.

The studies conducted to date do not identify the resultant effects on down gradient areas such as the Hanford Site. However, if reservoir leakage were to bypass the dam through the underlying overburden sediments or reach the Selah interbed, there could be significant regional effects on the groundwater system.

5.3.4 Seismotectonics

The Technical Memorandum titled *Probabilistic Seismic Hazard Assessment for Appraisal Studies of the Proposed Black Rock Dam* [14] documents the preliminary characterization of the earthquake potential at Black Rock damsite. Probabilistic Seismic Hazard Assessment (PSHA) is a technique that provides an assessment of the annual levels of earthquake ground motions that the site might experience based on the rates of seismic activity and fault movements in the region surrounding the site. Peak Horizontal Acceleration (PHA), a measure of very high frequency earthquake ground motions, can be estimated through PSHA and was used in the preliminary assessments of the potential Black Rock damsite.

Seismic hazard information is used to guide engineering decisions on the design and placement of the dam and related structures. High levels of earthquake ground motion can potentially lead to liquefaction (a loss of material strength that can result in large areas of slope failure) of saturated, lower density soils. Other potential concerns include the stability of natural and engineering slopes and the effects of potential fault displacements on the dam and related structures.

The initial assessment indicates that the Black Rock damsite lies in an area of relatively high earthquake potential. For example, at a return period of 10,000 years, the estimated mean PHA is about 0.95 g, a level of ground shaking that might be associated with the occurrence of magnitude 6 to 7+ earthquakes relatively near to the site. Faults that are associated with the Yakima Fold Belt near the Black Rock damsite are the main sources of potential ground motion. These include the large fold on Horsethief Mountain, which is related to a low-angle thrust fault (a part of the Black Rock Valley fault) that surfaces in the lower portion of the right (south) dam abutment and dips to the south beneath Horsethief Mountain. Because of its proximity to the site, the Black Rock Valley fault is the largest contributor to the initial estimates of PHA for the site. The Cascadia Subduction Zone (a deep fault zone along the coast of Washington and Oregon that is capable of producing very large magnitude earthquakes) is not a major contributor to the PHA at the damsite.

While the Black Rock Valley fault has not been studied in sufficient detail to define its activity, it is assumed at this stage of study that the fault may be capable of large-magnitude earthquake and that associated fault offsets within the dam footprint could range from a few centimeters to several meters. Given the orientation of the east-west folds comprising the Yakima Fold Belt, which includes Black Rock Valley, the orientation of the displacements would be in the north-south (cross valley) direction reflecting compression of the folds. Several secondary faults, scarps, and lineaments that appear to be related to the fold atop Horsethief Mountain are also potential sites of secondary faulting, fissuring, and landslides.

Findings: Based on presently available information, design ground motions for Black Rock damsite and associated facilities may be relatively large due to the potential activity of faults with close proximity to the sites.

Characterization of the Black Rock Valley fault has a significant impact on the evaluation of potential seismic hazards at the Black Rock damsite. No detailed studies are presently available for this fault. Detailed investigations of the Black Rock Valley fault and potentially related geologic structures within the Yakima Fold Belt are required to reduce the high levels of uncertainty associated with the current estimates.

5.3.5 Probable Maximum Flood

Reclamation's preliminary probable maximum flood study [15] offers insight into the hydrologic hazard associated with a potential Black Rock reservoir and assists in sizing the dam. The study examines how much storm runoff could be generated within the 61.2-square-mile Black Rock reservoir drainage area.

Typically, winter conditions (November through March) would produce the maximum precipitation amounts; however, the June through October summer months in this region would produce nearly 20 percent larger probable maximum precipitation. Therefore, this Assessment includes both the winter and summer general storm conditions. Large antecedent floods are most likely to occur in the winter months but are not likely at all in the summer months. Table 5-4 summarizes the probable maximum floods identified in this study.

Table 5-4. Probable maximum floods for a Black Rock reservoir

Flood Description	Peak (cfs)	Volume (acre-feet)	Duration (days)
winter general probable maximum precipitation storm (with 100-year antecedent rain flood between November and March)	20,200	29,100	10.5
summer general probable maximum precipitation storm (with no antecedent flood between June and October)	28,900	28,700	3.5
summer local thunderstorm (with no antecedent flood between June and October)	74,900	17,000	1

Findings: Concerns about a spillway channel and potential environmental impacts of discharging Columbia River water into Dry Creek,

which drains into the Yakima River, led to designs for a Black Rock dam high enough to completely contain a full probable maximum flood in the reservoir.

5.4 Columbia River Intake Facilities

Based on the Columbia River water availability assessment [3], this Assessment analyzes a large reservoir option with either a 3,500-cfs intake and pumping plant or a 3,500-cfs pump/generation facility that would permit Columbia River water stored in a Black Rock reservoir to return to the Columbia River to generate power. It also analyzes a small reservoir option with a 6,000-cfs intake and pumping plant on the Columbia River. This section first describes the intake facilities, then the pumping plant facilities, and last, the pump/generation plant facilities.

The appraisal-level design for the three intake options would include:

- an alternate access road along the alignment of an abandoned railroad track on the right side of the Columbia River from SH 24 to the intake facilities
- construction of a circular-type cofferdam in Priest Rapids Lake to permit construction of the intake facilities
- excavation of about 20 feet of overburden down to competent basalt.

5.4.1 Intake, Trashracks, and Fish Screens

The identified site for the intake structure would be on the right bank of Priest Rapids Lake about 3,600 feet upstream from Priest Rapids Dam. The intake channels and fish screen design would meet the maximum and minimum Priest Rapids Lake operating water surface elevations and provide sufficient freeboard to prevent overtopping during flood events. The fish screens and bypass pipes would meet the NOAA Fisheries salmonid criteria which include channel velocities, screen approach velocities, screen sweeping velocities, exposure time along screen, maximum bypass pipe flow velocity, and minimum radius of bypass pipe bends. A description of the appraisal-level designs for the three intake options follow.

5.4.1.1 3,500-cfs Pump Only Option

In this option, the 2,366-foot-long intake channel would run from the intake at Priest Rapids Lake to the face of the pumping plant. Maintenance roads would parallel each side of the channel. Guardrails and fencing would provide for safety protection. The initial 1,412 feet of the intake channel would have three channel bays with vertical structural concrete walls. Two of the channel bays would be each sized for 1,500-cfs flows, with a third channel sized for 500 cfs, totaling the 3,500-cfs flow capacity. Each channel would have bulkheads and guides to isolate that channel while maintaining the water diverting operation. Downstream from the fish screen, the three intake channels would open to a 608-foot-long single channel section. It would then widen into a 346-foot-long transition to the pumping plant.

Trashracks with an automated rake and a conveyor system would collect trash at the inlet. Three top-sealed radial gates at the reservoir intake would isolate the channels for emergency or short-term maintenance of the fish screens and could also regulate downstream water surfaces. An access bridge deck over the inlet would allow access across the intake channel.

The intake fish screens would be vertical, stainless-steel, wedge wire panels installed within metal guide/support structures. Adjustable baffles in guides directly downstream from the screens would provide for uniform flow distribution over the screen surface. Horizontal brush-type fish screen cleaners would clean and remove debris from the screens. Metal barrier panels above the screens would extend higher than the maximum design operating water surface.

5.4.1.2 6,000-cfs Pump Only Option

This option consists of four 1,500-cfs channel bays similar to the 1,500-cfs channel bays of the 3,500-cfs option (see section 5.4.1.1). The 2,340-foot-long intake channel would include the structural concrete channel bay section, an excavated unreinforced concrete-lined channel, and a transition to the pumping plant. The access bridge, maintenance roads, guardrails, and safety fencing would be similar to the 3,500-cfs option. Since this option would have four bays, the total channel width would be greater than the 3,500-cfs option. Four sets of bulkheads and guides would be available for both upstream and downstream use. Four top-sealed radial gates would isolate the channels for fish screen maintenance and to regulate downstream water surfaces. Larger trashracks and rakes would accommodate the extra bay for this option. The four bypass pipes and outfalls for the four fish screen bays would be the same as for the 3,500-cfs option.

5.4.1.3 3,500-cfs Pump/Generation Option

This option would have the same intake arrangement and criteria as described in section 5.4.1.1 for the 3,500-cfs intake channel, except that the intake area configuration would also accommodate a tailrace for power generation units. The channel layout would be the shortest possible path back to the reservoir.

The 483-foot-long tailrace channel, which would lie between the intake channel and Priest Rapids Lake, would consist of a transition from the powerplant face to a structural channel with vertical walls. The design velocity of the tailrace channel would be 10 feet per second during the minimum water surface elevation with a 3,500-cfs maximum power generation discharge. The velocity would decrease as the reservoir rises to the maximum water surface. Maintenance roads would parallel either side of the channel. An access bridge would align with the centerline of the existing Priest Rapids Dam embankment.

5.4.2 Pumping Plant and Switchyard

The pumping plant and service yard would be set at an elevation compatible with the surrounding area and to reduce their visibility from the Wanapum Indian Village. The plant would be a reinforced-concrete, indoor-type structure with a precast-concrete double-tee roof structure. A low, unit bay structure and a raised service bay superstructure would allow access and handling of equipment into and out of the building structure from the service yard.

5.4.2.1 3,500-cfs Pump Only Option

In this option, the 3,500-cfs pumping plant would house three 500-cfs pump units and two 1,000-cfs pump units that would require 62 feet of submergence below the minimum intake water surface elevation (see table 5-5). The 1,400-foot steady state lift from Priest Rapids Lake to a Black Rock reservoir is very high. Therefore, the spiral-case-type, two-stage pumping units would accommodate water in the months when downstream Columbia River flow targets would restrict the volume of water that could be pumped from the river. The smaller units would provide flexibility of operations, reduce the unit submergence requirements, and permit unit maintenance without sacrificing a large percentage of the plant capacity.

The plant would be equipped with two 200-ton overhead cranes acting in tandem in the unit bays and a 100-ton overhead crane in the service bay. The plant would have space for unit disassembly and auxiliary mechanical and electrical equipment, although specific equipment was not identified. A new 500-kilovolt powerline would run from the pumping plant to the Midway substation, which is 6 miles east of the Priest Rapids switchyard. The new switchyard would include transformers, circuit breakers, disconnect switches, and a circuit breaker and disconnect switches for the tie into the Midway substation.

Table 5-5. Preliminary Priest Rapids 3,500-cfs pumping plant unit data

Unit Data	500-cfs Units	1,000-cfs Units
number of pump units	three	two
type of units	two-stage spiral case	two-stage spiral case
design discharge	500 cfs	1,000 cfs
design head	1,400 feet	1,400 feet
motor	98,000 hp	200,000 hp
minimum impeller submergence	62 feet	62 feet
maximum spiral case dimension	18.2 feet	26.0 feet
top elevation of suction tube invert	468.0 feet	468.0 feet
guard valve	60-inch spherical	78-inch spherical
guard valve weight	110,000 lbs. each	175,000 lbs.

5.4.2.2 6,000-cfs Pump Only Option

This option would have a similar pumping plant and switchyard arrangement as the 3,500-cfs pump only option (see section 5.4.2.1), except the enlarged structure would accommodate six 1,000-cfs pumping units.

5.4.3 3,500-cfs Pump/Generation Plant and Switchyard

This option would have a similar arrangement as the 3,500-cfs pump only option (see section 5.4.2.1), except the enlarged structure and yard would accommodate two 1,750-cfs Francis turbines and a tailrace channel adjacent to the pumping plant intake channel. Table 5-5 shows the preliminary pump unit data; table 5-6 shows the preliminary powerplant turbine data.

Table 5-6. Preliminary Priest Rapids 3,500-cfs turbine unit data

Unit Data	1,750-cfs Unit
number of turbine units	two
type of units	Francis
design discharge	1,750 cfs
design head	1,130 feet
speed	400 rpm
assumed unit efficiency	90 percent
power output at design head	150 MW
minimum turbine submergence	29.8 feet
maximum scroll case dimension	26.5 feet
bottom elevation of draft tube	431.5 feet
guard valve	102-inch spherical

5.5 Inflow Conveyance System

The inflow conveyance system options evaluated to transport water from the Columbia River intake to a Black Rock reservoir include 3,500-cfs and 6,000-cfs pump only options and a 3,500-cfs pump/generation option.

The inflow conveyance facilities would have capacity to carry 3,500- to 6,000-cfs entering the reservoir via an outlet structure at approximately 100 feet above the valley floor during initial filling of the reservoir's inactive pool. To minimize erosion of the hillside until the reservoir storage reached the outlet elevation, a short open channel would direct flow from the outlet structure into a 20- to 24-foot-diameter steel pipe. The pipe would carry the flow downhill toward the valley bottom where the pipe would terminate with a 90-degree upward bend. A large concrete thrust block would decrease the water pressure as it exits the pipe.

5.5.1 3,500-cfs Pump Only Option

Design factors and assumptions for the 3,500-cfs pump only option led to two separate inflow conveyance systems (an all tunnel option and a tunnel/pipeline option). Both alignments would encroach on the Yakima Training Center to some extent. Discussions with Training Center representatives would be necessary to address alignment concerns.

5.5.1.1 All Tunnel Inflow Conveyance

The all tunnel option would include a manifold connected to a 17-foot-diameter tunnel sloping steadily up towards a Black Rock reservoir. The tunnel shaft would be similar to the WIS design, but would be simplified to have a constant slope. The tunnel portal would be located just outside the pumping plant switchyard with the centerline at elevation 495 feet. The end of the tunnel would be located at elevation 1440 feet, an elevation to prevent a negative down surge in the tunnel near Black Rock reservoir. The maximum down surge, the tunnel diameter, and the surge shaft diameter are based on a Black Rock reservoir elevation of 1500 feet (top of inactive pool). The maximum pressure at the pumping plant and the elevation at the top of the surge shaft are based on the top of the active reservoir pool (elevation 1775 feet). The tunnel would have a surge shaft. The top of the surge shaft would be on a level spot for construction activities and would be set to prevent overtopping.

Tunnel excavation would likely be accomplished using tunnel boring machines and could be excavated uphill. All of the tunnels would be above the current water table, so groundwater should not be a major problem. The tunnel design would include initial support during construction to stabilize the tunnel opening until the final support or lining was in place.

Design standards indicate that an unlined tunnel would be possible based on the mineralogy of the rock. However, this evaluation uses a tunnel lining to ensure reasonable hydraulic friction and to account for rock that may be highly fractured. The design uses some reinforcement to curtail leakage in highly fractured reaches in the pressure tunnels and incorporates steel lining at the portals to insure water tightness as the tunnel nears the surface. This steel liner would be backfilled with concrete and grouting. The tunnel portal beneath Black Rock reservoir would not require steel lining.

5.5.1.2 Tunnel/Pipeline Inflow Conveyance

The tunnel/pipeline option initially was to be a pressurized system from the intake pumping plant to a Black Rock reservoir. However, after reviewing the hydraulics and the transient analysis and increasing the size of the tunnel beyond the surge shaft, a gravity tunnel would work better. The selected design would thus include a 16-foot-diameter discharge pipe, tunnel and vertical shaft; a 21-foot-diameter gravity tunnel; and an 18-foot-diameter pipeline. The increased tunnel size (downstream from the surge shaft) and the hydraulic grade line of the gravity tunnel would allow the 3,500 cfs to flow around Yakima Ridge to Black Rock reservoir in the pipeline. Once the pipeline reached the south side of Yakima Ridge, the pipe diameter would reduce to 17 feet. The manifold and initial tunnel diameter would maintain a flow velocity below 20 feet per second. The discharge pipe and tunnel would have an 18-foot-per-second flow velocity at 3,500 cfs. The tunnel design would be similar to that of the all tunnel option. The pipeline would connect to the low-level Black Rock reservoir outlet works pipe so both the outlet works and the pipeline could use the same tunnel through the dam's abutment.

5.5.2 6,000-cfs Pump Only Option

The 6,000-cfs pump only option would be similar to the 3,500-cfs all tunnel design (see section 5.5.1.1) and would use a 22-foot-diameter tunnel sloping steadily up towards a Black Rock reservoir. The tunnel would have a surge shaft. The tunnel diameter would be sized for 6,000 cfs plus a 5 percent allowance to account for the pumps' wear factor and manufacturer's allowance. The end of the tunnel would be located to prevent a negative down surge in the tunnel near Black Rock reservoir. The top of the surge shaft would be set to prevent overtopping and would be located to provide a level spot for construction activities.

5.5.3 3,500-cfs Pump/Generation Option

The pump/generation inflow conveyance option would be the same as the 3,500-cfs pump only, all tunnel inflow conveyance (see section 5.5.1.1) option, except for a multi-level intake/outlet structure at Black Rock reservoir. This intake would control the withdrawal elevation for water returning to the Columbia River to meet water quality objectives. The valve-controlled intakes would be fixed at four different reservoir elevations and allow any combination of withdrawal levels. The intakes would discharge into a wet well before entering a tunnel to the Priest Rapids intake pump/generation plant. During normal pumping operations, pumped water would discharge through two gates at the bottom of the wet well.

Half-cylinder-shaped fish screens installed at each intake level (with flat side panels attached to the intake tower) would be used only during power generation. Passing pumped (back flush) water through the screens for a short period during pumping operation would clean the screens.

5.6 Black Rock Storage Facilities

The storage facilities would impound water received via the inflow conveyance system. Storage facility options suitable for the Black Rock damsite would include both a large dam/large reservoir and a small dam/small reservoir option, as well as two rockfill embankment dam types and a roller compacted concrete dam. This section first describes the design considerations related to the large dams, then the small dams. It explains why a spillway would not be needed and identifies the design options for an emergency evacuation outlet works, the reservoir, and highway/utility relocations.

5.6.1 Storage Dam Alignment

This Assessment analyzes two potential dam alignments. The original, farthest east (downstream) alignment proposed and explored by WIS, would have the shortest crest length; however, exploratory drilling identified more than 200 feet of overburden material toward the south (right) abutment that would likely have to be excavated. Drill hole testing at an alternate alignment located further west (upstream), where possibly less excavation would be needed, revealed the overburden was at least as deep as that of the downstream alignment. The alternate alignment resulted in about 10 percent fewer cubic yards of above-ground embankment materials, even though the crest length would be longer and the dam higher to get an equivalent reservoir storage. This could be because the ground surface rises heading upstream. The longer axis of the alternate site would result in significantly more below-ground excavation than the original site. The alternate axis would have about 10 million cubic yards more of combined above and below ground embankment fill materials, which would significantly increase costs. The alternate alignment lacks technical advantage (such as improved rock quality and better outlet works location) over the original alignment.

Findings: The alternate dam alignment, with no technical advantages and, needing about 10 million more cubic yards of embankment material, is dropped from further analyses.

5.6.2 High Seismicity

The Black Rock damsite lies in an area of high earthquake potential. Because of its proximity to the site, the Black Rock Valley fault is the largest seismic hazard contributor to the initial estimates of high frequency ground motions. This dictates that, at this stage of the work, a dam at this location be designed to resist potential ground shaking that might be associated with the occurrence of magnitude 6 to 7+ earthquakes. Earthquakes of this magnitude could cause lower density, saturated embankment or foundation soils to liquefy. This loss of material strength could result in large slope failures. Therefore, all potentially liquefiable foundation soils should be removed and all embankment materials compacted to high densities.

Designing a dam for severe and lengthy earthquake shaking that could induce embankment slope failures involves careful deformation analysis of the dam; designing crest dimensions, zoning, and embankment slopes to ensure stability; selecting strong materials; and including a drainage system to keep the phreatic surface (water level) in the embankment as low as possible.

5.6.3 Potential Fault Displacements

At least one low-angle thrust fault lies within the dam's footprint, at the base of the right (south) abutment. Preliminary investigation of available information leads to the assumption that fault offsets within the dam footprint are possible, and that such displacements could range from a few centimeters to several meters. The east-west fold orientation of the Yakima Fold Belt indicates displacement would reflect compression of the folds in a north-south (cross valley) orientation. Severe transverse cracks through the dam would likely result from low-angle fault offset.

An embankment dam generally would be less rigid than a concrete dam and may best accommodate potential fault displacements. An embankment dam would have filters and drains to ensure that cracking, offsets, or differential movements does not provide pathways for the reservoir contents to escape and erode the embankment. The clean, cohesionless, and permeable sands and gravels that make up these filters and drains would collapse or rearrange if the dam cracks, causing these materials to fill in the crack. While the upstream water barrier (such as an earth core or concrete face) would likely crack and possibly stay open from a fault offset, the filter would ensure that no fine-grained core materials eroded downstream through the filter. The gravel drain downstream from the filter would provide safe collection of seepage that passed through an earth core or concrete face crack.

Large rockfill shells, constructed of 3-foot rocks, would form a stable downstream buttress for the earth core or concrete face of a dam where fault displacement would be possible. Extensive reservoir leakage would safely flow through the rockfill zone without causing dam failure.

5.6.4 Large Rockfill Embankment Dam

For all dam types considered in this Assessment for the large 1,300,000-acre-foot reservoir, the top of normal water surface would be set at elevation 1775 feet; the maximum reservoir water surface would be set at elevation 1778 feet.

Basalt for a rockfill dam is present throughout the damsite and reservoir area, with relatively little soil cover on the abutment and reservoir rims. Quarrying would provide an unlimited basalt source of rockfill, making a rockfill dam suited for the Black Rock site. Rockfill dams are one of the best performing dams under the seismic conditions believed to be present at the Black Rock damsite. These dams keep a large downstream portion of the embankment material unsaturated and strong, while providing permeability to let seepage pass through should the impervious zone of the dam become cracked or damaged. The two types of rockfill embankments best suited to the Black Rock site are a concrete face rockfill dam and a central core rockfill dam. Due to the high earthquake potential, all embankment zones would be compacted to maximum practicable densities to prevent liquefaction.

5.6.4.1 Foundation Treatment

The amount of foundation treatment required would depend on the quality of rock encountered. Two overburden excavation variations (the complete excavation to bedrock option and the excavate to competent Ringold Formation option) address the uncertainty of the amount of Ringold Formation to be removed. The complete excavation to bedrock option would expose bedrock along the entire footprint of both rockfill dams. This would reduce all uncertainties of foundation liquefaction potential, and allow for use of steeper rockfill slopes. The excavate to competent Ringold Formation option would remove all of the overburden beneath the upstream portion of the dam to ensure a foundation of competent bedrock and that foundation treatment and grouting were effective. For most of the downstream portion of the dam, removing the fine-grained lake deposits in the upper portions of the Ringold Formation would minimize foundation settlement and the potential for liquefaction.

Foundation excavation likely would encounter several different basalt flows, areas of thin veneer basalt and sedimentary interbeds, and poor rock quality at the contacts of these various flows; all a result of the geologic folding in Black Rock Valley. Localized areas of overexcavation would remove poor quality rock, thin basalt veneers, and the interbed zone.

Available information is insufficient to positively confirm the presence and nature of an apparent fault beneath the right abutment. The types of foundation treatment for an uncovered fault zone depend on the nature of the material exposed and range from additional excavation, to an enlarged blanket and curtain grouting, to placing impermeable soils upstream from the water barrier, to covering a pervious zone with a filter/drain, to a cutoff zone to the depth of the fault.

Special upstream and downstream foundation treatment and filters would be required in areas of particularly poor rock quality, which may include highly fractured rock or highly weathered or altered rock, or in areas of faulting. This would prevent any potential seepage movement of poor foundation materials into the coarse rockfill embankment materials.

5.6.4.2 Large Concrete Face Rockfill Dam

An advantage of a concrete face rockfill dam is that it would not contain a soil core vulnerable to erosion under a concentrated leak. The upstream reinforced concrete face would act as a water barrier and would not be susceptible to erosion. The concrete face would tie into the rock foundation with a concrete footing (plinth). Downstream from the concrete face, a zone (zone 2) of well-graded sand and gravel with fines would serve as a firm foundation for the concrete face slab. Should any seepage pass through the concrete face, this zone 2 would form a semi-pervious barrier that would significantly increase head loss and the amount of seepage. A pervious transition zone 3 (of clean gravel and cobble) immediately downstream from zone 2 would ensure that zone 2 could not erode from concentrated leaks and would provide sufficient drainage to allow seepage flows to pass into and through the large downstream rockfill zone (zone 4) of the dam. The rockfill would be constructed in 3-foot-thick lifts, and compacted with large vibratory rollers to create a layer with larger rock at the bottom and an accumulation of fines at the top. These stratified rockfill layers would have high horizontal permeability and safely drain off large seepage flows.

A disadvantage of a concrete face rockfill dam is that any type of fault offset likely would cause extensive cracking in the concrete face. Although the rockfill dam likely would not fail, the reservoir may have to be drained after such an event until the concrete face were repaired.

The smooth, concrete face rockfill dam would have 15 feet of freeboard to prevent wind/wave overtopping. A rockfill dam at this site would unlikely need extra freeboard to protect against major embankment deformations resulting from seismic events.

The amount of foundation treatment required for the concrete face rockfill dam would depend on the quality of rock encountered. Excavating to competent Ringold Formation would minimize the potential for settlement of overburden that may cause cracking of the concrete face slab. In all areas, a minimum amount of treatment would be a combination of blanket consolidation and curtain grouting. Extensive grouting would be likely in areas of fractured basalt and poor rock quality.

5.6.4.3 Large Central Core Rockfill Dam

A central core rockfill dam would be more plastic or deformable, and less cracking damage may result from a fault offset within the dam footprint. Furthermore, a central core containing appreciable clay likely would self-heal the cracks. Repairs, if needed after a fault offset, might not entail draining the reservoir. The massive downstream rockfill zone would need far less foundation treatment than would be required beneath an impervious zone.

The water barrier of a central core dam would consist of impermeable soils. An upstream-sloping, thin earth core of zone 1 materials (clayey gravel and lean clay or silty gravel) would ensure that the rockfill zone (zone 4) of the dam remained strong and unsaturated, thereby affording much stability. Reduced costs would result from keeping the core thin as the site lacks impermeable soils. The sloping core should reduce the potential for core cracking due to differing settlement properties of rockfill and impermeable material. Immediately downstream from the earth core would be a zone 2 filter zone (consisting of clean sand and gravel) designed to prevent erosion of core materials in the event of cracking. Downstream from the zone 2 filter would be a clean gravel and cobble drainage zone (zone 3) to safely control and convey any seepage through core cracks. The majority of the central core dam would be rockfill as described for the concrete face rockfill dam.

The large central core rockfill dam, with a rougher rock upstream slope that would be more effective in dissipating waves, would have 10 feet of freeboard to prevent wind/wave overtopping.

Foundation treatment measures for the central core rockfill dam would be concentrated beneath the water barrier core of the dam and depend on the quality of rock encountered. Rock excavation and dental concrete would shape the bedrock surface to minimize abrupt surface changes and overhangs. Some slush grouting may be needed. A combination of blanket consolidation and curtain grouting would improve rock strength and create a low permeability zone beneath the core. Extensive grouting would be likely in some areas with a multiple row grout curtain likely over the entire footprint of the zone 1 core. Foundation treatment beneath the remainder of a rockfill dam would be less critical, except in areas of highly weathered rock or fault zones where seepage or displacement could occur.

5.6.5 Large Roller Compacted Concrete Dam

Roller compacted concrete (RCC) was selected for the concrete dam option since it would be more economical than mass concrete for wide canyons. RCC is a no-slump concrete placed by earth-moving equipment and compacted by vibrating rollers in horizontal lifts up to 12 inches thick. Bonding mortar would be placed at each lift line. RCC materials would be the same as those used for conventional mass concrete and include water, cementitious materials (cement and pozzolan), admixtures, and fine and coarse aggregate. Aggregate would be hauled from either the Columbia or Yakima River area due to the anticipated high cost of onsite processing of the Ringold Formation. The upstream and downstream faces of the dam would be slip-formed conventional concrete that serves as the forms for the RCC placement. Crack inducers and waterstops would be placed to form contraction joints. The dam would have drainage galleries and formed drains that would be drilled from the top of dam to the gallery near the upstream face to intercept any seepage through lift lines.

The RCC dam would have 6 feet of freeboard to the top of the parapet wall (elevation 1784) after storing the probable maximum flood.

The RCC dam requires a competent rock foundation beneath the entire footprint of the dam. Available geologic information indicates foundation excavation to the top of competent rock is 200 feet deep towards the right abutment. Ten feet of rock likely would be removed from the overall footprint to reach competent material.

5.6.6 Small Rockfill Embankment Dam

The large rockfill embankment dam design discussion (see section 5.6.4) also applies to the small rockfill embankment dam, which would still be a very large embankment. The only differences would be the crest elevation and dam height; all other design features would be the same. Table 5-7 compares the large and small embankment dams.

Table 5-7. Comparison of large and small rockfill embankment dams

Dam Type	Crest Elevation (feet)	Dam Height* (feet)
concrete face rockfill – large reservoir	1790	760
concrete face rockfill – small reservoir	1722	692
central core rockfill – large reservoir	1785	755
central core rockfill – small reservoir	1717	687
*The dam height is the maximum structural height from crest of the dam to the bottom of foundation excavation.		

5.6.7 Small Roller Compacted Concrete Dam

The large RCC dam design discussion (see section 5.6.5) also applies to the small RCC dam, which would also be a very large dam. The only differences would be the crest elevation, top elevation of the parapet wall, and dam height; all other design features would be the same. Table 5-8 compares the large and small RCC dams.

Table 5-8. Comparison of large and small RCC dams

Dam Type	Crest Elevation (feet)	Dam Height* (feet)
RCC dam – large reservoir	1781	751
RCC dam – small reservoir	1715	685
*The dam height is the maximum structural height from crest of the dam to the bottom of foundation excavation.		

5.6.8 Spillway

Both the large and small Black Rock reservoirs would be offstream and have large surface areas. Numerous concerns about a potential spillway located on the south side of Black Rock reservoir and concerns about discharging Columbia River water into the Yakima River led to investigating the possibility of storing the probable maximum flood in the reservoir rather than spilling the flood flows. Raising the large dam height by 3 feet and the small dam by 5 feet (to the heights shown on tables 5-7 and 5-8) eliminates the need for a spillway.

5.6.9 Low-Level Outlet Works

The low-level outlet works would be used to evacuate the reservoir contents into the normally dry Dry Creek in the event of a dam safety emergency. Trashracks would be provided at the outlet works intake; however, fish screens would not be provided since this outlet would be used infrequently, only for emergency evacuation. No separate detailed designs were prepared for the outlet works for the small reservoir, but rather, quantities are estimated to be about 95 percent of those for the large reservoir outlet works.

The outlet works for the rockfill embankment dams would be on the north (left) abutment rather than the right abutment due to more favorable geology. Concrete thicknesses for the conduits are based on other Reclamation projects with similar sized facilities. The upstream conduit would be steel lined to handle the extreme pressures and potentially fractured rock. Steel pipe thicknesses would be sized to handle full reservoir pressures. The downstream steel pipe would be buried for support. A fixed-wheel emergency gate housed in a gate chamber at the bottom of a vertical shaft would reduce the length of pressure pipe through the dam. Two jet flow gates would control the outlet works discharge. A plunge pool stilling basin, which likely would see little use, would be lined with impervious material and riprap. Large concrete thrust blocks would be sized to handle anticipated thrust loads at the pipe bends.

The RCC dam outlet works intake would be constructed within the dam structure on the upstream face near the right abutment to shorten the outlet works. The intake structure would have a fixed-wheel emergency gate. The downstream steel pipe would be buried for support. Two jet flow gates would control the outlet works discharge. A plunge pool stilling basin, which likely would see little use, would be lined with impervious material and riprap. Large concrete thrust blocks would be sized to handle anticipated thrust loads at the pipe bends.

5.6.10 Reservoir

Reclamation's water availability assessment [4] identifies two reservoir sizes that meet water delivery criteria for a water exchange with Roza and Sunnyside Divisions. Aerial topographic data provides a basis for reservoir elevation versus reservoir volume and area curves. Holding the inactive storage to a minimum would reduce the dam height required for total storage. Also, designing the dam to store the probable maximum flood in the reservoir would eliminate the need for a spillway. Table 5-9 identifies the large and small reservoir parameters.

Table 5-9. Preliminary Black Rock reservoir parameters

Design Parameter	Large Reservoir	Small Reservoir
maximum water surface elevation	1778 feet	1712 feet
normal water surface elevation:	1775 feet	1707 feet
active capacity	1,300,000 acre-feet	800,000 acre-feet
surface area	13.5 square miles	10 square miles
top elevation of inactive water surface:	1500 feet	
inactive capacity	157,610 acre-feet	
surface area	3.25 square miles	

5.6.11 Highway and Utility Relocations

A Black Rock reservoir would inundate up to 13.5 square miles of Black Rock Valley including SH 24, a 2-lane asphalt road. The WIS report [2] relocates SH 24 to the south of the reservoir in the Rattlesnake Hills and indicates that Black Rock Valley residents prefer a northern relocation.

However, a northern realignment would run SH 24 through the Yakima Training Center. Also, the topography of a northern realignment is such that the road would include many bridges.

Reclamation identified an approximate 11.8-mile-long realignment similar to the WIS alignment; however, more detailed aerial topography provided a more refined horizontal alignment and vertical profile for SH 24. The new, straighter alignment would avoid some of the difficult terrain and improve the Rattlesnake Hills crossing. It would include larger horizontal curves to accommodate a 50-mph speed limit for mountainous terrain and a 70-mph speed limit for level terrain. Although the vertical profile would follow the existing terrain more closely, large cut and fill areas would still lie along the straighter alignment.

Local residents and city and county representatives have voiced concern with the southern alignment. If the Storage Study proceeds, Reclamation would pursue the SH 24 relocation with them, as well as with representatives of the Washington Department of Transportation and the Yakima Training Center.

Utilities impacted by a Black Rock reservoir would include a buried fiber optic line along the existing SH 24 and two overhead 115-kilovolt power lines on H-frame-type wood-pole supports. The buried fiber optic line would be abandoned in place. The transmission lines would be removed from the valley floor. Both utilities would run along the realigned SH 24.

5.7 Black Rock Reservoir Outflow

5.7.1 Conveyance System

A single-level intake at elevation 1500 feet was considered for release of reservoir water to the outflow conveyance system. A multi-level intake was not considered for this Assessment because no specific water quality objectives have been identified for the irrigation water, and there are no downstream fish water quality considerations. Fish screens would be included on the outlet structure to prevent fish that may be stocked in the reservoir from migrating into the Yakima River basin. Fish screen sizing criteria is assumed to be the same criteria used to size the intake structure at Priest Rapids Lake. The fish screened intake assumed for this Assessment would be a half-cylinder-shaped screen supported on a reinforced concrete slab. An air burst backwash system would clean the screens, and bulkhead gates and guides would be used dewatering the outflow conveyance system during emergencies.

Several outflow conveyance options were considered for delivering water from a Black Rock reservoir to Roza Canal. A 2,500-cfs design flow was selected for the outflow conveyance based on the assumption of providing the Roza and Sunnyside Divisions' entire water supply. This amounts to an instantaneous flow of about 2,362 cfs plus an allowance for other entities whose main canal facilities are in the vicinity of Roza Canal.

The primary features of the selected option are shown in figure 5-5. The 17-foot-diameter tunnel would begin southeast of Taylor Ranch on the northern side of Black Rock reservoir and parallel the southern edge of Yakima Ridge for approximately 14 miles to the 40-foot-diameter surge shaft. Beyond the surge shaft, the tunnel would angle out of the mountains and end on the northern side of SH 24. Then a 17-foot-diameter buried steel pipeline would cross under SH 24 and run to a Black Rock powerplant. The distance from the surge shaft to the powerplant would be approximately 3.5 miles.

The top elevation of inactive storage in Black Rock reservoir is the basis for the maximum down surge and sizing of the tunnel and pipeline diameters and the surge shaft. The top elevation of active storage in Black Rock reservoir is the basis for the maximum pressure at the powerplant and the top elevation of the surge shaft. The required minimum water surface, or hydraulic grade line, at a Black Rock powerplant would enable water to be delivered to Sunnyside powerplant without another pumping plant.

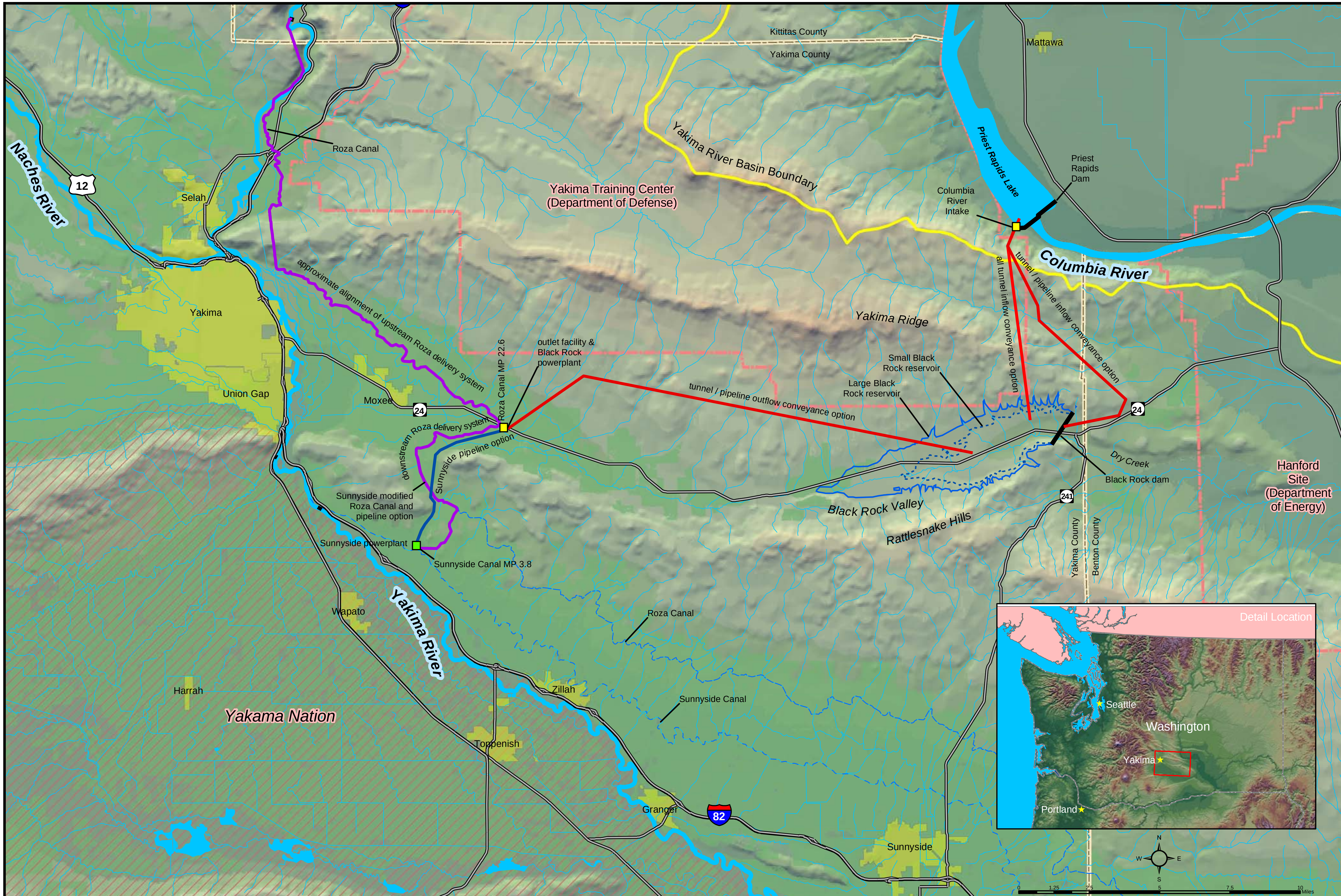


Figure 5-5. Preliminary Black Rock reservoir outflow conveyance system

5.7.2 Outlet Facility

The potential Black Rock outlet facility would be on the southeast corner of Roza Canal (at MP 22.6) and SH 24 intersection. The facility would include a Black Rock powerplant, a bypass structure to permit water deliveries when the unit was off line or to pass flows in excess of powerplant design flows, a flowmeter, and manifold piping and valving for pressure pipe diversions to Roza and Sunnyside Divisions. This location was selected for its position within the Roza and Sunnyside delivery systems, its proximity to a Black Rock reservoir, and its ease of access from SH 24.

The type of system selected to deliver water from the outflow conveyance system to the potential water exchange participants would determine the design capacity of the Black Rock powerplant. (Section 5.8 discusses water delivery systems.) The following preliminary Black Rock powerplant design flow options represent possible turbine capacities.

- With the canal delivery option (figure 5-6), all exchange water would be discharged from the outflow conveyance system through either a Black Rock powerplant and/or a bypass structure into a modified Roza Canal. The Black Rock powerplant turbine design flow would be 1,500 cfs, which represents the Roza and Sunnyside Divisions' combined April water rights.

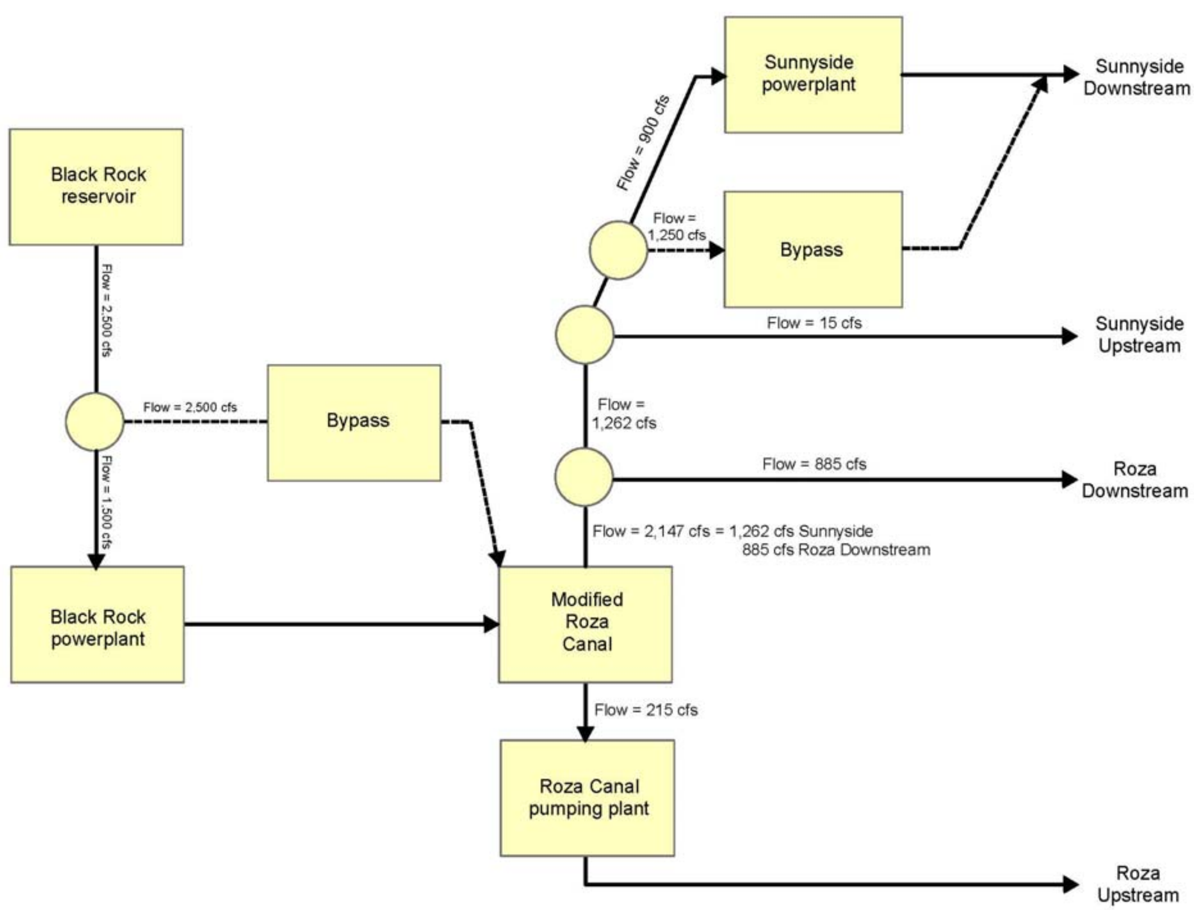


Figure 5-6. Preliminary Black Rock outlet facility flow diagram – canal delivery option

- With the pipeline delivery option (figure 5-7), only the exchange water required by Roza Division downstream from MP 22.6 (885 cfs) would be discharged from the outflow conveyance system through a Black Rock powerplant and bypass structure into Roza Canal. A 900-cfs turbine design, which represents anticipated deliveries to Roza Division downstream from MP 22.6, was selected for Black Rock powerplant under this type of delivery system. The exchange water required upstream from MP 22.6, and that for Sunnyside Division, would be diverted into pressurized pipeline delivery systems at bifurcation works upstream from the discharge to Black Rock powerplant.

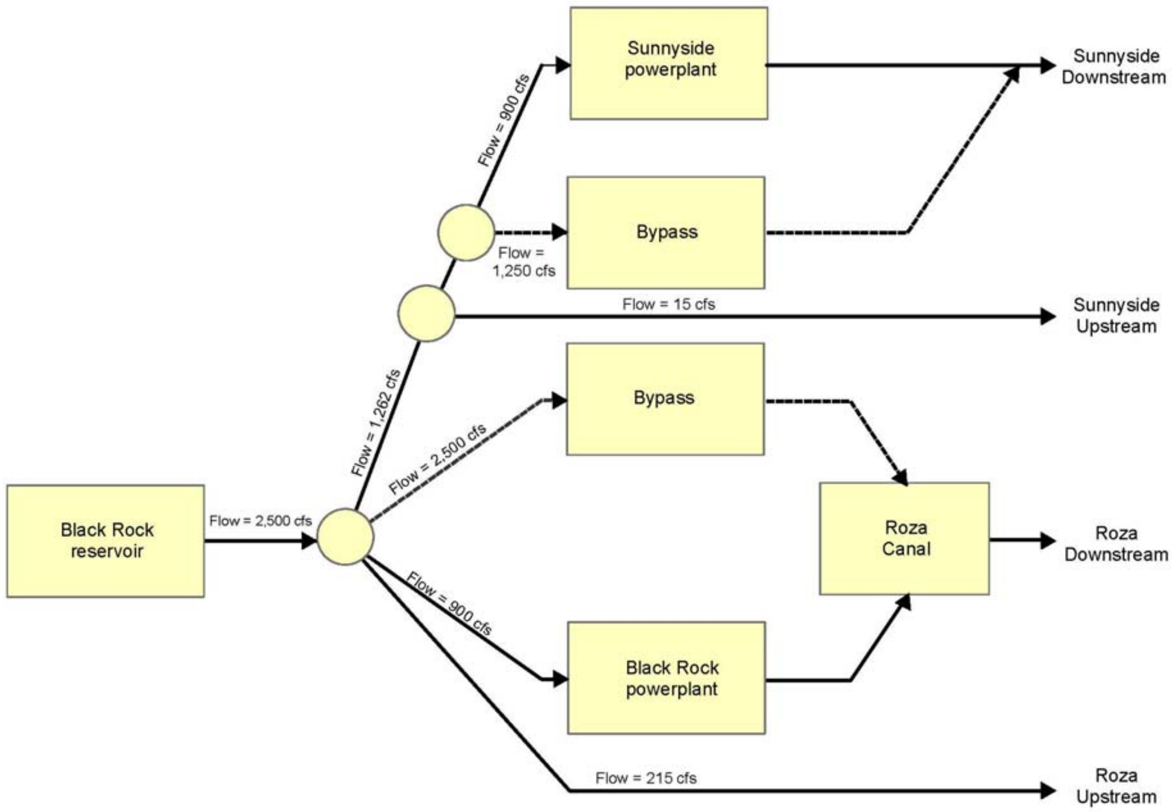


Figure 5-7. Preliminary Black Rock outlet facility flow diagram – pipeline delivery option

Although the outflow conveyance system's peak design flow would be 2,500 cfs, lesser turbine design flows were used so the powerplants could operate at full capacity for most of the April through October irrigation season and to reduce equipment costs. The bypass structure for both Black Rock powerplant options was sized to pass the total 2,500-cfs outflow conveyance system design flow.

The need for a temporary canal bypass was assumed during construction. Upstream and downstream earthen cofferdams with geomembrane linings would connect the transition structures to the canals. Three 9-foot-diameter corrugated metal pipes between the cofferdams would permit canal operation during construction.

The powerplant and bypass facilities would be contained in the same superstructure. The bypass would include four 84-inch sleeve valves to dissipate head. Each sleeve valve would discharge into a 33-foot-diameter by 20-foot-high stainless-steel-lined stilling chamber. A concrete-lined, open-channel outlet transition structure was sized to convey the outflow into Roza Canal.

Details and quantities for the 1,500-cfs powerplant and 2,500-cfs bypass structure were developed for this Assessment. No detailed layout or transient study of the 900-cfs powerplant were completed. For the 900-cfs powerplant option, the bypass was conservatively sized for the full outflow capacity to provide a means of bypassing the powerplant and pressurized water deliveries. This sizing should be reviewed and revised as necessary if the Black Rock alternative proceeds to feasibility design.

5.7.3 Outlet Powerplants

5.7.3.1 Black Rock Powerplant and Switchyard

A Black Rock powerplant would be an indoor-type plant with a structural steel superstructure enclosed with concrete masonry walls. The intermediate and substructure would be reinforced concrete. The powerplant would consist of a service bay and a single unit bay. The powerplant would use a single Francis turbine designed for longer operation at runaway speed and a reduced wicket gate closing rate. This turbine would be normal in design and available from most turbine manufacturers. One 90-ton overhead traveling crane would handle the powerplant and bypass electrical and mechanical items.

Black Rock reservoir operating water surface elevations would range from a low of 1500 feet to a high of 1775 feet. The water surface elevation in Roza Canal at MP 22.6 was assumed to be approximate 1170 feet. The steady state head at the Black Rock outlet facility (measured from canal water surface) would range from a low of 198 feet to a high of 477 feet. The powerplant design head for turbine sizing was assumed to be the average of the steady state head. Based on the assumed design criteria, table 5-10 shows a comparison of the Black Rock powerplant unit data for the two options.

Table 5-10. Preliminary Black Rock powerplant unit data

Unit Data	Canal Delivery 1,500-cfs powerplant	Pipeline Delivery 900-cfs powerplant
number/type of units	1 Francis turbine	1 Francis turbine
design discharge	1,500 cfs	900 cfs
design head	338 feet	338 feet
speed	327 rpm	400 rpm
assumed unit efficiency	90 percent	90 percent
power output at design head	38 MW	23 MW
minimum turbine submergence	30.5 feet	25 feet
maximum scroll case dimension	23.5 feet	19.0 feet
bottom elevation of draft tube	1118.8 feet	1128.3 feet
turbine guard valve	108-inch spherical	84-inch spherical

A switchyard would be located within a service yard sized to permit mobile crane access around the plant. A chain-link security fence would surround the service yard. The switchyard would include a transformer, circuit breakers, and disconnect switches, but no remote-control equipment.

5.7.3.2 Sunnyside Powerplant and Related Facilities

The potential Sunnyside powerplant, bypass, and switchyard would be located adjacent to Sunnyside Canal near its intersection with Konnowock Pass Road. Section 5.8.2 describes the two options (pipeline delivery and canal delivery) for conveyance of Black Rock reservoir water to Sunnyside powerplant and the bypass facilities.

The Sunnyside Canal outlet facilities would be similar in arrangement to the Roza Canal outlet facilities described in section 5.7.2. However, the Sunnyside bypass structure would be a separate indoor structure with a reinforced concrete substructure and a structural steel superstructure enclosed with concrete masonry walls. The bypass structure would house two 84-inch sleeve valves to dissipate head. Each sleeve valve would discharge into a 33-foot-diameter by 20-foot-high stainless-steel-lined stilling chamber. The bypass structure would discharge into a 12-foot-diameter steel pipe that would discharge into the riprap-lined outlet transition channel that would carry powerplant and bypass flows to Sunnyside Canal.

The Sunnyside powerplant would be an indoor-type plant with a structural steel superstructure enclosed with concrete masonry walls. The intermediate and substructure would be reinforced concrete. The powerplant would consist of a service bay and a single unit bay. A 125-ton overhead traveling crane would be provided to handle the powerplant electrical and mechanical items. Table 5-11 shows powerplant design considerations for the two delivery system options.

Table 5-11. Preliminary Sunnyside powerplant unit data

Unit Data	Pipeline Delivery Option	Canal Delivery Option
number/type of units	1 Francis turbine	1 Francis turbine
design discharge	900 cfs	900 cfs
design head	435 feet	221 feet
speed	400 rpm	300 rpm
assumed unit efficiency	90 percent	90 percent
power output at design head	29.5 MW	15 MW
minimum distributor submergence (negative if distributor is above tailwater)	+ 10.6 feet	- 1.1 feet
maximum scroll case dimension	19.4 feet	20.5 feet
bottom elevation of draft tube	859.2feet	854.5 feet
turbine guard valve	78-inch spherical	84-inch spherical

The service yard was sized to permit mobile crane access around the structures. A 7-foot chain-link fence was provided around the yard for security. Incoming power was assumed to be from a tap on an existing BPA line about 1 mile southwest of the switchyard. The line tap would include circuit breakers and disconnect switches. A new 69-kilovolt wood-pole line would be constructed from the tap to the switchyard. A 75-foot by 100-foot switchyard would be located within the service yard. The switchyard would include transformers, circuit breakers, and disconnect switches.

Findings: Based upon currently available information and the appraisal-level designs prepared for this Assessment, it is reasonably certain the construction of facilities to pump, store, and deliver Columbia

River water to willing exchange participants in the Yakima River basin would be technically viable.

5.8 Appraisal-Level Water Delivery System Plans

The appraisal-level water delivery plans developed to date could result in a Columbia River water exchange of up to 2,472 cfs. The extent of the exchange would depend on the capacity and configuration of delivery systems constructed to convey Columbia River water from the Black Rock outlet facility to exchange participants and upon the completion of exchange arrangements acceptable to the parties. At this time, potential exchange participants include Roza and Sunnyside Divisions, and Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts. Table 5-12 summarizes the irrigation requirements of potential exchange participants upstream and downstream from Roza Canal MP 22.6 and identifies possible water supply sources for each plan.

Table 5-12. Preliminary irrigation requirements based on six appraisal-level water delivery plans

Current Yakima River supply = 2,532 cfs						
Upstream From Roza Canal MP 22.6						
	(cfs)					
	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6
Irrigation requirements	385	385	385	385	385	385
Potential Columbia River supply						
Roza and Terrace Heights	215	175	175	175	175	35
Selah-Moxee	—	—	—	80	80	—
Union Gap	—	—	—	70	70	—
Total Columbia River supply	215	175	175	325	325	35
Continued Yakima River supply						
Roza and Terrace Heights	—	40	40	40	40	180
Selah-Moxee	100	100	100	20	20	100
Union Gap	70	70	70	—	—	70
Total Yakima River supply	170	210	210	60	60	350
Total upstream from MP 22.6	385	385	385	385	385	385
Downstream From Roza Canal MP 22.6						
	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6
Irrigation requirements	2,147	2,147	2,147	2,147	2,147	2,147
Potential Columbia River supply						
Roza	885	885	885	885	885	855
Sunnyside Division	1,262	1,262	1,262	1,262	1,262	1,262
Total Columbia River supply	2,147	2,147	2,147	2,147	2,147	2,117
Continued Yakima River supply						
Roza	—	—	—	—	—	30
Sunnyside Division	—	—	—	—	—	—
Total Yakima River supply	—	—	—	—	—	30
Total downstream from MP. 22.6	2,147	2,147	2,147	2,147	2,147	2,147
Potential Water Supply Sources						
Columbia River	2,362	2,322	2,322	2,472	2,472	2,152
Yakima River	170	210	210	60	60	380
Total	2,532	2,532	2,532	2,532	2,532	2,532

5.8.1 Plans For Delivery Upstream From MP 22.6

As described in the Roza delivery system assessment [7], six upstream plans provide various combinations of delivery of Columbia River water to Roza Division and Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts. Plans 1, 2, 3, and 4 would involve construction of a mainline delivery system extending from the Black Rock outlet facility. Plan 5 would involve installation of checks and pumps in Roza Canal to reverse the flow. Plan 6 would require no new construction.

The four appraisal-level plans (1, 2, 3, and 4) for mainline delivery systems would contain the following common features:

- A buried steel pipeline would originate at the Black Rock outlet facility bifurcation works. The static pressure resulting from the difference in head between stored water elevations (in a Black Rock reservoir) and mainline delivery system elevations would provide for upstream conveyance. A pressure-reducing valve system installed between the bifurcation works and the pipeline would dissipate any excess pressure to ensure the reliability and safety of the mainline delivery system.
- A buried steel pipeline would originate at a new pumping plant in Roza Canal at MP 22.6. Water discharged from the outlet facility through a new Black Rock powerplant would be pumped into the steel pipeline for upstream conveyance. Pressure would dissipate by discharging water through the generator.

Existing pumping plants of Roza and Terrace Heights Irrigation Districts currently lifting water from Roza Canal to high-elevation laterals upslope of Roza Canal would continue to be used in conjunction with the new mainline delivery systems in the following manner:

- With a high-pressure pipeline system originating at the bifurcation works, a dual operation would be required contingent on the Black Rock reservoir water surface elevation. When the reservoir was at elevation 1650.0 feet and higher, water released from the mainline delivery system would be routed through a new pressure-reducing valve system to the existing pumping plant discharge manifold extending to the high-elevation lateral. When the reservoir water surface was lower than elevation 1650.0 feet, water would be routed through the new pressure-reducing valve system to the existing pump sump for subsequent pumping to the high-elevation lateral. With a low-pressure pipeline, releases would go into the existing pump sump and then would be pumped to the high-elevation lateral.
- For a high-pressure system beginning at a new Roza Canal pumping plant, water released from the mainline delivery system for service to upslope lands would always be routed through the existing pumping plant discharge manifold to the high-elevation lateral. A low-pressure system starting at the same point would make releases to the existing pump sump for pumping at the existing plant to the high-elevation lateral.

Table 5-13 summarizes the above with respect to mainline water deliveries to existing Roza Canal pumping plants serving lands upslope of the canal. For purposes of discussing the individual plans, the two locations of the mainline inlet (at the bifurcation and at a new pumping plant) are identified in each plan, i.e., for plan 1, a mainline inlet at the bifurcation is option 1 and a mainline inlet at a new pumping plant is option 1A.

Table 5-13. Water delivery by mainline delivery system to lands upslope of Roza Canal

Pipeline Inlet	Type of System	Releases Routed To:	Is Pumping Required At Existing Plants?
new bifurcation	high pressure	existing pump manifold discharge to high-elevation lateral - existing pump sump to high-elevation lateral	No – if reservoir water surface were at elevation 1650.0 feet or higher Yes – if reservoir water surface were lower than elevation 1650.0 feet
	low pressure	existing pump sump to high-elevation lateral	Yes – regardless of reservoir water surface elevation
new pumping plant	high pressure	existing pump manifold discharge to high-elevation lateral	No
	low pressure	existing pump sump to high-elevation lateral	Yes – regardless of reservoir water surface elevation

Lands downslope from the mainline delivery system would be served by turnouts to the existing lateral systems.

A brief description of the six appraisal-level water delivery plans follows.

5.8.1.1 Upstream Plan 1 – 215-cfs Exchange Using High-Pressure Pipeline

Upstream plan 1 (figure 5-8) would be a total exchange for Roza and Terrace Heights, whose combined April through October irrigation requirements (215 cfs) between Roza Diversion Dam and MP 22.6 would be met with Columbia River water. Up to 1,020 cfs currently diverted for hydroelectric generation at Roza Powerplant would be terminated.[3] Roza Canal would be dewatered from Roza Diversion Dam to MP 22.6. Plan 1 would not deliver Columbia River water to Selah-Moxee or Union Gap Irrigation Districts.

Plan 1 would involve construction of a new high-pressure mainline delivery system extending to about MP 5.0. This would provide up to 40 cfs to the Roza-Selah lands (those lands upstream from the inlet of Roza Canal tunnel No. 3 served by Roza Irrigation District). Up to 175 cfs would be provided to Roza and Terrace Heights lands downstream from the tunnel outlet (MP 11.0 to 22.6). Option 1A would provide the same delivery from a new pumping plant on Roza Canal.

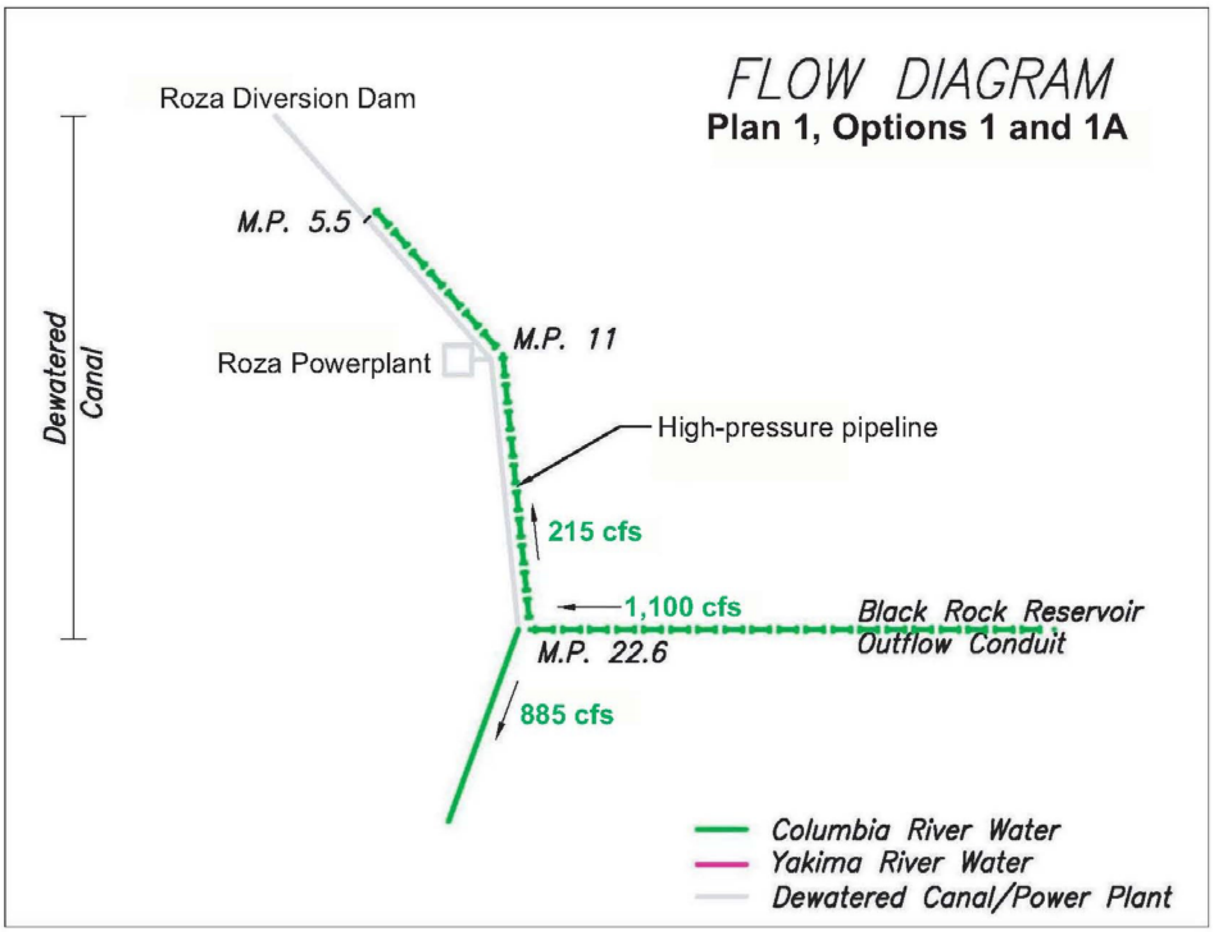


Figure 5-8. Flow diagram of upstream delivery plan 1

[3] The existing Roza Canal bifurcation works to the Roza Powerplant is at MP 11.0.

5.8.1.2 Upstream Plan 2 – 175-cfs Exchange Using High-Pressure Pipeline

Upstream plan 2 (figure 5-9) also would involve only Roza and Terrace Heights Irrigation Districts; however, the extent of the water exchange would decrease to 175 cfs by eliminating delivery of Columbia River water to the Roza-Selah lands. These lands would be served by continuing to divert 40 cfs from the Yakima River at Roza Diversion Dam (RM 127.9). This plan assumes Roza Powerplant near MP 11.0 would continue to operate (requiring the diversion of up to 1,020 cfs from the Yakima River), but that Roza Canal would be dewatered from MP 11.0 to MP 22.6. The new mainline high-pressure pipe system of plan 2 would extend upstream to about MP 11.7.

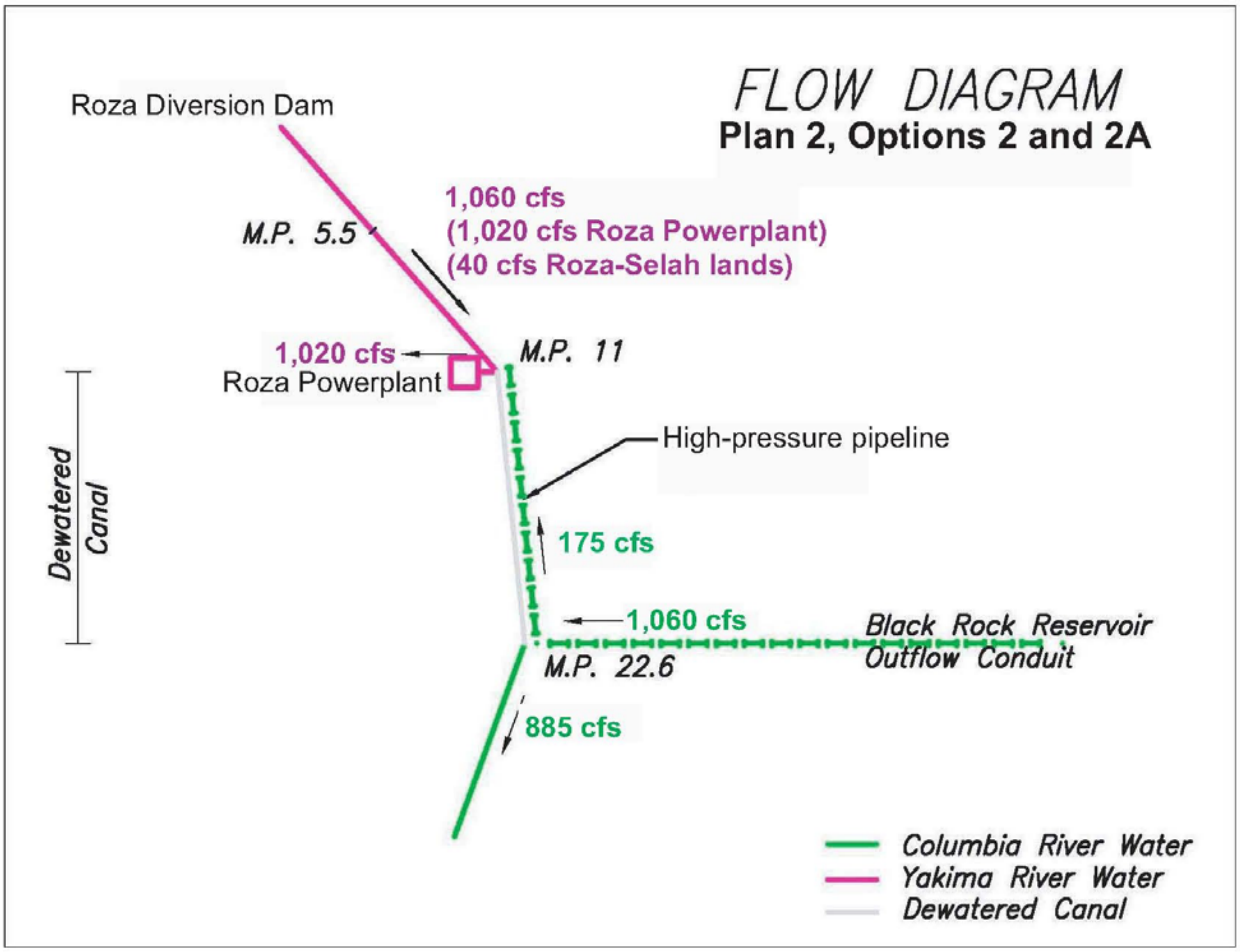


Figure 5-9. Flow diagram of upstream delivery plan 2

5.8.1.3 Upstream Plan 3 – 175-cfs Exchange Using Low-Pressure Pipeline

Upstream plan 3 (figure 5-10) would deliver 175 cfs of Columbia River water in the same manner as plan 2 – 175 cfs for Roza and Terrace Heights. The new mainline delivery system would be low pressure and require continued use of the existing pumping plants to lift water to the high-elevation laterals upslope of Roza Canal. This plan assumes Roza Powerplant would continue to operate (requiring the diversion of up to 1,020 cfs from the Yakima River), but that Roza Canal would be dewatered from MP 11.0 to MP 22.6.

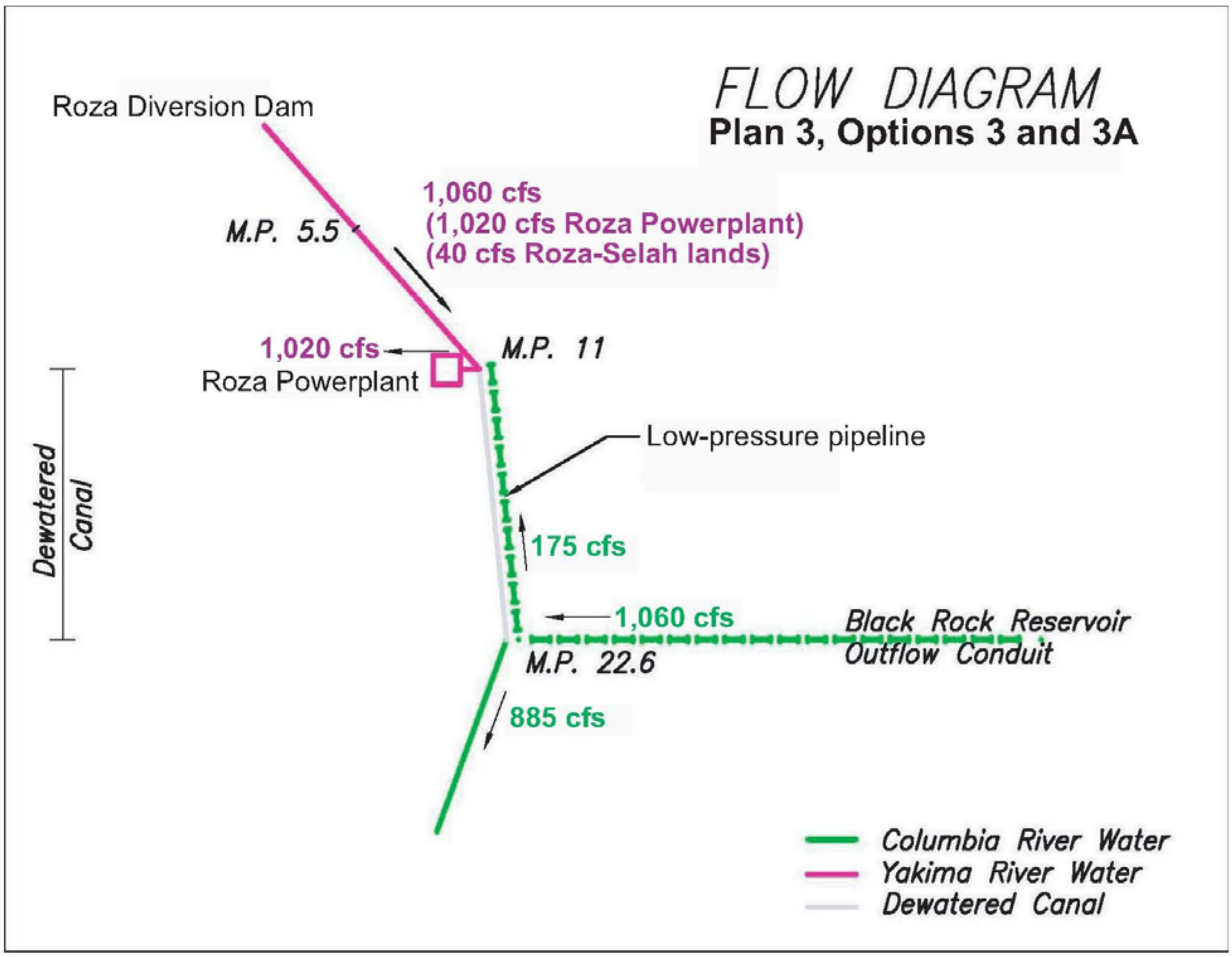


Figure 5-10. Flow diagram of upstream delivery plan 3

5.8.1.4 Upstream Plan 4 – 325-cfs Exchange Considering Three Pipeline Options

Upstream plan 4 (figure 5-11) would provide a total of 325 cfs of exchange water and include all potential water exchange participants upstream from MP 22.6 (Roza Division and Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts). This plan would meet all of the Roza and Terrace Heights irrigation requirements (175 cfs), except for the Roza-Selah lands, and all of the 70-cfs Union Gap irrigation requirements. Selah-Moxee would get 80 cfs of its 100-cfs requirement. Yakima River diversions of 60 cfs (40 cfs for the Roza-Selah lands and 20 cfs for Selah-Moxee lands) would continue. Plan 4 assumes Roza Powerplant would continue to operate (requiring the diversion of up to 1,020 cfs from the Yakima River) and that Roza Canal would be dewatered from MP 11.0 to MP 22.6.

This plan considers three mainline delivery systems:

- Option 4 would be a low-pressure pipeline extending from the bifurcation works.
- Option 4A would be a low-pressure pipeline extending from a new Roza Canal pumping plant.
- Option 4B would be a high-pressure, full-head-class pipe system beginning at the bifurcation works. This option would rely on the wall thickness of the pipe instead of a pressure-reducing valve system to handle the system pressure; thereby removing concerns that a pressure-reducing valve system (in option 4) may not consistently operate to ensure system pressure attributed to the head differential would not bypass the pressure-reducing valve system.

The new mainline delivery system would extend upstream to about M.P. 11.7. Water deliveries to the Selah-Moxee and Union Gap Canals would occur near this point.

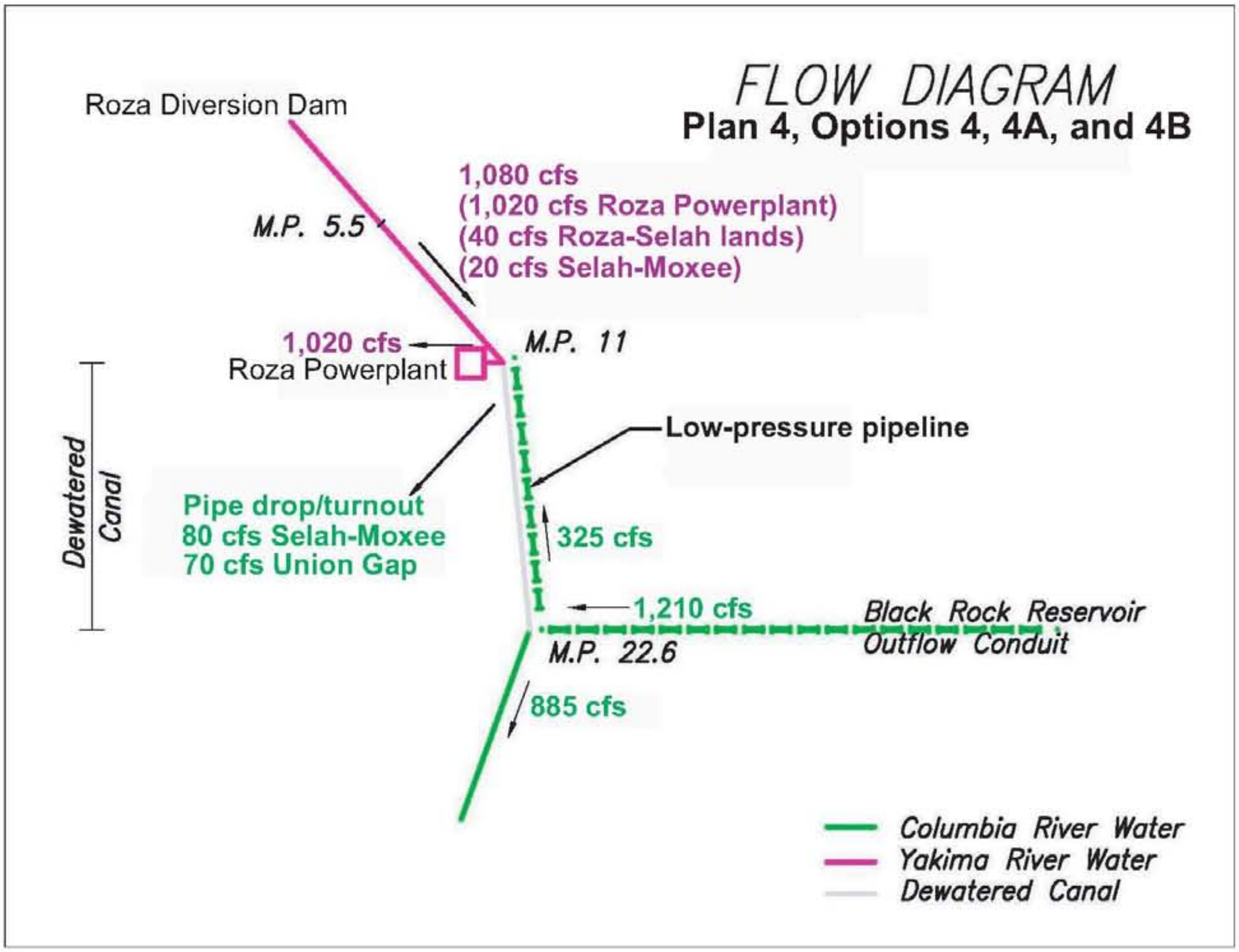


Figure 5-11. Flow diagram of upstream delivery plan 4

5.8.1.5 Upstream Plan 5 – 325-cfs Exchange Delivery With Checks and Relift Pumps

Upstream plan 5 (figure 5-12) would be similar to plan 4 and also deliver 325 cfs to the four upstream irrigation districts. However, this would be accomplished by installing checks and relift pumps to reverse the flow in Roza Canal from MP 22.6 to 11.7. Four new check structures and relift pumps would lift, in 5-foot increments, water discharged from the Black Rock outlet facility through a Black Rock powerplant. A terminal check would be also added at MP 11.7.

This plan assumes Roza Powerplant would continue to operate. Roza Canal from MP 11.7 to MP 22.6 would be watered up by the delivery of Columbia River water as the result of the reverse flow operation.

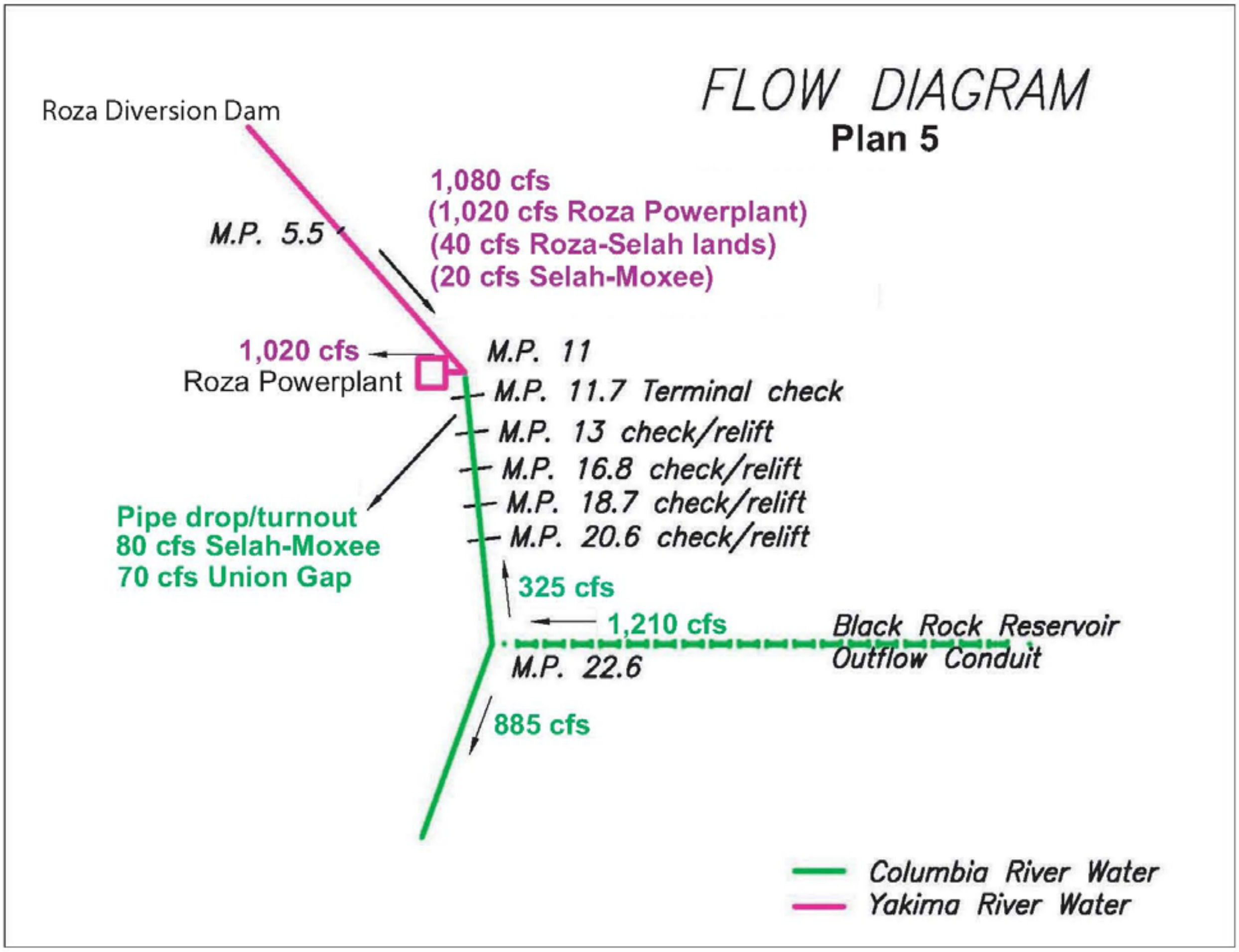


Figure 5-12. Flow diagram of upstream delivery plan 5

5.8.1.6 Upstream Plan 6 – 35-cfs Exchange

Under upstream plan 6 (figure 5-13), the only upstream water exchange would be with Roza Division. It would involve the delivery of 35 cfs of Columbia River water to meet a portion of the irrigation requirement at pumping plant No. 3 (65 cfs) at MP 22.5. Table 5-14 shows that Yakima River diversions would continue at 180 cfs.

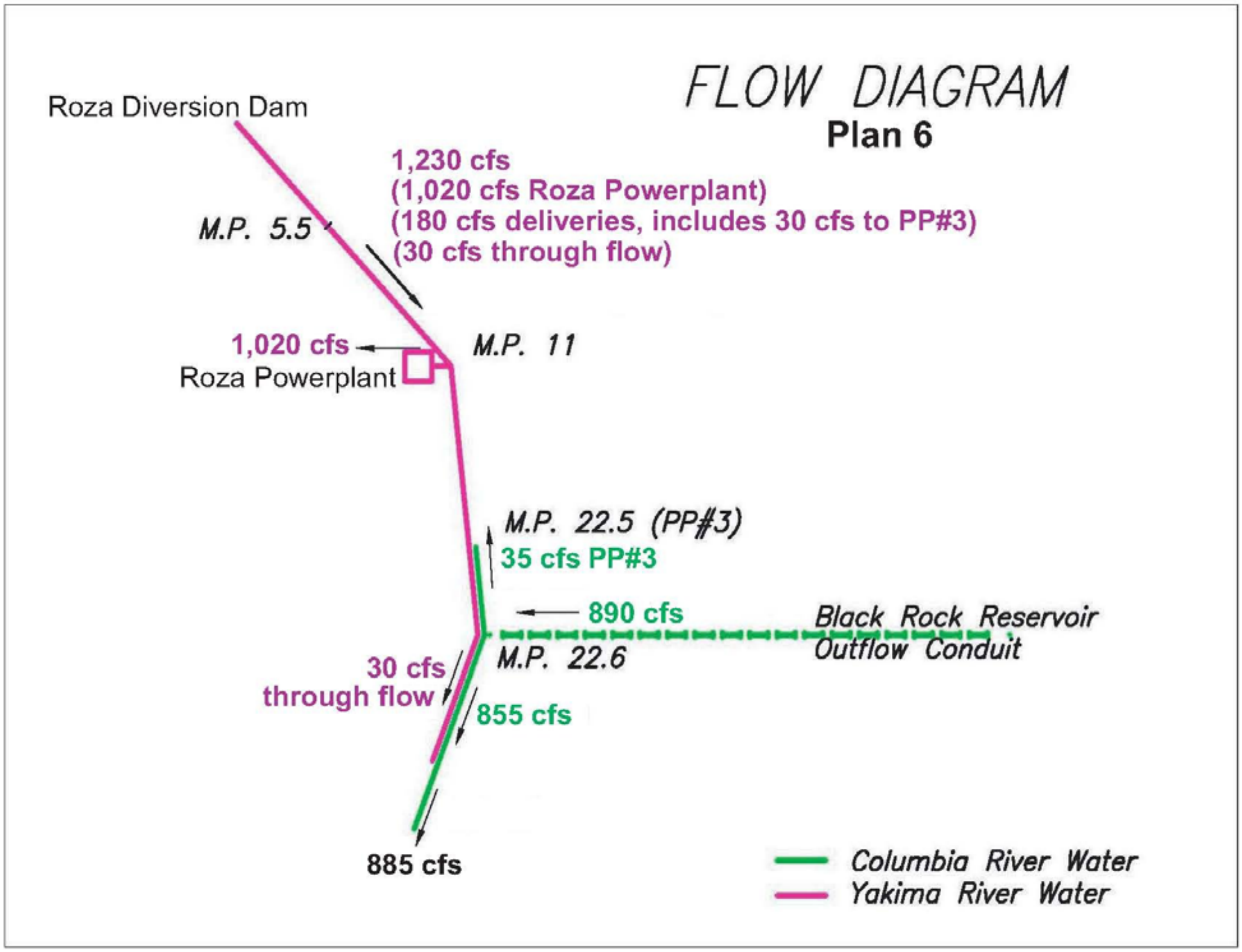


Figure 5-13. Flow diagram of upstream delivery plan 6

Table 5-14. Upstream delivery plan 6 Yakima River diversion requirements

Upstream from MP 11.0 (Roza-Selah lands)		40 cfs
MP 11.0 to MP 22.6 (total requirement)	175 cfs	
<less> pumping plant No. 3 exchange	–35 cfs	
Residual		140 cfs
Yakima River irrigation diversions		180 cfs

The 35 cfs from the Columbia River would be provided at pumping plant No. 3 from backflow of water discharged from the Black Rock outlet facility through a Black Rock powerplant into Roza Canal at MP 22.6. The Yakima River would provide the remaining 30 cfs required at pumping plant No. 3. In addition to the 180-cfs Yakima River diversion to meet upstream irrigation requirements, 30 cfs would also be diverted as flow-through water to keep the canal from getting stagnant. This flow-through water would then be used for irrigation downstream from MP 22.6.

5.8.2 Plans for Delivery Downstream From MP 22.6 – Roza and Sunnyside Divisions

As described in the Roza [7] and Sunnyside [8] delivery system assessments, two plans for delivery downstream from Roza Canal MP 22.6 would involve Roza Irrigation District and Sunnyside Division. Service to Roza Division would be by means of the existing Roza Canal. Service to Sunnyside Division would be either by a new pressure-pipe delivery system extending through Konnowock Pass to Sunnyside Canal or by enlarging Roza Canal combined with a shorter pipeline to Sunnyside Canal. Either system would have a new Sunnyside powerplant at the discharge to Sunnyside Canal.

Maximum Roza Division irrigation requirements downstream from MP 22.6 are 885 cfs. This requirement could be met entirely by Columbia River water provided from the Black Rock outlet facility without incurring additional costs for construction of water delivery facilities. This would be done by releasing water from the Black Rock outlet facility through a new Black Rock powerplant into Roza Canal. This exchange water then would be conveyed to existing pumping plants and turnouts for the irrigation of upslope and downslope lands.

The preliminary design discharge and generation capacities of the Black Rock powerplant would be 900 cfs (23 MW) to 1,500 cfs (38 MW) depending on the Sunnyside Division water delivery plan discussed below. (Section 5.7.3.1 describes the Black Rock powerplant options.) The following describes the two appraisal-level water delivery plans for Sunnyside Division.

5.8.2.1 Downstream Plan 1 – Pipeline From Black Rock Outlet Facility

Downstream plan 1 would involve a buried steel pipeline extending from the Black Rock outlet facility bifurcation works generally following Roza Canal across orchard lands to the top of Konnowock Pass and then downhill parallel to Konnowock Pass Road. The pipeline, with a total length of about 6.5 miles, would discharge into Sunnyside Canal at MP 3.83. A check structure constructed in Sunnyside Canal at MP 3.83 would prevent water from backing up in the canal. At Sunnyside Canal, a powerplant and a bypass structure would dissipate the excess pressure. A 12-foot-diameter steel pipeline would keep velocities under 12 feet per second. The pipeline would be sized using a 1,262-cfs flow capacity; the design of the turbine would be based on a 900-cfs flow.[4] The output of the powerplant (at the design head of 435 feet) would be 29.5 MW.

A 210-foot static hydraulic head at the beginning of the pipeline would deliver water to Sunnyside Canal. This would result in a minimum 438-foot hydraulic head at the new Sunnyside

[4] This capacity is representative of the Sunnyside Division's April water rights. The 900-cfs design flow permits the powerplant to operate at full capacity for most of the irrigation season and reduces equipment costs.

powerplant and a maximum 743-foot hydraulic head with Black Rock reservoir at maximum water surface elevation 1778 feet. The pipeline would be designed to the maximum hydraulic head and, in this respect, would be similar to upstream plan 4, option 4B, which would rely on the pipe wall thickness to handle the system pressure. This is a conservative approach at this stage of the Storage Study, and further analysis may result in other ways to handle this significant pressure.

Most of the discharge from the powerplant would flow into Sunnyside Canal for downstream delivery. However, a small number of Sunnyside Division water users upstream from this point would be served by delivery of 17 to 20 cfs by a pumping plant constructed at MP 3.83 and a buried PVC pipeline extending about 3.2 miles on the right embankment of Sunnyside Canal.

5.8.2.2 Downstream Plan 2 – Modified Roza Canal and New Pipeline

Downstream plan 2 would include a modified Roza Canal and a new pipeline to convey water to Sunnyside Canal. Beginning at MP 22.6, modifications would consist of a new siphon, enlargement of Roza Canal, and construction of a new tunnel No. 5 to carry an additional 1,262-cfs flow to about MP 29.2. At this point, the exchange water would be routed into wasteway No. 3, which would be enlarged from 1,252 cfs to 2,514 cfs to carry the additional flow. Five new check/drop structures would be also installed.

At about 1.75 miles from the headworks of the wasteway, a new turnout would divert Sunnyside Division exchange water into a 12-foot-diameter pipeline extending a little over 0.75 miles to Sunnyside Canal MP 3.83. Water would discharge into Sunnyside Canal through a new Sunnyside powerplant described for downstream plan 1. However, the output of the downstream plan 2 powerplant would be 15 MW at the design head of 221 feet. Deliveries to water users upstream from MP 3.83 would be handled in the same manner as upstream plan 1.

5.8.3 Preliminary Reactions to Appraisal-Level Delivery Plans

Input received from the potential water exchange participants as to concerns and preferences are noted below. Appraisal-level delivery plans affected by the concerns and preferences are also noted.

5.8.3.1 Roza Division Input

- Desire to keep Roza Powerplant in operation and is averse to a plan that would result in hydroelectric generation being terminated.

  Comment: *All upstream plans, except plan 1, assume continued diversion for hydroelectric generation at Roza Powerplant.*

- Prefer that Roza Canal be watered up during the irrigation season because the reinforced canal lining was not designed with expansion joints. If the canal were dewatered, there would be a tendency for thermal expansion and buckling of the lining during hot weather. Appraisal-level delivery plans that include dewatering of the canal may need to consider installation of expansion joints at appropriate intervals.

> ***Comment:*** *Upstream plans 5 and 6 assume Roza Canal remains watered up from Roza Diversion Dam to the canal's end near Prosser; upstream plans 2, 3, and 4 assume Roza Canal would be watered up from Roza Diversion Dam to MP 11.0 and from MP 22.6 to the canal's end near Prosser.*

- Receptive to delivery plans that would convey water to Selah-Moxee and Union Gap by a new mainline delivery system or by Roza Canal.

> ***Comment:*** *Upstream plans 4 and 5 include water service to Selah-Moxee and Union Gap.*

- Current operational practice is to flush and prime Roza Canal prior to the irrigation season by diversion of Yakima River March flood flows. These flows then discharge directly to the Yakima River.

> ***Comment:*** *Because of the direct discharge to the Yakima River, it would be undesirable to use Columbia River water for flushing and priming. The current operational practice would need to continue to rely on Yakima River diversions to prime the canal. Then deliveries from the Black Rock alternative could commence.*

- Wish to keep the existing system in place and operational as a back up to the Black Rock alternative.

> ***Comment:*** *There is no intent to decommission the existing facilities. Continued operational reliability and integrity of the existing system would need to be ensured.*

5.8.3.2 Sunnyside Division Input

Sunnyside Division has both technical and policy issues as follows:

<u>Technical Issues</u>

- Prefer the delivery system be built with equipment redundancy to ensure service in the event of equipment failure.
- Design velocities of the mainline delivery system (up to 12 feet per second) seem excessive.
- Delivery pressure should be at least 40 pounds per square inch.
- The upper 3.83 miles of Sunnyside Canal and the current Yakima River diversion works would need to remain in place and operable for the months of March and October. This would require a structure to permit downstream passage of water during certain months of the year.

Policy Issues

- How would construction and operation and maintenance costs be allocated for the new delivery system?
- Would the delivery system be reserved or transferred works?
- The delivery raises key issues for linking Roza and Sunnyside Canal operations.
- A fundamental issue is the effect of the potential water exchange on the priority dates of the Sunnyside Division's water rights and the current contracts between Reclamation and Sunnyside Division entities.

> ***Comment***: *Future phases of the Storage Study would address the above issues if the Black Rock alternative proceeds to the next phase.*

5.8.3.3 Selah-Moxee Irrigation District Input

The appraisal-level design for upstream plans 4 and 5 would include the delivery of Columbia River water to Selah-Moxee. The district's main canal diverts from the Yakima River near Pomona, runs parallel to and downslope of Roza Canal, tunnels through the Yakima Ridge, and ends in the southeast side of Moxee Valley. For design purposes, it was assumed the district's water demand was about 100 cfs with 80 cfs required downstream from the Yakima Ridge tunnel. The Yakima River would deliver the remaining 20 cfs. The appraisal-level design would limit service with use of Columbia River exchange water to the area downstream from the tunnel.

5.8.3.4 Union Gap Irrigation District Input

Appraisal-level design for upstream plans 4 and 5 also would include the delivery of Columbia River water to Union Gap. Currently, the district diverts from the Yakima River downstream from Pomona; its main canal is parallel to and downslope of Roza and Selah-Moxee Canals. After passing through Union Gap and to its end point north of Zillah, the canal is upslope of Sunnyside Canal.

All of the Union Gap service area lies downstream from Roza Canal MP 11.0. The district has indicated an interest in receiving Columbia River water as a full in-lieu supply as long as there would be no additional cost to the district.

> ***Comment***: *The question of allocation of project costs is beyond the scope of this Assessment.*

5.8.4 Delivery System Conclusions

5.8.4.1 Upstream From MP 22.6

Of the six appraisal-level plans developed for delivery of Columbia River water upstream from MP 22.6, only plans 4 and 5 would provide service to Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts. Roza Irrigation District has indicated a preference for plans that would not dewater any portion of Roza Canal. Only plan 5 would be viable under this condition while including all the irrigation districts.

Further, with the Black Rock alternative, there would be the need to maintain the continued operational viability of Roza Canal for use in the event of some type of system outage that would preclude delivery of exchange water. Any water delivery plan that precludes such emergency operation would be of concern. This could impact the viability of plan 5 unless the checks were capable of passing approximately 1,100 cfs downstream from MP 11.0.

Based on this information, it may be desirable to forego delivery of any Columbia River exchange water upstream from MP 22.6. Under this scenario, about 325 cfs would not be exchanged. However, this decision should be deferred pending examination of the benefits associated with inclusion of such service; this Assessment does not include a benefit analysis.

Upstream delivery plans 4, 4A, and 5 should receive further evaluation. The dewatering of Roza Canal under the current plan 4 would, however, have to be assessed further. Plan 6 would involve no delivery system construction costs, but because only 35 cfs would be associated with this exchange, and the potential for operational concerns, further analyses of this plan may not be warranted.

5.8.4.2 Downstream From MP 22.6

At this time, there is potential for a water exchange with Roza and Sunnyside Divisions downstream from Roza Canal MP 22.6. The potential 885-cfs downstream water exchange with Roza Division could be incorporated with each of the upstream plans and should receive further evaluation.

For the potential 1,262-cfs water exchange with Sunnyside Division, both plans 1 and 2 should receive further evaluation. Plan 2 would involve policy issues of modifying Roza Canal to permit conveyance of Sunnyside Division's exchange water from MP 22.6 to MP 29.2. The joint use of Roza Canal must be addressed if the Black Rock alternative proceeds to the next phase of the Storage Study.

6.0 Black Rock Reservoir Operation

6.1 Operations Concept

The following discussion focuses on the potential Black Rock reservoir operation given the availability of inflow from the Columbia River [3] and irrigation water for outflow from a Black Rock reservoir. Annual uncontrolled reservoir losses resulting from evaporation and seepage would need to be replaced.[5]

For this Assessment, the preliminary reservoir related operational parameters are summarized as follows:

- The only Columbia River water available for diversion would be that in excess of seasonal instream flow targets established in the December 2000 FCRPS Biological Opinion [4] and flow objectives for nonlisted salmon downstream from Priest Rapids Dam at Vernita Bar.

- Roza and Sunnyside Divisions would receive their water right supply entirely from a Black Rock reservoir. The monthly allocation and combined total supply (840,400 acre-feet) are as shown in table 3-6.[6] The combined maximum peak rate of withdrawal from the reservoir would be 2,500 cfs.

- Water delivery to Roza and Sunnyside Divisions would be reduced during proration years in the Yakima River basin consistent with Yakima Project operational procedures except that the proratable portion of their water rights would be not less than 70 percent of a full supply.

- No irrigation delivery of reservoir water would take place during the initial fill.

- The operational goal would be to maximize reservoir contents to assure carryover supplies for the water exchange. When water was available for pumping, and when the reservoir was less than full, pumps would operate to capacity to refill the reservoir.

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[5] Annual evaporation and seepage losses from the large reservoir are estimated at 45,100 acre-feet and 38,500 acre-feet from the small reservoir.

[6] As previously indicated, the water availability assessment [3] was based on a 840,400-acre-foot Roza and Sunnyside Division water exchange (810,400 acre-feet of April through October water rights and 30,000 acre-feet of March flood waters.)

6.2 Reservoir Capacity

As described in sections 3.2.4 and 5.6.10, two reservoir sizes were selected for analyses in this Assessment: a large reservoir with 1,300,000-acre-foot active capacity and a small reservoir with 800,000-acre-foot active capacity. Both reservoirs would contain inactive storage space of 157,610 acre-feet.

6.3 Operational Analysis

Reservoir operation related to inflow was analyzed through use of simulated Columbia River flows generated by BPA's Hyd-Sim computer model of the FCRPS. Hyd-Sim uses historic runoff over the 50-year period of 1929-1978, modified to reflect the current FCRPS operating requirements of each project, and the 1980 level of agricultural diversions. Reclamation used the simulated flows from this model to analyze pumping scenarios for a Black Rock reservoir as described in section 3.2. This analysis identified a need to pump throughout the year when flows were in excess of the flow targets, when reservoir space was available to meet identified irrigation demands, and to offset uncontrolled losses. A minimum 3,500-cfs pumping rate would be required in conjunction with the large reservoir and 6,000 cfs would be required with the small reservoir.

Adjustment of the irrigation delivery was necessary to account for proration conditions that would have been applied within the Yakima River basin in the 1929-1978 period. Based on data contained in the 1999 *Yakima River Basin Water Enhancement Project, Washington, Final Programmatic Environmental Impact Statement* [16], proratable water rights holders would have received less than their full water rights in 12 of the 50 years.

6.3.1 Time Required for Initial Reservoir Filling

Depending on Columbia River water availability conditions and assuming no delivery of stored water during the initial filling, the time to fill the 1,300,000-acre-foot reservoir would be 6 to 30 months with a 3,500-cfs pump capacity. The 800,000-acre-foot reservoir would take 2 to 13 months to fill with a 6,000-cfs pump capacity. The 157,610-acre-foot inactive pool for both reservoir sizes and pump capacities would fill in 1 month.

6.3.2 Annual Pumping

The volume of water pumped each month would vary in relation to the volume of Columbia River water available in excess of instream flow targets, the availability of reservoir space, and pump capability. The maximum monthly volume of water that could be pumped follows:

3,500-cfs pumping capability:
- 30-day period - 208,264 acre-feet
- 31-day period - 215,206 acre-feet

6,000-cfs pumping capability:

30-day period - 357,025 acre-feet

31-day period - 368,925 acre-feet

Using the two pumping plant/reservoir configurations and simulation of the 1929-1978 flow records, tables 6-1 and 6-2 show the monthly pumping that would have occurred.

Table 6-1. Monthly water volumes that could be pumped from Priest Rapids Lake for a 1,300,000-acre-foot active capacity reservoir and a 3,500-cfs pumping capacity (acre-feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1929	215,206	0	0	158,859	0	0	0	0	0	0	0	208,264	582,330
1930	215,206	0	0	0	194,380	0	0	0	0	0	0	208,264	617,851
1931	215,206	0	0	0	0	0	0	0	0	0	0	208,264	423,471
1932	215,206	0	0	0	0	215,206	208,264	215,206	208,264	215,206	0	208,264	1,485,619
1933	215,206	0	215,206	30,182	2,062	0	0	0	208,264	215,206	0	208,264	1,094,392
1934	215,206	33,133	1,656	1,714	2,062	32,932	93,520	133,997	0	0	0	208,264	722,484
1935	215,206	0	197,811	1,714	2,062	0	0	0	0	3,158	0	208,264	628,216
1936	215,206	0	0	0	0	70,835	0	215,206	0	0	0	208,264	709,512
1937	215,206	0	0	0	0	0	0	0	0	0	0	208,264	423,471
1938	215,206	0	215,206	215,206	194,380	215,206	33,528	215,206	0	0	0	208,264	1,512,205
1939	215,206	0	0	215,206	0	186,829	0	0	0	0	0	208,264	825,507
1940	215,206	0	215,206	211,836	1,829	32,932	0	0	0	0	0	208,264	885,274
1941	215,206	0	215,206	157,429	0	0	0	0	0	0	0	208,264	796,106
1942	215,206	0	215,206	98,447	2,062	0	0	0	140,623	215,206	0	208,264	1,095,016
1943	189,491	0	3,660	1,714	2,062	32,932	93,001	133,235	150,476	153,282	0	208,264	968,117
1944	101,934	0	1,513	1,714	0	0	0	0	0	0	0	208,264	313,426
1945	215,206	0	0	0	0	0	0	0	0	0	0	208,264	423,471
1946	215,206	0	215,206	215,206	194,380	215,206	86,638	141,514	0	215,206	0	208,264	1,706,829
1947	194,152	0	3,660	1,714	2,062	32,932	0	215,206	0	215,206	0	208,264	873,196
1948	206,462	2,004	1,656	1,714	2,062	32,932	36,366	180,757	151,393	154,203	0	208,264	977,812
1949	103,762	0	3,660	1,714	2,062	32,932	93,520	133,997	0	0	0	201,536	573,182
1950	215,206	0	113,341	46,739	2,062	32,932	93,520	133,997	151,393	154,203	0	208,264	1,151,657
1951	103,762	2,004	1,656	1,714	2,062	32,932	93,520	133,997	0	215,206	0	208,264	795,117
1952	194,152	2,004	1,656	1,714	2,062	32,932	93,520	133,997	0	0	0	208,264	670,300
1953	215,206	0	0	199,525	2,062	28,114	0	215,206	163,703	154,203	0	208,264	1,186,285
1954	103,762	778	1,656	1,714	2,062	32,932	46,760	180,757	151,393	154,203	76,551	182,784	935,351
1955	52,692	0	3,654	1,714	0	0	0	0	208,264	215,206	0	208,264	689,795
1956	215,206	35,195	1,656	1,714	2,062	32,932	93,520	133,997	151,393	154,203	0	208,264	1,030,142
1957	103,762	0	3,660	1,714	0	34,994	46,760	180,757	151,393	0	0	208,264	731,303
1958	215,206	0	46,418	1,714	2,062	32,932	0	215,206	163,703	0	0	208,264	885,506
1959	215,206	44,762	1,656	1,714	2,062	32,932	46,760	180,757	151,393	154,203	0	208,264	1,039,709
1960	103,762	2,004	1,656	1,714	2,062	32,932	93,520	0	208,264	215,206	0	208,264	869,384
1961	119,884	2,004	1,656	1,714	2,062	32,932	46,760	180,757	151,393	0	0	208,264	747,426
1962	215,206	0	12,811	1,714	0	0	128,513	0	0	0	0	208,264	566,509
1963	215,206	208,264	123,544	1,714	2,062	32,932	0	0	0	7,816	0	208,264	799,803
1964	215,206	0	215,206	170,823	2,062	0	0	0	208,264	215,206	0	208,264	1,235,033
1965	215,206	25,295	1,656	1,714	2,062	32,932	93,520	133,997	151,393	154,203	0	208,264	1,020,242
1966	103,762	2,004	1,656	1,714	0	14,927	46,760	0	0	215,206	0	208,264	594,293
1967	215,206	0	163,362	1,714	2,062	32,932	46,760	0	208,264	215,206	0	208,264	1,093,771
1968	166,644	2,004	1,656	1,714	2,062	32,932	0	0	208,264	215,206	0	208,264	838,747
1969	213,404	2,004	1,656	1,714	2,062	32,932	93,520	133,997	151,393	132,394	0	208,264	973,340
1970	103,762	0	3,660	1,714	2,062	32,932	0	0	208,264	0	0	0	352,393
1971	215,206	0	215,206	211,836	2,062	32,932	93,520	133,997	151,393	154,203	0	208,264	1,418,619
1972	103,762	989	1,656	1,714	2,062	32,932	46,760	180,757	151,393	154,203	76,551	182,784	935,561
1973	52,692	0	3,660	1,714	0	0	0	0	0	0	0	0	58,065
1974	215,206	0	215,206	215,206	143,027	32,932	93,520	133,997	151,393	154,203	76,551	182,784	1,614,026
1975	52,692	0	3,660	1,714	2,062	32,932	0	215,206	163,703	154,203	0	208,264	834,436
1976	103,762	2,004	1,656	1,714	2,062	32,932	93,520	133,997	53,685	199,857	76,551	182,784	884,523
1977	52,692	0	3,660	1,714	0	0	0	0	0	0	0	208,264	266,330
1978	215,206	0	215,206	98,447	2,062	32,932	46,501	179,736	0	215,206	0	208,264	1,213,561

Table 6-2. Monthly water volumes that could be pumped from Priest Rapids Lake for an 800,000-acre-foot active capacity reservoir and a 6,000-cfs pumping capacity (acre-feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1929	206,323	0	0	5,017	0	0	0	0	0	0	0	357,025	568,365
1930	368,925	0	0	0	115,269	0	0	0	0	0	0	357,025	841,219
1931	366,595	0	0	0	0	0	0	0	0	0	0	357,025	723,620
1932	368,925	0	0	0	0	44,035	91,910	131,633	97,510	88,401	0	254,600	1,077,015
1933	51,723	0	3,405	1,612	1,884	0	0	0	357,025	205,000	0	257,655	878,304
1934	52,323	1,838	1,567	1,612	1,884	32,563	92,947	133,158	0	0	0	357,025	674,916
1935	256,310	0	3,405	1,612	1,884	0	0	0	0	1,842	0	357,025	622,078
1936	368,925	0	0	0	0	41,320	0	262,083	0	0	0	357,025	1,029,353
1937	256,310	0	0	0	0	0	0	0	0	0	0	357,025	613,335
1938	368,925	0	156,359	1,612	1,884	32,563	15,383	179,631	0	0	0	357,025	1,113,381
1939	256,310	0	0	5,017	0	32,385	0	0	0	0	0	357,025	650,738
1940	368,925	0	102,731	1,612	975	32,563	0	0	0	0	0	357,025	863,831
1941	368,925	0	62,488	1,612	0	0	0	0	0	0	0	357,025	790,050
1942	368,479	0	3,405	1,612	1,431	0	0	0	82,030	331,638	0	228,630	1,017,226
1943	46,625	0	3,405	1,612	1,884	32,563	92,429	132,395	149,484	152,035	0	256,128	868,559
1944	52,023	0	821	1,612	0	0	0	0	0	0	0	357,025	411,481
1945	368,925	0	0	0	0	0	0	0	0	0	0	278,578	647,504
1946	368,925	0	145,035	22,268	1,884	32,563	55,100	140,388	0	303,357	0	257,655	1,327,176
1947	52,323	0	3,405	1,612	1,884	32,563	0	226,105	0	150,640	0	325,269	793,800
1948	52,323	1,838	1,567	1,612	1,884	32,563	21,083	179,631	150,401	152,956	0	257,655	853,513
1949	52,323	0	3,405	1,612	1,884	32,563	92,947	133,158	0	0	0	117,563	435,454
1950	368,925	0	18,179	1,612	1,884	32,563	92,947	133,158	150,401	152,956	0	257,655	1,210,280
1951	52,323	1,838	1,567	1,612	1,884	32,563	92,947	133,158	0	303,357	0	257,655	878,903
1952	52,323	1,838	1,567	1,612	1,884	32,563	92,947	133,158	0	0	0	357,025	674,916
1953	256,310	0	0	5,017	1,884	16,216	0	226,105	150,401	152,956	0	257,655	1,066,544
1954	52,323	416	1,567	1,612	1,884	32,563	46,474	179,631	150,401	152,956	76,048	181,607	877,481
1955	52,323	0	3,399	1,612	0	0	0	0	357,025	206,883	0	257,655	878,897
1956	52,323	1,838	1,567	1,612	1,884	32,563	92,947	133,158	150,401	152,956	0	257,655	878,903
1957	52,323	0	3,405	1,612	0	34,446	46,474	179,631	150,401	0	0	357,025	825,317
1958	105,909	0	3,405	1,612	1,884	32,563	0	226,105	150,401	0	0	357,025	878,903
1959	105,909	1,838	1,567	1,612	1,884	32,563	46,474	179,631	150,401	152,956	0	257,655	932,490
1960	52,323	1,838	1,567	1,612	1,884	32,563	92,947	0	283,558	152,956	0	257,655	878,903
1961	52,323	1,838	1,567	1,612	1,884	32,563	46,474	179,631	150,401	0	0	357,025	825,317
1962	105,909	0	548	1,612	0	0	127,393	0	0	0	0	357,025	592,488
1963	368,925	22,381	1,567	1,612	1,884	32,563	0	0	0	4,559	0	357,025	790,516
1964	368,925	0	75,883	1,612	1,884	0	0	0	357,025	205,000	0	257,655	1,267,983
1965	52,323	819	1,567	1,612	1,884	32,563	92,947	133,158	150,401	100,824	0	257,655	825,751
1966	52,323	1,151	1,567	1,612	0	8,571	46,474	0	0	368,925	0	357,025	837,648
1967	67,016	0	3,405	1,612	1,884	32,563	46,474	0	330,032	152,956	0	257,655	893,597
1968	52,323	1,135	1,567	1,612	1,884	32,563	0	0	357,025	172,437	0	257,655	878,200
1969	52,323	1,838	1,567	1,612	1,884	32,563	92,947	133,158	150,401	76,606	0	257,655	802,553
1970	52,323	0	3,405	1,612	1,884	32,563	0	0	357,025	0	0	0	448,811
1971	368,925	0	116,895	1,612	1,884	32,563	92,947	133,158	150,401	152,956	0	257,655	1,308,996
1972	52,323	529	1,567	1,612	1,884	32,563	46,474	179,631	150,401	152,956	76,048	181,607	877,594
1973	52,323	0	3,405	1,612	0	0	0	0	0	0	0	0	57,340
1974	368,925	0	368,925	42,131	1,884	32,563	92,947	133,158	150,401	152,956	55,021	181,607	1,580,518
1975	52,323	0	3,405	1,612	1,884	32,563	0	226,105	150,401	152,956	0	257,655	878,903
1976	52,323	1,838	1,567	1,612	1,884	32,563	92,947	133,158	31,316	197,618	76,048	181,607	804,481
1977	52,323	0	2,891	1,612	0	0	0	0	0	0	0	357,025	413,850
1978	368,479	0	3,405	1,612	1,884	32,563	46,214	178,610	0	301,519	0	357,025	1,291,311

Four years in the 1929-1978 period would have little water available for diversion. In 1931, 1937, and 1945, water in excess of flow targets would only be available for diversion in September and October. In those 3 drought years, a Black Rock reservoir would have needed to provide carryover for use during April through August. Similarly, while 1973 has Columbia River water available for pumping for 3 months (November through January), no water would be available for pumping after January, and no water would be available in September. Black Rock reservoir carryover would have been needed to supply the full water delivery criteria in April through September of 1973.

6.4 Reservoir Contents

Typically, reservoir water storage would be highest during the winter months when water was being stored. As water was released during the irrigation season, the storage would decrease, and the water surface would lower. Columbia River water would be available for diversion to a Black Rock reservoir in September and October and often in December through March. As release from a Black Rock reservoir would occur from April through October during the irrigation season, the storage would typically be lowest at the end of August. After August, a Black Rock reservoir would start to refill. Table 6-3 shows monthly maximum, minimum, and average reservoir contents for the 50-year period of analysis.

Table 6-3. End-of-month reservoir contents based on meeting the water delivery criteria (1,000 acre-feet*)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Storage	1,300,000-acre-foot active capacity reservoir											
Maximum	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1223	1300
Minimum	286	284	448	446	444	626	614	480	329	175	21	123
Average	1103	1109	1166	1210	1224	1230	1182	1141	1081	1031	888	983
Average percent full	85	85	90	93	94	95	91	88	83	79	68	76
800,000-acre-foot active capacity reservoir												
Maximum	800	800	800	800	800	800	800	800	800	800	723	800
Minimum	393	391	677	675	673	681	591	461	316	167	20	71
Average	769	768	792	793	795	787	736	695	653	610	468	647
Average percent full	96	96	99	99	99	98	92	87	82	76	59	81
* Add 157,610 acre-feet inactive pool to the above storage numbers (for both reservoir sizes) for the potential reservoir pool available throughout the year.												

Based on the water supply analysis of the 1929-1978 period, it is clear that in some water years it would be necessary to rely primarily on carryover of stored water from prior years to meet the majority of the irrigation delivery criteria. With reference to the 4 water-short years (1931, 1937, 1945, and 1973), the carryover conditions would have been as shown in table 6-4 for the large reservoir and table 6-5 for the small reservoir.

Table 6-4. Dry-year carryover based on a 1,300,000-acre-foot active capacity reservoir and 3,500-cfs pumping capacity

Period	Pumped	Released	Seepage Evaporation Losses	End-of-Month Reservoir Content
	(acre-feet)			
Aug 1930	0	119,600	5,800	475,400
Sept 1930	208,300	83,700	4,300	595,700
Oct 1930	215,200	40,800	2,900	767,200
Nov 1930 - Aug 1931	0	567,500	37,800	161,900
Sept 1931	208,300	83,700	4,300	282,200
Aug 1936	0	147,300	5,800	483,500
Sept 1936	208,300	101,900	4,300	585,600
Oct 1936	215,200	49,800	2,900	748,100
Nov 1936 - Aug 1937	0	688,700	37,800	21,600
Sept 1937	208,300	101,900	4,300	123,700
Aug 1944	0	134,400	5,800	635,400
Sept 1944	208,300	93,400	4,300	746,000
Oct 1944	215,200	45,600	2,900	912,700
Nov 1944 - Aug 1945	0	668,500	37,800	206,400
Sept 1945	208,300	98,900	4,300	311,500
Aug 1972	0	147,300	5,800	1,223,500
Sept 1972	182,700	101,900	4,300	1,300,000
Oct 1972	52,700	49,800	2,900	1,300,000
Nov 1972 - Aug 1973	5,300	607,900	37,800	659,600
Sept 1973	0	89,900	4,300	564,400

Table 6-5. Dry-year carryover based on an 800,000-acre-foot active capacity reservoir and 6,000-cfs pumping capacity

Period	Pumped	Released	Seepage Evaporation Losses	End-of-Month Reservoir Content
	(acre-feet)			
Aug 1930	0	119,600	4,800	207,100
Sept 1930	357,000	83,700	3,600	476,800
Oct 1930	366,600	40,800	2,600	800,000
Nov 1930 - Aug 1931	0	567,500	32,300	200,200
Sept 1931	357,000	83,700	3,600	469,900
Aug 1936	0	147,300	4,800	344,600
Sept 1936	357,000	101,900	3,600	596,100
Oct 1936	256,300	49,800	2,600	800,000
Nov 1936 - Aug 1937	0	688,700	32,300	79,000
Sept 1937	357,000	101,900	3,600	330,500
Aug 1944	0	134,400	4,800	140,600
Sept 1944	357,000	93,400	3,600	400,600
Oct 1944	368,900	45,600	2,600	721,300
Nov 1944 - Aug 1945	0	668,500	32,300	20,500
Sept 1945	315,400	98,900	3,600	232,700
Aug 1972	79,900	147,300	4,800	724,000
Sept 1972	181,500	101,900	3,600	800,000
Oct 1972	52,400	49,800	2,600	800,000
Nov 1972 - Aug 1973	5,000	607,900	32,300	164,800
Sept 1973	0	89,900	3,600	71,300

Despite significant active storage capacity, the reservoir would have drafted to the lowest level of 21,600 acre-feet in August 1937 (large reservoir) and to 20,500 acre-feet in August 1945 (small reservoir).

6.5 Potential Reservoir Surface Area

Based on an inactive pool of 157,610 acre-feet and end-of-month reservoir contents of the active pool, the surface area (acres) of the summertime reservoir pool would be as shown in table 6-6 during a repeat of the 1929-1978 record period.

Table 6-6. Summertime reservoir pool based on end-of-month reservoir contents and a 157,610-acre-foot inactive pool (acres)

	May	Jun	Jul	Aug	Sep	Oct
large reservoir	(acres)					
Maximum storage	8,732	8,732	8,732	8,732	8,732	8,732
Minimum storage	4,715	3,922	3,127	2,196	2,838	3,701
Average storage	7,984	7,695	7,457	6,924	7,197	7,801
small reservoir						
Maximum storage	6,334	6,334	6,334	6,334	6,334	6,334
Minimum storage	4,619	3,856	3,090	2,189	2,524	4,260
Average storage	5,832	5,618	5,397	4,828	5,571	6,187

7.0 Field Construction Cost Estimates

This chapter presents appraisal-level estimates only of field construction costs. Field construction costs are limited to the costs of construction contracts and do not include noncontract costs such as preparation of final engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, and construction contract administration and management. Thus, total estimated project costs, which have yet to be prepared, would be substantially in excess of estimated field construction costs.

Field construction cost estimates were prepared for this Assessment solely for screening potential facility options and developing preliminary configurations of the Black Rock alternative. These cost estimates are appraisal level based on available field data, which at this time are considerably limited. Thus, the field construction cost estimates presented here are only a preliminary indication of what actual field construction costs might be. Furthermore, these estimates of field construction costs will inevitably change if more data are collected, designs are refined, and feasibility-level analyses are prepared.

The configuration of the Black Rock alternative facilities and the appraisal-level field construction cost estimates provided in this Assessment reflect a maximum water exchange. A reduction in the amount of exchange water would result in a reduction in facility capacities, and possibly in the construction cost estimates.

7.1 Black Rock Assessment Field Data

Reclamation conducted site topographic work for this Assessment in 2003, and developed 2-foot contour maps for the potential Columbia River intake area, the intake pump/generation plant, the inflow conveyance system, Black Rock dam and reservoir area, the anticipated alignment of the outflow conveyance system, the outlet facility, and Black Rock powerplant. USGS maps with 20-foot-contour intervals provided topographic information not covered by the 2003 topographic work, including the Roza and Sunnyside delivery system alignments and Sunnyside powerplant. For the most part, the above-ground characteristics of the Black Rock site between the Columbia River and Roza Canal are adequately covered.

Field data of the below-ground characteristics are, however, very limited. WIS performed exploratory drilling in late 2002 [11] at five holes along their proposed damsite alignment. Bedrock was encountered at a depth of about 215 feet at the upstream toe of the alignment near the right abutment. In the center of the valley at the maximum section of the dam, depth to bedrock is about 160 feet. Depth to bedrock at the other holes is 10 feet (right abutment), less than 1 foot (left abutment), and about 12 feet (left abutment, upstream toe of dam). Because the actual overburden depth along this alignment significantly exceeded the depth they assumed during their study, WIS identified an alternate alignment located about 1 mile west of the original alignment that appeared to have the potential for shallower overburden depths.

Reclamation's exploratory drilling program during late 2003 and early 2004 focused on seven holes at the alternate damsite that WIS identified. Bedrock was encountered in only four of the seven holes due to limitations of the drilling equipment on site at that time. Bedrock in three holes (in the middle of the damsite alignment) was at a depth of approximately 145 feet, and at about 90 feet in the fourth hole (near the left abutment). One of these holes was drilled to a maximum depth of about 560 feet into the deep bedrock foundation. The top of bedrock is represented by the Pomona Basalt that was intersected in that hole at a depth of about 145.3 feet.

To date, only one groundwater exploratory hole has been drilled to assess the hydraulic conductivity of the reservoir basin. Reclamation used a specific geologic exploration hole drilled to perform a groundwater test to determine localized horizontal water conductivity as well as vertical conductivity between aquifers. While it appears the Pomona Basalt is a hydraulic barrier that may inhibit vertical leakage, this, and the potential for horizontal leakage near the dam abutments and the reservoir rim, needs further investigation. Groundwater flow direction and speed need further investigation to minimize impacts around the dam and reservoir.

Further geologic investigation of the dam and reservoir are necessary to better define top of bedrock and address potential issues relating to stability and strength of the foundation materials, slope stability, deformability of materials, groundwater occurrence and behavior, seepage paths, dewatering requirements, foundation grouting treatment, reservoir water-holding capability, seismicity and faulting, reservoir-induced seismicity, landslides, and sedimentation.

No exploratory drilling has been done at the identified site of the intake pump/generation plant, along the inflow conveyance alignment, at Black Rock reservoir intake and outlet structures, along the outflow conveyance alignment, at the outlet facility and Black Rock powerplant, along the delivery system alignments, or at Sunnyside powerplant. Geologic investigations of these sites are necessary to identify depth of overburden, bedrock characteristics, slope stability, groundwater occurrence, and dewatering requirements.

Field construction cost estimates were prepared within this framework of, and are limited by, available field data. The following sections explain how Reclamation developed the appraisal-level field construction cost estimates for this Assessment.

7.2 Comparison of Major Facilities

Appraisal-level cost estimates for construction pay items of potential major Black Rock alternative facilities [6] located between the Columbia River and Roza Canal MP 22.6 were developed to screen facility options when several options were being considered. For example, two options were being considered for the inflow conveyance system: an all tunnel option and a tunnel/pipeline option. A field cost estimate of each option was developed and the least costly identified.

Cost estimates of construction pay items were prepared using available existing design data from past WIS work and field data collected by Reclamation in 2003 and 2004. These cost estimates were generated using industry-wide, accepted cost estimating methodology, standards, and practices and reflect June 2004 prices.

Anticipated in-field activities are the primary basis for preparing cost estimates of construction pay items of the major Black Rock facility options. These in-field activities include those costs that would be incurred by contractors for labor and materials such as the following:

- Excavation of materials for structure foundations such as pumping plants and dams; and the alignment of tunnels, pipelines, channels, canals, access roads; and relocation of existing facilities
- Drilling and cement grouting in the foundation and abutments of the embankment storage dam
- Furnishing, forming, and placing concrete for structures
- Furnishing, placing, and compacting earth and rock materials for the embankment storage dam and backfilling and covering of structures and pipelines
- Furnishing and installing mechanical and electrical equipment in structures.

Based on preliminary general designs and drawings, approximate quantities (such as cubic yards of excavation, cubic yards of earth and rock material required for embankments, cubic yards of concrete, pounds of steel, and specific items of equipment such as pumps and motors) were developed for the primary activities, or pay items. Unit prices (in June 2004 prices) were then determined and applied against these quantities. Table 7-1 compares construction pay item cost estimates for potential major facility options located between the Columbia River and Roza Canal MP 22.6. It also includes the construction pay item cost for the potential Sunnyside powerplant and bypass structure that would be located at the point of exchange water discharge into Sunnyside Canal at MP 3.83.

Table 7-1. Comparison of appraisal-level construction pay item cost estimates for potential major facility options

Feature	Large Reservoir Pump Only Inflow= 3,500 cfs	Large Reservoir Pump/Generation Inflow= 3,500 cfs	Small Reservoir Pump Only Inflow= 6,000 cfs
Priest Rapids fish screen and intake	$58,035,920	$64,551,120	$78,815,990
Priest Rapids pumping plant	$182,919,070		$275,309,975
Priest Rapids pump/generation plant		$226,254,880	
Black Rock inlet/outlet tower		$85,565,400	
(Priest Rapids to Black Rock reservoir)			
Inflow conveyance:			
(Priest Rapids to Black Rock reservoir)			
all tunnel option	$186,471,700	$186,471,700	$248,397,600
tunnel/pipeline option	$357,838,420		
Black Rock dam:			
concrete face rockfill embankment	$774,496,000	$774,496,000	$621,530,800
central core rockfill embankment	$733,280,000	$733,280,000	$573,117,150
roller compacted concrete	$1,239,036,300	$1,239,036,300	$980,587,000
Low-level outlet works:			
for both embankment dams	$83,494,115	$83,494,115	$79,000,000
for roller compacted concrete dam	$23,384,515	$23,384,515	$22,000,000
Highway and utility relocations	$57,320,000	$57,320,000	$57,320,000
Black Rock reservoir outlet structure	$3,269,850	$3,269,850	$3,269,850
(Black Rock reservoir to Roza Canal)			
Outflow conveyance (2,500 cfs)	$306,402,600	$306,402,600	$306,402,600
(Black Rock reservoir to Roza Canal)			
Black Rock outlet facility:			
1,500-cfs powerplant	$104,010,535	$104,010,535	$104,010,535
900-cfs powerplant	$102,165,985	$102,165,985	$102,165,985
Sunnyside powerplant/bypass	$32,300,000	$32,300,000	$32,300,000

Findings: The appraisal-level construction pay item cost estimate for the all tunnel inflow conveyance system is $171 million less than the cost estimate for the tunnel/pipeline inflow conveyance system; therefore, the tunnel/pipeline option should be removed from further evaluation.

The appraisal-level construction pay item cost estimates for the rockfill embankment dams are significantly lower (about $500 million for the large dam and about $400 million for the small dam) than the cost estimates for the roller compacted concrete dams; therefore, the roller compacted concrete dams should be removed from further evaluation.

The appraisal-level construction pay item cost difference between the large dam concrete face rockfill option and the large dam central core rockfill option is $41 million; for the small dam, the

cost difference is $48 million. Both of these rockfill embankment dam options should receive further evaluation.

The difference between the appraisal-level construction pay item cost estimates for the 1,500-cfs and 900-cfs Black Rock powerplants at Roza Canal is less than 2 percent ($2 million). The selection of which option to pursue should consider costs associated with the Roza and Sunnyside delivery systems.

7.3 Comparison of Alternative Configurations

Following screening of facility options, appraisal-level field construction cost estimates were prepared for the major facilities of the three preliminary configurations of the Black Rock alternative. Field costs include the itemized pay items, plus costs for contractor mobilization, plus an allowance for unlisted items (collectively referred to as construction contract costs) and contingencies.

Mobilization costs include mobilizing contractor personnel and equipment to the work site during initial start up. The assumed ±5 percent of the pay items subtotal cost used in this Assessment is based on past experience with similar projects. The mobilization line item is a rounded value per Reclamation rounding criteria that may cause the dollar value to deviate from the actual percentage shown.

Unlisted items are a means to recognize the confidence level in the estimate, the level of detail, and the knowledge of site characteristics that was used to develop the estimated cost. This line item covers minor design changes and also provides an allowance for minor pay items that have not been itemized, but that would have some influence on the total construction cost. Reclamation’s Cost Estimating Handbook guidelines state the allowance for unlisted items in appraisal-level estimates should be at least ±10 percent of the listed items. Typically, a value of ±15 percent is used. Based on the level of detail provided for this Assessment's cost estimates, the unlisted items are set at ±10 percent of the sum of the pay item cost plus mobilization costs for all facilities. The unlisted line item is a rounded value per Reclamation rounding criteria that may cause the dollar value to deviate from the actual percentage shown.

Contingencies are then added to the construction contract cost (the sum of the pay items, mobilization costs, and unlisted items) to determine the field cost. Contingencies are funds to be used after construction starts to pay contractors for items such as overruns on quantities, changed site conditions, and changed orders. Reclamation’s Cost Estimating Handbook guidelines, state appraisal-level estimates should have ±25 percent added for contingencies. Based on the current level of design data, geologic information, and general knowledge of conditions at the various sites, the contingency line item was set at ±25 percent of the construction contract cost for all facilities. The contingency line item is a rounded value per Reclamation rounding criteria that may cause the dollar value to deviate from the actual percentage shown. Table 7-2 shows the estimated field cost for the three preliminary Black Rock alternative configurations located between the Columbia River and Roza Canal MP 22.6. It also includes the field cost for the potential Sunnyside powerplant and bypass structure that would be located at the point of exchange water discharge into the Sunnyside Canal at MP 3.83.

Table 7-2. Comparison of appraisal-level field construction costs for three preliminary configurations of the Black Rock alternative

Feature	Large Reservoir Pump Only Inflow = 3,500 cfs	Large Reservoir Pump/Generation Inflow = 3,500 cfs	Small Reservoir Pump Only Inflow = 6,000 cfs
Priest Rapids fish screen and intake	$58,035,920	$64,551,120	$78,815,990
Priest Rapids pumping plant	$182,919,070		$275,309,975
Priest Rapids pump/generation plant		$226,254,880	
Inflow conveyance (all tunnel)	$186,471,700	$186,471,700	$248,397,650
Black Rock inlet/outlet tower		$85,565,400	
Black Rock dam (central core rockfill embankment)	$733,280,000	$733,280,000	$573,117,150
Low-level outlet works	$83,494,115	$83,494,115	$79,000,000
Highway and utility relocations	$57,320,000	$57,320,000	$57,320,000
Black Rock reservoir outlet structure	$3,269,850	$3,269,850	$3,269,850
Outflow conveyance (2,500 cfs)	$303,132,750	$303,132,750	$303,132,750
Black Rock outlet facility (1,500 cfs)	$104,010,535	$104,010,535	$104,010,535
Sunnyside powerplant and bypass	$32,302,450	$32,302,450	$32,302,450
Subtotal of pay items	**$1,744,236,390**	**$1,879,652,800**	**$1,754,676,350**
Total mobilization costs (±5%)	**$87,600,000**	**$94,600,000**	**$87,600,000**
Total unlisted items (±10%)	**$165,163,610**	**$182,747,200**	**$184,723,650**
Construction contract cost	**$1,997,000,000**	**$2,157,000,000**	**$2,027,000,000**
Total contingencies (±25%)	**$510,000,000**	**$540,000,000**	**$480,000,000**
Total field cost	**$2,507,000,000**	**$2,697,000,000**	**$2,507,000,000**

The configuration of the large reservoir pump/generation option and the prior WIS work documented in their May 2002 report [2] for Benton County are similar in many respects. Following completion of the engineering work for this Assessment, Reclamation requested Benton County's assistance in obtaining WIS's review of this work. The WIS review focused primarily on differences in field construction cost estimates prepared by WIS and Reclamation. The November 30, 2004, letter from WIS to Reclamation provides the results of this review and is included in appendix B of this Summary Report.

Findings: The appraisal-level field construction cost estimates for the large reservoir 3,500-cfs pump only option and the small reservoir 6,000-cfs pump only option are the same. Both reservoir sizes should receive further evaluation. Further analysis of the extent of the water exchange, timing of Columbia River water availability and diversions, economics, and other aspects would help refine the most desirable storage/pump configuration.

The appraisal-level field construction cost estimate for the large reservoir 3,500-cfs pump/generation option is $190 million greater than the field cost estimate for the large reservoir 3,500-cfs pump only option. However, operational studies have not been

completed for the pump/generation option, and these studies may indicate a need to increase plant capacity to ensure annual delivery of exchange water when the facilities were operated in a pump/generation mode.

As discussed in section 5.8.4, upstream delivery plans 4, 4A, and 5 should receive further evaluation, as well as downstream delivery plans 1 and 2 for the Sunnyside Division. The maximum irrigation requirements of the Roza Division downstream from MP 22.6 could be met entirely by Columbia River exchange water without incurring additional costs for construction of water delivery facilities. Table 7-3 provides field construction cost estimates for these five delivery plans.

Table 7-3. Appraisal-level field construction cost estimates of select delivery system plans

	Sunnyside Division		Roza Division and Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts		
	(million $)				
	Plan 1	Plan 2	Plan 4	Plan 4A	Plan 5
Subtotal of Pay Items	$138.20	$44.83	$39.00	$43.00	$4.10
Mobilization (±5%)	$6.90	$2.20	$2.00	$2.00	$0.20
Unlisted Items (±15%)*	$19.90	$6.97	$6.00	$6.00	$0.70
Construction Contract Cost	$165.00	$54.00	$47.00	$51.00	$5.00
Contingencies (±25%)	$45.00	$14.00	$12.00	$13.00	$1.30
Total Field Cost	$210.00	$68.00	$59.00	$64.00	$6.30

* A 15-percent figure is used for unlisted items because of the level of the cost estimate.

As indicated, these appraisal-level field construction cost estimates are based on available, but limited, data and preliminary designs and drawings and professional assumptions [7 and 8]. Field costs are not the total construction cost necessary to take an authorized project to completion.

7.4 Summary of Field Construction Cost Estimates

Appraisal-level field construction costs of major facilities to divert, store, and deliver Columbia River water to Roza Canal MP 22.6 are estimated at about $2.5 to $2.7 billion (June 2004 price levels) depending on the configuration. Appraisal-level field construction costs to build new facilities or modify existing facilities to deliver exchange water from this point to participants' current facilities are estimated at up to $270 million depending on the type of delivery system and amount of a water exchange. Therefore, field construction costs are estimated at $2.8 to $3 billion.

7.5 Total Project Costs

Additional noncontract costs would need to be incurred once a proposed Federal water resource project was authorized and Congress provides construction appropriations. These additional cost estimates, which have yet to be prepared, would include such items as final design data collection, preparation of final designs, preparation of technical specifications, issuing and awarding construction contracts, coordination and project construction management by Reclamation and the contractor(s), and estimated costs associated with environmental activities. These additional costs are estimated to be from 20 to 35 percent of the field construction costs.

Based on current information, on these appraisal-level field construction cost estimates, and on industry-wide, accepted cost estimating methodology, standards, and practices, it is reasonable to anticipate the total project cost of the Black Rock alternative could range from $3.5 to $4 billion.

Additional data should be collected prior to refining potential concepts and project configurations. Value engineering methods of analysis should be applied to identify needs, major cost components, and to reduce overall costs. Value engineering is a problem-solving methodology that examines potential component features of a potential project to determine pertinent functions, governing criteria, and associated costs. Other proposals are then developed that either meet the necessary requirements at lower costs or that increase the long-term value.

8.0 Black Rock Alternative Effects

The Black Rock alternative would have both beneficial and adverse economic, social, environmental, and cultural effects. Some of these effects could be expressed in monetary terms, while others could be expressed qualitatively. While no indepth consideration of potential effects has been made at this time, this chapter briefly discusses some potential effects that could be attributed to the construction and operation of the Black Rock alternative. These potential effects, and others, will be addressed if the Storage Study proceeds. The initial observations offered here would likely change considerably as indepth analyses were performed.

8.1 Effects of Exchange Water in the Yakima River Basin

Exchange water in the Yakima River basin would serve three major purposes: instream flows, irrigation, and municipal water supplies.

8.1.1 Instream Flows

8.1.1.1 Introduction

One objective of the Storage Study is to assess restoring flow conditions in the Yakima River basin to some semblance of the natural (unregulated) hydrograph. This largely applies to the main stem Yakima, Cle Elum, Naches, and Tieton River reaches downstream from Keechelus Lake, Cle Elum Lake, Bumping Lake, and Rimrock Lake to the mouth of the Yakima River.

Stream ecologists have found that natural hydrologic variability is necessary to maintain a healthy river ecosystem (Richter, Baumgartner, Wigington and Braun, 1997) [17]. The underlying principle is that if some semblance of the natural hydrograph were achieved, then the river ecosystem would remain healthy, maintaining some normative level of the physical and biological processes conducive to a viable fishery resource.

For this Assessment, the objective is to investigate how the Black Rock alternative water exchange might result in modifications to Yakima Project operations so the flow regime of the Yakima and Naches Rivers would have some semblance of the natural (unregulated) hydrograph.

8.1.1.2 Methodology

For comparative purposes, the following three flow scenarios were examined for four main stem reaches of the Yakima and Naches Rivers:

- The unregulated scenario represents an estimated natural pre-Yakima Project stream regime unimpeded by reservoir impoundments or by diversions.

- The current operation scenario represents the current stream regime as managed by Yakima Project's present operations.
- The Black Rock scenario represents a possible stream regime through modification of Yakima Project operations using water obtained through the Black Rock alternative exchange with the Roza and Sunnyside Divisions. This scenario is based on the availability of 810,400 acre-feet of exchange water.

Reclamation gauging stations define the four stream reaches as follows, and figure 8-1 shows their general locations:

- The Easton gauge is located in the upper Yakima River downstream from Easton Diversion Dam at RM 202.0 (Easton reach).
- The Cle Elum gauge is located on the Yakima River near the city of Cle Elum at RM 183.1 (Cle Elum reach).
- The Parker gauge is located immediately downstream from Sunnyside Diversion Dam on the Yakima River at RM 103.7 (Wapato reach).
- The Naches River gauge near the city of Naches is located at RM 16.8 (Naches reach).

The evaluation conducted by Reclamation biologists and hydrologists includes use of results generated from the Yakima Project RiverWare (Yak-RW) model, which is a daily time step reservoir and river operation computer model of the Yakima Project created with the RiverWare software.[7] The Yak-RW model produced results for each scenario evaluated with the Indicators of Hydrologic Alteration software.[8] The Indicators of Hydrologic Alteration software outputs 33 hydrologic parameters that describe how a particular flow regime of a project operation compares to the natural (unregulated) hydrograph.

The Yak-RW model generated hydrographs shown in this Summary Report (figures 8-2, 8-3, 8-4, and 8-5) represent the median monthly flows for water years 1981 through 2003. Hydrographs for the unregulated scenario include vertical green lines representing the 25th percentile (top), 50th percentile (middle), and 75th percentile (bottom) of the monthly flows. This is an attempt to define a more natural (unregulated) hydrograph range of flow based on an acceptable variation around the median flow. Using the unregulated scenario in figure 8-2 as an example, the vertical green line for mid-October can be read as follows:

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[7] The RiverWare software is a river basin simulation tool developed at the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado in cooperation with Reclamation and Tennessee Valley Authority. The Center's website, http://cadswes.colorado.edu/riverware, provides supporting documents on the RiverWare software for interested users.

[8] The Nature Conservancy, in conjunction with Smythe Scientific Software (http://www.smythescisoft.com/smythe), developed the Indicators of Hydrologic Alteration software. The Nature Conservancy's website (http://www.freshwaters.org/tools) provides a download of the software and supporting documents for interested users.

- top of vertical line = 25 percent of the October flows were equal to or greater than 600 cfs.
- middle of vertical line = 50 percent of the October flows were equal to or greater than 400 cfs.
- bottom of vertical line = 75 percent of the October flows were equal to or greater than 200 cfs.

The evaluation relates river conditions for spring Chinook salmon and steelhead where appropriate. The underlying premise is that more natural flows are desirable and beneficial to salmonid productivity, abundance, and diversity. This discussion compares and contrasts the key findings among the current operation, Black Rock, and unregulated scenarios.

The findings to date are based solely on preliminary analysis of the hydrographs as related to the unregulated flow condition. The actual benefit to the fishery would need to be determined from the fish habitat analysis.

For the most part, the Black Rock scenario would make little improvement relative to the current operation scenario for the spring Chinook salmon spawning life stage in the upper Yakima River. This is because the current flip-flop reservoir operation was designed to maximize the benefit to the spring Chinook salmon spawning and incubation life stages.

The flip-flop reservoir operation is coordinated with the beginning of spring Chinook salmon spawning about mid-September in the upper Yakima River system. Irrigation releases from Cle Elum Lake are decreased and releases from Rimrock Lake are increased to meet irrigation demands downstream from the Naches River confluence. The decrease in Cle Elum Lake releases encourages spawning in the main river channels rather than along the stream margins. This operation allows more reservoir inflow to be stored in Cle Elum Lake later in the year rather than needing to be released to cover redds that otherwise would have been deposited along the stream margins.

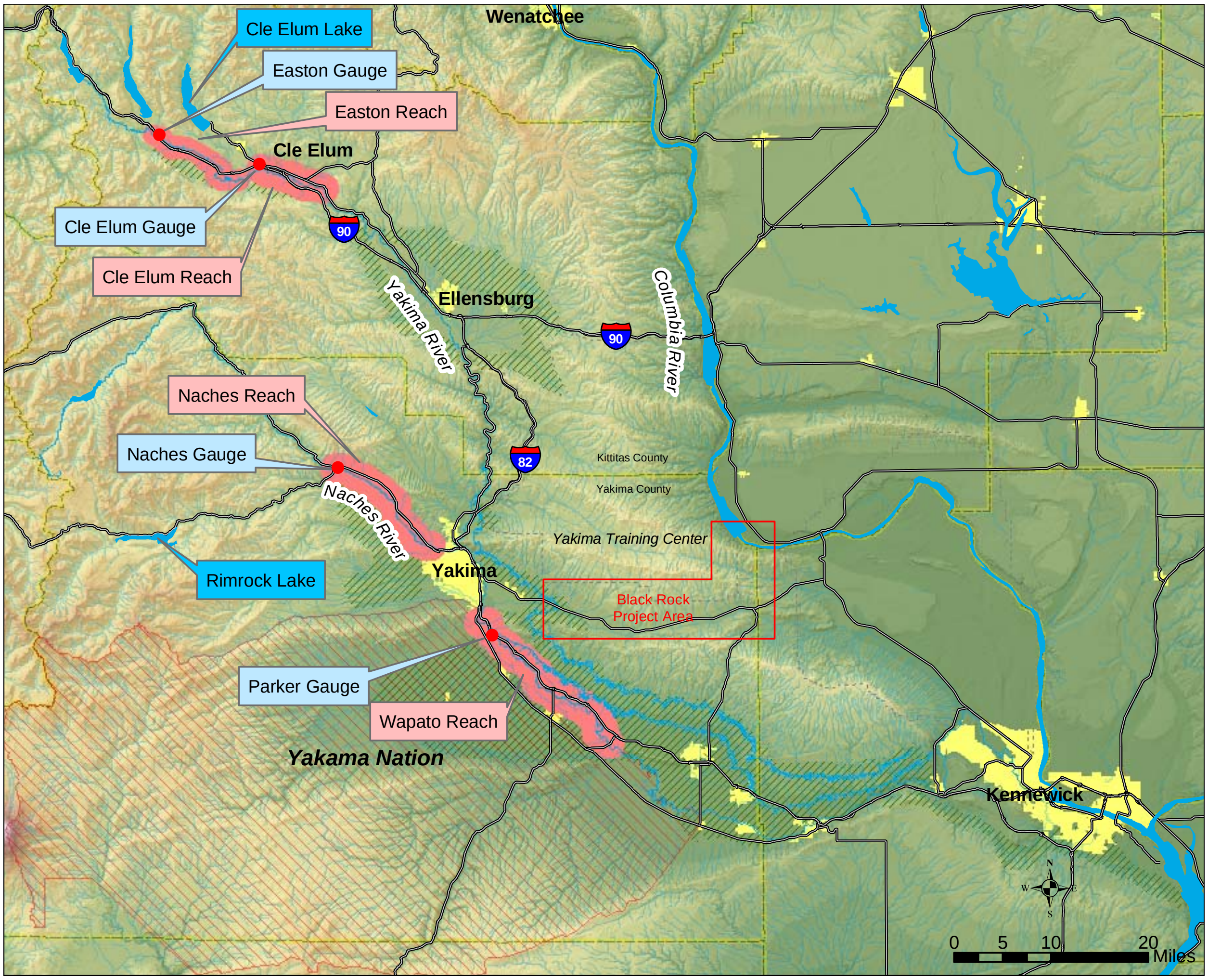

Figure 8-1. The four identified stream reaches and related Reclamation gauge locations

8.1.1.3 Easton Reach

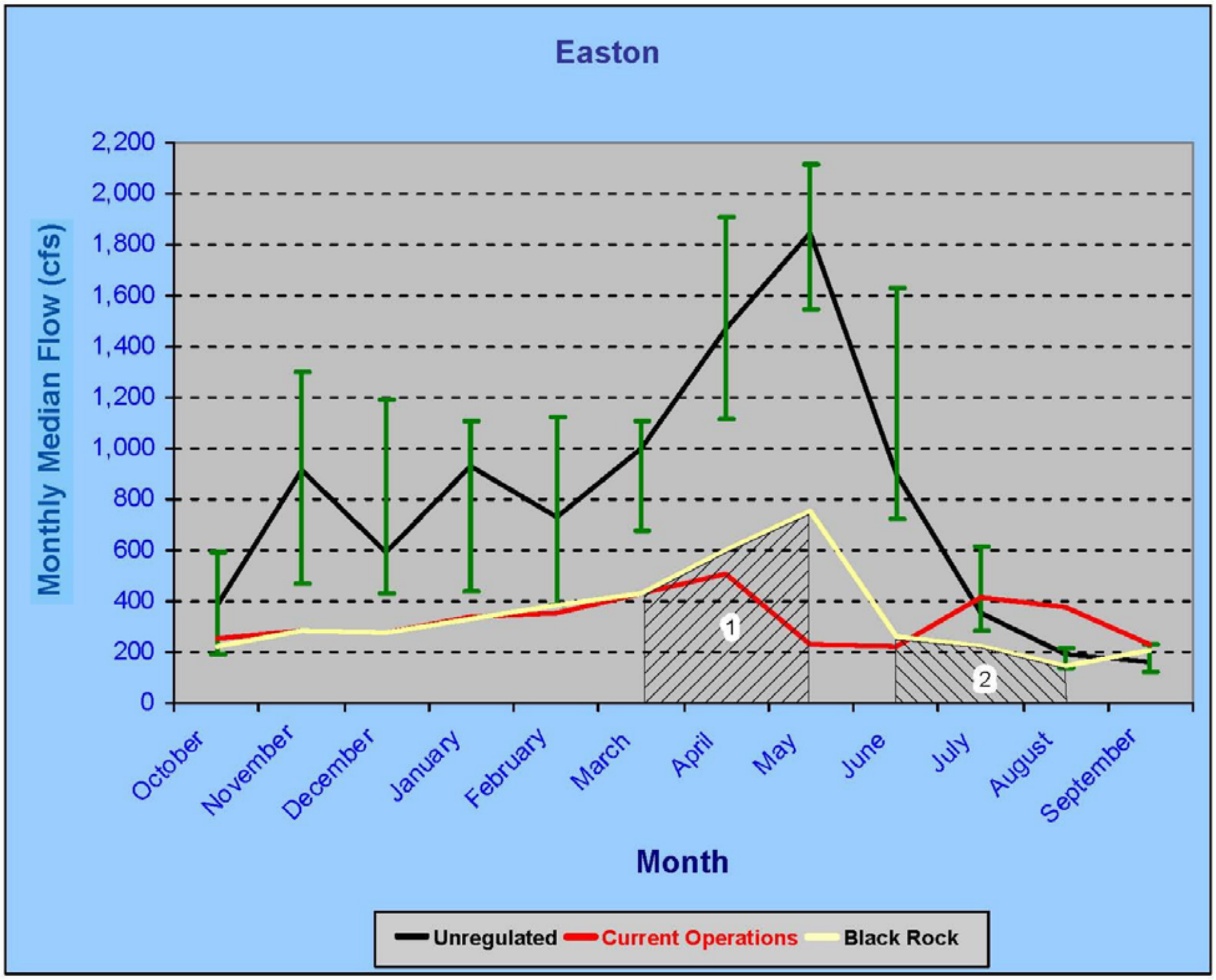

Figure 8-2. Comparison of estimated median monthly Easton reach flows under the three scenarios (based on the 1981-2003 period of record)

The following discussion describes the numeric indicators shown on figure 8-2.

1. The spring flow regime of the Black Rock scenario would represent a more natural (unregulated) hydrograph with peak runoff flows occurring in May at an average 750-cfs flow, instead of occurring in April at an average of about a 500-cfs flow. Also, the Black Rock scenario would provide nearly 100 cfs more in average April flow (597 cfs) compared to the current operation scenario (509 cfs). These two changes in the spring hydrograph would benefit all salmonid smolt outmigrants.

   The Black Rock scenario would further benefit spring Chinook salmon and steelhead smolt outmigrants and fry colonization life stages if a more gradual decrease in flows from May to June could be achieved. This change would reduce the risk of stranding emergent fry in side channels and decreasing rearing habitat, while increasing flows to aid late migrating smolts. It would also reduce the risk of dewatering early spawned steelhead redds. Similar to spring

Chinook salmon, steelhead spawn in shallow water along the stream margins and would use small side channels more than spring Chinook salmon.

2. The current upward trend in river flow from June through August would be eliminated with the Black Rock scenario, providing a more normative hydrograph during the summer rearing life stage.

8.1.1.4 Cle Elum Reach

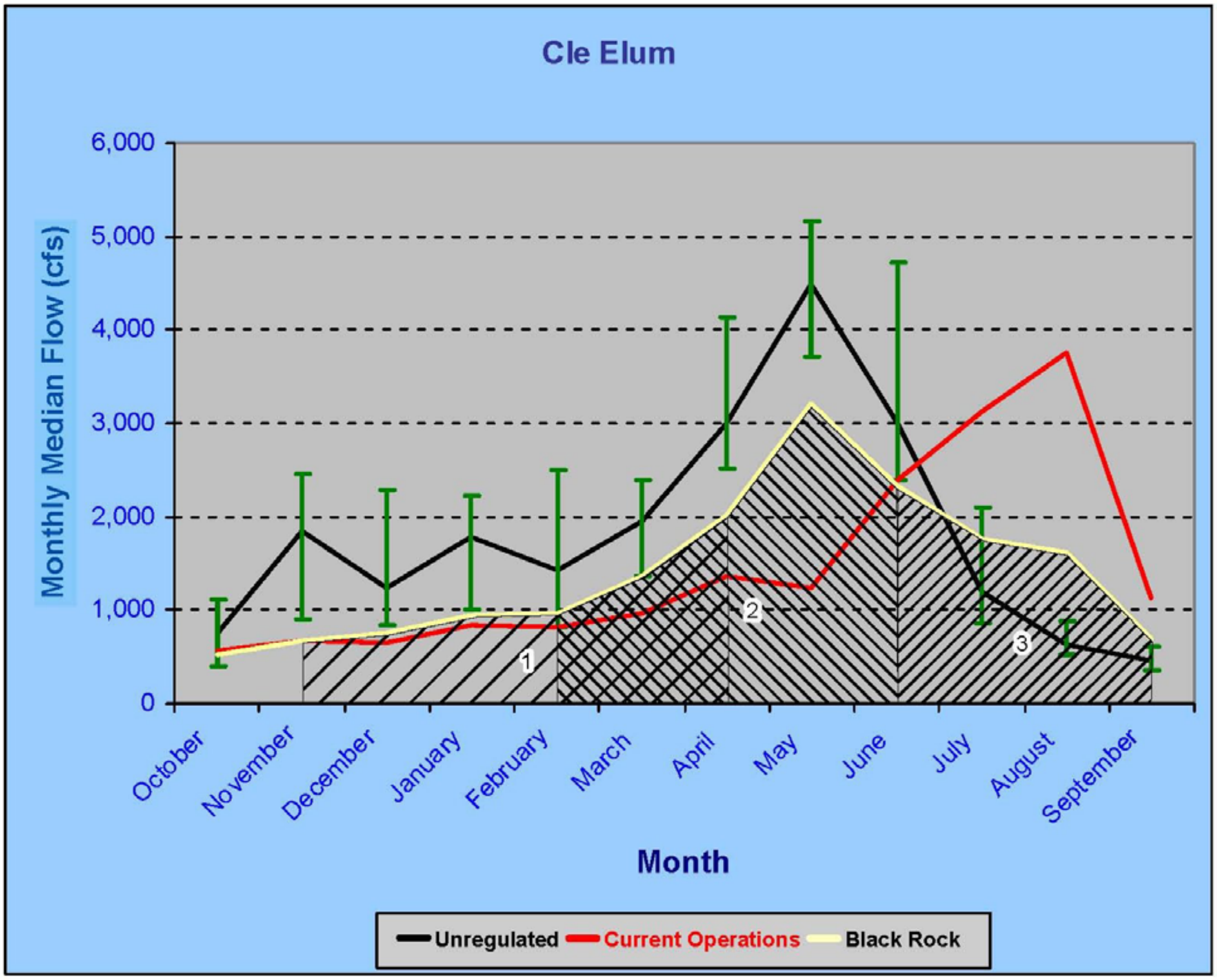

Figure 8-3. Comparison of estimated median monthly Cle Elum reach flows under the three scenarios (based on the 1981-2003 period of record)

The following discussion describes the numeric indicators shown on figure 8-3.

1. The Black Rock scenario would provide a slight improvement in winter rearing flows. Biologically, the potential exists for improved overwintering conditions by the creation of more side channel and backwater habitat, as well as increased interface of the water's edge with the riparian zone (i.e. overhanging vegetation and large woody debris along the stream margin).

   The Black Rock scenario would also provide some improvement in spring Chinook salmon egg incubation flows, especially with increased March and April flows. These improved flows would carry forward into the spring Chinook salmon fry colonization period (March through May) where the low range flows (≤25th percentile) would occur less frequently and middle range flows (>25th to <75th percentile) would occur more frequently than under the current operation scenario. This should improve emergent fry access to preferred side channel and backwater habitats, which are limited in most of the Yakima River downstream from the Cle Elum River. This is due, in part, to the lack of higher spring flows. With a more natural (unregulated) hydrograph, the side channels and backwater habitat would be watered up and provide excellent nursery areas for newly hatched spring Chinook salmonid fry. Emergent fry seek refuge in these quiet, shallow areas, which often provide good instream and overhead cover until the fry are large enough to safely rear in the main stem channels.

2. Smolt outmigrant flows with the Black Rock scenario would be much improved both in terms of timing (more closely following the natural hydrograph) and magnitude of peak flows (table 8-1).

Table 8-1. Cle Elum reach comparison of smolt out migration flows

	Black Rock Scenario	Current Operation Scenario
April flows	2,000 cfs	1,350 cfs
May flows	3,200 cfs	1,250 cfs
June flows	2,300 cfs	2,400 cfs

Potentially, the improved flows should increase smolt-to-smolt survival by reducing smolt travel time and exposure to predators, plus reducing residence time in the lower river in May and June when water quality typically begins to deteriorate (primarily because of sublethal to lethal water temperatures).

3. The Black Rock scenario would provide a more natural (unregulated) hydrograph for summer rearing spring Chinook salmon and steelhead, especially in July and August for the high flow ranges and, to a lesser degree, in September. The hydrograph, in general, would decline throughout the summer, which is comparable to the unregulated scenario; whereas under the current operation scenario, July and August flows would be significantly higher to meet downstream irrigation demand.

   The near elimination of flip-flop reservoir operation under the Black Rock scenario would be a major benefit to summer rearing salmonids by providing a more normative adjustment to habitat changes (i.e., flows in the main stem and side channels would decrease according to the natural flow pattern that fish have adapted to). Steelhead fry, in particular, are most sensitive to flip-flop operation because of their dependence on quiet, shallow rearing habitat, which is most vulnerable to flow changes.

8.1.1.5 Wapato Reach

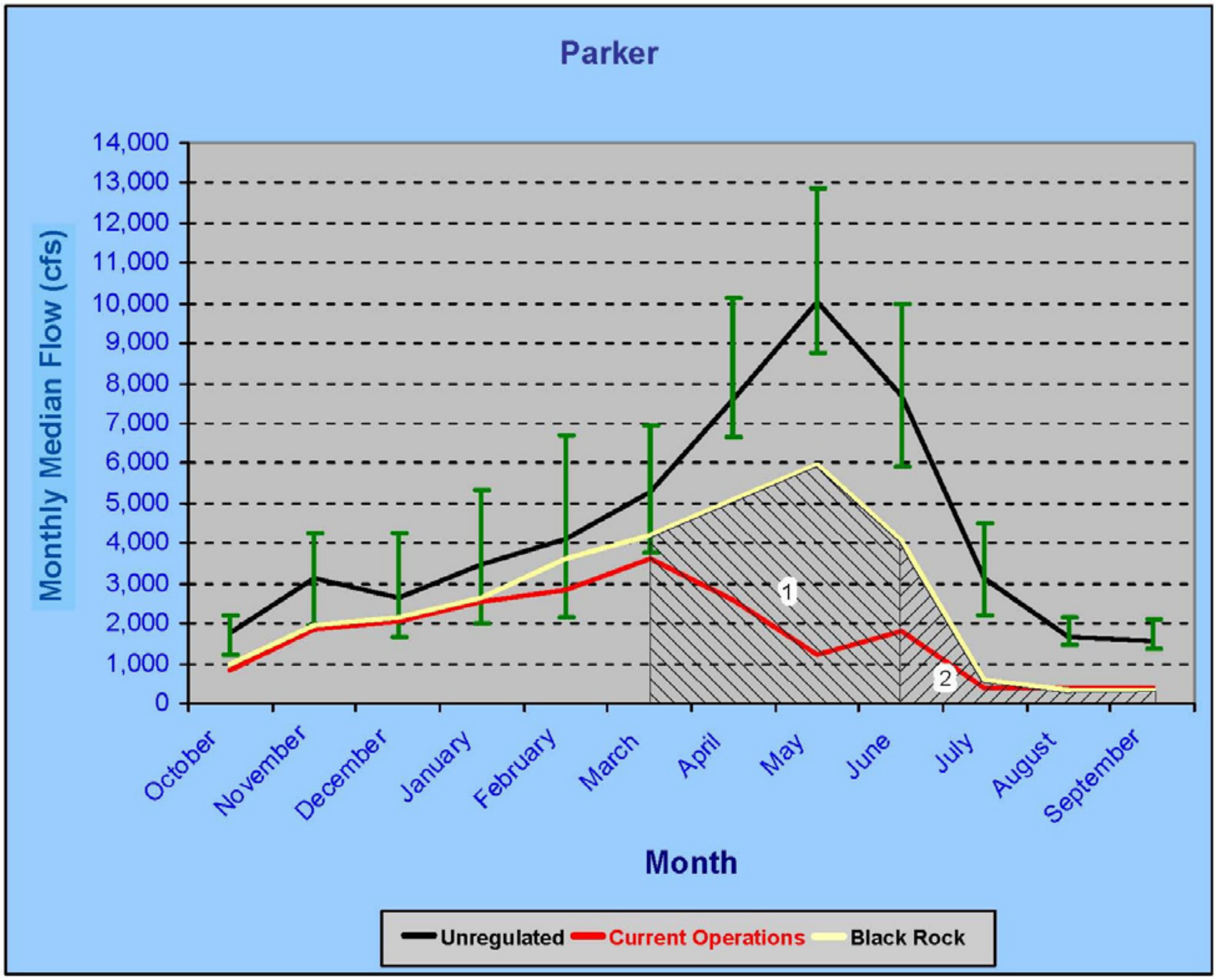

Figure 8-4. Comparison of estimated median monthly Wapato reach flows under the three scenarios (based on the 1981-2003 period of record)

The Wapato reach discussion is prefaced by acknowledging that spring Chinook salmon and steelhead use the mid-Yakima River primarily for winter rearing and smolt outmigration. However, fall Chinook salmon and coho salmon spawn and complete their life cycles within this portion of the Yakima River, and their life stage time periods generally coincide with those of spring Chinook salmon. The following discussion describes the numeric indicators shown on figure 8-4.

1. The Black Rock scenario would positively affect fry colonization and smolt out migration life stages relative to the current operation scenario. The April through June flows would resemble a more natural (unregulated) hydrograph in that monthly flows would more closely follow the natural flow regime. The Black Rock scenario mean May flow of 6,000 cfs would be about 5,000 cfs greater than the current operation scenario in May. The potential for increased spring flows should result in more side channel and backwater habitat, creating nursery areas for emergent fry (fall Chinook salmon and coho salmon). The Wapato reach has some of the best remaining side and backwater channel habitat in the basin, and the potential for increasing these habitat types in the spring would be a great benefit to salmonid

productivity. Smolt outmigrants would benefit through decreased travel time to the Columbia River, reduced predator exposure, and consequently, better smolt-to-smolt survival. The remaining spring Chinook salmon and steelhead life stages under the Black Rock scenario would be comparable to the current operation scenario.

2. Title XII of the Act of October 31, 1994, authorizing the Yakima River Basin Water Enhancement Project, provides for instream flow targets of 300-600 cfs over Sunnyside Diversion Dam during the irrigation season. While the Black Rock scenario would generate 500 cfs, it would be desirable to have an increase in summer flows (July through September) to a range of 1,000-1,200 cfs under the Black Rock scenario to enhance summer rearing habitat, especially for the side and backwater channels. This operation will be considered in future evaluations since the current operation scenario largely dewaters this habitat.

8.1.1.6 Naches Reach

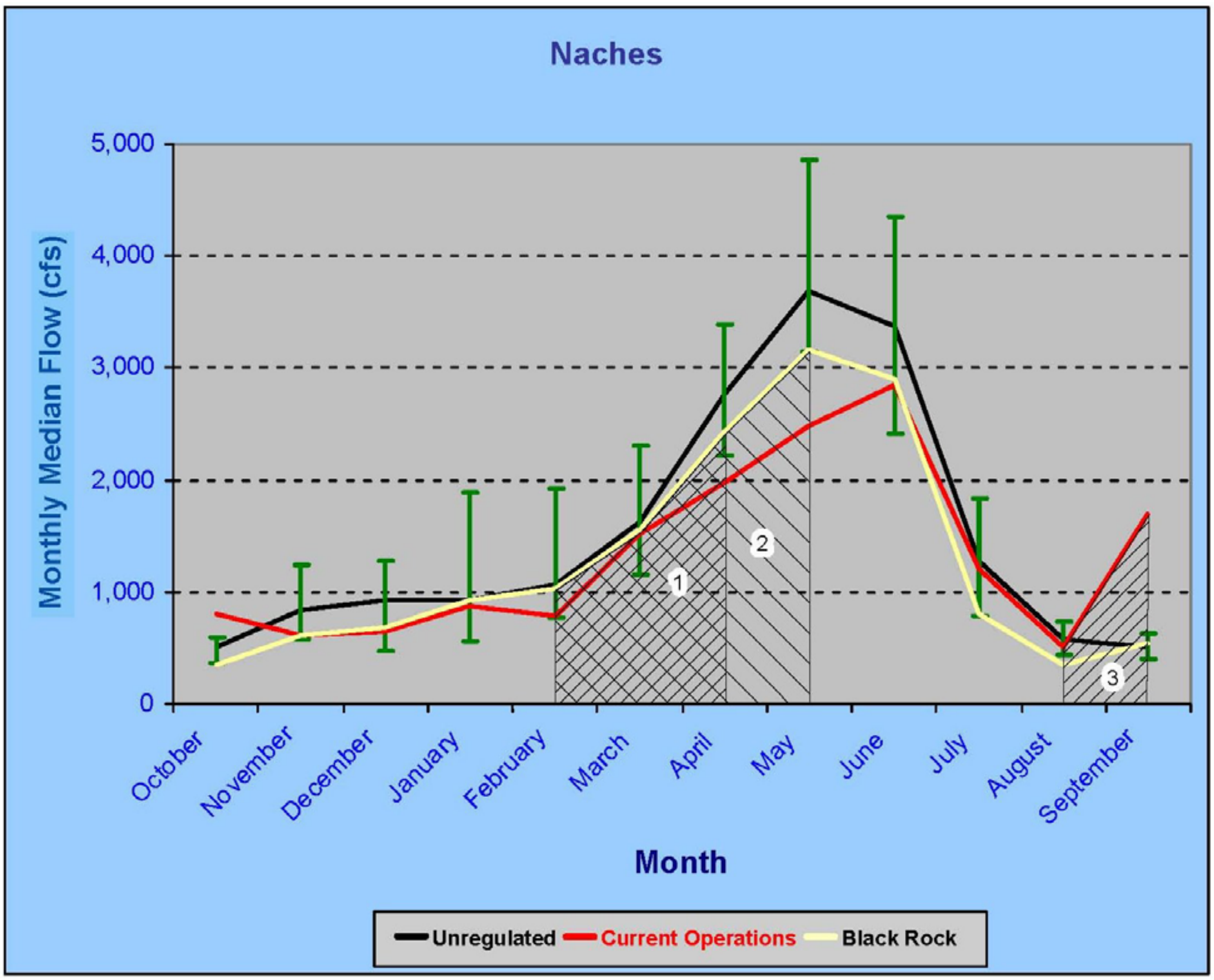

Figure 8-5. Comparison of estimated median monthly Naches reach flows under the three scenarios (based on the 1981-2003 period of record)

The following discussion describes the numeric indicators shown on figure 8-5.

1. The Black Rock scenario would improve flows during the March through April spring Chinook salmon fry colonization period through increased flows and correspondingly greater side and backwater channel habitat for newly emergent fry. Notably, a substantial amount of side and backwater channels is now available in the lower Naches River if adequate flow exists to keep it inundated.

2. Spring March through May flows for smolt outmigration would improve under the Black Rock scenario compared to the current operation scenario. Notably, peak flows would occur in May under the Black Rock scenario, which would coincide with the natural hydrograph and fall within the 25th-75th percentile bounds in all months, except August.

3. The removal of the August through September flip-flop reservoir operation effect would be a major benefit. September spring Chinook salmon spawning flows for the current operation scenario would average 1,700 cfs compared to 514 cfs for the unregulated scenario and 538 cfs for the Black Rock scenario. This would reduce the potential risk of dewatering spring Chinook salmon redds during the initial period of egg incubation for early spawning fish.

Flows in September and October under the Black Rock scenario would resemble a more natural (unregulated) hydrograph than those for the current operation scenario. The elimination of flip-flop reservoir operation would have significant effects from September to October. Biologically, this is a critical period when both juvenile spring Chinook salmon and steelhead initiate downstream movement in the Naches basin seeking outwinter refugia in the lower Naches River and beyond. The potential now exists for disrupting or displacing fish in side channel habitats especially as they seek outwinter rearing habitat. This would not occur with the Black Rock scenario.

The following findings are based solely on preliminary analysis of the hydrographs as related to the unregulated flow scenario.

Findings: **Overall across the four stream reaches, the Black Rock scenario would produce a more natural (unregulated) hydrograph than the current operation scenario.**

The magnitude and timing of spring runoff with the Black Rock scenario would resemble a more natural (unregulated) hydrograph.

The current flip-flop reservoir operation could be eliminated or significantly reduced with the Black Rock scenario. High summer flows in the Cle Elum reach resulting from the current operation of transporting irrigation water to the Roza and Sunnyside Divisions would be greatly reduced. High fall flows downstream from Tieton Dam, to meet Sunnyside Division and Wapato Irrigation Project water needs, would also be significantly reduced. This would

result in a return of the streamflow regime to a more natural (unregulated) hydrograph.

8.1.2 Irrigation

Another objective of the Storage Study is to increase the water supply available for existing irrigated agriculture use in the Yakima River basin during drought years. The legal and operational framework for Yakima River basin water allocation and management that has emerged through the years established two classifications of irrigation water users, proratable and nonproratable. In a water right relationship, the nonproratables are considered senior and the proratables are junior water right holders. During periods of annual water shortage, the proratable water users are limited to a less than full water supply based upon Reclamation's forecast of the total water supply available for Yakima Project purposes between April 1 and September 30. A specific objective of the Black Rock alternative water exchange is to provide the proratables a water supply of not less than 70 percent of their water allocation in years of proration.

In recent years, the Yakima River basin experienced water shortages in 1987, 1988, 1992, 1993, 1994, and 2001. The severity of shortage, as measured by the percentage of full water supply received by the proratables, ranged from 90 percent in 1988 to 37 percent in 1994 and 2001. In this Assessment, the irrigation water supply goal is to provide not less than 70 percent supply for proratable rights in dry years. This would increase the 1994 and 2001 proratable water supplies by 33 percent (from 37 to 70 percent).

Reclamation's most recent tabulation of irrigation allocation for entities upstream from the Parker gauge for the April through October irrigation season is dated April 29, 1994. Table 8-2 summarizes this tabulation pertinent to proratable water users.

Table 8-2. Proratable water users

Irrigation Entity	Proratable Acre-Feet Per Year
total basin allocation	1,279,883
potential exchange participants	
Roza Division	375,000
Sunnyside Division	142,684*
Terrace Heights Irrigation District	1,345*
Selah-Moxee Irrigation District	4,281*
Union Gap Irrigation District	4,642
subtotal	527,952
net proratable allocation	751,931
other proratable entities	
Wapato Project	350,000
Kittitas Reclamation District	336,000
Yakima-Tieton Irrigation District	34,835
Westside Irrigation Company	8,200
city of Ellensburg	6,000
city of Yakima	6,000
Naches-Selah Irrigation District	4,486
Yakima Valley Canal Company	4,305
other entities (8)	2,096
*Numbers differ from those shown in table 3-2, which incorporates post-1994 changes resulting from the *Acquavella* case.	

Findings: Based on the above tabulation, the irrigation benefits of the Black Rock alternative would have two primary parts as follows:

1. The five potential exchange participants accepting Columbia River water would receive not less than 70 percent of their proratable supply from that source.

2. A portion of the Yakima River water not delivered to the five potential exchange participants would be allocated to other Yakima Project proratable water users so they would receive not less than a 70 percent supply.

8.1.3 Municipal Water Supply

Another objective of the Storage Study is to provide water for current and future municipal water supply use within the Yakima River basin. Under the identified water exchange concept of the Black Rock alternative, a portion of the Yakima River basin irrigation season water supply not diverted could be allocated to municipal water supply.

The most recent quantitative analysis of the Yakima River basin municipal water supply needs is contained in the January 2003 Yakima River Basin watershed plan [18] prepared by the Yakima River Basin Watershed Planning Unit. Table 8-3 summarizes the plan's findings.

Table 8-3. Current and projected municipal demands
(annual demand in acre-feet per year)

Public Water Systems Serving 1,000 or More Connections	Year		
	2000	2010	2020
basin total (surface and groundwater)	54,340	66,690	83,620
basin total (surface water)			
city of Cle Elum	897	1,054	1,169
city of Yakima	18,609	22,932	28,119
total	19,506	23,986	29,288
percent of basin total	36	34	34

As table 8-3 indicates, the majority of the municipalities, both as to number and present water use, rely on groundwater. Only the cities of Cle Elum and Yakima currently divert from the Yakima River. Whether this practice would continue into the future depends on State water management policies with respect to issuance of new permits for groundwater appropriation.

Since the municipal water demand, by scale, is less in comparison to irrigation and instream flow use, this Assessment has not addressed the potential effect of the Black Rock alternative on municipal water supply. Future study would consider the needs, benefits, and allocation of water to meet population growth in the Yakima River basin if the Black Rock alternative proceeds to the next phase of the Storage Study.

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8.2 Diversion of Columbia River Water

8.2.1 Instream Flows

Diversion of Columbia River water with the Black Rock alternative raises the question of reduced Columbia River flow and effects on streamflow and hydroelectric generation. Pumping from Priest Rapids Lake to a Black Rock reservoir would certainly reduce streamflow in the 62-mile reach downstream from Priest Rapids Dam to the Yakima River confluence. However, at the confluence, the historic pattern of Yakima River inflows would increase due to the return of exchange water used in the Yakima Project.

As discussed below, it is not possible at this time to correlate monthly pumping to a Black Rock reservoir and the associated Columbia River depletions with the Yakima River inflow changes projected to occur. Consequently, the information presented in this section is solely related to the results of hydrologic modeling to show the projected changes in Yakima River flows at the Kiona gauge (RM 29.9, near the Yakima-Columbia River confluence) resulting from the Yakima Project's use of exchange water.

8.2.2 Hydrologic Models

Presently, the Hyd-Sim model of the FCRPS (used by BPA) and the Yak-RW model (used by Reclamation) do not have comparable time periods of historic hydrologic streamflow. The Hyd-Sim model uses current FCRPS operating requirements and historic Columbia River hydrologic flow conditions for the 50-year period from 1929-1978. The Yak-RW model used in simulating Yakima Project operations has a much shorter 23-year historical period of 1981-2003.

8.2.3 Yakima River Inflow Changes

Using the Yak-RW model to simulate current Yakima Project operations, the Yakima River basin annual water supply is grouped into three water supply conditions of wet, average, and dry years as represented by the April 1 total water supply available. The total water supply available is an indicator of the water supply projected to be available to the Yakima Project upstream from the Parker gauge from natural runoff, irrigation return flows, and stored waters for irrigation and instream flow targets during April 1 through September 30 of each year. For purposes of this analysis, wet, average, and dry years are defined as follows:

- wet year: April 1 total water supply available is greater than 3,250,000 acre-feet
- average year: April 1 total water supply available is between 2,250,000 and 3,250,000 acre-feet
- dry year: April 1 total water supply available is less than 2,250,000 acre-feet.

Table 8-4 shows these three water supply conditions, in order of available supply.

Table 8-4. Yakima River basin water supply conditions (1981-2003)

Water Year Type	Year	April 1 total water supply available (acre-feet)
Wet	1997	4,531,000
	1999	4,007,000
	1982	3,382,000
	1983	3,351,000
	2000	3,284,000
	2002	3,267,000
	1984	3,253,000
Average	1996	3,232,000
	1998	3,167,000
	1990	3,122,000
	1991	3,038,000
	1995	2,929,000
	1989	2,906,000
	1985	2,767,000
	2003	2,573,000
	1986	2,515,000
	1981	2,502,000
	1988	2,492,000
	1987	2,475,000
Dry	1993	2,161,000
	1992	2,119,000
	2001	1,800,000
	1994	1,800,000

Average monthly flows at Kiona gauge were then determined for the respective wet, average, and dry water supply conditions using the Yak-RW model monthly output for two scenarios: current Yakima Project operations and projected Yakima Project operations with the Black Rock alternative water exchange. Current operations reflect the present Yakima Project management for flood control, irrigation, and streamflow operations. Streamflow operations include the flow targets at Sunnyside and Prosser Diversion Dams (as provided by Title XII of the Act of October 31, 1994), as well as flip-flop reservoir operations, and other present instream operations throughout the river system as generally described in the *Interim Comprehensive Basin Operating Plan for the Yakima Project, Washington,* in chapter 5: Current Project Operations/Total Water Supply Available [19].

The Black Rock scenario involves the April through October water exchange with Roza and Sunnyside Divisions. This reflects operation of the Yakima Project according to the following assumed allocation of exchange water: (1) for instream flow purposes in wet and average Yakima River basin water supply years, and (2) for irrigation purposes for all other proratables (see table 8-2) to provide not less than a 70 percent supply in dry years. In dry years, the exchange water supply surplus to irrigation needs would be allocated to instream flows. The instream flow hydrograph mimics, to the extent possible, the natural unregulated flow regime.

Yakima River flows at Kiona gauge are comprised of the following: (1) unregulated natural flows, (2) surface and subsurface return flows accruing primarily from irrigation, and (3) Yakima

Project reservoir operations specifically for streamflow enhancement such as would occur from use of exchange water in mimicking the natural unregulated flow regime.

Figures 8-6, 8-7, and 8-8 show hydrographs of average monthly flows at Kiona gauge for the two scenarios under wet, average, and dry water supply conditions, respectively.

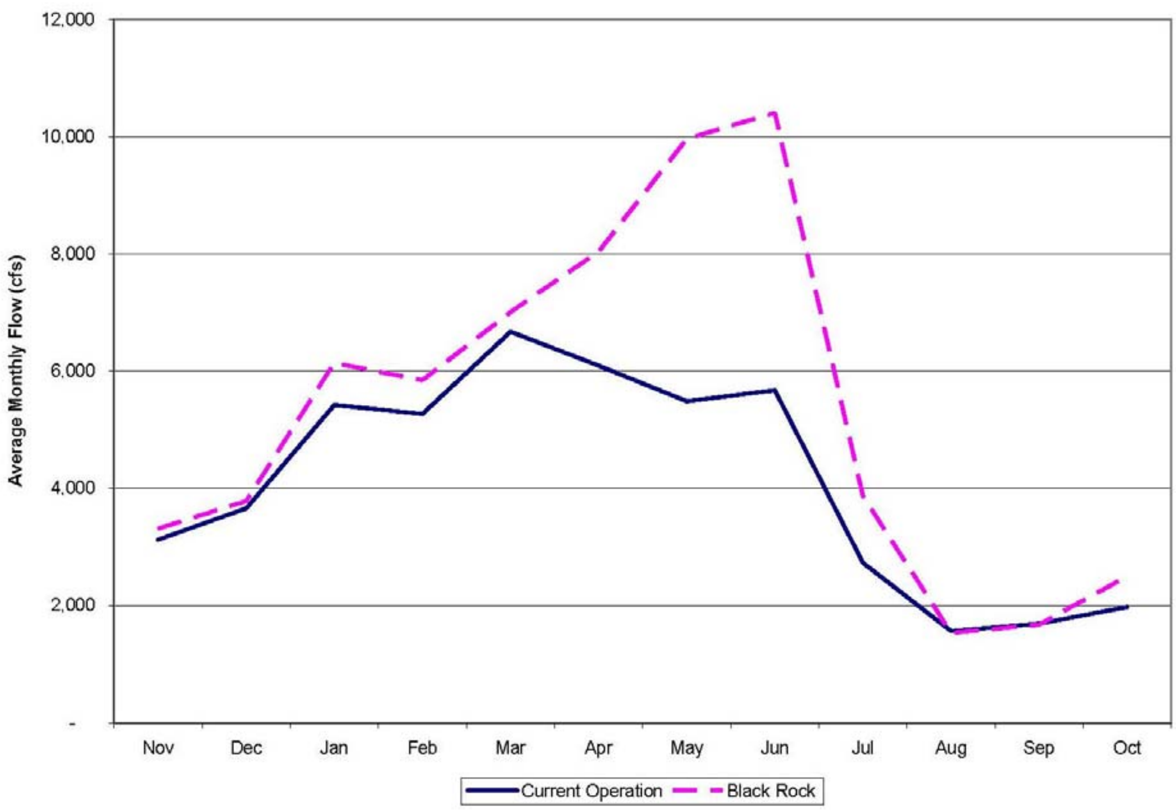

Figure 8-6. Average monthly flows at Kiona gauge under wet water supply conditions

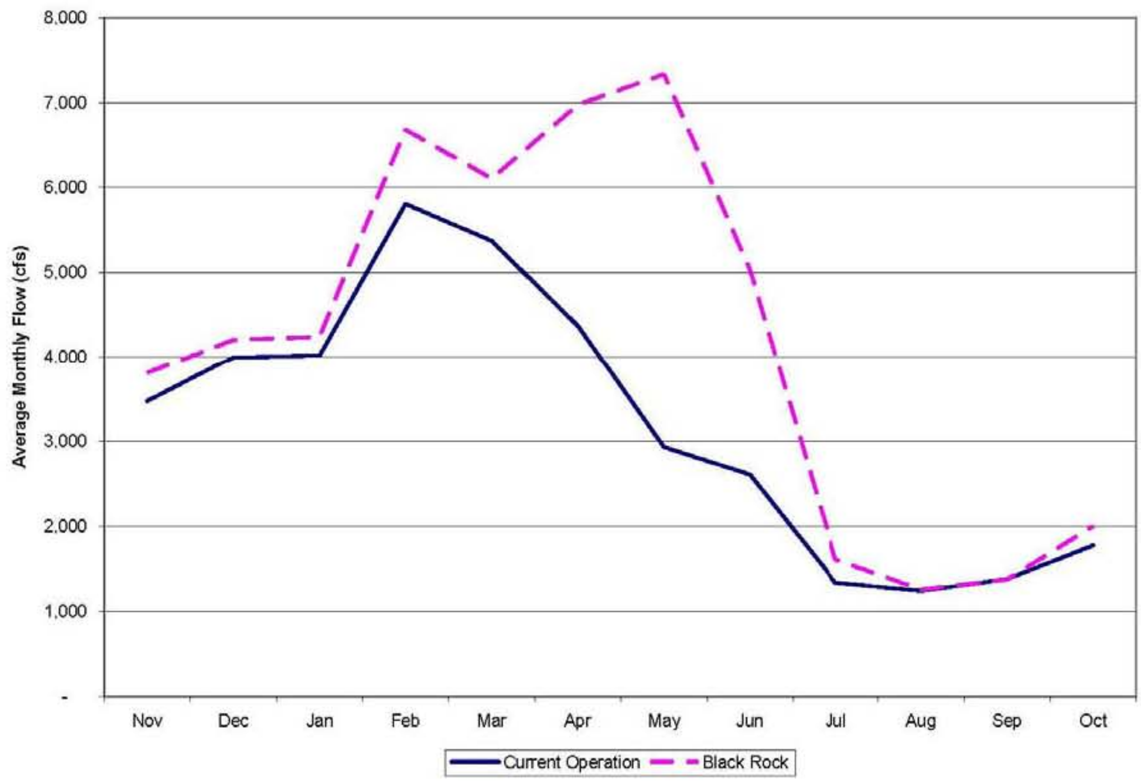

Figure 8-7. Average monthly flows at Kiona gauge under average water supply conditions

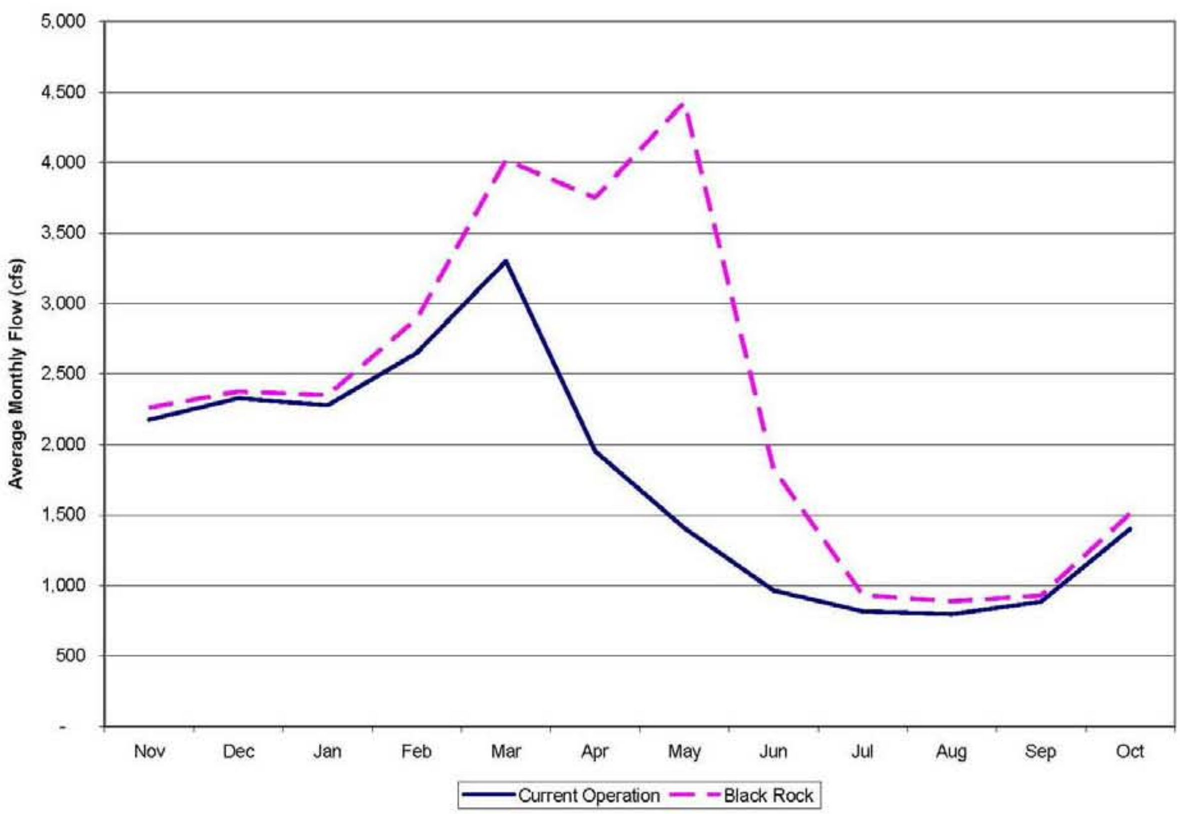

Figure 8-8. Average monthly flows at Kiona gauge under dry water supply conditions

Table 8-5 shows the resulting average monthly flows for wet, average, and dry Yakima River water supply conditions for the two scenarios. Annually, it is projected the additional flow in the Yakima River at its mouth could be 900,000 acre-feet with wet water supply conditions, 700,000 acre-feet with average water supply conditions, and about 400,000 acre-feet with dry water supply conditions.

Table 8-5. Average monthly Yakima River flows at Kiona gauge based on wet, average, and dry Yakima River basin water supply conditions

	Wet Years			Average Years			Dry Years		
Month	Current Operation	Black Rock	Difference	Current Operation	Black Rock	Difference	Current Operation	Black Rock	Difference
	(cfs)								
Nov	3,100	3,300	200	3,500	3,800	300	2,200	2,300	100
Dec	3,700	3,800	100	4,000	4,200	200	2,300	2,400	100
Jan	5,400	6,100	700	4,000	4,200	200	2,300	2,400	100
Feb	5,300	5,800	500	5,800	6,700	900	2,600	2,900	300
Mar	6,700	7,000	300	5,400	6,100	700	3,300	4,000	700
Apr	6,100	8,000	1,900	4,400	7,000	2,600	2,000	3,700	1,700
May	5,500	10,000	4,500	2,900	7,300	4,400	1,400	4,400	3,000
Jun	5,700	10,400	4,700	2,600	5,000	2,400	1,000	1,800	800
Jul	2,700	3,900	1,200	1,300	1,600	300	800	900	100
Aug	1,500	1,500	- -	1,200	1,300	100	800	900	100
Sep	1,700	1,700	- -	1,400	1,400	- -	900	900	- -
Oct	2,000	2,500	500	1,800	2,000	200	1,400	1,500	100
	(acre-feet)								
Annual	2,900,000	3,800,000	900,000	2,300,000	3,000,000	700,000	1,300,000	1,700,000	400,000

Yakima River flows at Kiona gauge during dry water supply years would be less than in wet and average water supply years due to the following:

- The additional Yakima Project water supply made available as the result of an exchange with Roza and Sunnyside Divisions would be less due to the categories of water rights in the exchange; about 60 percent are proratable rights subject to proration in dry years.
- Part of the available exchange water could be used in dry years to improve the water supply of all Yakima Project proratable rights to not less than 70 percent.[9] This results in the consumptive use of part of the exchange water for irrigation (a portion of this would accrue to the Yakima River as surface and subsurface return flows) while the residual available supply would be used for instream flow purposes.

Findings: As defined in this Summary Report, wet, average, and dry Yakima River basin water supply conditions over the 23-year period of analysis (1981-2003) have occurred as follows:

[9] With the exception of the Roza and Sunnyside Divisions which are provided Columbia River water.

Water Supply Condition	Number of Years	Percentage
Wet	7	29
Average	12	50
Dry	4	21
Totals	23	100

The Black Rock alternative water exchange would result in increased Yakima River streamflow entering the Columbia River at the Yakima River confluence. Estimated increased streamflow is:

- **wet Yakima River basin water supply conditions – 900,000 acre-feet**
- **average Yakima River basin water supply conditions – 700,000 acre-feet**
- **dry Yakima River basin water supply conditions – 400,000 acre-feet**

8.3 Hydropower Generation and Pumping Energy

The discussion of the mid-Columbia River system is extracted from Grant PUD's relicensing report of 2003 [15].

8.3.1 Existing Facilities

The Priest Rapids Project is located on the main stem Columbia River in Central Washington and includes two hydroelectric developments, Wanapum and Priest Rapids, owned and operated by Grant PUD. Each development consists of a dam, powerhouse, fishways, reservoir, 230-kilovolt transmission lines, and ancillary facilities. Wanapum and Priest Rapids powerhouses each have 10 turbine-generators with capacities of 900 MW and 850 MW, respectively, for a presently authorized, installed capacity of 1,750 MW. The maximum hydraulic capacity of each powerhouse is approximately 175,000 cfs assuming all units are operating at full capacity.

The two developments produced a total of 9.65 billion kilowatt-hours of electricity in 2002, which is equivalent to the energy consumed in a year by a city approximately the size of Seattle. Under current power purchase agreements, Grant PUD reserves 36.5 percent of the energy produced for its own use. The remaining 63.5 percent of the generation is provided under long-term contracts, at cost, to 12 Pacific Northwest utilities that collectively serve customers in Washington, Idaho, Oregon, Montana, and Utah.

Priest Rapids development is part of the much larger, seven-dam, mid-Columbia River hydroelectric system of about 14,000 MW, which extends from near the United States/Canada border to the beginning of the Hanford Reach, for a total of 351 miles (see figure 8-9). This includes two Federal facilities, Grand Coulee Dam (Reclamation) with an installed generation capacity of about 6,800 MW and Chief Joseph Dam (U.S. Army, Corps of Engineers) with an installed capacity of about 2,600 MW. Three Washington Public Utility Districts own and operate the five hydroelectric projects downstream from Chief Joseph Dam, having a combined installed generation capacity of about 4,500 MW. Priest Rapids Dam is at the downstream end of this integrated system of hydropower facilities. Table 8-6 provides information on the mid-Columbia River system.

Downstream from the mouth of the Yakima River, Federal powerplants on the lower Columbia River are at McNary, John Day, The Dalles, and Bonneville Dams.

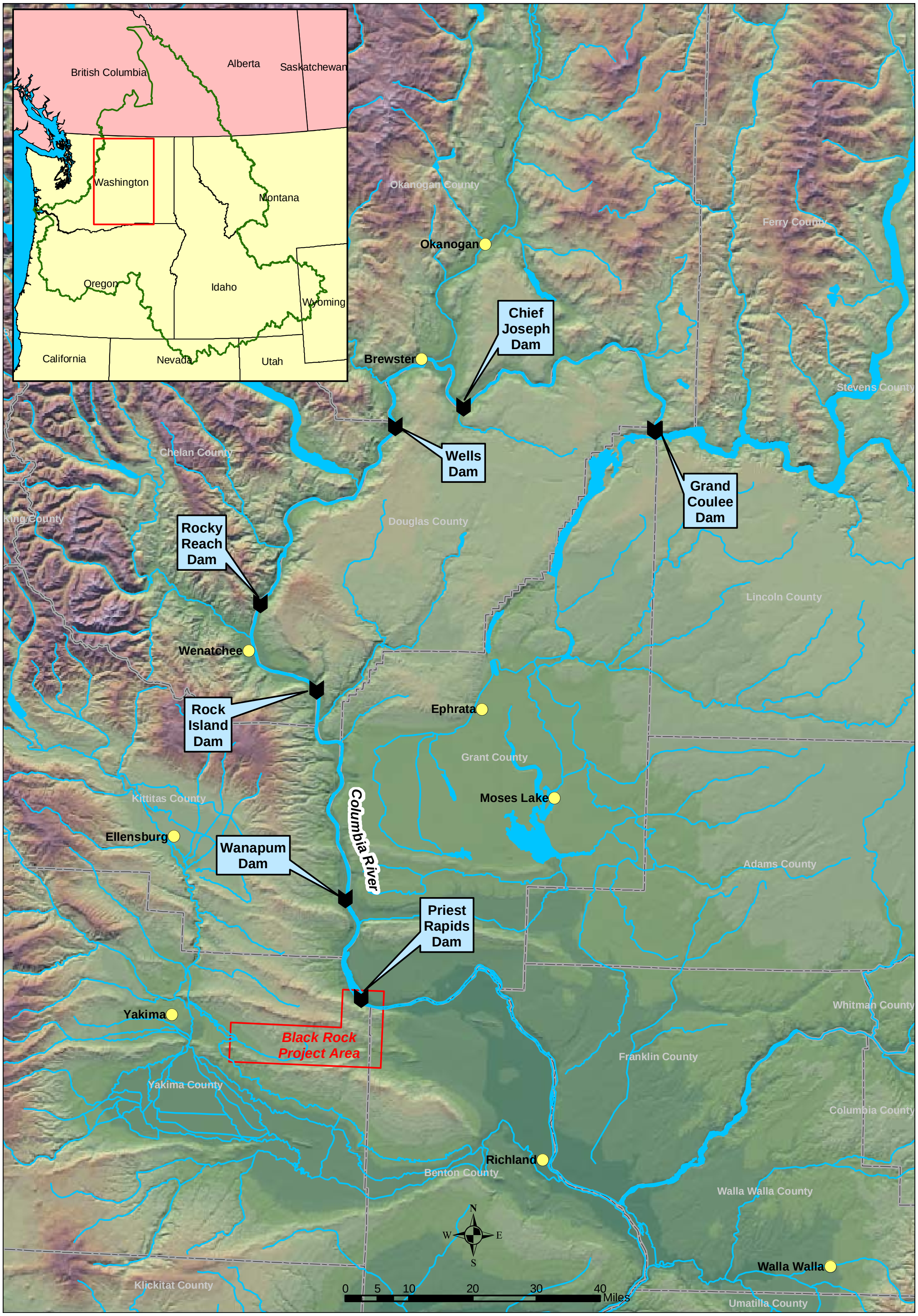

Figure 8-9. Mid-Columbia River hydroelectric system

Table 8-6. Summary of hydroelectric projects in the mid-Columbia River system

Project	Owner	Location (RM)	Drainage Area (mi^2)	Usable Storage[1] (million acre-feet)	Maximum Plant Hydraulic Capacity (cfs)	Installed Capacity (MW)
Grand Coulee	Reclamation	596.6	74,700	5.22	280,000	6,809[2]
Chief Joseph	Corps of Engineers	545.1	75,000	0.12	213,000	2,614
Wells[3]	Douglas PUD	515.8	86,100	0.10	220,000	840
Rocky Reach[3]	Chelan PUD	473.7	87,800	0.04	220,000	1,287
Rock Island[3]	Chelan PUD	453.4	89,400	0.01	220,000	660
Wanapum[3]	Grant PUD	415.8	90,900	0.16	180,000	900
Priest Rapids[3]	Grant PUD	397.1	96,000	0.04	175,000	855

[1] The volume of water contained within the normal reservoir operating range.
[2] Includes generating capacity of the pump/generator plant.
[3] Data for these private facilities obtained from Grant PUD's relicensing report of 2003 [20].

The seven-dam, mid-Columbia system contains a significant amount of active storage that enhances the reliability and flexibility of the Northwest's entire electric generation system. The usable storage in the mid-Columbia system is primarily at Grand Coulee (Franklin D. Roosevelt Lake) with over 5,200,000 acre-feet, while the six downstream projects account for about 440,000 acre-feet, or about 10 percent. Overall, 86 percent of the annual flow at Priest Rapids Dam is provided by controlled releases from Grand Coulee Dam.

Reclamation requested BPA's assistance in evaluating several power aspects of the Black Rock alternative. These include the following:

- Annual pumping energy required to lift water from Priest Rapids Lake to a Black Rock reservoir, and the estimated annual cost if purchased from the FCRPS
- Annual hydropower generation effects at the Priest Rapids development and at other non-Federal and Federal hydropower facilities
- The financial viability of pump generation at the Black Rock alternative
- Potential impacts relating to the Columbia River Treaty and operating agreements.

BPA used computer-modeling capabilities to analyze operation of the Black Rock alternative and estimate its effects on power production of Federal and non-Federal hydropower projects in the region. This analysis was performed using the Hyd-Sim hydroregulation model simulating current operations imposed on Columbia River streamflows represented by the years 1929 to 1978. Results from this study were then compared with a baseline analysis (excluding the Black Rock alternative) to estimate effects on power production of the existing system with the Black Rock alternative operation.

BPA followed operating criteria where diversion of Columbia River water to a Black Rock reservoir would occur at times when water was available in excess of instream flow targets.

BPA assumed if upstream reservoirs (primarily Franklin D. Roosevelt Lake) were fuller than necessary to meet ESA commitments, those reservoirs would release additional water to meet the pumping demands of the Black Rock alternative. BPA developed information for the following two Black Rock alternative configurations:

- a 1,300,000-acre-foot active reservoir capacity and a 3,500-cfs Columbia River pumping plant
- an 800,000-acre-foot active reservoir capacity and a 6,000-cfs Columbia River pumping plant.

8.3.2 Pumping Energy Requirements and Costs

As a part of their work, BPA conducted the Black Rock alternative pumping analysis to determine monthly Columbia River diversions that could be made to a Black Rock reservoir. In the analysis, BPA permitted the release of stored water from upstream reservoirs for pumping to a Black Rock reservoir, if otherwise allowed. This operation resulted in additional water being available for diversion primarily in wet years. (Reclamation did not use this assumption in the water availability assessment [3].) The results indicate a 172-MW average annual amount of energy would be necessary to meet the requirements of the Black Rock alternative with a 1,300,000-acre-foot reservoir. BPA calculated the cost of this power on an average annual basis to be $62 million. Pumping energy cost estimates used 2004 energy price assumptions as forecasted in BPA's August 2003 rate case and could be higher or lower if a new rates analysis were performed due to changes in market conditions. Table 8-7 shows the monthly pumping energy requirements and estimated costs as determined by BPA.

Table 8-7. Preliminary monthly pumping energy requirements to pump to a Black Rock reservoir

Month	1,300,000-acre-foot reservoir and 3,500-cfs pumping plant	800,000-acre-foot reservoir and 6,000-cfs pumping plant
Energy required to pump to a Black Rock reservoir		
	(average megawatts)	
August 1-15	205	179
August 16-31	39	41
September	466	607
October	344	372
November	216	36
December	89	0
January	10	0
February	0	0
March	63	59
April 1-15	108	103
April 16-30	76	73
May	209	202
June	210	249
July	239	236
Annual average	172	163
Cost of energy required to pump to a Black Rock reservoir		
Range of costs	$23 to $121 million	$22 to $100 million
Average annual costs	$62 million	$55 million

Findings: Average annual pumping energy required and the average annual cost are estimated at 172 megawatts and $62 million for the large reservoir pump only option and 163 megawatts and $55 million for the small reservoir pump only option.

8.3.3 Effects on Current Hydropower Generation

Hydropower generation effects associated with the Black Rock alternative as assessed by BPA would occur at both non-Federal and Federal hydropower projects of the mid to lower Columbia River. Because the FCRPS is operated as a coordinated system, flow changes as a result of the Black Rock alternative could have minor effects on power generation at other FCRPS hydropower facilities as well.

8.3.3.1 Non-Federal Hydropower Projects

Diversion of 3,500 cfs or 6,000 cfs from Priest Rapids Lake for pumping to a Black Rock reservoir would reduce generation at Priest Rapids Powerplant on the average by 4 MW, which is less than 1 percent annually. In the fall months when heavy pumping was taking place, pumping to a Black Rock reservoir may result in a 5 to10 percent loss in hydropower production at Priest Rapids Dam. Power generation impacts at other non-Federal projects would sometimes be positive and sometimes negative. These impacts would be related to the operational assumption of releasing stored water from upstream reservoirs (primarily Franklin D. Roosevelt Lake) for pumping to a Black Rock reservoir. Table 8-8 shows the monthly change in generation at non-Federal Columbia River hydropower projects and the estimated value of the change.

Table 8-8. Preliminary monthly change in non-Federal Columbia River hydropower generation related to operation of the Black Rock alternative

Month	1,300,000-acre-foot reservoir and 3,500-cfs pumping plant			800,000-acre-foot reservoir and 6,000-cfs pumping plant		
	Priest Rapids only	Non-Federal hydro without Priest Rapids	Non-Federal hydro including Priest Rapids	Priest Rapids only	Non-Federal hydro without Priest Rapids	Non-Federal hydro including Priest Rapids
	(average megawatts)					
August 1-15	-1	14	13	-1	12	11
August 16-31	0	-2	-2	0	3	3
September	-17	-2	-19	-24	-1	-25
October	-12	-5	-17	-14	-4	-18
November	-1	22	21	0	1	1
December	-6	5	-1	-1	11	10
January	-3	-18	-21	0	-8	-8
February	0	-8	-8	0	-8	-8
March	-2	6	4	-2	6	4
April 1-15	-1	22	21	-1	24	23
April 16-30	0	-1	-1	0	-2	-2
May	-1	-7	-8	-1	-6	-7
June	-1	-17	-18	-2	-15	-17
July	-2	2	0	-2	2	0
Annual average	-4	0	-4	-4	0	-4
Value of generation change at non-Federal Columbia River hydropower projects						
Range of value	-$3 million to 0		-$10 million to $5 million	-$3 million to 0		-$11 million to $5 million
Average annual value	-$2 million		-$1 million	-$2 million		-$1 million

8.3.3.2 Federal Hydropower Projects

Hydropower generation changes would occur at Federal facilities upstream from Priest Rapid Dam and downstream from the Yakima River confluence. With the Black Rock alternative in operation, diversions from Priest Rapids Lake would diminish streamflow in the 62-mile reach from Priest Rapids Dam to the Yakima River confluence, where there are no Federal hydropower facilities. Streamflow depletions from the Black Rock pumping would be somewhat offset by increased flows entering the Columbia River from the Yakima River as the result of use of the exchange water.

The model used to simulate Yakima Project operations with the Black Rock alternative water exchange is based on a 1981-2003 time period, whereas the Columbia River hydrogeneration model reflects a 1929-1978 period. Consequently, Reclamation developed preliminary estimates of Yakima River flows for the 50-year period for BPA's use in analyzing generation changes at Federal hydropower facilities downstream from the Yakima River confluence. On average, the FCRPS would lose approximately 5 MW of annual generation as shown on table 8-9.

Table 8-9. Preliminary monthly change in Federal Columbia River hydropower generation related to operation of the Black Rock alternative

Month	1,300,000-acre-foot reservoir and 3,500-cfs pumping plant	800,000-acre-foot reservoir and 6,000-cfs pumping plant
	(average megawatts)	
August 1-15	28	24
August 16-31	21	26
September	-30	-55
October	-39	-46
November	55	9
December	-62	-15
January	-35	-1
February	-1	0
March	6	7
April 1-15	8	14
April 16-30	5	3
May	-1	3
June	8	10
July	10	9
Annual average	-5	-4
Value of generation change at Federal Columbia River hydropower projects		
Range of value	-$11 million to $4 million	-$10 million to $4 million
Average annual value	-$3 million	-$2 million

8.3.3.3 Combined Regional

Table 8-10 shows the regional combined non-Federal and Federal hydropower generation effects (changes in generation and value of generation changes) related to operation of the Black Rock alternative.

Table 8-10. Preliminary monthly change in regional combined non-Federal and Federal hydropower generation related to operation of the Black Rock alternative

Month	1,300,000-acre-foot reservoir and 3,500-cfs pumping plant	800,000-acre-foot reservoir and 6,000-cfs pumping plant
	(average megawatts)	
August 1-15	41	35
August 16-31	19	29
September	-49	-79
October	-56	-64
November	76	11
December	-63	-6
January	-56	-9
February	-9	-8
March	10	11
April 1-15	29	37
April 16-30	4	2
May	-10	-4
June	-10	-6
July	10	9
Annual average	-9	-8
Value of generation change at regional Columbia River hydropower projects		
Range of value	-$20 million to $9 million	-$20 million to $9 million
Average annual value	-$4 million	-$4 million

Findings: Both positive and negative monthly changes in regional hydropower generation would result from the Black Rock alternative. The average annual change would be an 8- to 9-megawatt decrease in generation with a $4 million average annual decreased generation value.

8.3.4 Black Rock Alternative Hydropower Generation

There is potential for three hydropower generation facilities as features of the Black Rock alternative. These include an intake pump/generation operation between the Columbia River and Black Rock reservoir, a generation plant at the terminus of the Black Rock outlet facility near Roza Canal, and a generation plant at the Sunnyside Division discharge water delivery pipeline near Sunnyside Canal.

8.3.4.1 Intake Pump/Generation

An option considered for the Columbia River intake facilities includes a 3,500-cfs pump/ generation option (see section 5.4.1.3). This option was included to compare the estimated cost of a 3,500-cfs pump only and a pump/generation option. The construction cost estimate of the 3,500-cfs pump only option is $190 million less than the cost of a 3,500-cfs pump/generation option. However, no operation studies were conducted to determine how a Black Rock reservoir would fluctuate if stored water were released back to the Columbia River for generation purposes. It is not yet known if a 3,500-cfs pumping plant would be adequate with pump/generation for refilling the reservoir to ensure annual delivery of exchange water in a pump/generation mode. Further, the impact of a pump/generation operation on potential reservoir recreation opportunities has not been identified.

BPA was requested to provide their view on the financial viability of pump/generation under the Black Rock alternative. The closest power market, the mid-Columbia River point of interchange, could be used to value both the power lost to lifting water into a Black Rock reservoir and the subsequent generation of power by releasing water back into Priest Rapids Lake. The latest mid-Columbia River forecast was completed August 2004 to support development of final rates for fiscal year 2005. For the period from October 2004 to September 2006, the average heavy-load hour rate was 19.7 percent higher than the corresponding light-load hour rate.

This trend of narrow differentials is expected to persist into the future with falling (or at least steady) heavy-load hour – light-load hour differentials. Gas fired resources are generally on the margin in determining electricity prices in the Northwest. As replacement power projects come on line and older units are retired, the efficiency differential between the most efficient and the least efficient unit has shrunk. As a consequence, the differential between heavy-load hour and light-load hour prices has also dropped.

Assuming a pumping efficiency of 85 percent and a pump/generation efficiency of 92 percent, for every 1 MW used to pump water into a Black Rock reservoir, 0.78 MW of generation potential would be created. Therefore, to break even simply on an opportunity cost basis, there would need to be a heavy-load hour premium of 28 percent over light-load hour prices. Even though this hurdle rate makes no assumptions about potential head losses that would increase the required heavy-load hour price premium, an examination of the electricity price projections on a month-by-month basis shows few opportunities when pumping would meet this economic test (only 4 of the 24 months in the period were examined). These opportunities would be further limited by nonpower constraints on the FCRPS and the needs of the Black Rock alternative to refill the reservoir during those periods, leaving few, if any, economic pumping opportunities.

BPA did not have estimates for the incremental fixed costs of installing specialized pump generators and other alternative equipment to evaluate the return on investment from such capital expenditures. However, at this time, because the above returns are either negative or zero (based on the foregoing assumptions), pump generation appears financially not viable.

The matter of pump/generation was also discussed with Grant PUD. Grant PUD indicated it is doubtful that investing in pump/generation solely for the purpose of providing load factoring would be economical. It is possible, however, if pump/generation were developed with dynamic capability that was available at all times, there may be opportunities to partner with the Northwest's growing wind industry which has a great need for dynamic shaping services.

8.3.4.2 Generation at Points of Water Discharge

The Black Rock alternative facilities would include a generation plant at the terminus of the Black Rock outlet facility at Roza Canal MP 22.6, and a generation plant at the discharge of the Sunnyside Division water delivery pipeline at Sunnyside Canal. The powerplants would operate only during April through October when water was being delivered to the exchange participants for irrigation purposes. There are two options for each powerplant depending on the water delivery system selected. Section 5.7.3 describes these options. Table 8-11 shows the combination of options and the estimated annual kilowatt-hours (kWh) of energy produced.

Table 8-11. Preliminary new powerplants at points of water discharge

	Black Rock powerplant	Sunnyside powerplant (canal delivery option)	Total
Appraisal-level water delivery plans that discharge all water into Roza Canal			
Design discharge	1,500 cfs	900 cfs	--
Design head	338 feet	221 feet	--
Output at design head	38 MW	15 MW	53 MW
Annual energy produced	180 million kWh	71 million kWh	251 million kWh
Appraisal-level water delivery plans that connect Sunnyside delivery system to a Black Rock outlet facility bifurcation works			
Design discharge	900 cfs	900 cfs	--
Design head	338 feet	435 feet	--
Output at design head	23 MW	29.5 MW	52.5 MW
Annual energy produced	109 million kWh	140 million kWh	249 million kWh

For illustration purposes, the existing 11.25-MW Roza Powerplant operates year-round except when the powerplant is off line due to subordination of hydropower diversions for instream flow maintenance, icing conditions in Roza Canal that preclude delivery of water to the powerplant, or major maintenance. Average annual energy produced at Roza Powerplant over a recent 10-year period would be about 64 million kWh. This compares to a combined output of about 250 million kWh for these two new powerplants.

Findings: New hydropower facilities at the discharge of Columbia River water into Roza and Sunnyside Canals would provide about 53 megawatts of new generation capacity.

8.3.4.3 Transmission Facilities

The Black Rock alternative would be interconnected to the existing power transmission system in the area. This would require new facilities as well as the expansion and reinforcement of the surrounding transmission system that would serve the additional power load.

BPA has developed technical requirements for interconnecting lines and loads to ensure the safe operation, integrity, and reliability of the transmission system.[10] These technical requirements include performing technical studies such as power flow, voltage stability, and transient stability. These technical requirements would need to be completed prior to the interconnection of the Black Rock alternative. Until these studies are completed, the extent of the system expansion and reinforcement is unknown.

8.3.5 Columbia River Treaty and Operating Agreement Impacts

At this time, it is difficult to assess how the Black Rock alternative would impact the Columbia River Treaty (Treaty) and other arrangements because these agreements are complex, the demands being placed on the multi-purpose river system are changing, and the Black Rock alternative has undefined elements. There are, however, two particular issues that could potentially arise.

1. While operation of the Black Rock alternative itself would be an irrigation depletion that, to a large extent, returns to the Columbia River via Yakima River flow, initial filling of the inactive storage space in Black Rock reservoir would remove water from the Columbia River system. This would represent not only an additional one time impact to the other uses of the system (particularly flows for nonpower purposes and power production), but could also create issues for implementation of Treaty flows and the Pacific Northwest Coordination Agreement. The magnitude of these issues is unclear at this time.

2. The operational impacts of the Black Rock alternative could not be translated into Treaty studies for a considerable period because of the lag associated with collecting actual data and the modeling process dictated by Treaty requirements. The Columbia River Treaty Assured

[10] Technical requirements are identified in BPA's document DOE/BP-3183 which can be accessed at http://www.transmission.bpa.gov/PlanProj/LineLoadCon.pdf

Operating Plan is created 6 years in advance. These studies are informed by inputs on irrigation depletions, irrigation returns, and river flows based on collection of actual data once every 10 years. The Black Rock alternative would affect these assumptions (for example, the flow forecast at The Dalles Dam would likely be impacted to some degree by issues such as evaporation at the new reservoir), and it would take several years of Black Rock operation for these effects to appear in the actual data. Because of this lag, the actual effects of the Black Rock alternative on Treaty operations might not be fully reflected in the determination of Treaty benefits and optimization for 15 to 20 years. At this stage, it is difficult to surmise whether this lag would create issues for either the United States or Canada, or whether there would be remedies available to an impacted party.

8.4 Columbia River Fish and Wildlife Issues

8.4.1 Existing Fishery Resources

Fisheries information extracted from Grant PUD relicensing application [20] provides the basis for information contained in this section. The fish community in the vicinity of Priest Rapids Dam is composed of more than 40 species, including individuals from 14 of the 24 recognized families of North American freshwater fisheries. Among these species are both resident and anadromous fisheries, including two anadromous salmonid populations listed as endangered under ESA (spring Chinook salmon and summer steelhead) and one resident salmonid (bull trout) listed as threatened.

8.4.1.1 Anadromous Fish

Six anadromous fish species are known to inhabit or migrate through the Priest Rapids Dam area. Four of these species are classified as anadromous salmonids, including spring, summer, and fall Chinook salmon, summer steelhead, coho salmon, and sockeye salmon. Of these, only fall Chinook salmon are known to both spawn and actively rear within the area. Spring and summer Chinook salmon, steelhead, coho, and sockeye salmon migrate through the area as adults returning to upriver spawning areas, while smolts travel through on their downstream migration. Pacific lamprey follow migratory patterns similar to those of the anadromous salmonids. American shad is an introduced species that is currently restricted to the Columbia River downstream from Priest Rapids Dam because they do not use the submerged openings into the Priest Rapids fishways. With the exception of American shad, the species listed above are considered endemic to the Columbia River and culturally, economically, and commercially important.

Anadromous salmonid adults migrate through this area from April through November, although steelhead may overwinter in the area and show some movement during winter and early spring. Juvenile salmon and steelhead move through during spring and summer months, with most migrating downstream during the April through June time period. The migration of fall and summer Chinook salmon is typically later in the summer, with yearling Chinook salmon moving during the June through August time period.

The most abundant anadromous fish has been sockeye salmon, with returns averaging about 60,000 per year for the 42-year record of Priest Rapids Dam counts (1960-2002). Average returns of steelhead, and spring, summer, and fall Chinook salmon are somewhat similar, with abundance for these runs averaging 10,000 to 20,000 fish per year. Average abundance of Pacific lamprey is particularly difficult to determine, but appears to be the lowest level of anadromous fish returning to the mid-Columbia River.

A large population of fall Chinook salmon spawns in the Hanford Reach of the Columbia River downstream from Priest Rapids Dam.[11] The abundance of this stock has been increasing in recent years and is considered one of the healthiest inland stocks of Chinook salmon in the Pacific Northwest. From 1964 to 1982, the average escapement of fall Chinook salmon to the Hanford Reach was about 25,000; whereas from 1983 to 1996, the average escapement nearly doubled to about 50,000. From 1983 to present, the Vernita Bar Agreement provided stable spawning flows and ensured that minimum flows would keep a very high percentage of the redds covered through emergence. At about the same time, the original Priest Rapids spawning channel was converted to a conventional hatchery that releases nearly eight million high-quality fall Chinook salmon smolts annually. Many of these hatchery fish are known to spawn in the wild upon return, as the hatchery is immediately adjacent to one of the largest spawning areas at Vernita Bar.

8.4.1.2 Resident Fish

Although salmon and steelhead are widely regarded as the most important species in the Pacific Northwest, there is a growing interest among sport fishermen in the fish species that live their entire lives in freshwater. Resident fish in the vicinity of Priest Rapids Dam are a diverse mix of species native to the Columbia River and a variety of game and nongame species that were either accidentally or intentionally introduced to the Columbia River or its subbasins.

Resident fish species are important for a variety of reasons. Game fishes, such as walleye and smallmouth bass, support a recreational fishery. A large number of nongame fishes have importance in the Columbia River's ecology and food web and may be indicator species that demonstrate the basic condition of the river ecosystem. Northern pikeminnow, walleye, and smallmouth bass are known to negatively impact anadromous salmonids through predation on smolts.

A total of 38 resident fish species are known to occur in the Priest Rapids Dam area. These include native game fish, with rainbow trout and mountain whitefish being the most common; native nongame fishes such as the northern pikeminnow; introduced game fishes such as smallmouth mouth bass and walleye; and introduced nongame fishes.

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[11] Adult Chinook salmon returning to pass Priest Rapids Dam from August 14 through November 15 are classified as fall Chinook salmon.

8.4.2 Wildlife and Habitat Resources

If the Black Rock alternative proceeds to the next phase of the Storage Study, Reclamation would initiate wildlife and habitat resource inventories in the Black Rock area and would include specific resources that potentially could be affected by the Black Rock alternative, such as:

- the sage grouse, which the U.S. Fish and Wildlife Service is considering listing as threatened under ESA
- the Hanford National Monument area and its proximity to the Black Rock site.

8.4.3 Fish and Wildlife Issues and Data Needs

Reclamation initiated studies to address fish and wildlife resource issues associated with alternatives that may result from the Storage Study. One such study originated from a request to the Washington Department of Fish and Wildlife (WDFW) to identify fish and wildlife issues the Storage Study should address. WDFW responded with a 45-item list.

Reclamation next initiated a process for reviewing, screening, and refining the WDFW list. The intended result was to identify significant issues that would serve as the foundation for fish and wildlife analyses and impact assessment. To guide this process, Reclamation defined a fish or wildlife issue as significant if the resource response: (1) is anticipated to be measurable (i.e., either a positive or negative change from existing conditions) and (2) could be linked to more or less water in the Columbia or Yakima River systems resulting from implementation of some aspects of the Storage Study.

The basic approach was to identify and define significant issues involved using the knowledge and expertise of the Biology Technical Work Group (Work Group) in a collaborative workshop environment. The Work Group consists of technical representatives from NOAA Fisheries, U.S. Fish and Wildlife Service, WDFW, Ecology, the Yakama Nation, Yakima Basin Joint Board, Yakima Sub-Basin Fish and Wildlife Planning, and Reclamation's Upper Columbia Area Office (UCAO) and Technical Service Center. The goals of the workshops were:

- to identify and define significant fish and wildlife resource issues that may be associated with developing Black Rock reservoir, Bumping Lake enlargement, Wymer reservoir, Keechelus to Kachess pipeline, (these are all Storage Study alternatives) or some combination of the identified features that result in additional water storage.
- to identify for significant resource issues those questions: (a) for which there is adequate information for proper analysis and existing basic technical data references, and (b) requiring additional information before proceeding with proper analysis.

The Work Group met for two half-day workshop sessions (in March and April 2004) at Reclamation's UCAO in Yakima, Washington. Workshop participants received material initially developed by the WDFW and other information. During the workshops, key points were captured on flip charts and as notes on copies of the WDFW materials. Various project maps and charts were available for reference material. The process was basically an expert workshop approach where members of the Work Group discussed topics of concern and used their expertise to identify and define issues that should be addressed in the Storage Study.

The Work Group transformed the 45-item list into 16 significant fish and wildlife issues, 7 of which would be associated with the Columbia River water exchange. Nine Yakima River basin issues would be associated with changes in Yakima Project operations due to use of the freed-up water realized from the water exchange or from additional inbasin storage. These 9 issues in the Yakima River basin would be affected by other Storage Study options, as well as by the Black Rock alternative, and are, therefore, not discussed in this Summary Report. This issues list likely would change as the Storage Study progressed, additional discussions occurred, and new information developed. Six of the 16 fish and wildlife issues relevant to the potential pumping of Columbia River water from Priest Rapids Lake and storage in a Black Rock reservoir are:

- How would withdrawal of water from Priest Rapids Lake affect water temperature and water chemistry parameters, and how far would such effects extend within Priest Rapids Lake and downstream?
- How would withdrawal of water from Priest Rapids Lake affect anadromous fish spawning and rearing habitat, fry and juvenile stranding, and passage and migration?
- How would withdrawal of water from Priest Rapids Lake affect resident fish spawning and rearing habitat?
- How would withdrawal of water from Priest Rapids Lake affect fish mortality at the intake site?
- How would Black Rock reservoir seepage and groundwater affect the movement of contaminated groundwater at the Hanford Site into the Columbia and lower Yakima Rivers?
- How would construction and the presence of a Black Rock reservoir affect the loss of shrub-steppe habitats, the potential for isolation of local wildlife populations, and disruption of movement corridors?

An issue related to the Yakima River basin would be the use of the stored Black Rock reservoir water by potential water exchange participants. This issue is associated with the substitution of Columbia River water for irrigation purposes in exchange for some current Yakima River diversions.

- How would storage and delivery of Black Rock reservoir water to the lower Yakima River basin affect false attraction of Columbia River anadromous salmonids into Yakima River locations?

The workshops also produced several recommendations concerning the data necessary to assess resource issues. Major data requirements for issues associated with the Columbia River and a Black Rock reservoir include:

- Current monthly hydrology data for Priest Rapids Lake and the Hanford Reach of the Columbia River are needed and likely exist. These data should be compared to projected hydrographs resulting from pumping scenarios for a Black Rock reservoir and incorporated into additional modeling.

- A detailed water quality assessment, including temperature analyses, of Priest Rapids Lake and the Hanford Reach under current and future conditions is needed. Again, current information likely exists, but some additional modeling may be required to characterize future conditions.

A water quality study would first require a determination of the zone of influence within Priest Rapids Lake and perhaps downstream that would be affected under various pumping scenarios.

- Information is needed on the water quality characteristics of the groundwater underlying the Hanford Site and whether there are any contaminants of concern. An assessment of the volume of water that would be lost by leakage from a Black Rock reservoir is needed and estimates of how, or if, this could affect movement of groundwater and the possibility of increased loading in the Columbia and Yakima Rivers. Well data are available, but additional modeling may be required.

The *Defining Fish and Wildlife Resource Issues for the Yakima River Basin Water Storage Feasibility Study,* August 2004, report [21] more fully describes the above Storage Study activities. It briefly discusses these requirements and presents details of the issues, data requirements, and potential approaches to various analyses.

In conclusion, the initial steps have been accomplished to identify and define significant fish and wildlife issues and data needed to assess these issues. A list of fish and wildlife issues has been identified with the assistance of the WDFW, their initial listing of concerns associated with the Black Rock alternative, and the efforts of the Work Group. Reclamation must determine the extent of additional data collection and modeling effort required to address the issues and provide direction for assessment.

Findings: Six significant fish and wildlife issues in the vicinity of a identified Priest Rapids Lake diversion and Black Rock reservoir area have been identified. A seventh issue relates to the concern that Columbia River water used to irrigate water exchange participants' lands could enter the Yakima River as surface and subsurface return flows, which might result in false attraction of Columbia River salmonids into the Yakima River.

8.5 Cultural Resources

8.5.1 Cultural Context

The cultural context of the potential Black Rock site is not well documented. Based on adjacent locales with a legacy of systematic historical and archeological investigations, the Black Rock Valley would likely share a rich cultural heritage with its neighboring regions. Ethnographically, the expanse of the Columbia River above its juncture with the Snake River and the hinterlands adjacent to the river on either side, was home to speakers of the Echeesh-Keen language (formerly known as Sahaptin). Today, these people refer to themselves as Echeesh-Keen Sinwit, although to nonnative people, they are known as the Yakama.

The legally recognized Yakama Nation consists of 14 tribes and bands who were combined socially and politically following the Walla Walla Treaty of June 9, 1855. The 1855 Treaty ceded lands are affected by a potential Black Rock reservoir. The Yakama Nation governing Tribal Council, located at the Yakama Nation Reservation headquarters at Toppenish, speaks for and manages the interests of the constituent 14 tribes and bands.

To understand the cultural heritage of the Black Rock area, it is important to learn about the Wanapum, one of the 14 bands and tribes. The Black Rock reservoir area ceded lands are the home territory of the Wanapum band. Historically, Wanapum shared a language, fisheries, lifestyle, resource procurement strategies, and relatives with nearby Yakama peoples. Although the Wanapum band has been successful asserting a separate identity, they do not have Federal recognition as a tribe. Most Wanapum are enrolled Yakama, while others are enrolled in other tribes. The trust relationship between the Wanapum and the Federal government is indirect and through the membership Wanapum individuals have in federally recognized tribes.

No systematic archeological surveys have been conducted in the Black Rock Valley; therefore, no definitive statements regarding expectations about cultural resources can be made at this time. The Army Training Center, in an environment and landscape analogous to the Black Rock Valley north of Yakima Ridge, has undergone various levels of cultural resource surveys and test excavations over the past 20 years. Archeological research has been intensive the past few years on the Columbia River as a requirement for the Grant PUD's relicensing of the Wanapum and Priest Rapids hydroelectric projects. Further systematic archeological research has occurred immediately downstream on the Department of Energy's Hanford Site. This research reveals that a diversity of site types, as well as sites of great antiquity, are present in the region. A presumption for a similar archeological record can be made for the Black Rock Valley.

Lands in the Black Rock site are currently in private ownership but have been used in the past by native peoples. Systematic research and cultural resource surveys of the alternative area are needed to identify such use.

8.5.2 Managing Cultural and Historic Resources

Because the cultural context of the potential Black Rock site is not well documented, investigations and studies to identify, evaluate, and manage cultural and historical resources would be conducted if the Black Rock alternative proceeds to the next phase of the Storage Study.

The size of the potential storage facility and associated impacts, the relationship of the Black Rock site to the Columbia River and Indian ceded lands, the Holocene geomorphology, and the high site density in nearby locales are indicators of a high level of complexity in the cultural and historic resources. In addition, these factors predispose the Black Rock alternative to a high level of interest and scrutiny from Indian tribes, State and Federal partners and reviewers, the professional historic preservation community, and the public.

Further investigations and studies could include the following:

- Class I survey, which is preparation of a historic resources and ethnographic overview
- Class III survey, which is a field survey to identify sites and traditional cultural properties
- Evaluate those sites or properties for eligibility to the National Register of Historic Places
- Develop mitigation measures at eligible properties that cannot be avoided by alternative actions
- Post-project site management, interpretation, and stewardship.

The sequence of study activities would most likely be scheduled as follows:

1. Conduct the Class I overview survey, Class III field reconnaissance, and the traditional cultural properties inventory as a single activity.
2. Conduct investigations at selected historic properties (based on the Class III survey) for their eligibility to the National Register.
3. Conduct data recovery operations at those properties determined eligible for the National Register but that cannot be avoided by construction and operation activities.

One objective of the above work would be to identify the cultural resource and ethnographic information necessary for input into the environmental impact statement phase of the Storage Study.

Findings: The Black Rock Valley area is likely to have a rich cultural heritage similar to its neighboring regions. Extensive investigations are necessary to identify and evaluate cultural resources.

8.6 Recreation

The Yakima River basin currently provides a wide variety of water-based recreation activities enjoyed by local and regional residents. The Black Rock alternative could enhance these activities by providing increased streamflows, higher reservoir elevations at existing reservoirs, and new reservoir storage. Each of these effects could vary as to recreational benefits depending on Reclamation’s operational procedures for Yakima Project.

The Storage Study has not progressed to the point of evaluating recreational benefits associated with the Black Rock alternative. Initial discussions have taken place among Reclamation staff and representatives of Washington State agencies involved in recreation programs. There is agreement that data collection and studies are needed, particularly with respect to existing and future demand for flat-water related recreation activities in the Yakima River basin. State agencies have agreed to participate in these activities if the Black Rock alternative proceeds to the next phase of the Storage Study.

Findings: A Black Rock reservoir could create flat-water recreation opportunities resulting in monetary benefits to the local and regional economies. The extent to which recreational use of the reservoir might be a substitution for, or a displacement of, other regional recreation sites must be assessed.

9.0 Further Black Rock Alternative Investigation Needs

WIS's work conducted to date for Benton County, and Reclamation's work, indicates importing Columbia River water to the Yakima River basin for a water exchange with some lower basin irrigation entities would restore instream flow conditions to some semblance of the natural (unregulated) hydrograph, would improve dry-year water supply conditions for junior irrigation water rights, and would provide additional surface water supply for municipal growth.

A purpose of this Assessment was to complete many technical studies to respond to fundamental questions for the Black Rock alternative. The findings of the technical studies are included in the text of this Summary Report. While many of the questions have been answered, some of the questions require further investigations, if the Black Rock alternative proceeds to the next phase of the Storage Study.

9.1 Technical Viability of the Black Rock Alternative

The following discussion identifies specific questions followed by a brief response as organized by the major aspects of the Black Rock alternative.

9.1.1 Exchange Water

Have potential water exchange participants been identified?

> **Response**: Yes, Roza and Sunnyside Divisions of the Yakima Project and Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts are potential water exchange participants.

Can Columbia River water physically be delivered to the potential exchange participants?

> **Response**: Yes. The Black Rock alternative could physically deliver Columbia River water to Roza Canal.

Have the potential water exchange participants committed to an exchange?

> **Response**: No, but they have indicated a willingness to proceed. A commitment requires defining terms and conditions addressing such items as water service contracts and water rights, reimbursable and nonreimbursable project costs, and operational conditions and costs.

Has the block of exchange water needed to meet the study goals been identified?

> **Response**: No, the block of exchange water used in this Assessment is the amount that would fulfill the entire water rights of Roza and Sunnyside Divisions, Terrace Heights and Union Gap Irrigation District, and most of the water rights of Selah-Moxee Irrigation District. While the amount of exchange water needed to meet the dry-year irrigation goal

of Yakima River basin irrigation entities with junior rights is known, the amount could change depending upon which irrigation entities actually participate in an exchange. Also, the amount required for the instream flow targets is unknown at this time. The hydrographs in section 8.1 show how this specific block of exchange water could be managed to best mimic the natural (unregulated) hydrograph. Future investigations are necessary to identify fishery habitat improvements, production, escapement, and ultimately, fishery monetary benefits associated with blocks of exchange water. These investigations would help arrive at a preferred Black Rock water exchange concept and alternative configuration.

9.1.2 Water Supply

Is Columbia River water available to divert?

Response: Yes, there is water in excess of current instream flow targets in the Columbia River. However, preliminary information provided as a part of the State's Columbia River Initiative (which is being referred to the 2005 State Legislature) suggests no diversions from April 1 through August 31 of each year without payment into a mitigation account. Therefore, it may be desirable to reexamine the water availability assessment [3] to determine if there is adequate supply for diversion to a Black Rock reservoir outside of these months.

Can State authorization for diversion of Columbia River water be obtained?

Response: This is unknown at this time. Washington State needs to address Columbia River water policy.

Are the Columbia River and Yakima River hydrologic models compatible to determine the net streamflow effects of Columbia River diversions to a Black Rock reservoir?

Response: No, the Columbia River hydrologic model uses the 1929-1978 historic period of record while the Yakima River model uses the 1981-2003 historic period of record. This difference makes it difficult to determine the exact impacts of the exchange on Columbia River flows downstream from the mouth of the Yakima River. Future work would include making the models compatible with similar periods of record.

9.1.3 Pump/Generation

Is pump/generation financially viable?

Response: Financial viability of pump/generation is unknown at this time. Information provided to date indicates that pump/generation would not be financially viable. However, exchange proponents have considerable interest in pump/generation for possible use with wind energy. Specific work could be undertaken regarding operating a Black Rock reservoir in pump/generation mode, sizing of a pumping plant for reservoir refill to ensure the delivery of exchange water, and the marketability of generated power.

9.1.4 Storage Dam

Is there a viable damsite in Black Rock Valley?

Response: Yes, however, it may require extensive excavation of material (possibly up to a depth of 200 feet) to provide a suitable dam foundation. Further geologic exploration is needed to better define the depth to bedrock.

Is there potential for major earthquakes at this damsite?

Response: Yes. The initial assessment of the level of earthquake ground motion that the Black Rock damsite could experience identified several areas of uncertainty in the seismic hazard conclusions. These uncertainties include details of the geologic structure and ages of faulting and folding. Further investigations of the Black Rock Valley fault and the Yakima Fold Belt are needed to guide future engineering decisions for design of a storage dam and related facilities.

Has the type of storage dam most suitable for this site been determined?

Response: Yes. Appraisal-level cost estimates for the rockfill embankment dams are significantly lower than the cost estimates for the roller compacted concrete dams; therefore, the roller compacted concrete dams should be removed from further evaluation. Also, there is not a significant cost difference between the concrete face rockfill and central core rockfill embankment dams. Both of these embankment dams should receive further evaluation.

9.1.5 Reservoir

Has the preferred design for conveying Columbia River water to the reservoir been determined?

Response: Yes, the appraisal-level cost estimate for the all tunnel inflow conveyance system is significantly less than the cost estimate for the tunnel/pipeline inflow conveyance system; therefore, only the all tunnel option should receive further evaluation.

Can the reservoir basin retain stored water?

Response: This is unknown at this time. The Pomona Basalt Formation appears to be a hydraulic barrier to downward seepage, at least at the site of the initial hydrologic testing. However, if vertical joints and fractures exist in the Pomona Basalt elsewhere in the reservoir basin, significant leakage from the reservoir could occur. Should reservoir leakage reach the geologic units that underlie the Pomona Basalt, there could be significant regional effects on the groundwater system. Future investigations would include working with the Pacific Northwest National Laboratory to estimate potential leakage and the impact to the Hanford Site. Further investigations are necessary to characterize the leakage potential of geologic units around the reservoir site.

In addition, current information indicates permeable geologic units may be exposed or covered only by a thin soil layer on the dam abutments and reservoir rim. Depending on the structure and fracturing of these units, significant reservoir leakage could occur.

Exploratory drilling is required along the reservoir rim to determine the geologic structure of the potential leakage areas. Further hydrologic testing is also required within the reservoir basin to substantiate the hydrologic conditions within the Pomona Basalt.

Have the reservoir size and pump capacity been determined?

Response: The exact reservoir size and pump capacity are unknown at this time. The appraisal-level cost estimates for the large reservoir pump only option (1,300,000-acre-foot active capacity with 3,500-cfs pump capacity) and the small reservoir pump only option (800,000-acre-foot active capacity with 6,000-cfs pump capacity) are the same. Both reservoir sizes should receive further evaluation. Further analysis of the extent of the water exchange, timing of Columbia River water availability and diversions, economics, and other aspects would help refine the most desirable storage/pump option.

9.1.6 Irrigation Delivery Systems

Have plans been developed for delivery of exchange water to potential exchange participants?

Response: Yes. However, there are still questions regarding the type and extent of the systems. There is a need to maintain the existing systems to allow diversion of Yakima River March flood waters for system priming and for use in an emergency should there be an extended outage of the Black Rock alternative facilities. Three upstream delivery plans and two downstream plans should receive further evaluation.

Is hydropower generation viable within the irrigation delivery system?

Response: Yes. These facilities appear technically viable, but no analysis has been prepared to determine their financial viability. Power generation sites are identified at the delivery locations of the Black Rock alternative water to both Roza and Sunnyside Canals. At the delivery location to Roza Canal, hydraulic capacities were identified for a 1,500-cfs and a 900-cfs powerplant. The powerplant field construction cost difference between the two capacities is less than 2 percent. The hydraulic capacity of a powerplant at Sunnyside Canal would be 900 cfs. All three powerplant options should receive further evaluation.

9.1.7 Cultural Resources

Are the cultural resources of the Black Rock site known?

Response: No, further work is necessary to develop a historic and ethnographic overview of the area. Then the appropriate field surveys would be conducted to identify and evaluate sites and cultural properties. This work would be accomplished in cooperation with the Yakama Nation and other interested entities.

9.1.8 Fish and Wildlife Resources

Have potential fish and wildlife issues associated with the Black Rock alternative been identified and evaluated?

Response: Yes. Potential fish and wildlife issues have been identified. The most significant issue appears to be the potential for false attraction of migrating Columbia River salmonids into the Yakima River basin. This is associated with the use of Columbia River water as an exchange irrigation water supply and the possible effects of surface and subsurface irrigation return flows entering the Yakima River.

9.1.9 Cost Estimates

Have annual operation and maintenance costs for the Black Rock alternative been determined?

Response: No. Annual costs for operation and maintenance of potential Black Rock facilities would be developed to compare storage alternatives.

Are the field construction cost estimates presented in this Summary Report of adequate detail to establish an alternative cost ceiling?

Response: No. The field cost estimates presented in this Summary Report are appraisal level based on available, but limited, field data and preliminary designs. The field costs were estimated for the purpose of screening facility options and developing preliminary configurations of the Black Rock alternative. Additional costs (termed noncontract costs) would be incurred once a proposed Federal water resource project was authorized and construction appropriations were provided by Congress. Further field investigations and design data development are necessary to prepare feasibility-level total project cost estimates that would become the basis for determining a project cost ceiling for project authorization.

9.1.10 Economic Justification and Financial Viability

Has the economic justification of the Black Rock alternative been determined?

Response: No. Economic justification involves comparison of estimated alternative benefits and costs. Work has begun on the benefit unit values, but the final values have not been determined.

Has the financial viability of the Black Rock alternative been determined?

Response: No. Financial viability involves a cost allocation to determine reimbursable and nonreimbursable project costs and the manner of repayment of reimbursable costs. A cost allocation requires estimated benefits associated with each project purpose. As indicated above, project benefits have yet to be determined.

9.2 Conclusions

This Assessment has identified no technical reason to eliminate the Black Rock alternative from further investigation. Studies to date have identified several areas of uncertainty and concern that must be examined further. Of concern is the question of potential reservoir leakage. The results of further examinations could have negative implications as to the Black Rock alternative viability or costs.

Based upon currently available information and the appraisal-level designs prepared for this Assessment, it is reasonably certain the construction of facilities to pump, store, and deliver Columbia River water to willing exchange participants in the Yakima River basin would be technically viable.

If the Congress provides funding for the Storage Study beyond fiscal year 2005, the Storage Study plan formulation phase would compare all potential storage opportunities (such as a Bumping Lake enlargement, a new Wymer dam and reservoir, and a Keechelus to Kachess pipeline), and a viable alternative(s) would be selected for the feasibility phase. Whether the Black Rock alternative would be among the alternatives examined in the plan formulation phase would depend upon whether Reclamation decides to carry that alternative forward. The feasibility phase, the last phase of the Storage Study, would include detailed evaluation of selected alternative(s) to meet the Study Storage objectives in terms of engineering, economic and environmental considerations, and cultural and social acceptability. Preparation of the Feasibility Report/Environmental Impact Statement would be a part of this final phase.

10.0 References

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Appendix A

Reclamation’s December 28, 2004, letter requesting a Columbia River water withdrawal

United States Department of the Interior

BUREAU OF RECLAMATION
Pacific Northwest Region
1150 North Curtis Road, Suite 100
Boise, Idaho 83706-1234

IN REPLY
REFER TO:

DEC 28 2004

PN-1000
WTR-4.10

OVERNIGHT EXPRESS

Mr. Joe Stohr
Water Resource and Program Manager
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Subject: Withdrawal of Water for Yakima Basin Storage from the Columbia River Basin

Dear Mr. Stohr:

Please take notice that pursuant to the Act of Congress of June 17, 1902, (32 Stat.388), and acts amendatory thereof and supplementary thereto, the United States intends to make examinations and surveys for the utilization of the unappropriated waters of the Columbia River and its tributaries as may be required for operation of storage and distribution facilities under the Act of February 20, 2003 (PL 108-7). These examinations and surveys are more commonly referred to as the Yakima Basin Storage Study.

The United States provides the foregoing notice pursuant to the Revised Code of Washington section 90.40.030 with the understanding that those waters will not be subject to appropriation by others during the initial period stated in said section, and during such further time or times after said period as may be granted thereunder.

Please take further notice that the list of lands attached hereto, identified as Exhibit "A" and made part hereof is a list of lands owned by the State of Washington, over and upon which the United States requires rights of way for canals, ditches, laterals and sites for reservoirs and structures appurtenant thereto, along with such additional rights of way and quantities of land as may be required for the operation and maintenance of the completed works for the proposed Black Rock project. Please file this notice, together with the attached list, in your office, as a reservation from sale or other disposition of such lands, so described, by the State of Washington.

Should you desire any further information concerning the proposed use of these waters by the United States, please feel free to contact me and I will furnish it to you promptly.

Sincerely,

J. William McDonald
Regional Director

Enclosure

cc: Mr. Doug Sutherland
Commissioner of Public Lands
Washington Department of Natural Resources
P.O. Box 47001
Olympia WA 98504-7001

Exhibit A

List of Washington State lands to be withdrawn under RCW 90.40 related to the Black Rock Project

Legal descriptions below encompass, but are not necessarily co-extensive with Washington State lands.

All of Section 16	T 11 N, R 23 E, W.M.
All of Section 20	T 11 N, R 23 E, W.M.
S1/2 N1/2 Section 16	T 12 N, R 20 E, W.M.
All of Section 16	T 12 N, R 21 E, W.M.
NE1/4 Section 27	T 12 N, R 21 E. W.M.
SE1/4 SE1/4 Section 13	T 12 N, R 22 E, W.M.
N1/2 Section 30	T 12 N, R 22 E, W.M.
All of Section 16	T 12 N, R 23 E, W.M.
All of Section 36	T 13 N, R 23 E, W.M.
N1/2 N1/2 Section 2	T 14 N, R 23 E, W.M.
S1/2 Section 35	T 14 N, R 23 E, W.M.

Appendix B

Washington Infrastructure Services, Inc.'s review comments on Reclamation's *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates, Final Report, Technical Series No. TS-YSS-2*

Reclamation's explanation of the differences in table 7-2 of the Summary Report and WIS's table on "Comparison of WIS and BOR Estimated Costs for Black Rock Reservoir"

Reclamation's field cost estimate of $2.7 billion referred to on the first page of the November 30, 2004, letter from Dick Fotheringham, and shown in column 10 of the table "Comparison of WIS and BOR Estimated Costs for Black Rock Reservoir," is different than the cost shown on table 7-2 of this Summary Report. This is explained as follows:

- The "Subtotal direct costs" on the WIS comparison table is referred to as "Subtotal of pay items" in table 7-2.
- The cost differences between the two tables are:

Feature	WIS Comparison Table Column 10	Reclamation's Table 7-2 Large Reservoir Pump/Generation Option
Direct cost	$1,888,566,350	
Black Rock dam		- $41,216,000[12]
Sunnyside powerplant and bypass		+$32,302,450[13]
Difference		-$8,913,550
Subtotal of pay items		$1,879,652,800
Mobilization	$95,000,000	$94,600,000
Unlisted items	$186,433,650	$182,747,200
Contingencies	$530,000,000	$540,000,000
Subtotal	$811,433,650	$817,347,200
Total field cost	$2,700,000,000	$2,697,000,000

[12] Reclamation used the central core rockfill dam in its three project configurations while the WIS comparison table shows the concrete face rockfill dam

[13] The WIS comparison table does not include the Sunnyside powerplant and bypass which Reclamation included at Sunnyside Canal MP 3.83.

PRJ2.4

Washington Group International
Integrated Engineering, Construction, and Management Solutions

November 30, 2004

Mr. Kim McCartney
U S Department of the Interior
Bureau of Reclamation
Upper Columbia Area
1917 Marsh Road
Yakima, WA 98901

SUBJECT: Yakima River Basin Water Storage Feasibility Study
Black Rock Project
Review of Project Cost Estimate

Dear Mr. McCartney:

This letter responds to your request to review and comment on the Bureau's estimated cost to implement a water exchange scheme involving pumping water from the Columbia River to a new reservoir in Black Rock Valley including an outlet system that would deliver water from the Black Rock Reservoir to a portion of the existing irrigation system within the Yakima Valley. For this review, Washington utilized a "Draft Final" version of the Bureau report, "Black Rock Project Facilities and Cost Estimate for Black Rock Project Assessment Draft Report of Findings," dated August 20, 2004.

Washington Infrastructure Services (WIS), under contract to Benton County, completed a reconnaissance level study of multiple alternative arrangements to supply water from the Columbia River to the Black Rock Reservoir and the Roza Irrigation District in May 2002. Subsequently, the Bureau performed a pre-feasibility study for a scheme of which the general characteristics are very similar to the recommended scheme developed by WIS. The estimated cost, in 2002 dollars of the WIS recommended scheme is $1,569,675,000; with the addition of mobilization for those features that did not have mobilization and escalated to July 2004 dollars (by using the BOR's CCT), the cost is $1,776,446,000. The Bureau's estimated cost for the project, in June 2004 dollars is $2,700,000,000, or $923,554,000 higher than the WIS cost estimate adjusted to the same timeframe (and mobilization).

Attached is a two-page "Review of Cost Estimates" summary that discusses the four largest cost differences between the two estimates. In addition, the attached spreadsheet table, titled "Comparison of WIS and BOR Estimated Costs for Black Rock Reservoir" shows original and adjusted WIS estimated values, and differences between WIS and BOR values for features of the Black Rock Reservoir Project. In summary fashion, these differences, from the largest to the least, are as follows:

Mr. McCartney
November 17, 2005
Page 2

Mobilization, Unlisted Items and Contingencies	$416,460,035
Concrete Faced Rockfill Dam:	$286,559,043
Priest Rapids Pump/Generator Plant	$100,318,302
Roza Canal Outlet Facility	$ 78,877,202
Total, Four Largest Items	$882,214,582

The Bureau uses a larger contingency than did WIS in the first item. This reflects the Bureau's practice. For the Concrete Faced Rockfill Dam, the WIS estimate is based on an assumed excavation depth of 20 feet to the foundation level; this was increased after subsurface explorations showed a potential depth to foundation level of 200 feet. The WIS estimate was not adjusted for this situation that was identified after the WIS Final Report had been issued. Much of this increased is due to the difference in the depth to the foundation and is therefore a requirement.

For the Priest Rapids Pump/Generator Plant, the Bureau utilized a larger facility with more units than did the WIS arrangement, resulting in a significant cost difference. The Bureau's design represents what they would build. Similarly, the Roza Canal Outlet Facility is larger and more sophisticated than that provided by WIS. The Bureau design represents what they believe is necessary to discharge the water into the irrigation systems.

This review is not designed as a challenge to the Bureau's arrangement. Most of the cost differences involve the manner by which the Bureau decided to design each facility, and the magnitude of contingency they have assigned to the estimate. Only the dam cost increase can be explained primarily as the result of a change in knowledge about the site and what is required to construct a large dam such as Black Rock.

If you have any questions or comments, please feel free to call me at (425) 451-4566.

Very truly yours,

Dick Fotheringham

Dick Fotheringham
Manager of Engineering

JRF: jrf/Ltr_USBR-11-30-04
Attachments as noted
cc:
Gary Ballew, Benton County Deputy Administrator

BLACK ROCK RESERVOIR

REVIEW OF COSTS ESTIMATES
BETWEEN WASHINGTON INFRASTRUCTURE SERVICES AND
UNITED STATES BUREAU OF RECLAMATION

LARGEST COST DIFFERENCES (Jun/Jul 2004 dollars)

1 - Mobilization, Unlisted Items and Contingencies:

WIS adjusted Estimate:	$394,973,615
USBR Estimate:	$811,434,650
Difference:	$416,460,035

Comments:

a) WIS adjusted Mobilization costs included.

b) USBR utilizes a category, "Unlisted Items" to cover potential items not identified at this stage of the estimate. This is really a form of contingency.

c) USBR utilizes a larger contingency than WIS.

2 - Concrete Faced Rockfill Dam:

WIS adjusted Estimate:	$487,936,957
USBR Estimate:	$774,496,000
Difference:	$286,559,043

Comments:

a) Geotechnical explorations indicating a need to excavate up to 200 feet below grade were not available when WIS made their estimate. WIS estimated a nominal 20 feet of excavation; geotechnical exploration made after WIS report was completed identify a need to go to the greater depth.

3 - Priest Rapids Pump/Generator Plant:

WIS adjusted Estimate:	$125,936,578
USBR Estimate:	$226,254,880
Difference:	$100,318,302

Comments:

a) WIS utilized a two unit arrangement requiring a 160 ft by 50 ft structure.

b) USBR utilized 5 pump units and 2 generating units requiring a 480 ft by 140 ft structure.

c) The USBR design provides a high degree of versatility.

4 - Roza Canal Outlet Facility:

WIS adjusted Estimate:	$ 25,133,333
USBR Estimate:	$104,010,535
Difference:	$ 78,877,202

Comments:

a) WIS utilized a 2 unit arrangement requiring a 86 ft by 65 ft structure.

b) USBR used a single generating unit with 4 energy dissipating valves requiring a 214 ft by 94 ft structure.

c) The USBR arrangement can provide water even if the generating unit is not operating.

Total estimated cost difference among the four biggest items: $882,214,582

COMPARISON OF WIS and BOR ESTIMATED COSTS for BLACK ROCK RESERVOIR

[1] Ref No.	[2] Feature	[3] Original WIS Est. (Oct '01)	[4] WIS Est. Adj by BOR (Jul '04)	[5] BOR Escalation Coln [3] to [4] (Percent)	[6] Escal using BOR_CCT (see Ref)	[7] Ref Row # Escal Factor (See Ref)	[8] WIS Est. w/Escalation Coln [3] X [6] (Percent)	[10] BOR Est. (Jun '04)	[11] BOR Est. minus WIS Esc by BOR to Jul '04	[12] BOR Est. minus WIS Esc by CCI to Jul '04	[13] Comments
1	Priest Rapids Fish Screen & Intake	73,000,000	77,800,000	6.58%	111.40%	#8	81,324,561	64,551,120	-13,248,880	-16,773,441	
2	Priest Rapids Pump/Generating Plant	115,700,000	122,900,000	6.22%	109.36%	#7	125,936,578	226,254,880	103,354,880	100,318,302	
					108.33%	#12					
3	Inflow Convenance (PG Plant to Blk Rock Res)	183,200,000	195,300,000	6.60%	109.38%	#22	200,375,000	186,471,700	-8,828,300	-13,903,300	
4	Black Rock Inlet/Outlet Tower (PG Plant to Blk Rock Res)	89,620,000	98,100,000	9.46%	111.40%	#8	99,839,825	85,565,400	-12,534,600	-14,274,425	
5	Concrete Faced Rockfill Dam	440,100,000	471,200,000	7.07%	110.87%	#2	487,936,957	774,496,000	303,296,000	286,559,043	
6	Spillway/Saddle Dam	620,000	700,000	12.90%	114.15%	#3	707,736	0	-700,000	-707,736	
7	Low Level Outlet Works	30,000,000	32,800,000	9.33%	113.30%	#4	33,991,416	83,494,115	50,694,115	49,502,699	
8	Black Rock Outlet Structure (Blk Rock Res to Roza Canal)	70,000,000	74,600,000	6.57%	111.40%	#8	77,982,456	3,269,850	-71,330,150	-74,712,606	
9	Outflow Conveyance (Blk Rock Res to Roza Canal)	224,300,000	237,400,000	5.84%	107.78%	#17	241,755,253	303,132,750	65,732,750	61,377,497	
10	Roza Canal Outlet Facility	23,200,000	24,700,000	6.47%	108.33%	#12	25,133,333	104,010,535	79,310,535	78,877,202	
11	Project Roads	6,000,000	6,300,000	5.00%	108.15%	#32	6,489,270	57,320,000	51,020,000	50,830,730	
12	Subtotal Direct Costs	1,255,740,000	1,341,800,000	6.85%			1,381,472,385	1,888,566,350	546,766,350	507,093,965	Subtotal Direct
13	Mobilization	0	0			note 1	**39,685,000**	95,000,000	95,000,000	55,315,000	Mobilization
14	Unlisted Items	0	0				0	186,433,650	186,433,650	186,433,650	Unlisted Items
15	Contingencies	313,935,000	335,450,000	6.85%			355,288,615	530,000,000	194,550,000	174,711,385	Contingencies
16	Total Field Cost	1,569,675,000	1,677,250,000	6.85%			1,776,446,000	2,700,000,000	1,022,750,000	923,554,000	Total Field Cost

Column Notes

[1] Reference Number
[2] List of Features
[3] Original Washington Group Conceptual Level Construction Cost Estimates, in October 2001 US Dollars
[4] Values from Coln [3] escalated by BOR to Jun/Jul 2004 US Dollars
[5] Calculation of escalation percentages used by BOR = Coln [4]/Coln[3] - 1.00, expressed as Percentage
[6] Values to escalate Washington Group original estimates from October 2001 to July 2004 (see spreadsheet "BORCCT1.xls")
[7] Reference Row No. in spreadsheet "BORCCT1.xls" that was used for values in Coln [6]
[8] Escalation of Washington Group original Estimate using BOR CCT values given in Coln [6]. Values in July 2004 US Dollars; plus Mobilization Allowance of 5% applied to all features, except I/O Tower (#4) and Conc Faced Rockfill Dam (#5)
[9] Spot check of Feature estimates using escalation rates suggested by A. Binger. Values in July 2004 US Dollars
[10] Bureau of Reclamation (BOR) Cost Estimates in Jun 2004 US Dollars
[11] BOR estimate minus WIS estimate, as escalated by BOR, both estimates in Jun/Jul 2004 US Dollars; Coln[10] - coln [4].
[12] BOR estimate minus escalated WIS estimate (using BOR CCT values), both estimates in Jun/Jul 2004 US Dollars; Coln[10] - coln [8].
[13] Comments

Other Notes

note 1: mobilization, at the rate of 5% of direct cost, added for features 1,2,3,6,7,8,9,10,and 11; features 4 and 5 have mobilization included in the unit rate for those items.

Benton Co. BUREAU OF RECLAMATION CONSTRUCTION COST TRENDS Rev 10/26/04

CONSTRUCTION INDEXES	Escal factor 10/01 to 7/04			
	Oct-01	Jul-04	Ratio Jul 04 to Oct 01	Row Ref
Earth Dams	201	226	112.4%	1
Dam Structure	184	204	110.9%	2
Spillway	212	242	114.2%	3
Outlet Works	233	264	113.3%	4
Concrete Dams	229	251	109.6%	5
Diversions Dams	231	254	110.0%	6
Pumping Plants	235	257	109.4%	7
Structures and Improvements	228	254	111.4%	8
Equipment	247	264	106.9%	9
Pumps and Prime Movers	252	267	106.0%	10
Accessory Elect + Misc. Equip.	240	261	108.8%	11
Powerplants	240	260	108.3%	12
Structures and Improvements	228	254	111.4%	13
Equipment	249	265	106.4%	14
Turbines and Generators	252	267	106.0%	15
Accessory Elect + Misc. Equip	236	257	108.9%	16
Steel Pipelines	257	277	107.8%	17
Concrete Pipelines	231	251	108.7%	18
Canals	224	251	112.1%	19
Canal Earthwork	209	233	111.5%	20
Canal Structures	235	261	111.1%	21
Tunnels	256	280	109.4%	22
Laterals and Drains	243	288	118.5%	23
Lateral Earthwork	206	229	111.2%	24
Lateral Stuctures	263	323	122.8%	25
Distribution Pipelines	232	253	109.1%	26
Switchyards and Substations	235	256	108.9%	27
Wood Pole Transmission Lines	203	231	113.8%	28
Poles and Fixtures	197	232	117.8%	29
Overhead Conductors and Device	213	232	108.9%	30
Steel Tower Transmission Lines	233	254	109.0%	31
Primary Roads	233	252	108.2%	32
Secondary Roads	273	284	104.0%	33
Bridges	257	281	109.3%	34
General Property - Buildings	231	261	113.0%	35
OTHER INDICATORS				
Composite Trend	**236**	**265**	112.3%	36
Machinery and Equipment (BLS)	240	252	105.0%	
Federal Salary	245	280	114.3%	

	2001				2002				2003				2004				2005		
CONSTRUCTION INDEXES	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL	OCT	JAN	APR	JUL
Earth Dams	203	200	200	201	198	198	203	207	209	214	213	214	217	222	226				
Dam Structure	185	183	184	184	180	180	185	188	190	198	194	195	196	200	204				
Spillway	215	212	211	212	209	210	215	220	221	226	225	228	231	238	242				
Outlet Works	233	232	232	233	232	233	238	242	242	246	247	250	253	259	264				
Concrete Dams	231	229	229	229	228	228	232	236	237	240	241	243	245	248	251				
Diversions Dams	229	229	229	231	231	231	234	236	237	241	242	243	244	250	254				
Pumping Plants	232	233	234	235	236	237	239	241	242	244	246	247	248	253	257				
Structures and Improvements	225	225	226	228	228	229	231	233	235	238	239	240	241	249	254				
Equipment	243	244	245	247	249	250	253	253	254	256	257	258	260	262	264				
Pumps and Prime Movers	248	249	250	252	254	255	257	257	258	259	261	261	262	265	267				
Accessory Elect + Misc. Equip.	236	236	238	240	242	242	246	247	248	250	253	254	256	259	261				
Powerplants	237	237	239	240	241	242	245	246	247	249	250	252	253	257	260				
Structures and Improvements	225	225	226	228	228	229	231	233	235	238	239	240	242	249	254				
Equipment	245	245	247	249	250	251	254	255	255	257	258	260	261	263	265				
Turbines and Generators	248	248	250	252	253	254	257	258	258	260	261	263	264	266	267				
Accessory Elect + Misc. Equip	233	233	235	236	238	239	242	243	243	245	247	248	250	254	257				
Steel Pipelines	252	253	255	257	258	259	262	264	266	268	270	271	273	275	277				
Concrete Pipelines	226	227	230	231	232	233	236	237	238	242	243	244	244	248	251				
Canals	222	221	222	224	222	223	226	229	232	237	236	238	239	246	251				
Canal Earthwork	211	209	209	209	205	205	210	213	216	225	220	222	223	228	233				
Canal Structures	231	232	233	235	236	236	239	241	243	246	247	249	250	257	261				
Tunnels	252	253	254	256	256	257	260	261	262	265	266	268	269	275	280				
Laterals and Drains	241	240	241	243	242	243	246	251	255	261	260	262	263	277	288				
Lateral Earthwork	207	205	205	206	203	203	207	211	213	221	217	219	220	225	229				
Lateral Stuctures	260	260	261	263	264	265	268	274	278	284	285	287	289	307	323				
Distribution Pipelines	226	227	230	232	232	234	237	238	239	242	244	245	246	250	253				
Switchyards and Substations	232	231	233	235	235	236	239	240	241	241	243	244	246	251	256				
Wood Pole Transmission Lines	200	200	203	203	201	205	205	205	205	204	206	210	211	222	231				
Poles and Fixtures	189	190	196	197	194	201	200	201	199	197	201	206	207	219	232				
Overhead Conductors and Device:	216	214	214	213	212	212	213	212	214	215	216	217	220	227	232				
Steel Tower Transmission Lines	233	233	233	233	233	233	234	234	234	235	236	236	238	247	254				
Primary Roads	229	228	232	233	231	230	233	235	237	240	241	241	242	248	252				
Secondary Roads	258	260	273	273	264	255	262	264	269	279	280	278	280	282	284				
Bridges	250	251	255	257	257	255	259	261	264	269	270	271	273	278	281				
General Property - Buildings	228	228	230	231	233	234	237	238	238	240	243	246	247	256	261				
OTHER INDICATORS																			
Composite Trend	**234**	**234**	**235**	**236**	**236**	**237**	**240**	**242**	**244**	**247**	**248**	**250**	**252**	**259**	**265**				
Machinery and Equipment (BLS)	240	240	240	240	240	240	242	243	243	245	247	247	247	250	252				
Federal Salary	245	245	245	245	257	257	257	257	268	268	268	268	280	280	280				

APPENDIX B – WIS'S REVIEW COMMENTS