Upper Columbia Alternative Flood Control and Fish Operations

Columbia River Basin

Final Environmental Impact Statement

US Army Corps
of Engineers®
Seattle District

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ACRONYMS AND ABBREVIATIONS

AFS	American Fisheries Society
AOP	Assured Operating Plan
APE	Area of Potential Effect
ATV	all terrain vehicle
BA	biological assessment
BC	British Columbia
BCFN	British Columbia First Nation
BCMWLAP	British Columbia Ministry of Water, Land and Air Protection
BPA	Bonneville Power Administration, Department of Energy
BLM	Bureau of Land Management, Department of the Interior
BSF	Big Sky Fishing
CCT	Colville Confederated Tribes
CDN	Canadian
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CEQ	Council on Environmental Quality
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers, Department of the Army
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRN	Canadian Rockies Net
CRT	Columbia River Treaty
CSKT	Confederated Salish and Kootenai Tribes
CSSR	Coalition for Smart Salmon Recovery
CVWMA	Creston Valley Wildlife Management Area
CWA	Clean Water Act
DEQ	Department of Environmental Quality
DMP	Drought Management Plan
DOE	Department of Energy
DOI	Department of the Interior
DOP	Detailed Operating Plan
DPS	distinct population segment
EA	Environmental Assessment
EIS	Environmental Impact Statement

EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FC	flood control
FCOP	flood control operating plan
FCRPS	Federal Columbia River Power System
FEIS	Final Environmental Impact Statement
FELCC	firm energy load carrying capability
FERC	Federal Energy Regulatory Commission
FR	Federal Register
FRO	Fisheries Resource Office
GEI	GEI Consulting
GIS	geographic information system
HHAPI	Hungry Horse Archaeological Project Investigation
HLH	heavy load hours
HUC	hydrological unit code
HYSSR	Hydro System Seasonal Regulation Program
IBIS	Interactive Biodiversity Information System
ICF	initial controlled flow
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDUPA	Intertie Development and Use Programmatic Agreement
IJC	International Joint Committee
ISAB	Independent Scientific Advisory Board
kcfs	thousand cubic feet per second
KRWSRT	Kootenai River white sturgeon recovery team
KTOI	Kootenai Tribe of Idaho
KVRI	Kootenai Valley Resource Initiative
LLH	light load hours
LRNRA	Lake Roosevelt National Recreation Area
MDEQ	Montana Department of Environmental Quality
MAF	million acre-feet
MFWP	Montana Fish Wildlife and Parks
MOU	Memorandum of Understanding
MW	megawatt

NA	not applicable
NAICS	North American industry classification system
NASS	National Agricultural Statistical Service
NEPA	National Environmental Policy Act
NGVD	national geodetic vertical datum
NHPA	National Historic Preservation Act
NM	no measurements
NMFS	National Marine Fisheries Service, Department of Commerce (NOAA Fisheries or NOAA Fisheries Service)
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NPPC	Northwest Power Planning Council (currently the Northwest Power and Conservation Council)
NPS	National Park Service, Department of the Interior
OAHP	Washington Office of Archaeology and Historic Preservation
ORC	operating rule curve
OY	operating year
PCB	polychlorinated biphenyls
PFMC	Pacific Fishery Management Council
PNCA	Pacific Northwest Coordination Agreement
PPL	PPL Montana
PUD	public utility district
PWC	personal watercraft
RD	regional district
Reclamation	Bureau of Reclamation, Department of the Interior
RI/FS	Remedial Investigation and Feasibility Study
RM	river mile
SAIC	Science Applications International Corporation
SHPO	State Historic Planning Office
SOR	System Operation Review
SRD	storage reservation diagram
SSARR	Streamflow Synthesis and Reservoir Regulation
STI	Spokane Tribe of Indians
TCP	traditional cultural properties
TDG	total dissolved gas
TGG	Transboundary Gas Group

TMDL	total maximum daily load
UPA	updated proposed action
USDA	U.S. Department of Agriculture
USFS	United States Forest Service, Department of Agriculture
USFWS	United States Fish and Wildlife Service, Department of the Interior
USGS	United States Geological Survey, Department of the Interior
VNRP	voluntary nutrient reduction program
WAC	State of Washington administrative code
WDOE	Washington Department of Ecology
WRCC	Western Regional Climate Center
WSF	water supply forecast

EXECUTIVE SUMMARY

Introduction

In accordance with the National Environmental Policy Act of 1969 (NEPA), 42 USC §§ 4321-4370e, this Final Environmental Impact Statement (EIS) assesses the effects of a proposed Federal action and alternatives, which have the potential to significantly affect the human environment. The proposed Federal action consists of:

1. Implementation of alternative flood control operations at Libby Dam on the Kootenai River and Hungry Horse Dam on the South Fork Flathead River. Called variable discharge flood control, this alternative action is known as "VARQ FC," with VAR representing variable, Q representing engineering shorthand for discharge, and FC representing flood control.
2. Flow augmentation that such alternative flood control would facilitate in the Kootenai River, the Flathead River, and mainstem Columbia River for fish populations listed as threatened or endangered under the Endangered Species Act (ESA). Flow augmentation (i.e., fish flows) includes release of water for bull trout, salmon, and, at Libby Dam, white sturgeon.

The U.S. Army Corps of Engineers (Corps) is the lead agency for this EIS, with the Bureau of Reclamation (Reclamation) acting as a cooperating agency.

Purpose of the Proposed Action

The purpose of the proposed action is to provide reservoir and flow conditions at and below Libby and Hungry Horse dams for anadromous (mainstem Columbia River) and resident fish listed as threatened or endangered under the ESA, consistent with authorized project purposes, including maintaining the current level of flood control benefits.

Need for the Proposed Action

Multiple use project operations[1] at Libby, Hungry Horse, and other dams have altered the natural river hydrology of the Columbia River and some of its major tributaries. These

[1] These include flood control, hydropower, fish and wildlife, recreation, navigation, irrigation, water supply, and water quality.

dams store the spring snowmelt runoff to control floods, and release water for multiple uses. Populations of threatened and endangered fish in the Columbia River Basin (Kootenai River white sturgeon, Columbia Basin bull trout, and several Columbia River salmon and steelhead stocks) benefit from certain high flow periods, which historically were determined by natural runoff patterns driven by snowmelt and rainfall. While the status of bull trout populations in the Kootenai and Flathead rivers is generally better than some others in the Columbia River Basin, long-term monitoring has shown that bull trout populations in both watersheds have declined since construction of Libby and Hungry Horse dams. Kootenai River white sturgeon numbers are estimated at fewer than 500, down from numbers of 5,000 to 6,000 in the 1980s, and are declining at approximately 9 percent per year. Several salmon and steelhead populations in the Columbia River Basin are in various states of decline.

In accordance with the ESA, the Corps, Reclamation and the Bonneville Power Administration (the Action Agencies) have engaged in formal consultation on the effects of the operation of the Federal Columbia River Power System (FCRPS) on anadromous and resident fish species listed as threatened or endangered. In December 2000, the National Marine Fisheries Service (NMFS, also referred to NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS), issued biological opinions on the effects of the operation of the FCRPS on the species under their jurisdiction. The NMFS and USFWS 2000 biological opinions both included a Reasonable and Prudent Alternative (RPA), with a recommendation to implement VARQ FC at Libby and Hungry Horse dams. In response, the Corps and Reclamation began the process to ensure the recommended flood control and fish flow operations at Libby and Hungry Horse dams were consistent with our responsibilities under the NEPA as represented in the purpose and need for this EIS. The recommendations carried over into the NMFS 2004 BiOp and the USFWS 2006 BiOp. For more details on ESA consultations and biological opinions from the NOAA Fisheries and USFWS, refer to Sections 1.4.1 and 1.4.2, respectively, of the Final EIS.

Columbia River System and Local Flood Control

The basic objective of Columbia River system flood control operations is to regulate the total reservoir system to, when possible, minimize flood damages in Canada and the United States in areas that are prone to potential flooding; and, in years with very high runoff, to regulate flows at The Dalles, Oregon, for the protection of Portland, Oregon, and Vancouver, Washington. Storage dam operations are designed to manage for flood control while increasing probability of refill of storage reservoirs at the end of the spring runoff.

In the context of system flood control operations, storage reservoirs throughout the Columbia River Basin release water from January through April using guidance provided by a storage reservation diagram (SRD) to create flood control storage space. A SRD shows how much water storage space is required on a certain date in each reservoir for the most current seasonal water supply forecast. In early January, water supply forecasts (WSFs) are developed for each subbasin and for the Columbia River system to The Dalles. Based on the WSF, and using the SRD as guidance, the Corps calculates the end-of-January reservoir target elevation required to provide storage space to meet flood control objectives at The Dalles. In early February, a new WSF is used to develop updated end-of-February reservoir target elevations. This process is repeated for each month through April. Reservoirs typically reach their maximum flood control draft on or about May 1. Reservoir refill in May and June is based on the calculated natural flow at The Dalles, the remaining water supply forecast, available reservoir space, and the weather forecast.

In addition to providing water storage for system flood control, Libby and Hungry Horse dams also provide local flood control for downstream river reaches in the vicinity of the dams.

Standard and VARQ Flood Control

In the past, Libby and Hungry Horse dams operated using Standard FC. Under Standard FC, the dams would generally release high flows from January through April in order to make space to capture the spring runoff in May, June, and July; from January through April, reservoir levels typically drop. This process of reducing reservoir levels by releasing water is called "drafting." Because the reservoirs drafted a large amount of storage under Standard FC, they historically released little water during the May through July period in order to refill. An assumption of the Standard FC procedure was that each dam could minimize outflow during the refill period.

The Corps and Reclamation now release water from Libby and Hungry Horse dams to augment flows for fish. At Hungry Horse Dam, for example, these releases occur during the summer months for salmon flow augmentation and year-round in the form of minimum flows for bull trout. Libby Dam provides flow augmentation for white sturgeon in addition to summer bull trout minimum flows and salmon flow augmentation. Because these fish flow releases are higher than those originally designed into Standard FC, the reservoirs have a noticeably reduced likelihood and frequency of refilling.

Variable discharge flood control was developed to improve the multipurpose operation of Libby and Hungry Horse dams while maintaining the level of local or mainstem flood protection in the Columbia River. Implementation of VARQ FC at Libby and Hungry Horse Dams enables the Corps and Reclamation to more reliably supply spring and summer flows for fish while simultaneously better ensuring higher reservoir elevations in the summer. The USFWS and NOAA Fisheries support VARQ FC because of the improved probability of providing flows for listed fish in spring while also ensuring a higher probability of reservoir refill for summer fish flow releases.

Generally, VARQ FC provides less system flood control space at Libby and Hungry Horse dams prior to spring runoff. The flood control space needed in a given year varies based on each dam's seasonal water supply forecast (WSF) for that year. In years where the April to August seasonal WSF is between about 80 and 120 percent of average at Libby Dam and between 80 and 130 percent at Hungry Horse Dam, the VARQ FC reservoir elevation would be higher than the Standard FC reservoir elevation during the January through April drawdown period. For forecasts greater than 120 percent of average, Libby Dam typically does not draft to the VARQ FC or Standard FC reservoir elevations because outflows must be reduced to comply with the IJC Order of 1938 concerning Kootenay Lake levels. In years where the seasonal water supply forecast is higher than about 120 percent of the average volume at Libby Dam and 130 percent at Hungry Horse Dam, storage space for flood control would be the same for either VARQ FC or Standard FC.

During reservoir refill, VARQ FC and Standard FC also differ. Standard FC may reduce dam releases to minimum flows during the refill period from May through July. In contrast, in years where the WSF at Libby and Hungry Horse dams are about 80 to 120 percent of average, the VARQ FC refill outflow is generally greater than minimum flows. The basic premise of VARQ FC is that the dam releases during the refill period can vary based on the seasonal WSF, actual reservoir elevation, and the estimated duration of flood control. Some of the water that would be stored during the refill period under Standard FC is instead passed through the dam under VARQ FC.

Since the flood control draft at Grand Coulee Dam is based, in part, on the available storage space upstream from The Dalles, VARQ FC at Libby and Hungry Horse dams influences operations for system flood control at Grand Coulee Dam. In years when VARQ FC operations result in higher reservoir elevations and less flood control storage space at Libby and Hungry Horse dams, Grand Coulee Dam may draft deeper to maintain system flood protection at The Dalles. In practice, Grand Coulee Dam may draft deeper for flood control in years with seasonal WSFs between 86 and 100 percent of average. The increase in flood control draft at Grand Coulee Dam is less than the net decrease in draft at Libby and Hungry Horse dams.

Interim Implementation of VARQ FC

Based on analyses of the effects of interim (short-term) implementation of VARQ FC operation at Hungry Horse and Libby dams, Reclamation began implementation of VARQ FC at Hungry Horse Dam in winter 2002 and the Corps began implementation of VARQ FC at Libby Dam in winter 2003. This Final EIS addresses the long-term implementation of VARQ FC at both dams. In addition, this Final EIS evaluates potential effects of fish flow operations at Libby Dam involving discharges greater than the existing powerhouse capacity, actions which were beyond the scope of the interim decision-making process.

Libby Dam Alternatives

The alternatives for Libby Dam are referred to by the abbreviations shown in Table S-1. The alternative operations vary in terms of the flood control operation and recommended fish flow augmentation.

Table S-1. Alternative abbreviations used in this EIS.

Abbreviation	Project Feature or Alternative Operation
L	Libby Dam
H	Hungry Horse Dam
S	Standard FC
V	VARQ FC
1	sturgeon flows up to powerhouse capacity (25 kcfs)
2	sturgeon flows up to 10 kcfs above powerhouse capacity (35 kcfs)
B	sturgeon flows up to 10 kcfs above powerhouse capacity for up to 14 days, using spill when reservoir, inflow and temperature conditions are suitable

kcfs = thousand cubic feet per second

The Corps, Reclamation and the Bonneville Power Administration (the Action Agencies) have engaged in several ESA consultations on the effects of the operation of the Federal Columbia River Power System (FCRPS) on anadromous and resident fish species listed as threatened or endangered under the ESA. With the designation of Kootenai River white sturgeon critical habitat, the Corps and BPA reinitiated consultation with the USFWS on the effects of the operation of Libby Dam on the Kootenai River white sturgeon, its designated critical habitat, and bull trout. On February 18, 2006, the USFWS issued a biological opinion (USFWS 2006), which included a Reasonable and Prudent Alternative (RPA) recommending continued implementation of VARQ FC at Libby Dam and flow augmentation for sturgeon in the spring.

The RPA from the 2006 USFWS Biological Opinion recommends a range of releases from Libby Dam up to 35 kcfs for up to 14 days, pending appropriate water conditions, providing for a normative hydrograph to achieve the desired habitat attributes of depth, velocity and temperature. The USFWS identified these habitat attributes to support successful sturgeon spawning and recruitment. Currently, the only means available to provide up to 10 kcfs above the powerhouse capacity (approximately 25 kcfs) for a total release of 35 kcfs from Libby Dam is by spill. Spill of up to 10 kcfs will increase total dissolved gas (TDG) above the Montana water quality standard of 110%. The Corps, BPA, and the USFWS are coordinating with the State of Montana on the TDG effects of spilling up to 10 kcfs.

The 2006 USFWS Biological Opinion RPA recognizes that there are several ways to achieve the desired habitat attributes and allows the Corps and BPA the flexibility to select the means to provide for these attributes. This is called a performance-based adaptive management approach. While release of flows up to 35 kcfs out of Libby is the method currently available to achieve the desired attributes in the near term, the Corps and BPA are pursuing habitat actions that may reduce the need for such releases in the future. As information is gained on the biological response to providing the habitat attributes, flows may be adjusted under the adapative management approach provided for in the 2006 USFWS Biological Opinion.

In response to the RPA in the USFWS 2006 Biological Opinion, additional alternatives concerning the operation of Libby Dam were added to this Final EIS. These alternatives, LSB and LVB, identify the use of the spillway as the mechanism for achieving flows up to 35 kcfs (10 kcfs above powerhouse capacity), which is an operational component of the USFWS 2006 RPA. Because the use of the spillway to provide flows up to 35 kcfs had not been included in the Draft EIS, as analysis of the effects associated with this operation, including the TDG levels and the condition of the spillway surface, has been incorporated in the Final EIS. Other impacts associated with the additional alternatives fall within the range of the impacts associated with the alternatives analyzed in the Draft EIS.

Detailed descriptions of the Libby Dam alternatives and benchmarks follow.

Alternative LS1 – Standard FC with fish flows up to powerhouse capacity (No Action Alternative)

Alternative LS1, the no action alternative for Libby Dam, consists of Standard FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate up to the existing powerhouse capacity (about 25 kcfs). Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LV1 – VARQ FC with fish flows up to powerhouse capacity (Preferred Alternative)

As of 2003, Alternative LV1 is the current interim operation for Libby Dam and consists of VARQ FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate up to the existing powerhouse capacity (about 25 kcfs). Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

With the release of the 2006 USFWS Biological Opinion and its Reasonable and Prudent Alternative, Alternative LV1 is no longer the preferred alternative for Libby Dam.

Alternative LS2 – Standard FC with fish flows up to powerhouse capacity plus 10 kcfs

Alternative LS2 is the same as Alternative LS1, except that sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate at some level up to 10,000 cfs above the approximately 25,000-cfs powerhouse capacity. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

LS2 differs from LSB in that LS2 does not identify a specific mechanism to achieve the 10 kcfs of additional flow and the corresponding analysis presumes that the additional 10 kcfs of flow would be provided for all sturgeon flow augmentation events except when limited to avoid exceeding flood stage of 1,764 feet at Bonners Ferry, Idaho. Impacts of the flows and reservoir elevations are addressed on that basis for LS2. This would contrast with LSB, where the additional 10 kcfs of flow would be provided when the reservoir elevation is at or above 2415 feet and reservoir inflows are sufficient to maintain that reservoir elevation during spill operations for sturgeon. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LV2 – VARQ FC with fish flows up to powerhouse capacity plus 10 kcfs

In years when sturgeon flows are requested and conditions are met (see Section 1.1), Alternative LV2 is the same as Alternative LV1, except that sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate at some level up to 10,000 cfs above the approximately 25,000-cfs powerhouse capacity. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

LV2 differs from LVB in that LV2 does not identify a specific mechanism to achieve the 10 kcfs of additional flow and the corresponding analysis assumes that the additional 10 kcfs of flow would be provided for all sturgeon flow augmentation events except when limited to avoid exceeding flood stage of 1,764 feet at Bonners Ferry, Idaho. As with LS2, impacts from flows and reservoir elevations are addressed based on that assumption.

This contrasts with LVB, where the additional 10 kcfs of flow would be provided only when the reservoir elevation is about 2415 feet and reservoir inflows are sufficient to maintain that reservoir elevation during spill operations for sturgeon. Dam releases would be optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LSB – Standard FC with fish flows up to powerhouse capacity plus 10 kcfs, using spill when reservoir and inflow conditions make this possible

Alternative LSB consists of Standard FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes consistent with the 2006 USFWS FCRPS Biological Opinion. Annual operations would be based on a scientific approach for testing different releases from Libby Dam and determining the effectiveness for achieving the habitat attributes and meeting the conservation needs established for sturgeon as described in the 2006 USFWS Biological Opinion. Maximum peak augmentation flows up to 35kcfs would be provided for up to 14 days, when water supply conditions are conducive, during the peak of the spawning period. After the peak augmentation flows, remaining water would be provided to maximize flows for up to 21 days with a gradually receding hydrograph. As before, sturgeon augmentation flows would include no dedicated sturgeon flows during a Tier 1 water year (see Section 1.4.2); otherwise, LSB would provide either dam releases up to existing powerhouse capacity, or dam releases to powerhouse capacity plus up to 10 kcfs via the Libby Dam spillway.

Specific details for determining appropriate flows in any given year are being developed in a Flow Plan Implementation Protocol in collaboration with the states, tribes and other Federal agencies.

For this alternative, the reservoir elevation would have to be no lower than about 2415 feet in order to release 10 kcfs via the Libby Dam spillway (which has a spillway crest elevation of 2405 feet); and, reservoir inflows would need to be sufficient to maintain the reservoir at or above elevation 2415 feet to maintain these releases for up to two weeks. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop. When the reservoir elevation is not high enough to allow spillway releases in the spring, sturgeon flow augmentation would be provided using adaptive management consistent with the Flow Plan Implementation Protocol, with a maximum release rate of about 25 kcfs (the existing powerhouse capacity at Libby Dam). Under Standard FC, review of the monthly modeling data shows that the appropriate conditions to allow for releases of sturgeon flows through the Libby Dam spillway occurs for some period of time in approximately 25% of years. Actual duration and quantity of spill operations would vary in any given year.

Alternative LVB - VARQ FC with fish flows up to powerhouse capacity plus 10 kcfs, using spill when reservoir and inflow conditions make this possible (Preferred Alternative)

Alternative LVB is the preferred alternative. LVB is similar to LSB, but with VARQ FC rather than Standard FC. It includes sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as specified in the 2006 USFWS FCRPS Biological Opinion. Annual operations would be based on a scientific approach for testing different releases from Libby Dam and determining the effectiveness for achieving the habitat attributes and meeting the conservation needs established for sturgeon as described in the 2006 USFWS Biological Opinion. Maximum peak augmentation flows up to 35 kcfs would be provided for up to 14 days, when water supply conditions are conducive, during the peak of the spawning period. After the peak augmentation flows, remaining water would be provided to maximize flows for up to 21 days with a gradually receding hydrograph. Consistent with the 2006 USFWS Biological Opinion, during a Tier 1 water year, dedicated sturgeon augmentation flows are not provided (see Section 1.4.2); otherwise, dam releases would range from within existing powerhouse capacity up to an additional 10 kcfs using the Libby Dam spillway for up to 14 days depending on water supply conditions. Specific details for determining appropriate flows in any given year are being developed in a Flow Plan Implementation Protocol in collaboration with the states, tribes and other Federal agencies.

For this alternative, the reservoir elevation would have to be no lower than about 2415 feet in order to release 10 kcfs via the Libby Dam spillway (which has a spillway crest elevation of 2405 feet); and, reservoir inflows would need to be sufficient to maintain the reservoir at or above elevation 2415 feet in order to maintain these release for up to two weeks during sturgeon flow augmentation. Dam releases would be timed and optimized to provide temperatures of approximately 50^{o} F with no more than a 3.6^{o} F drop. When the reservoir elevation is not high enough to allow spillway releases in the spring, sturgeon flow augmentation would be provided using adaptive management consistent with the Flow Plan Implementation Protocol, with a maximum release rate of about 25 kcfs (the existing powerhouse capacity at Libby Dam). Under VARQ FC, review of the monthly modeling data shows that conditions to allow for releases of sturgeon flows from the Libby Dam spillway for some period of time occur in approximately 50% of years. Actual duration and quantity of spill operations would vary in any given year.

LVB is consistent with the Reasonable and Prudent Alternative for Libby Dam operations included in the 2006 USFWS Biological Opinion.

LS and LV Benchmarks

The LS and LV benchmarks are descriptive of Libby Dam operations that do not include fish flows. These benchmark operations discuss additional information that became available after publication of the 1995 Columbia River System Operation Review (SOR) EIS (BPA *et al*. 1995) on potential effects associated with fish flows up to existing Libby Dam powerhouse capacity, and are included for that purpose.

This new information also provides an opportunity to update the evaluation of groundwater seepage in the Kootenai River valley in Idaho and assist in evaluating the effects of flows on sturgeon reproduction. The benchmarks are not included as alternatives because they do not meet the purpose and need of the proposed action.

Hungry Horse Dam Alternatives

The alternatives for Hungry Horse Dam operations vary in terms of flood control and both alternatives provide bull trout minimum flows and salmon flow augmentation. The effects of bull trout minimum flows and drafts for salmon flow augmentation were addressed in the 1995 Columbia River SOR EIS.

Alternative HS – Standard FC with fish flows (No Action Alternative)

Alternative HS, the no action alternative for Hungry Horse Dam is Standard FC with bull trout and salmon augmentation flows. Standard FC operations are the historic operations and are based on the principle of deep winter drafts of the reservoir for flood control then minimizing outflow during the refill period from May through June 30.

Alternative HV – VARQ FC with fish flows (Preferred Alternative)

Alternative HV, the preferred alternative for Hungry Horse Dam, consists of flood control using VARQ FC with bull trout and salmon augmentation flows. This is the current interim operation at Hungry Horse Dam and is based on less winter reservoir draft for flood control during years with 80% to 130% normal forecast and increases releases during the refill period in May and June.

Mainstem Columbia River Alternative and Benchmark Combinations

The effects of Libby Dam and Hungry Horse Dam alternatives and benchmarks are evaluated in the mainstem Columbia River downstream from the Kootenai River and Pend Oreille River tributary systems. Thus, for analysis of the environmental effects in the Columbia River upstream and downstream from Grand Coulee Dam for power generation and related economic values, alternative and benchmark combinations are derived by combining Libby Dam and Hungry Horse Dam alternatives and benchmarks

(Table S-2). As with Libby Dam benchmarks LS and LV, benchmark combinations LS+HS and LV+HV are included as a tool to derive the effects of fish flows from Libby Dam on the mainstem Columbia River.

Table S-2. Mainstem Columbia River alternative combinations and benchmarks.

	Flood Control Method at Libby and Hungry Horse Dams		**Fish Flows Provided at Libby Dam**				**Fish Flows Provided at Hungry Horse Dam**	
Alternative Combinations	Standard FC	VARQ FC	Sturgeon up to ~25 kcfs	Sturgeon up to ~35 kcfs	Bull trout	Salmon	Bull trout	Salmon
LS1+HS	X		X		X	X	X	X
LV1+HV		X	X		X	X	X	X
LS2+HS	X			X	X	X	X	X
LV2+HV		X		X	X	X	X	X
LSB+HS	X		X[a]	up to 25% of years	X	X	X	X
LVB+HV		X	X[a]	up to 50% of years	X	X	X	X
Benchmark Combinations								
LS+HS	X		none				X	X
LV+HV		X	none				X	X

a. Sturgeon flows provided in years with sturgeon volume Tiers 2-6 (see Fig. 1-2). Depending upon reservoir elevation, reservoir inflow, and/or water temperatures, releases may vary from 25 kcfs to 35 kcfs. Duration of the release would also vary year to year.

Issues Addressed in this EIS

The Corps and Reclamation initiated a joint NEPA process to analyze the effects of long-term implementation of the VARQ FC strategies at Libby and Hungry Horse dams with publication in the Federal Register of the Notice of Intent to prepare an EIS on October 1, 2001.

Public scoping meetings were held at Grand Coulee, Washington; Sandpoint, Idaho; Bonners Ferry, Idaho; Portland, Oregon; Libby, Montana; Eureka, Montana; Kalispell, Montana; and in Creston, British Columbia, Canada. In addition to the meeting comments, comment forms and letters from tribes, agencies, and interested parties were also received.

Through scoping and interdisciplinary analysis, the following issues were identified for consideration in this Final EIS.

Issue 1: Flood control and related impacts

Libby Dam and Hungry Horse Dam are important facilities for management of local and system flooding and related impacts. The Final EIS addresses how the alternatives would modify flood control operations and fish flows.

Issue 2: Fisheries and other biological impacts and benefits

The proposed modifications to flood control operations and fish flows are primarily intended to benefit fish stocks listed under the ESA, including Kootenai River white sturgeon (endangered), bull trout (threatened), and various stocks of Chinook, chum, coho, and sockeye salmon, and steelhead (threatened and endangered). The Final EIS addresses how the alternatives would affect the fisheries resource.

Issue 3: Water and air quality impacts

The Final EIS addresses how the changes in flood control operations and fish flows influence water quality and may have indirect effects on air quality.

Issue 4: Cultural resource protection and related impacts

The Final EIS addresses how changes in reservoir elevations and shoreline erosion and exposure can influence the likelihood of discovery, looting, and vandalism of prehistoric artifacts and human remains along Lake Roosevelt (the reservoir behind Grand Coulee Dam) and elsewhere.

Issue 5: Recreation impacts

The Final EIS addresses how changes in reservoir levels and streamflows can influence the quality and availability of water-based recreation opportunities.

Issue 6: Power generation impacts

The Final EIS addresses how changes in flood control operations and fish flows can affect power generation at Hungry Horse Dam, Libby Dam, and numerous dams downstream.

Issue 7: Economic impacts

The Final EIS addresses how changes in flood control operations and fish flows can directly or indirectly influence local and regional economies.

Cumulative Impacts

Cumulative impacts for the Kootenai and Pend Oreille subbasins and along the mainstem Columbia River were analyzed based on the incremental consequences of the different alternatives when added to other past, present, and reasonably foreseeable future actions. Notable potential cumulative impacts are summarized below.

Kootenai River Basin

Adaptive management of dam operations would consider multiple uses to provide more normative flow conditions and help maintain Lake Koocanusa levels during the summer. While the flow patterns that are possible under the alternatives would provide a semblance of normative river conditions, over the course of any given year, they would still be significantly different from pre-dam conditions in terms of magnitude, duration, and timing. Due to heat storage in Lake Koocanusa as a result of Libby Dam construction, the addition of fish flows would tend to increase the possibility of temperature fluctuations in the river downstream of the dam. The expansion of Brilliant Dam on the Kootenay River downstream of Kootenay Lake may serve to decrease the duration or degree of high TDG levels resulting from fish flows or VARQ FC operations.

Physical modification of riparian and floodplain areas and various operational requirements (Kootenay Lake operations, flood control requirements) can, under certain circumstances, constrain opportunities for ecosystem and species recovery actions that rely solely on operational flexibility that would be provided by the various alternatives. Such constraints could prevent or diminish effectiveness of the suite of actions that are possible under the different alternatives and likely necessary to successfully recover and sustain ecosystem functions. All of the alternatives would provide a degree of flexibility to provide more normative river flows during the spring and summer, with resultant synergistic benefits to ecosystem functions (i.e. riparian habitat development, habitat connectivity) and sensitive, threatened, and endangered species such as sturgeon, bull trout, burbot, and bald eagles. The VARQ FC alternatives and higher fish flows possible under LS2. LV2, LSB, and LVB provide the greatest flexibility to manage river flows in concert with ecosystem recovery efforts to generate higher relative ecosystem benefits.

Benefits to the regional ecosystem under the VARQ FC alternatives could provide long-term recreational opportunities to anglers and eco-tourists, with resulting benefits to local economies. However, together with other factors that have adversely affected the local economy, adverse impacts to businesses relying on angling would further impact the potential for economic growth in the vicinity of Libby. Future expansion of hops or other crops that tend to be more sensitive to shallow groundwater could further worsen agricultural impacts from groundwater seepage linked to higher river flows during the spring and summer.

Climate change could result in changes in the temperature regime of Lake Koocanusa, which could assist in optimizing spring release temperatures for benefit of sturgeon spawning and reproduction. Libby Dam construction and the resulting creation of Lake Koocanusa has placed some cultural resources out of reach of looters and vandals, but has allowed exposure of others in wave-affected zones. All known sites around Lake Koocanusa have been impacted by reservoir operations since 1972. The better the chance of refill under the VARQ FC alternatives would reduce exposure.

Pend Oreille River Basin

Cumulatively, implementation of VARQ FC at Hungry Horse Dam would work in concert with the proposed Flathead Lake Drought Management Plan to improve lake refill while meeting minimum flow requirements below Kerr Dam..

The various state programs such as the 1998 Watershed Planning Act in Washington, the water quality restoration plans and new TMDL program in Montana and the establishment of TMDLs in Idaho are intended to improve water quality, water supply, and habitat.

Cumulatively, ongoing stream and riparian restoration measures, TMDL processes, state agency programs, and other conservation activities in conjunction with Federal recovery efforts, could help preserve and possibly improve habitat conditions for bull trout populations.

Mainstem Columbia River

Climate changes may alter runoff patterns. Since system flood control under all alternative combinations is essentially equivalent, cumulative impacts under all the alternative combinations would also be comparable.

Alternative combinations with VARQ FC would assist in efforts to provide more normative hydrographs in the mainstem Columbia River which would likely provide a cumulative benefit to overall ecosystem health. At Grand Coulee Dam and Lake Roosevelt, small changes in the timing and degree of reservoir fluctuation that would result from the various alternative combinations will not substantially alter the character, scope, or nature of Lake Roosevelt, particularly since any observed changes will be within the current operating range.

Alternative combinations that result in lower annual or monthly generation may result in more power generation from sources such as fossil fuel-powered generators. Changes in flow patterns resulting from climate changes may force additional changes in system operations to better balance power generation with ecosystem recovery objectives. Any reduction in flows from drought or climate shifts may lead to relatively lower ecosystem recovery capability. No cumulative impacts on the electrical transmission system are anticipated.

Actions now being undertaken, such as flow deflector construction at Chief Joseph Dam, expansion of Brilliant Dam, and operational shifts of generation and spill between Grand Coulee and Chief Joseph dams, would enhance the ability of the system to manage spill and TDG generation. Further population growth in the region might cause development of greater power generating and transmission capacity with potential of reducing involuntary spill and resulting TDG impacts.

The provision of more normative flows for fish and aquatic life presents opportunities for successful maintenance of habitat conditions. Fish flows in all alternative combinations would cumulatively improve the ability of the system to meet flow objectives at Priest Rapids and McNary dams for anadromous fish migration and would provide more options to achieve recovery of threatened and endangered fish stocks over the long term. Demands for water, and impacts to watersheds would continue to be a factor in determining the health of aquatic species. It is conceivable that aquatic species would continue to be adversely affected in the long run as development and mitigation balance against each other.

Continued regional growth is expected to add to demand for recreational use. Further degradation of water quality, loss of fish and wildlife habitat and visual resources and esthetic values might also decline. To the extent that habitat is maintained or enhanced, and to the extent that fish and wildlife resources can be maintained and recovered in the face of competing interests, then cumulative impacts to recreation would be decreased.

All known historic properties at Lake Roosevelt have undergone impacts from the operation of Lake Roosevelt over the past 70 years, including loss of site integrity and of individual items. Cumulative effects from past, present, and foreseeable future actions include increased weathering to organic materials, artifact movement or damage from human and animal use of the shoreline, and loss from illegal collecting activities.

Mitigation

All alternatives in this EIS are formulated with the primary intent of avoiding or minimizing impacts. Some impacts cannot be avoided while meeting the purpose and need of the proposed action.

Potential mitigation measures are identified in this EIS, even if they are outside the jurisdiction of the Corps or Reclamation. Some of the identified measures may be undertaken by other entities or individuals. No commitments are made in this EIS to any mitigation action, particularly those that are not currently authorized, programmed, and funded. Notable potential mitigation measures are summarized below.

Kootenai River Basin

Mitigation for occasional flooding has not been identified, because the alternatives are not considered to increase flood risk. Levee repairs and upgrades, structural relocation, and individual structural floodproofing are potential measures that local landowners may consider to further decrease flood risk above that provide by Libby Dam operations. Potential mitigation for agricultural impacts due to high groundwater includes upgrades to drainage and pumping systems or removing affected areas from agricultural production. The cost-effectiveness of mitigation for agricultural seepage may be low. Bank stabilization work of vulnerable shoreline sections (ranging from bioengineering techniques to placement of riprap) would prevent or minimize potential bank erosion that may occur primarily in areas upstream of Bonners Ferry under alternatives with generally higher flows.

Modification of the dam to provide for spillway deflectors, additional discharge capacity via the powerhouse, or other options could reduce TDG loadings resulting from spill and resulting adverse impacts to aquatic life. The Corps is currently studying temperature stratification in the Libby Dam forebay to determine if it is possible to improve selective withdrawal system use, including possible water withdrawals closer to the surface, to more accurately provide desired downstream temperatures in the spring and consequently aid sturgeon migration and spawning. Ongoing fertilization of the Kootenai River and Kootenay Lake will help minimize effects from any increased nutrient flushing. Options to reduce potential adverse effects from flooding of waterfowl and shorebird nesting areas, as well as reptile and amphibian reproductive sites, could include increased pumping capacity or increasing the height of levees protecting sensitive nesting areas, in the Creston Valley Wildlife Management Area. Other possible mitigation may include connection to the river for nesting areas which are currently behind dikes, so that water level rises in nesting areas are more synchronous with onset of lowland runoff.

Appropriate mitigation for adversely affected cultural resources sites is being formulated in Site Treatment Plans and Site Protection Plans by the Corps, and mitigation planning will continue under the current cultural resources management program at Libby Dam—Lake Koocanusa. Mitigation may include documentation, surface collection of artifacts and features, site stabilization, or more intensive data recovery. The Corps, BPA, Kootenai National Forest, Confederated Salish and Kootenai Tribes, and the Montana SHPO will continue to coordinate to mitigate impacts as needed under the current program.

Pend Oreille River Basin

No mitigation needs were identified based on the impact analysis.

Mainstem Columbia River

Coordinated operation of the system is to minimize TDG. Flow deflector construction at Chief Joseph Dam and operational shifts of generation and spill between Chief Joseph and Grand Coulee dams would cumulatively reduce the magnitude of high TDG levels below Grand Coulee Dam.

Mitigation for cultural resources could include appropriate additional management actions for historic properties affected by implementation of VARQ FC including erosion monitoring targeted to affected sites, completion of the evaluation process for affected sites to determine appropriate mitigation efforts, and public outreach/education. Protective patrols are already in place during the April drawdown, and Reclamation would work with patrolling agencies and tribes to make any needed adjustments in spatial focus.

Discovery of new sites or site components, or impacts to known sites, would be managed through the current cultural resources program at Lake Roosevelt. No specific mitigation is needed or planned for cultural resources impacts below Grand Coulee Dam.

Reduction in hydropower generation in Canada and consequent compensation issues are matters appropriately addressed through established Columbia River Treaty processes.

Effects on other resources are expected to be beneficial, minor, or not capable of being mitigated.

Unavoidable Adverse Effects

The various alternatives may create some unavoidable and adverse effects on some resources in some impact areas. Notable unavoidable adverse effects are summarized below.

Kootenai River Basin

Potential unavoidable adverse impacts in the Kootenai River basin include:

- Possible flooding under any of the alternatives since Libby and Hungry Horse dams were not designed to prevent flooding under all circumstances.

- Spill at Libby Dam up to 10,000 cfs for up to 14 days under appropriate conditions under the Preferred Alternative, with TDG saturations over 130% below the dam.
- Increased likelihood of forced spill, in terms of frequency and duration, at Libby Dam with the VARQ FC alternatives compared to the Standard FC alternatives. Spill would increase TDG concentrations in the river downstream, between the dam and Kootenai Falls, which could adversely affect aquatic life (including sensitive and threatened fish species).
- Possible entrainment of fish through the turbines and/or over the spillway at Libby Dam.
- Increased nutrient flushing from Kootenay Lake.
- Fish stranding in the Duncan River delta.
- Adverse effects on spawning burbot due to relatively high winter water temperatures under all alternatives.
- Adverse effects to wetland vegetation under Standard FC due to relatively lower spring and summer river levels and resulting poor hydrologic connectivity between the river and riparian areas.
- Adverse effects to amphibians, and nesting waterfowl and shorebirds in the Creston Valley Wildlife Management Area due to high water levels under VARQ FC.
- Reduction in recreational use and access along Lake Koocanusa, and reduction in swimming and shore fishing days on the Kootenai River downstream of Libby Dam.
- Impacts to archaeological sites and other historic properties along the reservoir shoreline due to their static and perishable nature.
- Increased costs for agricultural drainage pumping along the Kootenai River.
- Economic losses due to impacts from groundwater seepage in agricultural lands.
- Economic losses due to less-reliable Lake Koocanusa refill under Standard FC or alternatives with fish flows to 10 kcfs above current Libby powerhouse capacity.

Pend Oreille River Basin

- Existing potential for adverse flooding effects under the implementation of either alternative.
- Occasional TDG levels above 120% saturation, with a high incidence under VARQ FC alternative combinations, at Cabinet Gorge Dam, which may adversely affect aquatic life, including threatened and endangered fish, in the Clark Fork.

- Impacts arising from implementation of either alternative to archaeological sites or other historic properties along the reservoir shoreline, because of the static nature of historic properties.

Mainstem Columbia River

Potential unavoidable adverse impacts along the mainstem Columbia River include:

- Potential flooding as the storage capacity of the FCRPS was not designed to prevent all flooding.
- Under VARQ FC alternative combinations, reduction in power generation in winter.
- TDG levels above 120% saturation under VARQ FC alternative combinations, at Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams, which may adversely affect aquatic life, including threatened and endangered fish, in the mainstem Columbia River.
- Some increased vandalism, erosion, and looting arising from VARQ FC alternative combinations at archaeological sites and other historic properties along the Lake Roosevelt shoreline, primarily because of the static nature of these resources.
- Reduction in power generation in the winter under VARQ FC alternative combinations.

Summary Comparison of Alternatives

The following tables provide summary comparisons of the alternatives and benchmarks at Libby Dam, alternatives at Hungry Horse Dam, and alternative and benchmark combinations in the mainstem Columbia.

Table S-3. Summary comparison of the no action and action alternatives and benchmarks at Libby Dam.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Hydrology and Flood Control								
Lake Koocanusa	Median draft 2370'; median July elevation 2440'; within 5' of full in 12% of years.	Median draft 2396'; median July elevation 2446'; within 5' of full in 31% of years.	Median draft 2370'; median July elevation 2440'; within 5' of full in 10% of years.	Median draft 2396'; median July elevation 2445'; within 5' of full in 31% of years.	Median draft and refill range between LS1 and LS2.	Median draft and refill range between LV1 and LV2.	Median draft 2370'; median July elevation 2458'; within 5' of full in 98% of years.	Median draft 2396'; median July elevation 2458'; within 5' of full in 98% of years.
Kootenai River downstream from Libby Dam	Libby Dam peak releases at about 25 kcfs. Fish flows eliminate need for flood control spills above powerhouse capacity.	Libby Dam peak releases similar to LS1. Highest average outflow during July/Aug. of any alternative. Increased likelihood of 1' higher river stage at Bonners Ferry than LS1 (below 1764').	Libby Dam peak releases at about 35 kcfs. Peak stages at Bonners Ferry are the second highest of any alternative 20% of time, but lowest river stage 80% of time.	Libby Dam peak releases slightly higher than LS2 (35 kcfs) during drier years, similar to LS2 in wetter years. Peak stages at Bonners Ferry are the highest of any alternative.	Peak dam releases range between LS1 and LS2. Bonners Ferry maximum daily elevation and stage-duration range between LS1 and LS2.	Peak dam releases range between LV1 and LV2. Bonners Ferry maximum daily elevation and stage-duration range between LV1 and LV2.	Average Libby Dam releases and Bonners Ferry stages during May, June, and August are the lower than all alternative and LV. Peak releases are distinctly lower than all alternatives for most years below flood stage.	Libby Dam peak releases are lower than all alternatives. Below flood stage, tends to produce peak Bonners Ferry stages higher than LS, but below all of the alternatives.
Kootenay Lake to confluence with Columbia River	Lowest lake levels of all alternatives.	Peak lake elevation tends to be slightly higher than LS1, but lower than LS2 or LV2.	Peak lake elevation tends to be higher than any alternative other than LV2.	Produces the highest likelihood of any given Kootenay Lake peak stage.	Median lake elevation, month-end average stages, and maxim um daily elevations range between LS1 and LS2. Elevation-duration would be similar to or within the range of LS1 and LS2.	Median lake elevation, month-end average stages, and maximum daily elevations range between LV1 and LV2. Elevation-duration would be similar to or within the range of LV1 and LV2.	Tends to produce lower Kootenay Lake peak stages than any alternative.	Produces lower Kootenay Lake peak stages than any alternative.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Water Quality								
Lake Koocanusa	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives,	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives
Kootenai River downstream from Libby Dam	Similar release temperatures to other alternatives. TDG saturation >110% in 1 out of 52 yrs, >120%&>125% in 0 out of 52 yrs	Similar release temperature to other alternatives. TDG saturation >110% in 3 out of 52 yrs, > 120%&>125% in 2 out of 52 yrs, > 130% in 1 out of 52 yrs	Similar release temperature as other alternatives except possibly slightly cooler in spring. No evaluation of TDG since mechanism to achieve add'l 10 kcfs of flow not known.	Similar release temperature as other alternatives except possibly slightly cooler in spring. No evaluation of TDG since mechanism to achieve add'l 10 kcfs of flow not known	Similar release temperature to LS1 except possibly slightly warmer in spring. TDG levels up to about 125% saturation near dam, and 112% at 8 mi. downstream, in 25% of years; otherwise about 100% saturation throughout.	Similar release temperature to LV1 except possibly slightly warmer in spring. TDG levels up to about 125% saturation near dam, and 112% at 8 mi. downstream, in 50% of years; otherwise about 100% saturation throughout.	TDG saturation >110% in 11 out of 52 yrs, >120%&>125% in 6 out of 52 yrs, >130% in 3 out of 52 yrs	TDG saturation > 110% in 13 out of 52 yrs, >120%&>125% in 7 out of 52 yrs, > 130% in 5 out of 52 yrs
Kootenay Lake to confluence with Columbia River	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	No anticipated increase in TDG levels from dams below Kootenay Lake.	No anticipated increase in TDG levels from dams below Kootenay Lake.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Aquatic Life								
Lake Koocanusa	Relative to VARQ FC alternatives, reduced primary productivity; lower zooplankton production; lower benthic production; lower terrestrial insect deposition; lower kokanee growth. Possible entrainment of fish and plankton through turbines.	Relative to Standard FC alternatives, higher primary productivity; higher zooplankton production; higher benthic production; higher terrestrial insect deposition; high kokanee growth. Possible entrainment of fish and plankton through turbines	Lake productivity similar to LS1. Possible entrainment of fish and plankton through turbines	Lake productivity similar to LV1. Possible entrainment of fish and plankton through turbines	Primary productivity, entrainment of primary producers, zooplankton production, benthic insect production, benthic biomass production, terrestrial insect deposition, fish entrainment, and fish growth would range between LS1 and LS2.	Primary productivity, entrainment of primary producers, zooplankton production, benthic insect production, benthic biomass production, terrestrial insect deposition, fish entrainment, and fish growth would range between LV1 and LV2.	In lake, second highest primary productivity and zooplankton production; low benthic production; mostly high terrestrial insect deposition; high kokanee growth.	In lake, highest primary productivity and zooplankton production; high benthic production; highest terrestrial insect deposition; highest kokanee growth.
Kootenai River downstream from Libby Dam	Mixed benthic production; low TDG risk; less likelihood of low winter flow for burbot; flow benefits for sturgeon. Low probability of involuntary spill with TDG impacts.	High benthic production; somewhat higher TDG risk; greater likelihood of low winter flow for burbot; flow benefits for sturgeon. Some probability of involuntary spill with TDG impacts.	Productivity similar to LS1; less likelihood of low winter flow for burbot; higher flow benefits for sturgeon.	Productivity similar to LV1; greater likelihood of low winter flow for burbot; higher flow benefits for sturgeon.	Benthic biomass would range between LS1 and LS2. Possible TDG impacts to aquatic life in 25% of years, especially at spill levels above 2-3kcfs	Benthic biomass would range between LS1 and LS2. Possible TDG impacts to aquatic life in 50% of years, especially at spill levels above 2-3kcfs.	Mixed benthic production; relatively high TDG risk; less likelihood of low winter flow for burbot; no flow benefits for sturgeon.	Relatively high benthic production; highest TDG risk; greater likelihood of low winter flows for burbot; no flow benefits for sturgeon.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Kootenay Lake to confluence with Columbia River	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possibly higher washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Biological effects would range between LS1 and LS2.	Biological effects would range between LV1 and LV2	Possibly lower washout of nutrients and plankton; possible fish stranding in Duncan delta (Note: Potential for fish stranding a result of low lake levels that may not be significantly affected by the different alternatives)	Lower washout of nutrients and plankton; possible fish stranding in Duncan delta.
Sensitive, Threatened and Endangered Species								
	No likely effect on terrestrial species exc. bald eagle; moderate flow benefits for sturgeon, moderate flexibility for research, monitoring, & evaluation (RM&E) of sturgeon responses; relatively low likelihood of winter low flows for burbot; minimum flows maintained for bull trout. Low probability of involuntary spill with TDG impacts.	No likely effect on terrestrial species exc. bald eagle; flow benefits for sturgeon same as LS1, slightly higher flexibility for RM&E of sturgeon responses than LS1; relatively high likelihood of low flows in winter for burbot; minimum flows maintained for bull trout. Some probability of involuntary spill with TDG impacts.	No likely effect on terrestrial species exc. bald eagle; high flow benefits for sturgeon, high flexibility for RM&E of sturgeon responses; same winter flows as LS1 for burbot; minimum flows maintained for bull trout. No TDG evaluation because mechanism to pass flows above powerhouse capacity not known.	No likely effect on terrestrial species exc. bald eagle; highest flow benefits for sturgeon, highest flexibility for RM&E of sturgeon responses; same winter flows as LV1 for burbot; minimum flows maintained for bull trout. No TDG evaluation because mechanism to pass flows above powerhouse capacity not known.	Most biological effects of flow would range between LS1 and LS2. Higher flow benefits for sturgeon than LS1 or LV1, moderate flexibility for RM&E of sturgeon responses. TDG impacts to fish below Libby Dam in years of spill (about 25% of years), especially when spill exceeds 2-3 kcfs.	Most biological effects of flow would range between LV1 and LV2. Higher flow benefits for sturgeon than LS1 or LV1, moderate flexibility for RM&E of sturgeon responses. TDG impacts to fish below Libby Dam in years of spill (about 50% of years)—especially when spill exceeds 2-3 kcfs.	No likely effect on terrestrial species exc. bald eagle; no flow benefits for sturgeon; same winter flows as LS1 for burbot; no minimum flows for bull trout.	No likely effect on terrestrial species exc. bald eagle; no flow benefits for sturgeon; same winter flows as LV1 for burbot; no minimum flows for bull trout.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Vegetation and Wildlife								
Lake Koocanusa	Little or no riparian vegetation below full reservoir level. Minimal effect on wildlife.	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.	Effects would range between LS1 and LS2.	Effects would range between LV1 and LV2	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.
Kootenai River downstream from Libby Dam	Some riparian vegetation enhancement due to fish flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows; possible enhancement due to lower winter flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows; possible enhancement due to lower winter flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Effects to wildlife and vegetation would range between LS1 and LS2.	Effects to wildlife and vegetation would range between LV1 and LV2.	Little or no benefit to riparian vegetation; possible loss, with corresponding effects on wildlife.	Little or no benefit to riparian vegetation; possible loss, with corresponding effects on wildlife.
Kootenay Lake to confluence with Columbia River	Little or no change in existing lakeshore vegetation, which should remain extensive.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.
Recreation								
Lake Koocanusa in United States	1,340 boat ramp days May-Sep; 107 swimming days Jun-Aug; 45 camping days above elev. 2439' May-Sep; 113 camping days above 2409' May-Sep	1,467 boat ramp days May-Sep; 150 swimming days Jun-Aug; 65 camping days above elev. 2439' May-Sep; 126 camping days above 2409' May-Sep	1,351 boat ramp days May-Sep; 92 swimming days Jun-Aug; 42 camping days above elev. 2439' May-Sep; 112 camping days above 2409' May-Sep	1,454 boat ramp days May-Sep; 142 swimming days Jun-Aug; 61 camping days above elev. 2439' May-Sep; 124 camping days above 2409' May-Sep	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	1,627 boat ramp days May-Sep; 217 swimming days Jun-Aug; 102 camping days above elev. 2439' May-Sep; 122 camping days above 2409' May-Sep	1,665 boat ramp days May-Sep; 221 swimming days Jun-Aug; 104 camping days above elev. 2439' May-Sep; 130 camping days above 2409' May-Sep

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Lake Koocanusa in Canada	352 boat ramp days May-Sep, and 29 swimming days Jun-Aug.	414 boat ramp days May-Sep, and 51 swimming days Jun-Aug	343 boat ramp days May-Sep, and 24 swimming days Jun-Aug	404 boat ramp days May-Sep, 24 swimming days Jun-Aug	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	503 boat ramp days May-Sep, and 131 swimming days Jun-Aug	522 boat ramp days May-Sep, and 133 swimming days Jun-Aug
Kootenai River downstream of Libby Dam	May-Sep: 77 shore-fishing days and 88 boating days.	May-Sep: 50 shore-fishing days and 101 boating days.	May-Sep: 80 shore-fishing days and 88 boating days.	May-Sep: 54 shore-fishing days and 105 boating days.	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	May-Sep 74 shore-fishing days and 85 boating days.	May-Sep: 48 shore-fishing days and 115 boating days.
Kootenay Lake to confluence with Columbia River	135 days in preferred range May-Sep; 52 boat moorage days Jan-May; 83 fishing days above elev. 1744' May-Sep; 77 swimming days below lake elev. 1749' Jun-Aug	132 days in preferred range May-Sep; 52 boat moorage days Jan-May; 90 fishing days above elev. 1744' May-Sep; 76 swimming days below lake elev. 1749 Jun-Aug	134 days in preferred range May-Sep; 52 boat moorage days Jan-May; 82 fishing days above elev. 1744' May-Sep; 76 swimming days below lake elev. 1749 Jun-Aug	132 days in preferred range May-Sep; 52 boat moorage days Jan-May; 89 fishing days above elev. 1744' May-Sep; 75 swimming days below lake elev. 1749' Jun-Aug	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	142 days in preferred range May-Sep; 51 boat moorage days Jan-May; 79 fishing days above elev. 1744' May-Sep; 84 swimming days below lake elev. 1749' Jun-Aug	139 days in preferred range May-Sep; 52 boat moorage days Jan-May; 86 fishing days above elev. 1744' May-Sep; 82 swimming days below lake elev. 1749' Jun-Aug
Environmental Health								
Lake Koocanusa	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 87% of time May, & 32% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 60% of time May, and 13% of time June	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 88% of time May, & 37% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 62% of time May, & 18% of time June	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 83% of time May, & 14% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 56% of time May, & 7% of time June
Cultural Resources								
Lake Koocanusa in United States	268 sites possibly exposed to erosion, looting, and vandalism	247 sites possibly exposed to erosion, looting, and vandalism	Similar to LS1	Similar to LV1	Similar to LS1	Similar to LV1	Similar to LS1 Note: This exposure is due to FC operations and not a factor of fish flows	Similar to LV1
Kootenai River below Libby Dam	Possible erosion at 6 sites within 5 miles of Libby Dam	Same as LS1.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Lowest likelihood of erosion at sites downstream from dam.	Relatively low likelihood of erosion at sites downstream from dam.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Indian Sacred Sites								
	During informal consultations with the CSKT, they have chosen not to discuss sacred sites at Libby Dam-Lake Koocanusa. Therefore, the possible effects on TCPs are not assessed in this analysis.	Same as LS1.	Same as LS1.	Same as LS1.	Same as LS1	Same as LS1.	Same as LS1.	Same as LS1.
Other Affected Tribal Interests								
	No impacts	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Socioeconomics								
Lake Koocanusa	Adverse impacts on employment and income from recreation and tourism.	Potential positive effects on employment and income from recreation/ and tourism.	Adverse socioeconomic impacts slightly greater than LS1.	Socioeconomic benefits slightly lower than LV1.	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Positive effects on employment and income from recreation/tourism.	Positive effects on employment and income from recreation/tourism.
Kootenai River downstream of Libby Dam	Avg. annual flood damages of $21,780; 455,600 kW-hr of ag. pumping; moderate ag. losses from high groundwater (i.e. seepage).	Avg. annual flood damages same as LS1. 452,500 kW-hr of ag. pumping; relatively high ag. losses from high groundwater.	Avg. annual flood damages same as LS1. 456,100 kW-hr of ag. pumping; ag. losses from high groundwater similar to LS1.	Avg. annual flood damages same as LS1. 453,000 kW-hr of ag. pumping; highest ag. losses from high groundwater.	Avg. annual flood damages same as LS1. ag. pumping costs and losses from high groundwater between LS1 and LS2. Also likely TDG impacts to game fish in 25% of years, affecting recreation economy.	Avg. annual flood damages same as LS1. ag. pumping costs and ag. losses from high groundwater between LV1 and LV2. Also likely TDG impacts to game fish in 50% of years, affecting recreation economy.	Avg. annual flood damages same as LS1. 457,100 kW-hr of ag. pumping; lowest ag. losses from high groundwater.	Avg. annual flood damages of $22,950 in Idaho. 455,300 kW-hr of ag. pumping; ag. losses from high groundwater higher than LS, but tend to be lower than fish flow alternatives.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Kootenay Lake	Moderate likelihood of flood damages around Kootenay Lake.(Damages would occur below established zero-damage elevation)	Likelihood of flood damages around Kootenay Lake similar to LS1	Highest likelihood of flood damages around Kootenay Lake.	Likelihood of flood damages around Kootenay Lake similar to LS2	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Lowest likelihood of flood damages around Kootenay Lake.	Relatively low likelihood of flood damages around Kootenay Lake.
Municipal Water and Wastewater Treatment								
	No impacts identified.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Transportation								
	No impacts identified.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Dam Structural Condition								
	Minor add'l deterioration of spillway surface. Repairs would remain relatively low urgency	Same as LS1	No analysis since mechanism to achieve add'l 10 kcfs of flow not known	Same as LS2	Accelerated deterioration of spillway surface. Repairs would become a higher priority maintenance activity.	Same as LSB	Lowest rate of add'l deterioration of spillway surface.	Rate of deterioration of the spillway surface would be low, but slightly higher than LS1 or LV1.

Table S-4. Summary comparison of the no action and preferred alternatives at Hungry Horse Dam.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Hydrology and Flood Control		
Hungry Horse Reservoir	Hungry Horse Reservoir would continue to have deeper winter flood control drafts in slightly below average to slightly above average water years. The average winter draft would be to elevation 3501 feet. The average June 30 refill would be to elevation 3558.17 feet.	Hungry Horse Reservoir would have shallower winter flood control drafts in slightly below average to slightly above average water years. The average winter draft would be to elevation 3512 feet. This would allow for a slight improvement in probability of refill; the average maximum refill would be to elevation 3558.5 feet.
Hungry Horse Outflows	Due to deeper winter flood control drafts, average outflows would be higher under HS during the January to April period. Average outflows would be about: January – 4995 cfs February – 4930 cfs April – 5648 cfs May – 3423 cfs June – 3054cfs Average outflows for flow augmentation would be about: July – 5174 cfs August - 5474 cfs	Given shallower winter flood control drafts, more water would be released later in the spring in order to maintain the same level of flood protection. Average outflows would be about: January – 4151cfs February – 3906 cfs April – 3560 cfs May – 5637 cfs June – 4243 cfs Average out flows for flow augmentation would be about: July – 5302 cfs August – 5476 cfs Releases for flow augmentation are higher under HV because of the improved probability of refill.
Columbia Falls	During slightly below average to slightly above average water years, HS flows would be higher during the January to April period. Average outflows would be about: January – 6594 cfs February – 6486 cfs April – 12681 cfs May – 23874 cfs June – 23650 cfs Under both alternatives there would continue to be an 18% probability of reaching or exceeding flood stage at Columbia Falls (14 feet).	During slightly below average to slightly above average water years, HV flows would be higher in May and June. Average outflows would be about: January – 5751 cfs February – 5461 cfs April – 10592 cfs May – 26088 cfs June – 24839 cfs Under both alternatives there would continue to be an 18% probability of reaching or exceeding flood stage at Columbia Falls (14 feet).
Flathead Lake	Under HS, there is a 7% probability of exceeding Flathead Lake's full pool elevation of 2893 feet.	Under HV there is 10% probability of exceeding Flathead Lake's full pool elevation of 2893 feet.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Lake Pend Oreille	Due to the attenuation of flows in the river reaches downstream from Hungry Horse Dam and reregulation of flows through Flathead Lake and Kerr Dam, water surface elevations at Lake Pend Oreille would be essentially identical.	Same as HS.
Downstream from Albeni Falls Dam	Average outflows from Lake Pend Oreille would lower in June. Average outflows would be about: January – 17411 cfs February – 19434 cfs April – 28588 cfs May – 53,678 cfs June – 54518 cfs There would continue to be a 27% probability of exceeding the flood stage of 100,000 cfs below Albeni Falls Dam.	Average outflows from Lake Pend Oreille would be slightly lower in January to April period. The slight reduction in April flows could provide flood relief in the Cusick area when Calispell and Trimble Creeks are high. Average outflows would be about: January – 16981 cfs February – 18033 cfs April – 28020 cfs May – 53,536 cfs June – 56578 cfs There would continue to be a 27% probability of exceeding the flood stage of 100,000 cfs below Albeni Falls Dam.
Water Quality		
	Under simulated releases, there is less chance of HS exceeding TDG standards.	Under simulated releases, the chance of HV exceeding the 15 percent spill is 1 % in June. Overall, spill analysis indicates that implementation of HV could result in increases in TDG saturation levels from May through July. Changes in the saturation levels are not quantifiable with the available data, but appear to be minor. Based on modeling, HV operations would generally increase benthic biomass production in the Flathead River because the natural temperature regime and other physical properties of the river would be more closely mimicked.
Aquatic Life		
	Deep drafts implemented under HS would continue to limit food availability and habitat quality at Hungry Horse Reservoir and the Flathead River. Modeling results showed minimal differences between alternatives from Flathead Lake downstream.	Implementation of HV would likely benefit resident fish, especially those in Hungry Horse Reservoir and immediately downstream in the Flathead River. Hungry Horse releases would follow a more normative hydrograph and would be higher in March, May, and June. Reduced winter drafts would help achieve refill at Flathead Lake, especially in dry years. Higher late-spring releases would help meet Kerr Dam minimum outflow requirements, thus providing minor benefits to aquatic resources in Flathead Lake and downstream from Kerr Dam.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Sensitive, Threatened and Endangered Species		
	Deep drafts implemented under HS would continue to limit food availability and habitat quality at Hungry Horse Reservoir and the Flathead River. Modeling results showed minimal differences between alternatives from Flathead Lake downstream.	Implementation of HV would benefit bull trout through general improvements in biological conditions at Hungry Horse Reservoir and immediately downstream in the Flathead River. Below Flathead Lake, HV would result in a slightly more normative hydrograph and minor increases in TDG saturation levels. Neither alternative is likely to appreciably affect existing conditions within designated bull trout critical habitat HV may result in minor benefits to the fish prey base for bald eagles at Hungry Horse Reservoir and Flathead Lake and neither alternative is likely to affect bald eagle nesting, roosting, and feeding habitats.
Wildlife		
	Existing riparian and wetlands habitat would remain unchanged.	May provide minor benefits to riparian and wetland habitats and associated wildlife along Flathead Lake and immediately upstream on the Flathead River. Otherwise, existing wildlife habitats generally would not be affected.
Vegetation		
	Existing riparian and wetlands would remain unchanged.	May provide minor benefits to riparian areas and wetlands along Flathead Lake and immediately upstream on the Flathead River.
Recreation		
	Slightly more fishing and kayaking days on the Flathead River downstream from Hungry Horse Dam in the early summer due to optimal flows.	May result in minor improvements in boater access to Hungry Horse Reservoir and Flathead Lake owing to higher average water surface elevations during the recreation season and an increase in the usability of boat ramps. Slightly better aesthetics due to higher surface water elevations.
Environmental Health		
	No measurable effect on human or environmental health within the affected area.	Same as HS.
Cultural Resources		
	Some erosion and slumping would continue at archaeological sites within Hungry Horse Reservoir.	Likely would be a minor increase in the potential for winter erosion and ice impacts to cultural resources. HV also may provide minor benefits to cultural resources during the summer recreation season owing to the increased probability of reservoir refill. Once full, the reservoir helps protect cultural sites below the high water line which otherwise would be exposed to impacts from summer erosion and visitor use.
Indian Sacred Sites		
	No Indian sacred sites have been identified.	Same as HS.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Other Affected Tribal Interests		
	No effect on other interests	Same as HS.
Transportation		
	No effect on existing transportation systems	Same as HS.
Municipal Water and Wastewater Treatment		
	No effect likely on existing municipal water sources or treatment/disposal facilities.	Same as HS.
Socioeconomics		
	Existing levels of flood protection would continue.	Results in a minor (4%) increase in potential flood effects at Flathead Lake, primarily for damage to waterfront land and docks. HV would also result in a 12% increase in potential flood effects below Albeni Falls Dam, primarily for damages to agricultural and residential property.

Table S-5. Summary comparison of alternative and benchmark combinations on the mainstem Columbia River.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Hydrology and Flood Control								
Grand Coulee Dam-upstream	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies no greater than LS+HS	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies same as LV+HV	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies no greater than LS+HS	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies same as LV+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Birchbank: 99% exceedance frequency 93.6 kcfs, 50% exceedance. frequency 162.5 kcfs; 1% exceedance frequency 250 kcfs	Birchbank: 99% exceedance frequency 95.1 kcfs, 50% exceedance frequency 167 kcfs; 1% exceedance frequency 251 kcfs
Lake Roosevelt	2nd half of April elevations (feet): Minimum 1208.0 Maximum 1280.0 Average 1244.0	2nd half of April elevations (feet): Minimum 1208.0 Maximum 1280.0 Average 1242.4	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Apr2 same as LV1+HV Lower Jan-May elevations during some years

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	Peak 1-day release exceedance frequencies for The Dalles no more than for LS+HS. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly lower than for LV1+HV, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LV+HV. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly higher than for LS1+HS, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LS+HS. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly lower than for LV2+HV, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LV+HV. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly higher than for LS2+HS, and above flood stage In 2 of the 10 years.	Similar to LS1+HS and LS2+HS. For peak daily releases at The Dalles, values would be between LS1+HS and LS2+HS. Peak 1-day elevations at Vancouver would fall between LS1+HS and LS2+HS.	Similar to LV1+HV and LV2+HV. For peak daily releases at The Dalles, values would be between LV1+HV and LV2+HV. Peak 1-day elevations at Vancouver would fall between LV1+HV and LV2+HV.	The Dalles: 99% exceedance frequency: 205 kcfs 50% exceedance frequency: 401 kcfs; 1% exceedance frequency: 670 kcfs	The Dalles: 99% exceedance frequency: 211 kcfs 50% exceedance frequency: 411 kcfs; 1% exceedance frequency: 670 kcfs
System Power								
Winter (Jan-Apr)	Monthly average winter generation (aMW): 16,556 System; 8,252 Federal; 3,812 non-Federal; Canadian monthly average generation 631 on Pend d'Oreille, 702 on Kootenay.	Monthly average winter generation (aMW): 16,220 System; 8,008 Federal; 3,718 non-Federal Canadian monthly average generation 616 aMW on Pend d'Oreille 626 on Kootenay	Monthly average winter generation (aMW): 16,555 system; 8,252 Federal; 3,812 non-Federal Canadian monthly average generation 631 on Pend d'Oreille, 702 on Kootenay	Monthly average winter generation (aMW): 16,219 System; 8,008 Federal; 3,718 non-Federal Canadian monthly average generation 616 on Pend d'Oreille, , 626 on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average winter generation (aMW): 16,556 System; 8,259 Federal; 3,813 non-Federal Canadian monthly average generation 631 on Pend d'Oreille, 704 aMW on Kootenay	Monthly average winter generation (aMW): 16,226 System; 8012 Federal; 3,718 non-Federal; Canadian monthly average generation 616 on Pend d'Oreille, 627 on Kootenay

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Spring/summer (May-Aug)	Monthly average generation (aMW): 16,993 System; 9,011 Federal; 4,272 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 922 aMW on Kootenay	Monthly average generation (a MW): 17,252 System; 9,237 Federal; 4,317 non-Federal; Canadian monthly average generation 794 aMW on Pend d'Oreille, 948 on Kootenay	Monthly average generation (aMW): 16,977 System; 9,009 Federal; 4,273 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 921 aMW on Kootenay	Monthly average generation (aMW): 17,235 System; 9,235 Federal; 4,317 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 947 aMW on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average generation (aMW): 16,716 System; 8,763 Federal; 4,219 non-Federal; Canadian monthly average generation 797 on Pend d'Oreille, 886 aMW on Kootenay	Monthly average generation (aMW): 16,993 System; 9,003 Federal; 4,269 non-Federal; Canadian monthly average generation 798 on Pend d'Oreille, 901 on Kootenay
Fall (Sept-Dec)	Monthly average generation (aMW): 11,500 System; 5,780 Federal; 2,821 non-Federal; Canadian monthly average generation 507 on Pend d'Oreille, 477 on Kootenay	Monthly average generation (aMW): 11,550 System; 5,805 Federal; 2,836 non-Federal; Canadian monthly average generation 510 on Pend d'Oreille, 483 on Kootenay	Monthly average generation (aMW): 11,493 System; 5,775 Federal; 2,820 non-Federal; Canadian monthly average generation 507 on Pend d'Oreille, 476 on Kootenay	Monthly average generation (aMW): 11,545 System; 5,803 Federal; 2,834 non-Federal; Canadian monthly average generation 509 on Pend d'Oreille, 483 on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average generation (aMW): 11,863 System; 6,805 Federal; 2,906 non-Federal; Canadian monthly average generation 504 on Pend d'Oreille, 580 on Kootenay	Monthly average generation (aMW): 11,888 System; 6,092 Federal; 2,910 non-Federal; Canadian monthly average generation 505 on Pend d'Oreille, 580 on Kootenay
Water Quality								
Grand Coulee Dam – upstream TDG	Existing seasonally-elevated TDG levels in the Columbia River at the international border and in Lake Roosevelt would continue, as would ongoing efforts to ameliorate them.	TDG levels in the Columbia River at the international border likely would be marginally higher than at present at times, primarily due to minor increases in involuntary spill at Canadian hydropower facilities on the Kootenay River.	Same as LS1+HS	Same as LV1+HV	Values would range between LS1+HS and LS2+HS.	Values would range between LV1+HV and LV2+HV.	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Temperature	Operational changes at Hungry Horse and Libby Dams are unlikely to affect Columbia River temperatures because of the large intervening distance involved.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Grand Coulee Dam – downstream TDG	Slightly increase spill cap exceedance index and the amount of spill in excess of the spill cap compared to benchmarks which indicates the potential to increase TDG levels.	Highest spill cap exceedance index and the amount of spill in excess of the spill cap.	Same as LS1+HS	Same as LS1+HS and has a higher spill cap exceedance index at Rock Island and Priest Rapids Dams than LV1+HV.	Values would range between LS1+HS and lS2+HS.	Values would range between LV1+HV and LV2+HV.	Spill cap exceedance index and spill in excess of spill cap would be lower than Standard FC alternative combinations.	Spill cap exceedance index and spill in excess of spill cap would be lower than VARQ FC alternative combinations.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Aquatic Life								
Grand Coulee Dam - upstream	The present habitat characteristics, species assemblages, and population dynamics at Lake Roosevelt generally would remain unchanged. Large annual flood control drafts would continue to limit natural reproduction of many fish species in the reservoir and would continue to facilitate entrainment. Nutrient flushing and low spring water surface elevations would continue to limit the growth of some species.	Minor increases in spring drawdowns at Lake Roosevelt could result in periodic, small reductions in present levels of spawning success for smallmouth bass, yellow perch, and shoreline spawning kokanee. Minor reductions in water retention times may result in small increases in the loss of nutrients from the reservoir which in turn may lead to minor decreases in growth rates for some species. Minor increases in entrainment would occur in some years.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	Continued similar influence on the timing and magnitude of flows in the Columbia River. The present habitat characteristics, presence/ absence and migration patterns of species generally would remain unchanged.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Sensitive, Threatened and Endangered Species								
Grand Coulee Dam - upstream	The present habitat characteristics, species presence, and population dynamics at Lake Roosevelt and upstream generally would remain unchanged. Large annual flood control drafts would continue to limit benthic productivity and may also continue to limit the juvenile-growth potential of bull trout in the reservoir. Bald eagle numbers and distribution would likely remain unchanged.	Minor increases in spring drawdowns at Lake Roosevelt could result in small reductions in present levels of benthic productivity. Primary impacts to bull trout would most likely be growth-related. The fish prey base for bald eagles would not likely be noticeably affected, and bald eagle numbers and distribution would likely remain unchanged.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	River flows and reservoir elevations would remain within the current range of operations. In general, related ongoing effects to threatened and endangered species would remain unchanged from those previously consulted upon and addressed in biological opinions.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LV1+HV
Anadromous Fish –Priest Rapids Dam	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly flow objectives met in 32-47 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.
Anadromous Fish -McNary Dam	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 3-42 of 52 years.	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Monthly flow objectives met in 3-42 of 52 years.	Monthly flow objectives met in 2-42 of 52 years.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Spill	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in slightly lower potential TDG levels and durations as compared to the VARQ FC alternative combinations.	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in a slight potential increase in TDG levels and durations as compared to the Standard FC alternative combinations.	Same as LS1+HS	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in the highest potential TDG levels and durations as compared to all other alternative combinations.	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this benchmark combination results in the lowest potential TDG levels and durations.	Same as LV1+HV
Vegetation								
	River flows and reservoir elevations would remain within the current range of river and reservoir operations, and; therefore, related effects on vegetation would be similar. Riparian and wetland areas within the influence of the Columbia River and its impoundments generally would remain unchanged.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Wildlife								
	Riparian and wetland habitats within the influence of the Columbia River and its impoundments generally would remain unchanged. Associated terrestrial wildlife populations also are not likely to be affected.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Recreation								
Grand Coulee Dam - upstream	Current levels of recreation access and scenic quality at Lake Roosevelt generally would remain unchanged. There would be no change in usable boat ramp days during the summer.	There would be a minor decrease (less than 5%, primarily in May) in average usable boat ramp days at Lake Roosevelt. Otherwise, there would be no change in the present function of boat ramps or marinas, particularly during the summer. A slight degradation in visual resources may be noticeable in May due to slightly lower reservoir elevations.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	No change in present levels and quality of boating and shoreside recreation.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Environmental Health								
Grand Coulee Dam - upstream	There would be no change in the timing, duration, or magnitude of annual flood control drawdowns at Lake Roosevelt. Similarly, there would be no change in the annual exposure of lake bed sediments, or in the exposure of humans and other organisms to contaminants present in those sediments. Preliminary results of an ongoing air quality study indicate that none of the samples taken at Lake Roosevelt study sites have exceeded established standards.	There would be slightly lower reservoir surface elevations and thus slightly increased exposure of lake bed sediments during the spring flood control draft in average to moderately dry water years. When compared to present conditions, the likelihood of measurable impacts to environmental and human health through inhalation, ingestion, or direct contact with contaminated bed-sediments is expected to be extremely low.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	There are no identified flow-related environmental health concerns below Grand Coulee. All alternative combinations would continue to similarly influence the timing and magnitude of flows in the Columbia River.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Cultural Resources								
Grand Coulee Dam – upstream	There would be no change in the timing, duration, or magnitude of annual flood control drawdowns at Lake Roosevelt. Similarly, there would be no change in the periodic exposure of cultural resources to wave action, erosion, displacement, weathering, or collection/looting.	There would be slightly lower reservoir surface elevations and thus slightly increased exposure of cultural resources during the spring flood control draft in average to moderately dry water years. When compared to present conditions, the likelihood of impacts to cultural resources is expected to be minor.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	There would be essentially no change in management or protection of cultural resources downstream from Grand Coulee Dam. Effects to cultural resources (primarily erosion and site exposure) from river flows and reservoir operations would be similar for all alternative combinations.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Indian Sacred Sites								
	No sacred sites have been identified.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Other Affected Tribal Interests								
	Tribal interests in fishing would be affected by all alternative combinations to the extent that salmon and steelhead survival and recovery are affected. The analysis for anadromous fish discusses how the flow objectives at McNary and Priest Rapids dams are achieved by the various alternative combinations. Fish flows from Libby and Hungry Horse in July and August are intended to assist salmon outmigration. Spring flow augmentation for Kootenai River white sturgeon also can assist in meeting flow objectives in the lower Columbia River. No discernible effect on lamprey is expected.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Socioeconomics								
Flood Damages	No increase in economic losses from floods to areas protected by major levee systems. Fish flows may cause minor increase in levee maintenance costs.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Agriculture	No impacts identified.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Hydropower	Annual hydropower values (billions): $4.946 System; $2.516 Federal; $1.211 non-Federal	Annual hydropower values (billions): $4.932 System; $2.504 Federal; $1.202 non-Federal	Annual hydropower values (billions): $4.944 System; $2.525 Federal; $1.212 non-Federal	Annual hydropower values (billions): $4.931 System; $2.508 Federal; $1.202 non-Federal	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Annual hydropower values (billions): $4.967 System; $2.533 Federal; $1.213 non-Federal	Annual hydropower values (billions): $4.948 System; $2.520 Federal; $1.203 non-Federal
Transportation and Navigation	No effects to Keller or Inchelium ferries	Keller Ferry north landing would be used more frequently.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV
Municipal Water and Wastewater Treatment								
	No effect on municipal water sources, wastewater treatment or disposal.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Transportation								
Grand Coulee Dam – upstream	The Keller and Inchelium Ferries would continue normal operations within the current range of reservoir levels. Lake Roosevelt end-of-April elevation would be less than 1248 feet approximately 60% of all years. Keller Ferry North landing must be used when elevation is below 1248 feet	The Keller and Inchelium ferries would continue normal operations within the current range. Lake Roosevelt end-of-April elevation would be less than 1248' approximately 70% of all years, therefore, the Keller Ferry's alternative north landing would have to be used more frequently than at present.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV
Grand Coulee Dam – downstream	No effect	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Chapter 1 Introduction and Background

1.1 The Proposed Action

In accordance with the National Environmental Policy Act of 1969 (NEPA), 42 USC §§ 4321-4370e, this Final Environmental Impact Statement (EIS) assesses the effects of a proposed Federal action and alternatives, which have the potential to significantly affect the human environment. The proposed Federal action consists of:

1. Implementation of alternative flood control operations at Libby Dam on the Kootenai River and Hungry Horse Dam on the South Fork Flathead River. Called variable discharge flood control, this alternative action is known as "VARQ FC," with VAR representing variable, Q representing engineering shorthand for discharge, and FC representing flood control.
2. Flow augmentation that such alternative flood control would facilitate in the Kootenai River, the Flathead River, and mainstem Columbia River for fish populations listed as threatened or endangered under the Endangered Species Act (ESA). Flow augmentation (i.e., fish flows) includes release of water for bull trout, salmon, and, at Libby Dam, white sturgeon.

The U.S. Army Corps of Engineers (Corps) is the lead agency for this EIS, with the Bureau of Reclamation (Reclamation) acting as a cooperating agency.

1.2 Purpose of and Need for the Proposed Action

1.2.1 Purpose of the Proposed Action

The purpose of the proposed action is to provide reservoir and flow conditions at and below Libby and Hungry Horse dams for anadromous and resident fish listed as threatened or endangered under the ESA, consistent with authorized project purposes, including maintaining the current level of flood control benefits.

1.2.2 Need for the Proposed Action

Multiple use project operations[2] at Libby, Hungry Horse, and other dams have altered the natural river hydrology of the Columbia River and some of its major tributaries. These dams store the spring snowmelt runoff to control floods, and release water for multiple uses. Populations of threatened and endangered fish in the Columbia River Basin (Kootenai River white sturgeon, Columbia Basin bull trout, and several Columbia River salmon and steelhead stocks) benefit from certain high flow periods, which historically were determined by natural runoff patterns driven by snowmelt and rainfall. While the status of bull trout populations in the Kootenai and Flathead rivers is generally better than some others in the Columbia River Basin, long-term monitoring has shown that bull trout populations in both watersheds have declined since construction of Libby and Hungry Horse dams. Kootenai River white sturgeon numbers are estimated at fewer than 500, down from numbers of 5,000 to 6,000 in the 1980s, and are declining at approximately 9 percent per year. Several salmon and steelhead populations in the Columbia River Basin are in various states of decline. For example, lower Columbia River coho salmon were listed as threatened in June 2005. See NOAA Fisheries (2005) for status of individual salmon and steelhead stocks.

In accordance with the ESA, the Corps, Reclamation and the Bonneville Power Administration (the Action Agencies) have engaged in formal consultation on the effects of the operation of the Federal Columbia River Power System (FCRPS) on anadromous and resident fish species listed as threatened or endangered. In December 2000, the National Marine Fisheries Service (NMFS, also referred to NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS), issued biological opinions on the effects of the operation of the FCRPS on the species under their jurisdiction. The NMFS and USFWS 2000 biological opinions both included a Reasonable and Prudent Alternative (RPA), with a recommendation to implement VARQ FC at Libby and Hungry Horse dams. In response, the Corps and Reclamation began the process to ensure the recommended flood control and fish flow operations at Libby and Hungry Horse dams were consistent with our responsibilities under the NEPA as represented in the purpose and need for this EIS. The recommendations carried over into the NMFS 2004 BiOp and the USFWS 2006 BiOp. For more details on ESA consultations and biological opinions from the NOAA Fisheries and USFWS, refer to Sections 1.4.1 and 1.4.2, respectively.

[2] These include flood control, hydropower, fish and wildlife, recreation, navigation, irrigation, water supply, and water quality.

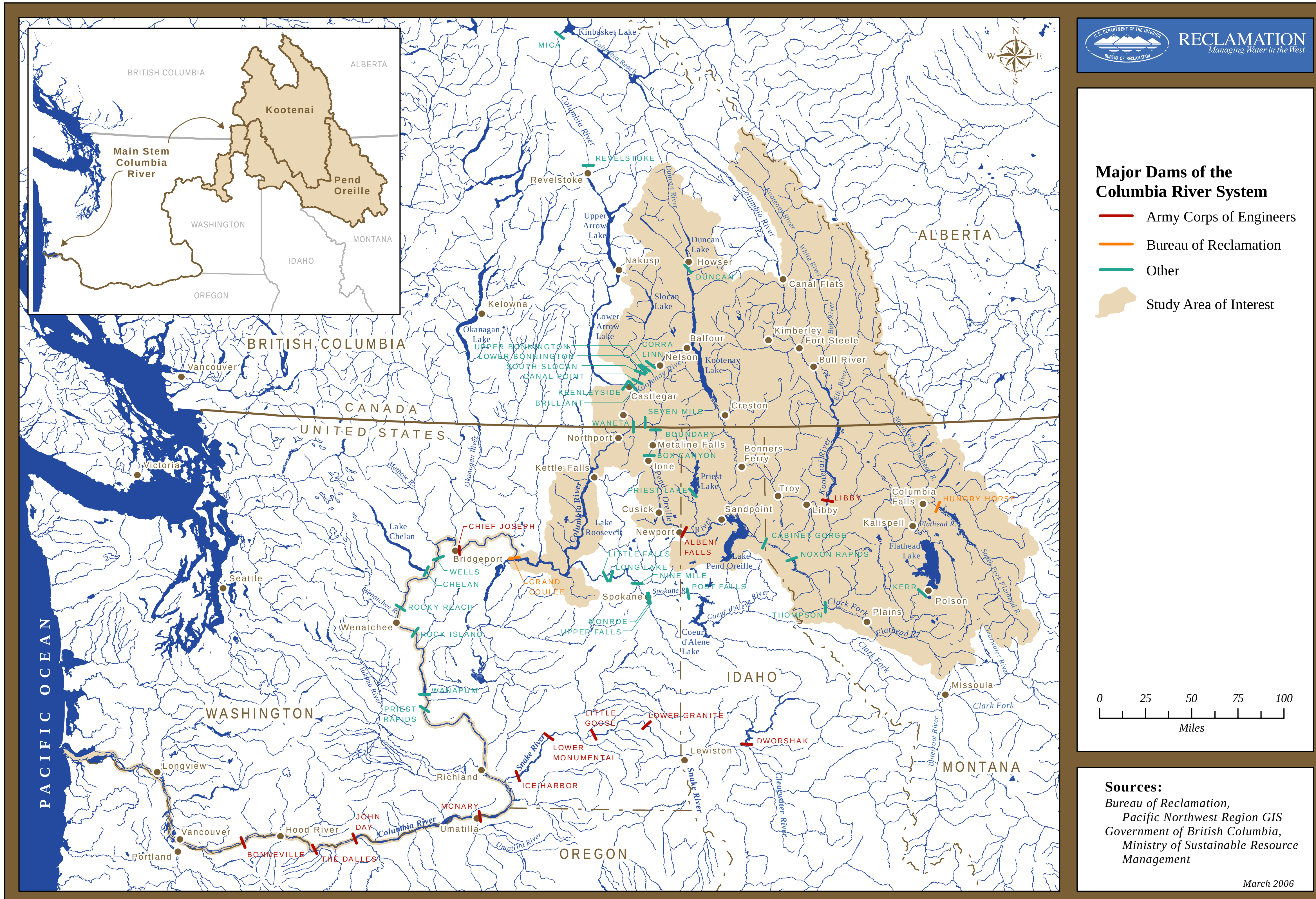

Figure 1-1. Major Dams of the Columbia River System.

1.3 General Setting

1.3.1 Kootenai River Basin

The Kootenai River basin encompasses 16,180 square miles (NPPC 2004), of which 8,985 square miles are upstream from Libby Dam (Corps 1984). About 70 percent of the basin lies within British Columbia (Figure 3-1).

The Kootenay River[3] originates in British Columbia, flowing southward into northwestern Montana. Libby Dam impounds Lake Koocanusa at river mile (RM) 222, about 40 miles south of the international boundary. At the city of Libby, Montana (RM 204), the river turns westward, then north near Bonners Ferry, Idaho (RM 153), and back into British Columbia at RM 106. The river enters Kootenay Lake about 25 miles north of the international boundary, draining through West Arm near Nelson, British Columbia, and into the Columbia River near Castlegar, British Columbia. Average annual runoff at Libby Dam is about 8 million acre-feet (Berkas *et al.* 2004) and about 9 million acre-feet at its mouth (NPPC 2004).

1.3.2 Pend Oreille River Basin

The Middle Fork and South Fork Flathead River are headwater tributaries within the Pend Oreille River basin that originate near the Continental Divide in the Northern Rocky Mountains in the United States; the North Fork originates in British Columbia, Canada. Hungry Horse Dam is at RM 5 of the South Fork Flathead River. The South Fork joins the North and Middle Forks a few miles upstream from Columbia Falls, Montana. The Flathead River downstream from Columbia Falls flows through meandering channels in a wide floodplain and enters Flathead Lake about 20 miles downstream from Kalispell, Montana.

From Kerr Dam at the Flathead Lake outlet near Polson, Montana, the Flathead River continues southward to the Clark Fork. The Clark Fork flows northwesterly into Idaho and Lake Pend Oreille. From the Lake Pend Oreille outlet at Albeni Falls Dam the river turns north for about 74 miles, crossing the border into British Columbia, where it flows the last 16 miles before its confluence with the Columbia River just upstream from the international boundary. The confluence of the Pend d'Oreille and Columbia Rivers is about 30 miles downstream from the Kootenay River confluence with the Columbia River.

[3] The Canadian spelling is used when the geographic feature is in Canada.

The Flathead River watershed above Kerr Dam covers about 7,100 square miles and produces an average annual runoff of about 2.5 million acre-feet at Hungry Horse Dam and 8.6 million acre-feet at Perma, Montana (Berkas *et al.* 2000). The Pend Oreille-Clark Fork watershed encompasses about 26,000 square miles and has an average annual runoff of about 18.2 million acre-feet at Albeni Falls Dam (Kimbrough *et al.* 2003). These watersheds are referred to as the Pend Oreille River basin in this document (Figure 4-1).

1.3.3 Mainstem Columbia River

The Columbia River originates at Columbia Lake in the Rocky Mountains of British Columbia, Canada, and flows 1,214 miles to the Pacific Ocean. From its source, the river flows northwest for approximately 200 miles, then reverses course and travels south for nearly 300 miles through mountainous terrain in southeastern British Columbia. The Columbia River crosses into the United States near the northeastern corner of the state of Washington and continues south through highlands before bending westward. After veering south and then east, the river turns south and then west and flows for over 300 miles to the Pacific Ocean. In the United States, eleven private and public dams are located on the mainstem Columbia River. Grand Coulee Dam is located at RM 597 in north-central Washington.

The Columbia River Basin drains over 259,000 square miles and produces an average annual runoff at The Dalles of about 138 million acre-feet (Kimbrough *et al.* 2003). The Kootenai, Pend Oreille, and Snake Rivers are the largest tributaries of the Columbia River (Figure 1-1).

1.4 Background

For purposes of this EIS, the term “FCRPS” refers to a series of 14 Federal dams in the United States which were the subject of the USFWS 2000 and 2006 and NOAA Fisheries 2004 FCRPS Biological Opinions.[4] These dams operate in coordination with Canadian and private facilities to provide for a variety of uses such as hydropower, flood control, navigation, and fish and wildlife purposes. System operations are optimized through cooperative processes to use the limited water supply to maximize benefits to all resources. The Corps is authorized to operate and maintain the following 12 dams: Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams in the lower Snake River basin; Albeni Falls, Libby, and Chief Joseph dams in the upper Columbia River basin; and McNary, John Day, The Dalles and Bonneville dams in the lower Columbia River basin. Reclamation is authorized to operate and maintain two

[4] While this EIS uses FCRPS as defined in the 2000 USFWS and 2004 NOAA Fisheries FCRPS Biological Opinions, different definitions of the FCRPS can be found in other documents. For example, the FCRPS for power marketing purposes consists of 31 federally-owned hydropower projects together with the associated electrical transmission system.

dams: Grand Coulee and Hungry Horse in the Upper Columbia River basin. The impacts associated with ongoing operation of the FCRPS have been addressed in prior NEPA documents including the System Operation Review (SOR) EIS (BPA *et al*. 1995; see http://www.nww.usace.army.mil/planning/er/reports.htm#EIS), the Operations Analysis EIS (Corps *et al*. 1992), and its Supplemental EIS (Corps 1993), and the project Operational and Maintenance EISs. This EIS focuses on those environmental conditions that would be modified by implementation of the proposed Federal action and alternatives. The SOR EIS was undertaken with several goals in mind, including the development of a system operating strategy and a regional forum for non-Federal parties' input into system planning. The SOR EIS was also prepared to provide environmental analysis needed for Federal agencies to sign new agreements for coordinating power generation (the Pacific Northwest Coordinating Agreement, or PNCA), and for allocation, among Federal and non-Federal parties, of the return of Canadian Entitlement power to Canada (Canadian Entitlement Allocation Agreements, or CEAA). Ultimately, the SOR EIS and the selected plan recognize the river system and its operations are dynamic, and incorporate adaptive management principles to modify operations in response to changes in the natural environment.

1.4.1 NOAA Fisheries FCRPS Biological Opinion and 2004 UPA

As discussed above, in December 2000, NOAA Fisheries issued a biological opinion in accordance with the ESA on the operations of the FCRPS by the Action Agencies (NMFS 2000). NOAA Fisheries concluded that operation of the FCRPS was likely to jeopardize eight listed populations of Columbia Basin salmon and steelhead and to adversely modify their designated critical habitats. NOAA Fisheries also recommended a reasonable and prudent alternative (RPA), pursuant to ESA § 7(b)(3)(A) and 50 CFR § 402.14(h)(3). The RPA included implementation of VARQ FC at Hungry Horse and Libby Dams.

In May 2003, the U.S. District Court for Oregon ruled, in *National Wildlife Federation* et al. *v. National Marine Fisheries Service*, that the 2000 biological opinion violated ESA implementation regulations because it had improperly relied on offsite Federal activities that had not undergone Section 7 ESA consultation and non-Federal activities that were not reasonably certain to occur. The Court ordered that the biological opinion be remanded to NOAA Fisheries for correction.

As part of the remand process, the Action Agencies completed an updated proposed action (UPA) on the effects of FCRPS operations on listed anadromous species. The NOAA Fisheries considered the UPA and issued the 2004 NOAA Fisheries FCRPS Biological Opinion on November 30, 2004 (NMFS 2004). The 2004 UPA generally reflects, with certain modifications, the hydropower, habitat, hatchery, and harvest measures recommended in the 2000 biological opinion RPA including implementation of VARQ FC at Libby Dam and Hungry Horse Dam.

In May 2005, the U.S. District Court for Oregon ruled, in *National Wildlife Federation et al. v. National Marine Fisheries Service*, that the NOAA 2004 FCRPS biological opinion was "not consistent with the requirements of the Endangered Species Act," and again remanded to NOAA Fisheries. The court ordered remand includes a collaborative process with sovereign parties and NOAA Fisheries and the Action Agencies; and, a biological opinion is to be produced by NOAA Fisheries by October 2006. In the interim, the NOAA 2004 biological opinion remains in effect, as modified by court order.

Salmon Flow Augmentation at Libby and Hungry Horse Dams

As described in the 2004 UPA and the 2004 NOAA Fisheries FCRPS Biological Opinion, the reservoirs at Hungry Horse and Libby dams would be drawn down (drafted) during July and August to augment summer flows in the Columbia River for salmon and steelhead migration.

Reclamation manages Hungry Horse Dam to refill to elevation 3560 feet (full pool) on or about June 30. After refill, the 2004 UPA specifies water releases for salmon flow augmentation from Hungry Horse Dam to a draft limit elevation of 3540 feet (20 feet from full) by August 31. A draft of 20 feet from full pool provides up to 454,840 acre-feet of additional water from Hungry Horse Reservoir.

The Corps manages Libby Dam to refill Lake Koocanusa to elevation 2459 feet (full pool) by July 1, when possible. After refill, the 2004 UPA specifies water releases to augment Columbia River flows for salmon from Libby Dam to a draft limit elevation of 2439 feet (20 feet from full pool) by August 31. A draft of 20 feet from full pool provides up to 891,000 acre-feet of additional water from Lake Koocanusa.[5]

Through July and August, Hungry Horse and Libby Dam releases are maintained at or above bull trout minimum flows. In any given year, the timing and magnitude of the summer drafts for salmon at Hungry Horse and Libby dams are coordinated through the in-season management process.

As Federal agencies responsible for managing and operating Federal hydroelectric facilities, the Corps and Reclamation must take into account the Northwest Power and Conservation Council's Fish and Wildlife Program and Mainstem Amendments in the decision-making process. The Mainstem Amendment recommendations for summer operations at Libby and Hungry Horse dams, consisting of stable or flat flows that extend into September with a 10-foot draft limit in most years, differ from the operations

[5] In some years, the salmon draft at Lake Koocanusa may be reduced, with the Lake Koocanusa water exchanged with water from Canadian reservoirs under the Libby Coordination Agreement.

analyzed the 2004 NOAA Fisheries' Biological Opinion (2004 BiOp). However, the operation of the FCRPS, including the summer flow augmentation operations from the Libby and Hungry Horse projects, is being discussed in the collaborative remand process ordered by Judge Redden, U.S. District of Oregon. The summer operations recommended in the Mainstem Amendments for Libby and Hungry Horse dams are within the normal range of operations and within the range of impacts previously analyzed in this EIS or other NEPA documents; therefore, no further NEPA analysis would be needed if these recommendations are adopted at a later date.

For purposes of this EIS, the provisions for salmon flow augmentation considered in the 2004 NOAA Fisheries FCRPS Biological Opinion were evaluated. The 2004 UPA and 2004 NOAA Fisheries Biological Opinion recognize that future salmon flow augmentation operations will occur, unless subsequently modified through adaptive management.

1.4.2 2000 USFWS FCRPS and 2006 Libby Dam Biological Opinion

The USFWS in their December 2000, FCRPS Biological Opinion determined that the proposed operation of the FCRPS did not jeopardize threatened bull trout; however, with respect to the endangered Kootenai River white sturgeon, the USFWS made a jeopardy determination and provided an RPA. Included in the RPA, the USFWS recommended completion of NEPA documentation and coordination with Canada to implement VARQ FC at Libby Dam and certain flow augmentation from Libby Dam during the spring (USFWS 2000). For bull trout, the USFWS provided terms and conditions to minimize incidental take, including certain minimum flows at Libby and Hungry Horse dams.

In response to the designation of Kootenai River white sturgeon critical habitat, the Corps and BPA reinitiated consultation with the USFWS on the effects of the operation of Libby Dam, one of the FCRPS projects, on the Kootenai River white sturgeon, its designated critical habitat, and bull trout. On February 18, 2006, the USFWS issued a biological opinion (USFWS 2006), which supersedes the USFWS 2000 biological opinion with respect to Libby Dam operations. The USFWS 2000 biological opinion concerning Hungry Horse operations remains in effect.

In the 2006 Biological Opinion, the USFWS again found that the proposed operation of Libby Dam would likely jeopardize the continued existence of endangered Kootenai River white sturgeon and adversely modify its designated critical habitat. The USFWS recommended an RPA that would avoid jeopardizing the continued existence of the sturgeon and would not adversely modify its critical habitat. As part of the RPA, the USFWS recommended continued implementation of VARQ FC at Libby Dam and flow augmentation for sturgeon in the spring. The USFWS 2006 Biological Opinion concluded no jeopardy for the proposed Libby Dam operations on bull trout, and included terms and conditions to minimize incidental take. These included certain minimum flows and ramping rates.

Sturgeon Flow Augmentation

The USFWS 2006 Biological Opinion recommended that Libby Dam provide minimum tiered volumes of water, based on the seasonal water supply, for augmentation of Kootenai River flows during periods of sturgeon spawning and early life stage development. These tiered volumes are consistent with those used for implementation of the 2000 Biological Opinion. Figure 1-2 shows the sturgeon volume tiers for different seasonal water supply forecasts (WSF). Less volume is dedicated for sturgeon flow augmentation in years of lower water supply. Measurement of sturgeon volumes excludes the 4,000 cubic feet per second (cfs) minimum flow releases from the dam.

After release of the USFWS 2000 FCRPS Biological Opinion, the Corps and USFWS, through adaptive management, determined the minimum sturgeon volume would be interpolated between tiers according to the WSF (Figure 1-2) (Corps 2002c). The Corps and USFWS agreed the minimum sturgeon flow volume would be measured at Libby Dam rather than Bonners Ferry. In practice, the timing and shaping of these volumes are based on seasonal requests from the USFWS to provide river conditions where sturgeon successfully and reliably reproduce, as well as to meet other conditions, such as those required for evaluation of experimental release of sturgeon larvae. These tiered volumes remain the same in the 2006 Biological Opinion.

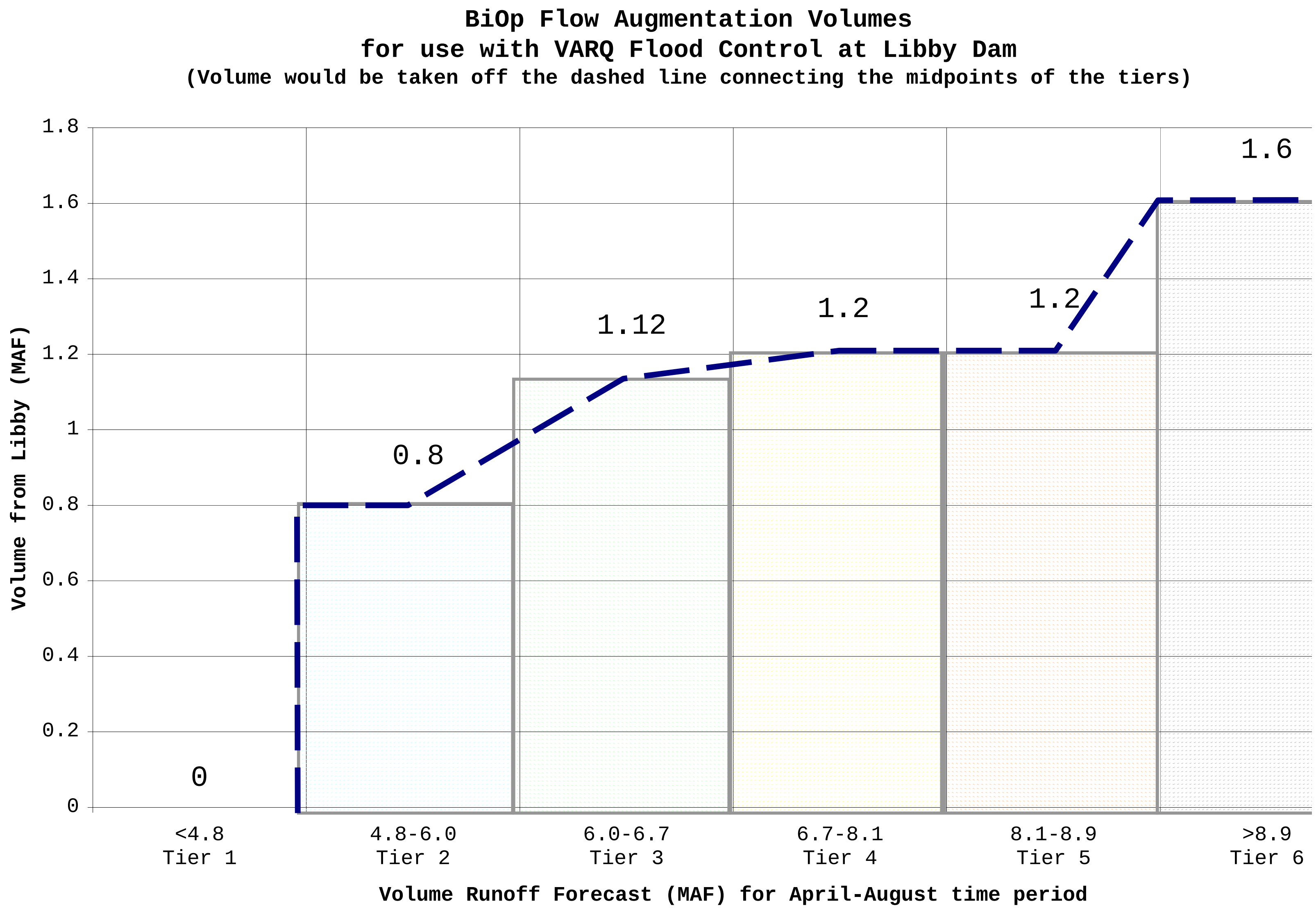

Figure 1-2. Sturgeon flow augmentation volumes from Libby Dam.

This EIS evaluates the effects of combining flood control alternatives with two sturgeon flow operations: 1) sturgeon flows to existing powerhouse capacity and 2) sturgeon flows to 10,000 cfs above the existing powerhouse capacity (see Chapter 2). This is consistent with the USFWS 2006 Biological Opinion RPA which recommends releases from Libby Dam up to 35 kcfs, pending appropriate water conditions, providing for a normative hydrograph to achieve the desired habitat attributes of depth, velocity and temperature. Depending on the tiered volumes, local inflow and the backwater effect from Kootenai Lake, peak releases from Libby could range from powerhouse capacity (25 kcfs) up to 35 kcfs.

Currently, the only means available to provide up to 35 kcfs (10 kcfs above the powerhouse capacity of approximately 25 kcfs) from Libby Dam is by spill. Spill of up to 10 kcfs will increase Total Dissolved Gas (TDG) above the Montana water quality standard of 110%. The Corps, BPA, and the USFWS are coordinating with the State of Montana on the TDG effects of spilling 10 kcfs.

Bull Trout Minimum Flows

The USFWS in their 2000 and 2006 biological opinions recommended minimum flows from Hungry Horse and Libby dams throughout the year for the benefit of bull trout. Minimum flows help maintain productivity of aquatic habitat, particularly during the spring, summer, and early fall. In turn, habitat productivity benefits bull trout. At both dams, water releases are managed to the extent possible to maintain or gradually transition flows to minimize a “double peak” that may result in dewatering habitat for a short period between spring freshet flows and summer high flows for salmon flow augmentation.

Hungry Horse Dam operates to provide minimum flows at Columbia Falls on the mainstem Flathead River, and below the dam in the South Fork Flathead River to benefit resident bull trout. The bull trout minimum flow thresholds are based on a sliding scale according to the WSF period from April through August (Table 1-1). Minimum flows in January are based on the January final WSF, in February based on the February final WSF, and minimum flows from March through December are based on the March final WSF.

Table 1-1. Minimum summer bull trout flows at Columbia Falls, Montana.

April-August Water Supply Forecast (million acre-feet)	Minimum Bull Trout Flows at Columbia Falls (kcfs)	Minimum Bull Trout Flows From Hungry Horse Dam (kcfs)
> 1.79	3.5	.9
< 1.19	3.2	.4
1.19 < forecast < 1.79	3.2 – 3.5	.4 -.9

kcfs = thousand cubic feet per second

Libby Dam operates to provide minimum flows for bull trout. Minimum year-round flow from Libby Dam is 4,000 cfs. From May 15 to September 30, minimum bull trout flows are based on the April through August WSF at Libby Dam (Table 1-2). Bull trout minimum flows would be provided through September in years when no salmon flow augmentation occurs due to low reservoir levels.

Table 1-2. Minimum summer bull trout flows from Libby Dam.

April-August Water Supply Forecast (million acre-feet)	Minimum Bull Trout Flows (kcfs)
≤ 4.80	6
4.80 < forecast ≤ 6.00	7
6.00 < forecast ≤ 6.70	8
6.70 ≤ forecast	9

kcfs = thousand cubic feet per second

1.4.3 Columbia River System Flood Control

The basic objective of Columbia River system flood control operations is to regulate the total reservoir system to, when possible, minimize flood damages in Canada and the United States in areas that are prone to potential flooding and, in years with very high runoff, to regulate flows at The Dalles, Oregon, for the protection of Portland, Oregon, and Vancouver, Washington. Storage dam operations are designed to manage for flood control while increasing probability of refill of storage reservoirs at the end of the spring runoff.

In the context of system flood control operations, storage reservoirs throughout the Columbia River Basin release water from January through April using guidance provided by a storage reservation diagram (SRD) to create flood control storage space. A SRD shows how much water storage space is required on a certain date in each reservoir for the most current seasonal water supply forecast.

In early January, WSFs are developed for each subbasin and for the Columbia River system to The Dalles. Based on the WSF, and using the SRD as guidance, the Corps calculates the end-of-January reservoir target elevation necessary to provide storage space to meet flood control objectives at The Dalles. In early February, a new WSF is used to develop updated end-of-February reservoir target elevations. The process repeats for each month through April. Reservoirs typically reach their maximum flood control draft on or about May 1. Reservoir refill in May and June is based on the calculated natural flow at The Dalles, the remaining water supply forecast, reservoir space available, and the weather forecast.

The Columbia River Treaty (CRT) between the United States and Canada, ratified in 1964, forms the basis for major hydropower and flood control related development on the Columbia River system. Under the CRT terms, four major water storage dams were built: Mica, Arrow, and Duncan Dams in Canada, and Libby Dam in the United States. The combined storage of these treaty dams more than doubled the flood control storage capacity of the system. In addition to these CRT dams, a number of other storage projects in the Columbia River Basin, including Hungry Horse Dam on the South Fork Flathead River in Montana, also provide flood control storage that is managed for system and local flood control.

1.4.4 Local Flood Control

In addition to providing water storage for system flood control, Libby and Hungry Horse dams provide local flood control for downstream river reaches in the vicinity of the dams. Operations for local flood protection occur on a real-time basis and are provided for individual dams.

Standard and VARQ Flood Control

In the past, Libby and Hungry Horse dams operated using Standard FC. Under Standard FC, the dams would generally release high flows from January through April in order to make space to capture the spring runoff in May, June, and July; from January through April, reservoir levels typically dropped. This process of reducing reservoir levels by releasing water is called “drafting.” Because the reservoirs drafted a large amount of storage under Standard FC, they historically released little water during the May through July period in order to refill. An assumption of the Standard FC procedure was that each dam could reduce releases to minimum outflow during the refill period.

The Corps and Reclamation now release water from Libby and Hungry Horse dams for flow augmentation. At Hungry Horse Dam, for example, these releases occur during the summer months for salmon flow augmentation and year-round in the form of minimum flows for bull trout. Libby Dam provides flow augmentation for white sturgeon in addition to summer bull trout minimum flows and salmon flow augmentation. Because these fish flow releases are higher than those originally designed into Standard FC, the reservoirs have a noticeably reduced likelihood and frequency of refilling.

Variable discharge flood control was developed to improve the multi-purpose operation of Libby and Hungry Horse Dams while not reducing the level of flood protection in the Columbia River. As a flood control procedure, VARQ FC was not designed specifically for flow augmentation for fish. However, implementation of VARQ FC at Libby and Hungry Horse dams enables the Corps and Reclamation to more reliably supply spring and summer flows for fish while simultaneously better ensuring higher reservoir elevations in the summer. The USFWS and NOAA Fisheries support VARQ FC because of the improved probability of providing flows for listed fish in spring while also ensuring a higher probability of reservoir refill for summer fish flow releases.

Generally, VARQ FC provides less system flood control space at Libby and Hungry Horse dams prior to spring runoff. The flood control space needed in a given year varies based on each dam's seasonal WSF for that year. In years where the April to August seasonal WSF is between about 80 and 120 percent[6] of average at Libby Dam and from 80 to 130 percent at Hungry Horse Dam, the VARQ FC reservoir elevation would be higher than the Standard FC reservoir elevation during the January through April drawdown period. In years where the seasonal water supply forecast is high (above about 120 percent of the average volume at Libby Dam and above 130 percent at Hungry Horse Dam), storage space for flood control would be the same for either VARQ FC or Standard FC.

During reservoir refill, VARQ FC and Standard FC also differ. Standard FC may reduce dam releases to minimum flows during the refill period from May through July. In contrast, in years where the WSF at Libby and Hungry Horse dams are about 80 to 120 percent of average, the VARQ FC refill outflow is generally greater than minimum flows. The basic premise of VARQ FC is that the dam releases during the refill period can vary based on the seasonal WSF, actual reservoir elevation, and the estimated duration of flood control. Some of the water that would be stored during the refill period under Standard FC is instead passed through the dam under VARQ FC.

Since the flood control draft at Grand Coulee Dam is based, in part, on the available storage space upstream from The Dalles,[7] VARQ FC at Libby and Hungry Horse dams influences operations for system flood control at Grand Coulee Dam. In years when VARQ FC operations result in higher reservoir elevations and less flood control storage space at Libby and Hungry Horse dams, Grand Coulee Dam may draft deeper to maintain system flood protection at The Dalles. In practice, Grand Coulee Dam typically may draft deeper for flood control in years with seasonal WSFs between 86 and 100 percent of average. The increase in flood control draft at Grand Coulee Dam would be less than the net decrease in draft at Libby and Hungry Horse dams caused by VARQ FC operations.

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[6] For forecasts greater than 120 percent of average, Libby Dam typically does not draft to VARQ FC or Standard FC reservoir elevations because outflows must be reduced to comply with the IJC Order of 1938 concerning Kootenay Lake levels.

[7] Flood control storage space upstream from The Dalles is available behind Mica, Arrow, and Duncan Dams in Canada and Libby, Hungry Horse, Kerr, Noxon Rapids, Albeni Falls, Grand Coulee, Dworshak, Brownlee, and John Day Dams in the United States. Dworshak and Brownlee Dams are on the Snake River.

1.4.5 Interim Implementation of VARQ FC

The USFWS and NOAA Fisheries indicated in 2002 correspondence that failing to implement VARQ FC prior to completion of an EIS would not meet the intent of the RPA in the 2000 Biological Opinions. Preparation of an EIS, including scoping and various technical studies, would have delayed implementation of VARQ FC beyond the implementation dates recommended in the biological opinions. In response to NOAA Fisheries and USFWS, the Corps and Reclamation evaluated the effects of interim (short-term) implementation of VARQ FC operation at Hungry Horse and Libby dams.

Reclamation documented its evaluation of environmental effects associated with interim VARQ FC implementation at Hungry Horse Dam in a March 2002 voluntary environmental assessment (EA) (Reclamation 2002). The Corps and Reclamation documented the combined environmental effects associated with interim VARQ FC operation at Libby Dam and Hungry Horse dam in a December 2002 EA (Corps 2002a). Based on these interim EA analyses, Reclamation implemented VARQ FC at Hungry Horse Dam in winter 2002 and the Corps implemented VARQ FC at Libby Dam in winter 2003. The USFWS 2006 Biological Opinion calls for continuation of VARQ FC at Libby Dam.

This EIS addresses long-term implementation of VARQ FC at both dams. In addition, this EIS evaluates potential effects of fish flow operations at Libby Dam involving releases greater than the existing powerhouse capacity, actions which were beyond the scope of the interim EA process.

1.5 Issues Addressed in this EIS

The Corps and Reclamation initiated a joint NEPA process to analyze the effects of long-term implementation of the VARQ FC strategies at Libby and Hungry Horse dams with publication in the Federal Register of the Notice of Intent (NOI) to prepare an EIS on October 1, 2001.

Public scoping meetings were held at Grand Coulee, Washington; Sandpoint, Idaho; Bonners Ferry, Idaho; Portland, Oregon; Libby, Montana; Eureka, Montana; Kalispell, Montana; and in Creston, British Columbia, Canada. In addition to the meeting comments, comment forms and letters from agencies and interested parties were also received. Detailed information on the scoping process may be found on the Upper Columbia Alternative Flood Control and Fish Operations EIS web site at http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=VARQ&pagename=VARQhttp://www.usbr.gov/pn/programs/VARQ/scoping.html.

Through scoping and interdisciplinary analysis, the following issues were identified for consideration in this EIS.

Issue 1: Flood control and related impacts

Libby Dam and Hungry Horse Dam are important facilities for controlling local and system flooding and related impacts. Each of the action alternatives would modify flood control operations and/or fish flows. This EIS addresses how each of the alternatives would affect:

- Frequency and duration of reservoir and lake levels and related concerns
- Timing and volume of dam releases
- Stream flows, elevations, and related concerns
- Levee integrity along the Kootenai River in Idaho and British Columbia
- Groundwater seepage from prolonged high spring flows along the Kootenai River in Idaho
- Local and system flooding, flood damage, and related concerns
- Operation of downstream storage and hydropower dams
- Operation of irrigation and water supply facilities
- Shoreline erosion

Issue 2: Fisheries and other biological impacts and benefits

The proposed modifications to flood control operations and fish flows are primarily intended to benefit fish stocks listed under the ESA, including Kootenai River white sturgeon (endangered), bull trout (threatened), and various stocks of Chinook, chum, and sockeye salmon and steelhead (threatened and endangered). The EIS addresses how each of the alternatives would affect:

- Listed species and their habitats
- Other aquatic species and their habitats
- Wetlands and riparian areas
- Fish propagation and rearing facilities at Lake Roosevelt and Lake Rufus Woods
- Wildlife use

Issue 3: Water and air quality impacts

Changes in flood control operations and fish flows may directly influence water quality and may have indirect effects on air quality. The EIS addresses how each alternative would affect:

- Total dissolved gas at key points in the system
- Seasonal water temperatures at certain locations in the system
- Sediment and nutrient loads, distribution and flushing
- Suspension, mobilization, and potential aerial transport of lake bed contaminants at Lake Roosevelt
- Impacts on septic tanks, drain fields, drinking water, and seepage along the Kootenai River

Issue 4: Cultural resource protection and related impacts

Changes in reservoir elevations and shoreline erosion and exposure can influence the likelihood of discovery, looting, and vandalism of prehistoric artifacts and human remains along Lake Roosevelt (the reservoir behind Grand Coulee Dam) and elsewhere. This EIS addresses how each alternative would affect:

- Timing and duration of cultural resource site exposure
- Protection and management of cultural resources

Issue 5: Recreation impacts

Changes in reservoir levels and streamflows can influence the quality and availability of water-based recreation opportunities. The EIS addresses how each alternative would affect:

- Reservoir and lake recreation opportunities, including boat launch access, boating and beach/shoreline use
- River-based recreation opportunities
- Fishing opportunities

Issue 6: Power generation impacts

Changes in flood control operations and fish flows can affect power generation at Hungry Horse Dam, Libby Dam, and numerous dams downstream. This EIS addresses how each alternative would affect:

- Quantity, timing, and value of hydropower production

- Power generation at Canadian dams downstream from Libby Dam, an issue pertaining to the CRT.

Issue 7: Economic impacts

Changes in flood control operations and fish flows can directly or indirectly influence local and regional economies. This EIS addresses how each alternative would affect basic social and economic conditions within the EIS area.

1.6 Issues Considered But Not Addressed in Detail

It is normal practice to develop an exhaustive list of potential issues during scoping, which occurs early in the environmental review process, and then focus the subsequent analysis on those issues considered most important and relevant to the decision(s) to be made. For this EIS, the following potential issues were identified, but as explained, were not addressed in detail:

Variable December 31 draft at Libby Dam

Historically the Corps drafted Lake Koocanusa to a fixed elevation of 2411 feet on December 31 every year. In some drought years, the fixed draft requirement would impact the ability to reach flood control target elevations under VARQ FC. In 2003, the Corps developed and implemented a variable December 31 draft at Libby Dam which would allow less draft in some years (i.e., hold the reservoir elevation higher) based on a new forecast procedure that computes early season WSF in November and December. The December 31 variable draft would be implemented in about 25 percent of years. The variable December 31 draft, which was initiated after the VARQ hydro-regulation modeling was completed, included a requirement that flood control drafts in January, February, and March still be achieved consistent with the VARQ FC hydro-regulation modeling. However, since the flood control draft of Grand Coulee is partially dependent on upstream space available, a sensitivity analysis was completed to determine what if any impacts there would be on Grand Coulee flood control operations due to the implementation of the December 31 variable draft at Libby. Effects on salmon flow augmentation and winter flows in the Kootenai River were also evaluated. Results of the sensitivity analysis show that operations of Libby Dam under the December 31 Libby variable draft would not differ substantially from the operations modeled in this EIS (Appendix M). All additional drafts at Grand Coulee due to the variable December 31 draft at Libby Dam would be within the range of differences resulting from alternatives in this EIS.

Firm load

Firm load is the amount of energy that can be generated under the region's driest historical water conditions. Study results indicate implementation of VARQ FC would increase the probability of meeting or exceeding firm load. Firm load would be met in 98.5 percent of periods with Standard FC and 99.2 percent with VARQ FC. Improvements in ability to meet firm load are attributed to improved refill of Libby Reservoir.

System and individual dam operating flexibility

Implementation of VARQ FC could potentially improve both system and dam operating flexibility by improving the probability of refill of Libby and Hungry Horse reservoirs. Improved refill provides more water to meet competing needs. The flood control rule curves provide a constraint on the upper limit for reservoir elevations in the winter and spring months. It is not a lower limit. The operating agencies can draft lower than the flood control curves with proper coordination to provide flexibility.

System reliability

System reliability is a measure of the degree of certainty that the system will continue to meet load for a specified period of time or ensure that electricity will be delivered reliably without interruption. It serves as a basis for determining how much nonhydro power will be needed to meet expected energy loads in a region.

Model runs conducted for this EIS are monthly models and therefore are not relevant for analyzing reliability. However, since the modeling indicates a slight improvement in the ability to meet firm load, then it is expected that system reliability due to implementation of VARQ FC will be maintained or improved as well.

Hourly coordination agreement

The hourly coordination agreement was implemented after Grand Coulee Dam's third powerhouse was built, to balance the operations of Grand Coulee and Chief Joseph dams with the five non-Federal mid-Columbia dams (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids). The operation of these seven dams is coordinated as a group for hourly power operations.

Study results indicate that monthly effects on the water surface elevation at Lake Roosevelt and flow releases from Grand Coulee Dam due to the implementation of VARQ FC are minor. This is not expected to have a measurable effect on the hourly coordination.

Effects on existing coordination agreements for dam operations

None of the alternatives for Libby Dam and Hungry Horse Dam would require changes to the coordination agreements such as the Pacific Northwest Coordination Agreement and coordination agreements addressing operations of Hungry Horse and Kerr dams. Dam operations would continue to be coordinated within the Columbia River Basin consistent with the provisions of existing agreements.

Effects on reservoir operation at Lake Pend Oreille

Lake Pend Oreille winter operation for kokanee would continue to be coordinated with the USFWS consistent with the 2000 FCRPS Biological Opinion. Real-time decisions on the operation of Albeni Falls will be coordinated with the NOAA Fisheries Regional Forum Technical Management Team and other forums. Winter operations would not be impacted by implementation of any alternatives considered in this EIS.

Addressing all actions from the 2000 USFWS and 2004 NOAA Fisheries FCRPS Biological Opinions, and the 2006 USFWS Biological Opinion in a single EIS

The 2000 USFWS and the 2004 NOAA Fisheries FCRPS Biological Opinions, and the 2006 Libby Biological Opinion call for implementation of a wide range of actions by the Action Agencies over a period of years. While these actions may share a common purpose for conservation of threatened and endangered fish species, the actions are not related closely enough to be evaluated in a single EIS. Many of the actions are not connected to each other and do not automatically trigger other actions, rely on other actions to proceed, share common timing or geography, or depend on a larger action for their justification (40 CFR Parts 1508.25). In addition, some of these actions have been addressed in prior NEPA documents and some are categorically excluded from or do not require further NEPA analysis. If it is determined that future actions are connected or interdependent, or where similar actions sharing common timing or geography are proposed, the responsible agencies would conduct appropriately scaled analyses.

1.7 Legal Authorities and Constraints

The 2000 and 2006 USFWS Biological Opinions and 2004 UPA/Biological Opinion call for the Corps and Reclamation to undertake various actions at the FCRPS dams to assist in recovery of fish species listed under the ESA. The Corps and Reclamation are authorized by Congress to operate and maintain FCRPS projects to provide for multiple uses, including hydropower generation, flood control, irrigation, navigation, fish, wildlife, water quality, municipal and industrial water, and recreation. The actions described in these biological opinions that are adopted by Corps and Reclamation are discretionary actions and are consistent with providing for the authorized multiple project purposes. Specifically, the Corps' work at Libby Dam is under their Operations and Maintenance funding authority and Reclamation's authority is under the Hungry Horse Project, Act of June 5, 1944, ch. 234, 58 Stat. 270, Public Law 329.

1.7.1 Libby Dam Authorization

Libby Dam on the Kootenai River, Montana, was authorized for multiple purposes under Public Law 516, the Flood Control Act of 17 May 1950, 81st Congress, Second Session, in accordance with the plan set forth in House Document 531, 81st Congress, Second Session. The dam was constructed and is operated in accordance with the Columbia River Treaty between the United States and Canada relating to international cooperation in water resources development of the Columbia River Basin. The reservoir created by Libby Dam was designated Lake Koocanusa by Public Law 91-625, dated 31 December 1970. The authority for public use development is derived from the Flood Control Act of 1944, Public Law 78-534, as amended.

1.7.2 Hungry Horse Dam Authorization

Under Public Law 329, 78th Congress, Second Session, approved 5 June 1944, the Secretary of the Interior was authorized to "proceed as soon as practicable with the construction, operation, and maintenance of the proposed Hungry Horse Dam (including facilities for generating energy), to such height as may be necessary to impound not less than one million acre-feet of water" and Hungry Horse Dam was subsequently constructed on the South Fork Flathead River, Montana. Reclamation operates Hungry Horse Dam and in coordination with the Corps, under section 7 of the Flood Control Act of 1944, has responsibility for flood control operations.

Chapter 2 Alternatives

2.1 Introduction

This Final EIS assesses the potential effects of the proposed action, which consists of implementation of VARQ FC at Libby and Hungry Horse dams and flow augmentation for threatened and endangered bull trout, salmon, steelhead, and white sturgeon. All proposed changes, including the selection of the preferred alternative, are consistent with provisions included in biological opinions (BiOps) prepared by the USFWS and NOAA Fisheries under the ESA. At the conclusion of the EIS process, the Corps and Reclamation will issue separate Records of Decision in accordance with the respective authorities and responsibilities of each agency.

The alternatives are referred to by the abbreviations shown in Table 2-1. Combinations of the four letters “L, H, S, V” form the alternative abbreviations. For example, Alternative LV designates VARQ FC operations at Libby Dam and Alternative HS designates Standard FC operations at Hungry Horse Dam. For Libby Dam, a number after the letter indicates the two proposed fish flow operations at Libby Dam: “LS1” means Libby Dam Standard FC with fish flows up to powerhouse capacity and “LS2” means Libby Dam Standard FC with fish flows up to 10,000 cfs (10 kcfs) above powerhouse capacity.[8] The notation “B” means that alternative incorporates dam operations as recommended in the 2006 U.S. Fish and Wildlife Service Biological Opinion on the effects of the operation of Libby Dam on Kootenai River white sturgeon, its designated critical habitat and bull trout. At Hungry Horse Dam, fish flows are the same under both alternatives.

Table 2-1. Alternative abbreviations used in this EIS.

Abbreviation	Project Feature or Alternative Operation
L	Libby Dam
H	Hungry Horse Dam
S	Standard FC
V	VARQ FC
1	sturgeon flows up to powerhouse capacity (25 kcfs)
2	sturgeon flows up to 10 kcfs above powerhouse capacity (35 kcfs)
B	sturgeon flows up to 10 kcfs above powerhouse capacity for up to 14 days, using spill when reservoir, inflow and temperature conditions are suitable
kcfs = thousand cubic feet per second	

[8] For benchmarks, LS means Libby Dam Standard FC without fish flows and LV means Libby Dam VARQ FC without fish flows.

The alternatives evaluated and considered to meet the purpose and need for the proposed action include fish flows because these flow operations are identified in existing Section 7 ESA Biological Opinions. Fish flows have been implemented for sturgeon, bull trout, salmon and steelhead since the 1990s and are included in the 2006 USFWS Biological Opinion and the 2004 NOAA Fisheries Biological Opinion.

Two alternatives, referred to as LSB and LVB, have been added to the Final EIS to specifically include the operational components for flood control and fish flows as recommended in the Reasonable and Prudent Alternative (RPA) in the most recent USFWS Biological Opinion issued on February 18, 2006.

2.2 Libby Dam Alternatives

The RPA from the 2006 USFWS Biological Opinion recommends a range of releases from Libby Dam up to 35 kcfs for up to 14 days, pending appropriate water conditions, providing for a normative hydrograph to achieve the desired habitat attributes of depth, velocity and temperature. The USFWS identified these habitat attributes to support successful sturgeon spawning and recruitment. Currently, the only means available to provide up to 10 kcfs above powerhouse capacity (approximately 25 kcfs) for a total release of 35 kcfs from Libby Dam is by spill. Spill of up to 10 kcfs will increase total dissolved gas (TDG) above the Montana water quality standard of 110 percent. The Corps, BPA, and the USFWS are coordinating with the State of Montana on the TDG effects of spilling up to 10 kcfs.

The 2006 USFWS Biological Opinion RPA recognizes that there are several ways to achieve the desired habitat attributes and allows the Corps and BPA the flexibility to select the means to provide for the attributes. This is called a performance-based adaptive management approach. While release of flows up to 35 kcfs out of Libby is the method currently available to achieve the desired attributes in the near term, the Corps and BPA are pursuing habitat actions that may reduce the need for such releases in the future. As information is gained on the biological response to providing the habitat attributes, flows may be adjusted using this adaptive management approach provided for in the 2006 USFWS Biological Opinion.

In response to the RPA in the USFWS 2006 Biological Opinion, additional alternatives concerning the operation of Libby Dam were added to this Final EIS. These alternatives, LSB and LVB, identify the use of the spillway as the mechanism for achieving flows up to 35 kcfs (10 kcfs above powerhouse capacity), which is an operational component of the USFWS 2006 RPA. The spillway is the only means currently available to achieve this increased flow. Because the use of the spillway to provide flows up to 35 kcfs had not been included in the Draft EIS, as analysis of the effects associated with this operation, including the TDG levels and the condition of the spillway surface, has been incorporated in the Final EIS. Other impacts associated with the additional alternatives fall within the range of the impacts associated with the alternaitives analyzed in the Draft EIS.

The alternatives for Libby Dam operations vary in terms of the flood control operation and the recommended fish flow augmentation. Detailed descriptions of the Libby Dam alternatives and benchmarks follow.

Alternative LS1 – Standard FC with fish flows up to powerhouse capacity (No Action Alternative)

Alternative LS1, the no action alternative for Libby Dam, consists of Standard FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate up to the existing powerhouse capacity (about 25 kcfs). Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LV1 – VARQ FC with fish flows up to powerhouse capacity

As of 2003, Alternative LV1 is the current interim operation for Libby Dam and consists of VARQ FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate up to the existing powerhouse capacity (about 25 kcfs). Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

With the release of the 2006 USFWS Biological Opinion and its Reasonable and Prudent Alternative, Alternative LV1 is no longer the preferred alternative for Libby Dam.

Alternative LS2 – Standard FC with fish flows up to powerhouse capacity plus 10 kcfs

Alternative LS2 is the same as Alternative LS1, except that sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate at some level up to 10,000 cfs above the approximately 25,000-cfs powerhouse capacity. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

LS2 differs from LSB in that LS2 does not identify a specific mechanism to achieve the 10 kcfs of additional flow and the corresponding analysis presumes that the additional 10 kcfs of flow would be provided for all sturgeon flow augmentation events except when limited to avoid exceeding flood stage of 1,764 feet at Bonners Ferry, Idaho. Impacts of the flows and reservoir elevations are addressed on that basis for LS2. This would contrast with LSB, where the additional 10 kcfs of flow would be provided when the reservoir elevation is at or above 2415 feet and reservoir inflows are sufficient to maintain that reservoir elevation during spill operations for sturgeon. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LV2 – VARQ FC with fish flows up to powerhouse capacity plus 10 kcfs

In years when sturgeon flows are requested and conditions are met (see Section 1.1), Alternative LV2 is the same as Alternative LV1, except that sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate at some level up to 10,000 cfs above the approximately 25,000-cfs powerhouse capacity. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

LV2 differs from LVB in that LV2 does not identify a specific mechanism to achieve the 10 kcfs of additional flow and the corresponding analysis assumes that the additional 10 kcfs of flow would be provided for all sturgeon flow augmentation events except when limited to avoid exceeding flood stage of 1,764 feet at Bonners Ferry, Idaho. As with LS2, impacts from flows and reservoir elevations are addressed based in that assumption. This contrasts with LVB, where the additional 10 kcfs of flow would be provided only when the reservoir elevation is about 2415 feet and reservoir inflows are sufficient to maintain that reservoir elevation during spill operations for sturgeon. Dam releases would be optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LSB – Standard FC with fish flows up to powerhouse capacity plus 10 kcfs, using spill when reservoir and inflow conditions make this possible

Alternative LSB consists of Standard FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes consistent with the 2006 USFWS FCRPS Biological Opinion. Annual operations would be based on a scientific approach for testing different releases from Libby Dam and determining the effectiveness for achieving the habitat attributes and meeting the conservation needs established for sturgeon as described in the 2006 USFWS Biological Opinion. Maximum peak augmentation flows up to 35 kcfs would be provided for up to 14 days, when water supply conditions are conducive, during the peak of the spawning period. After the peak augmentation flows, remaining water would be provided to maximize flows for up to 21 days with a gradually receding hydrograph. As before, sturgeon augmentation flows would include no dedicated sturgeon flows during a Tier 1 water year (see Section 1.4.2); otherwise, LSB would provide either dam releases up to existing powerhouse capacity, or dam releases to powerhouse capacity plus up to 10 kcfs via the Libby Dam spillway.

Specific details for determining appropriate flows in any given year are being developed in a Flow Plan Implementation Protocol in collaboration with the states, tribes and other Federal agencies.

For this alternative, the reservoir elevation would have to be no lower than about 2415 feet in order to release 10 kcfs via the Libby Dam spillway (which has a spillway crest elevation of 2405 feet) and reservoir inflows would need to be sufficient to maintain the reservoir at or above elevation 2415 feet to release the full 10 kcfs, in addition to maintain these releases. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop. When the reservoir elevation is not high enough to allow spillway releases in the spring, sturgeon flow augmentation would be provided using adaptive management consistent with the Flow Plan Implementation Protocol, with a maximum release rate of about 25 kcfs (the existing powerhouse capacity at Libby Dam). Under Standard FC, review of the monthly modeling data shows that the appropriate conditions to allow for releases of sturgeon flows using the Libby Dam spillway occur for some period of time in approximately 25 percent of years. Actual duration and quantity of spill operations would vary in any given year.

Alternative LVB - VARQ FC with fish flows up to powerhouse capacity plus 10 kcfs, using spill when reservoir and inflow conditions make this possible (Preferred Alternative)

<u>Alternative LVB is the preferred alternative.</u> LVB is similar to LSB, but with VARQ FC rather than Standard FC. It includes sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as specified in the 2006 USFWS FCRPS Biological Opinion. Annual operations would be based on a scientific approach for testing different releases from Libby Dam and determining the effectiveness for achieving the habitat attributes and meeting the conservation needs established for sturgeon as described in the 2006 USFWS Biological Opinion. Maximum peak augmentation flows up to 35 kcfs would be provided for up to 14 days, when water supply conditions are conducive, during the peak of the spawning period. After the peak augmentation flows, remaining water would be provided to maximize flows for up to 21 days with a gradually receding hydrograph. Consistent with the 2006 USFWS Biological Opinion, during a Tier 1 water year, dedicated sturgeon augmentation flows are not provided (see Section 1.4.2); otherwise, dam releases would range from within existing powerhouse capacity up to an additional 10 kcfs using the Libby Dam spillway for up to 14 days depending on water supply conditions.

Specific details for determining appropriate flows in any given year are being developed in the Flow Plan Implementation Protocol in collaboration with the states, tribes and other Federal agencies as discussed above at the beginning of Section 2.2.

For this alternative, the reservoir elevation would have to be no lower than about 2415 feet in order to release 10 kcfs via the Libby Dam spillway (which has a spillway crest elevation of 2405 feet) and reservoir inflows would need to be sufficient to maintain the reservoir at or above elevation 2415 feet in order to maintain these releases for up to two weeks during sturgeon flow augmentation. Dam releases would be timed and optimized to provide temperatures of approximately 50^o F with no more than a 3.6^o F drop. When the reservoir elevation is not high enough to allow spillway releases in the spring, sturgeon flow augmentation would be provided using adaptive management consistent with the Flow Plan Implementation Protocol, with a maximum release rate of about 25 kcfs (the existing powerhouse capacity at Libby Dam). Under VARQ FC, review of the monthly modeling data shows that conditions to allow for releases of sturgeon flows from the Libby Dam spillway for some period of time occurs in approximately 50 percent of years. Actual duration and quantity of spill operations would vary in any given year.

LVB is consistent with the Reasonable and Prudent Alternative for Libby Dam operations included in the 2006 USFWS Biological Opinion.

LS and LV Benchmarks

The LS and LV benchmarks are descriptive of Libby dam operations that do not include fish flows. These benchmark operations discuss additional information that became available after publication of the 1995 Columbia River System Operation Review (SOR) EIS (BPA *et al.* 1995) on potential effects associated with fish flows up to existing Libby Dam powerhouse capacity, and are included for that purpose

This new information also provides an opportunity to update the evaluation of groundwater seepage in the Kootenai River valley in Idaho and assist in evaluating the effects of flows on sturgeon reproduction. The benchmarks are not included as alternatives because they do not meet the purpose and need of the proposed action.

The components of each alternative and benchmark are summarized in Table 2-2. Figure 2-1 and Figure 2-2 show how the alternatives and benchmarks compare to each other with respect to reservoir elevations and outflows in a typical year[9]. In wet or dry years, the differences between both Lake Koocanusa elevation and Libby Dam release for the different alternatives would tend to be more similar than in this typical year. In years when Libby releases remain within powerhouse capacity, Lake Koocanusa elevation and Libby Dam release under Alternatives LSB or LVB would be similar to that shown for LS1 and LV1, respectively. For years when Libby releases are provided up to 10 kcfs above powerhouse capacity for up to 14 days, Lake Koocanusa elevation and Libby Dam release under Alternative LSB would fall within a range between that shown for LS1 and

[9] The typical river and reservoir hydrographs are based on model simulations of 1968, which represents a year that had an actual April-August runoff volume (6240 kaf) almost identical to the 30-year-average runoff volume (6248 kaf).

LS2, and those same parameters for LVB would fall within a range between that shown for LV1 and LV2.

Table 2-2. Libby Dam summary of alternatives and benchmarks.

	Flood Control Method		Fish Flows Provided			
Alternatives	Standard FC	VARQ FC	Sturgeon up to ~25 kcfs	Sturgeon up to ~35 kcfs	Bull trout	Salmon
LS1	X		X		X	X
LV1		X	X		X	X
LS2	X			X	X	X
LV2		X		X	X	X
LSB	X		X[a]	up to 25% of years	X	X
LVB		X	X[a]	up to 50% of years	X	X
Benchmarks						
LS	X		No fish flows			
LV		X	No fish flows			

a. Sturgeon flows provided in years with sturgeon volume Tiers 2-6 (see Fig. 1-2). Depending upon reservoir elevation, reservoir inflow, and/or water temperatures, releases may vary from 25 kcfs to 35 kcfs. Duration of the release would also vary year to year.

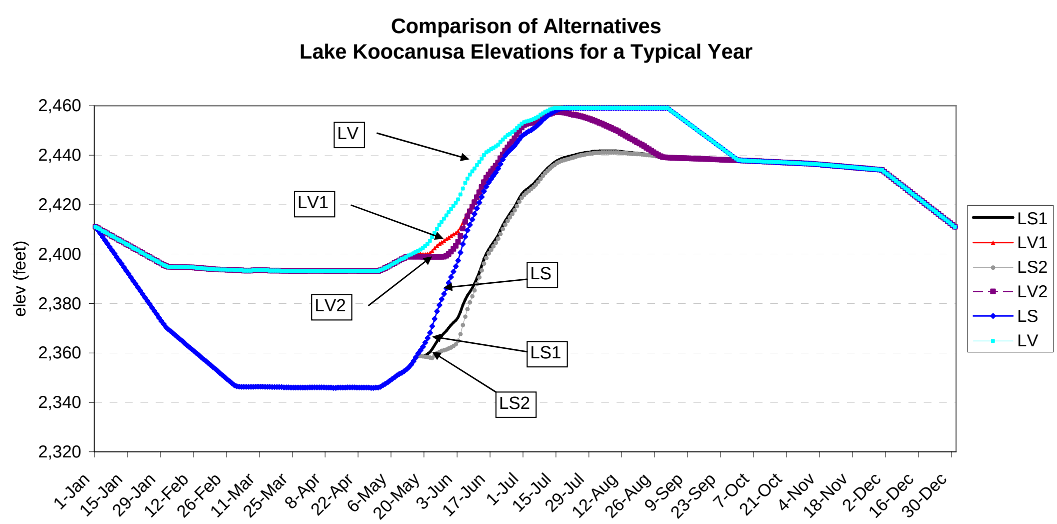

Figure 2-1. Comparison of alternatives and benchmarks– Simulated Lake Koocanusa elevations for a typical year. Alternative LSB falls within a range between LS1 and LS2. LVB falls within a range between LV1 and LV2.

2.3 Hungry Horse Dam Alternatives

The alternatives for Hungry Horse Dam operations vary in terms of flood control and both alternatives provide bull trout minimum flows and salmon flow augmentation. The effects of bull trout minimum flows and drafts for salmon flow augmentation were addressed in the 1995 Columbia River SOR EIS (BPA *et al.* 1995).

Alternative HS – Standard FC with fish flows (No Action Alternative)

Alternative HS, the no-action alternative for Hungry Horse Dam, is Standard FC with bull trout and salmon augmentation flows. Standard FC operations are based on the principle of deep drafts for flood control, then minimizing outflow during the refill period from May through June 30.

Alternative HV – VARQ FC with fish flows (Preferred Alternative)

Alternative HV, the preferred alternative for Hungry Horse Dam, consists of flood control using VARQ FC with bull trout and salmon augmentation flows. This is the current interim operation at Hungry Horse Dam.

Figure 2-3 and Figure 2-4 show how the alternatives compare to one another with respect to reservoir elevations and outflows in a typical year.

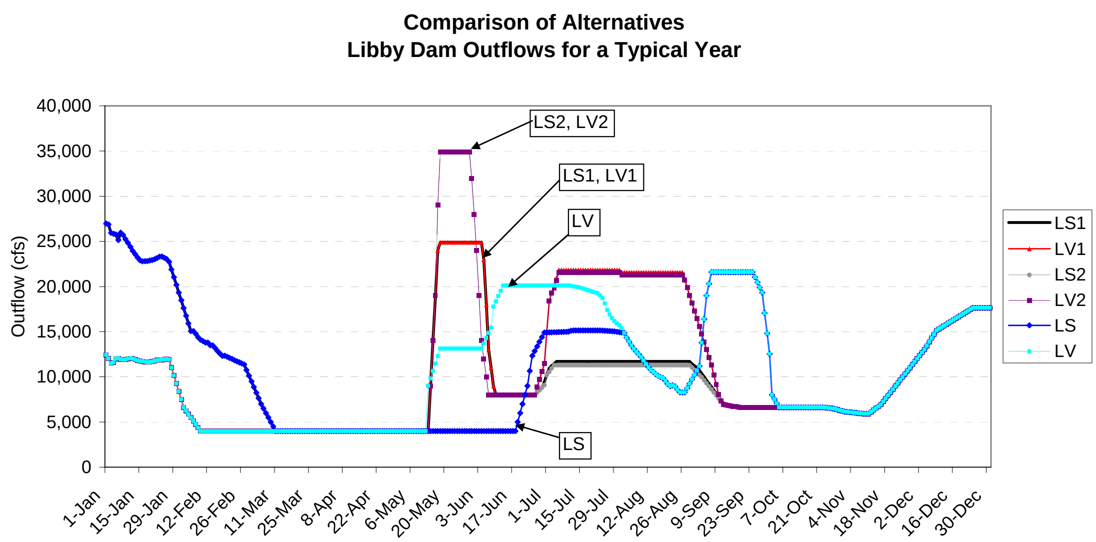

Figure 2-2. Comparison of alternatives and benchmarks–simulated Libby Dam outflows based on 1968, a typical year. Alternative LSB falls within a range between LS1 and LS2. LVB falls within a range between LV1 and LV2.

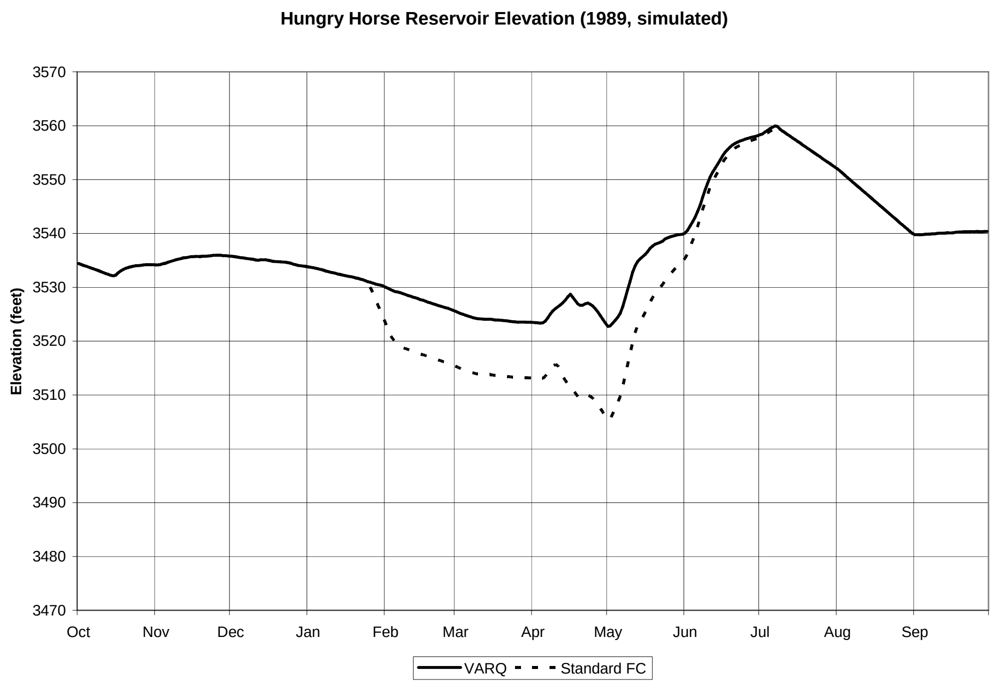

Figure 2-3. Comparison of alternatives–Hungry Horse Reservoir elevations for a typical year.

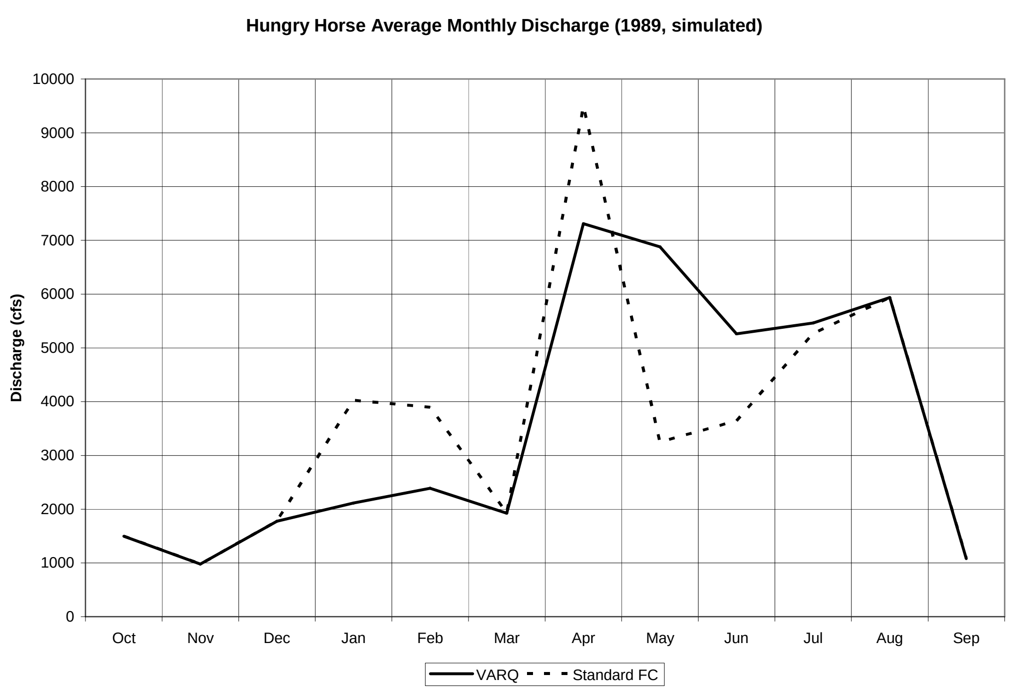

Figure 2-4. Comparison of alternatives–Hungry Horse Dam outflows for a typical year.

2.4 Mainstem Columbia River Alternative and Benchmark Combinations

The combined effects of Libby Dam and Hungry Horse Dam alternatives and benchmarks are evaluated in the mainstem Columbia River downstream from the Kootenai River and Pend Oreille River tributary systems. Thus, for analysis of the environmental effects in the Columbia River upstream and downstream from Grand Coulee Dam for power generation and related economic values, alternative and benchmark combinations are derived by combining Libby Dam and Hungry Horse Dam alternatives and benchmarks (Table 2-3). As with Libby Dam benchmarks LS and LV, benchmark combinations LS+HS and LV+HV are included as a comparison tool to derive the effects of fish flows from Libby Dam on the mainstem Columbia River and on the Columbia system.

Table 2-3. Mainstem Columbia River alternative and benchmark combinations.

	Flood Control Method at Libby and Hungry Horse Dams		**Fish Flows Provided at Libby Dam**				**Fish Flows Provided at Hungry Horse Dam**	
Alternative Combinations	Standard FC	VARQ FC	Sturgeon up to ~25 kcfs	Sturgeon up to ~35 kcfs	Bull trout	Salmon	Bull trout	Salmon
LS1+HS	X		X		X	X	X	X
LV1+HV		X	X		X	X	X	X
LS2+HS	X			X	X	X	X	X
LV2+HV		X		X	X	X	X	X
LSB+HS	X		X[a]	up to 25% of years	X	X	X	X
LVB+HV		X	X[a]	up to 50% of years	X	X	X	X
Benchmark Combinations								
LS+HS	X		None				X	X
LV+HV		X	None				X	X

a. Sturgeon flows provided in years with sturgeon volume Tiers 2-6 (see Fig. 1-1). Depending upon reservoir elevation, reservoir inflow, and/or water temperatures, releases may vary from 25 kcfs to 35 kcfs. Duration of the release would also vary year to year.

2.5 Alternatives Eliminated from Further Consideration

Five alternatives were considered but rejected from further analysis because they (1) did not meet established ESA requirements for VARQ FC and fish flows, (2) failed to meet Columbia River system or local flood control needs, (3) were outside the scope of the EIS, or

(4) were similar in scope, intent, and effects to other alternatives being considered in this EIS. The five alternatives considered but rejected are discussed below.

VARQ FC with physical stream changes near Bonners Ferry, Idaho

This alternative was formulated to reduce the adverse effects of higher fish flows in the Kootenai River from Libby Dam to Kootenay Lake, British Columbia, particularly in the Bonners Ferry area. Essentially, this option would involve operations as described for VARQ FC plus the construction of in-water structures and possible substrate modification in the Kootenai River to create zones with favorable depths, velocities, turbulence, and spawning substrate. This alternative did not meet the purpose of the proposed action, which focuses on operations at Libby and Hungry Horse dams to provide reservoir and flow conditions for fish listed as threatened or endangered under the ESA (see Section 1.2). It therefore was not considered in detail in this EIS.

However, the Corps and BPA recently completed Section 7 consultation with the USFWS on the effects of the continued operation of Libby Dam on Kootenai River white sturgeon and its designated critical habitat, and bull trout. The proposed action for the consultation included a suite of actions including habitat improvements and flow management to provide the habitat attributes necessary for successful spawning and recruitment. The 2006 BiOp from USFWS includes an RPA that is performance based and allows the action agencies to select the means to achieve the attributes. Habitat improvements may reduce the need to rely on releases of up to 35 kcfs in the future, but until such measures are in place, release of flows out of Libby is the means currently available to achieve the desired attributes in the near term.

The preferred alternative in this Final EIS, LVB, is responsive to the 2006 USFWS BiOp and RPA, and will allow the agencies to evaluate the role of a range of flow levels, in conjunction with the other actions to meet the habitat attributes. NEPA documentation for future habitat improvements would be addressed in the future when those projects are identified.

VARQ FC with modified Flathead Lake flood control

Under this alternative, the flood control regulation of Libby and Hungry Horse dams would be the same as described for the VARQ FC alternatives. Changes would be made to the Flathead Lake flood control regulation that would better ensure refill by reducing the amount of drawdown needed when the volume forecast is low.

Altering flood control at Flathead Lake, which is operated by a private utility, falls outside the scope of this EIS, as well as the purpose of the proposed action, which focuses on operational actions at Libby and Hungry Horse dams to benefit species of fish listed as threatened or endangered under the ESA.

Integrated rule curves

In the late 1980s, Montana Fish, Wildlife and Parks (MFWP) developed a set of rule curves called Integrated Rule Curves (IRCs) to integrate fisheries concerns with the need for flood control. The intent of the IRCs was to more closely approximate natural snowmelt flow conditions in the rivers and to improve reservoir refill in comparison to Standard FC. The IRCs were evaluated in the SOR EIS (BPA *et al.* 1995). Integrated Rule Curve operations call for modified reservoir draft points by April 30 for Libby and Hungry Horse dams. Libby and Hungry Horse reservoirs would draft less under the IRCs and VARQ FC than Standard FC in years with medium and low runoff forecasts. During the public scoping process for this EIS, representatives from MFWP identified VARQ FC as meeting all of the constraints and needs identified through the development of their IRCs.

This alternative was not considered further because VARQ FC is similar to the IRCs in scope, intent, and effect.

Standard FC or VARQ FC without fish flows

Implementation of flood control operations without fish flows would not provide reservoir and flow conditions at and below Libby and Hungry Horse dams for anadromous and resident fish listed as threatened or endangered, and therefore does not fulfill the purpose of the proposed action. Accordingly, these operations are not considered as potential alternatives within the context of this EIS. However, Libby Dam operations without fish flows are utilized as benchmarks from which to evaluate the incremental effects of providing fish flows from Libby Dam.

Additional turbines or other structural modifications at Libby Dam to allow releases of flows for fish above powerhouse capacity

Installing additional turbines, flow deflectors, or other structural modifications at Libby Dam to provide flows up to 10,000 cfs above powerhouse capacity (approximately 35 kcfs total) without exceeding state of Montana’s standard for TDG were considered by the Corps and BPA.

It was determined that installation of additional units is not feasible or appropriate in the near term, given the complex issues related to transmission line stability, load transfers between projects, and high costs including transmission line upgrades. In addition, these actions would require congressional action and considerable time to implement given funding capability, environmental and engineering studies, and potential real estate actions.

Several other mechanisms to provide for the additional release capacity were also evaluated. Such mechanisms include the installation of flow deflectors or flip buckets, tailrace and sluiceway modifications, and converting unused penstocks to regulating outlets. The conclusion of these studies was that these mechanisms would not accommodate the desired flows *and* maintain TDG within the State of Montana's 110 percent saturation standard. The determination that these mechanisms were not feasible is supported by the July 2004 Supplemental Biological Assessment on the Effects of the Operation of Libby Dam on Kootenai River White Sturgeon (BA), and subsequent additional information that was submitted to the USFWS for the ESA Section 7 consultation. These documents can be viewed from the Web site for this EIS at http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=VARQ&pagename=VARQ.

The 2006 USFWS BiOp includes an RPA that allows flexibility to achieve the habitat attributes necessary for successful sturgeon spawning and recruitment. Given the high costs and time necessary to implement structural modifications at Libby Dam and the uncertainty that they are necessary in order to achieve the habitat attributes, the Corps and BPA have determined that it is prudent to evaluate and establish the need for flows above powerhouse capacity before pursuing structural modifications. An objective of the 2006 USFWS RPA and the referenced Implementation Protocol is to provide a comprehensive evaluation of various flow treatments and the resultant biological response. The preferred alternative, LVB, provides the flexibility to optimize water conditions (for example increasing flows by 10,000 cfs through spill) in any given year to conduct the evaluation and determine whether structural modifications are warranted in the long term. Attempts to achieve habitat attributes and sturgeon reproduction may result in sufficient biological support to conclude that dam modifications are warranted. If structural modifications to provide additional flows are determined to be necessary to achieve sturgeon recruitment, appropriate NEPA documentation will be completed.

(Note: Additional turbines or other structural modifications at Libby Dam are not technically "alternatives" in the context of this EIS in that they do not meet the intended purpose of the proposed action on their own, but are potential components of alternatives LVB, LV2, and LS2 as mechanisms to achieve the flow levels above powerhouse capacity.)

2.6 Summary Comparison of Alternatives

Table 2-4, Table 2-5, and Table 2-6 provide summary comparisons of the impacts associated with the alternatives at Libby Dam and Hungry Horse Dam, and mainstem Columbia River alternative and benchmark combinations upstream and downstream from Grand Coulee Dam.

Table 2-4. Summary comparison of the no action and action alternatives and benchmarks at Libby Dam.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Hydrology and Flood Control								
Lake Koocanusa	Median draft 2370'; median July elevation 2440'; within 5' of full in 12% of years.	Median draft 2396'; median July elevation 2446'; within 5' of full in 31% of years.	Median draft 2370'; median July elevation 2440'; within 5' of full in 10% of years.	Median draft 2396'; median July elevation 2445'; within 5' of full in 31% of years.	Median draft and refill range between LS1 and LS2.	Median draft and refill range between LV1 and LV2.	Median draft 2370'; median July elevation 2458'; within 5' of full in 98% of years.	Median draft 2396'; median July elevation 2458'; within 5' of full in 98% of years.
Kootenai River downstream from Libby Dam	Libby Dam peak releases at about 25 kcfs. Fish flows eliminate need for flood control spills above powerhouse capacity.	Libby Dam peak releases similar to LS1. Highest average outflow during July/Aug. of any alternative. Increased likelihood of 1' higher river stage at Bonners Ferry than LS1 (below 1764').	Libby Dam peak releases at about 35 kcfs. Peak stages at Bonners Ferry are the second highest of any alternative 20% of time, but lowest river stage 80% of time.	Libby Dam peak releases slightly higher than LS2 (35 kcfs) during drier years, similar to LS2 in wetter years. Peak stages at Bonners Ferry are the highest of any alternative.	Peak dam releases range between LS1 and LS2. Bonners Ferry maximum daily elevation and stage-duration range between LS1 and LS2.	Peak dam releases range between LV1 and LV2. Bonners Ferry maximum daily elevation and stage-duration range between LV1 and LV2.	Average Libby Dam releases and Bonners Ferry stages during May, June, and August are the lower than all alternative and LV. Peak releases are distinctly lower than all alternatives for most years below flood stage.	Libby Dam peak releases are lower than all alternatives. Below flood stage, tends to produce peak Bonners Ferry stages higher than LS, but below all of the alternatives.
Kootenay Lake to confluence with Columbia River	Lowest lake levels of all alternatives.	Peak lake elevation tends to be slightly higher than LS1, but lower than LS2 or LV2.	Peak lake elevation tends to be higher than any alternative other than LV2.	Produces the highest likelihood of any given Kootenay Lake peak stage.	Median lake elevation, month-end average stages, and maxim um daily elevations range between LS1 and LS2. Elevation-duration would be similar to or within the range of LS1 and LS2.	Median lake elevation, month-end average stages, and maximum daily elevations range between LV1 and LV2. Elevation-duration would be similar to or within the range of LV1 and LV2.	Tends to produce lower Kootenay Lake peak stages than any alternative.	Produces lower Kootenay Lake peak stages than any alternative.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Water Quality								
Lake Koocanusa	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives,	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives
Kootenai River downstream from Libby Dam	Similar release temperatures to other alternatives. TDG saturation >110% in 1 out of 52 yrs, >120%&>125% in 0 out of 52 yrs	Similar release temperature to other alternatives. TDG saturation >110% in 3 out of 52 yrs, > 120%&>125% in 2 out of 52 yrs, > 130% in 1 out of 52 yrs	Similar release temperature as other alternatives except possibly slightly cooler in spring. No evaluation of TDG since mechanism to achieve add'l 10 kcfs of flow not known.	Similar release temperature as other alternatives except possibly slightly cooler in spring. No evaluation of TDG since mechanism to achieve add'l 10 kcfs of flow not known	Similar release temperature to LS1 except possibly slightly warmer in spring. TDG levels up to about 125% saturation near dam, and 112% at 8 mi. downstream, in 25% of years; otherwise about 100% saturation throughout.	Similar release temperature to LV1 except possibly slightly warmer in spring. TDG levels up to about 125% saturation near dam, and 112% at 8 mi. downstream, in 50% of years; otherwise about 100% saturation throughout.	TDG saturation >110% in 11 out of 52 yrs, >120%&>125% in 6 out of 52 yrs, >130% in 3 out of 52 yrs	TDG saturation > 110% in 13 out of 52 yrs, >120%&>125% in 7 out of 52 yrs, > 130% in 5 out of 52 yrs
Kootenay Lake to confluence with Columbia River	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	No anticipated increase in TDG levels from dams below Kootenay Lake.	No anticipated increase in TDG levels from dams below Kootenay Lake.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Aquatic Life								
Lake Koocanusa	Relative to VARQ FC alternatives, reduced primary productivity; lower zooplankton production; lower benthic production; lower terrestrial insect deposition; lower kokanee growth. Possible entrainment of fish and plankton through turbines.	Relative to Standard FC alternatives, higher primary productivity; higher zooplankton production; higher benthic production; higher terrestrial insect deposition; high kokanee growth. Possible entrainment of fish and plankton through turbines	Lake productivity similar to LS1. Possible entrainment of fish and plankton through turbines	Lake productivity similar to LV1. Possible entrainment of fish and plankton through turbines	Primary productivity, entrainment of primary producers, zooplankton production, benthic insect production, benthic biomass production, terrestrial insect deposition, fish entrainment, and fish growth would range between LS1 and LS2.	Primary productivity, entrainment of primary producers, zooplankton production, benthic insect production, benthic biomass production, terrestrial insect deposition, fish entrainment, and fish growth would range between LV1 and LV2.	In lake, second highest primary productivity and zooplankton production; low benthic production; mostly high terrestrial insect deposition; high kokanee growth.	In lake, highest primary productivity and zooplankton production; high benthic production; highest terrestrial insect deposition; highest kokanee growth.
Kootenai River downstream from Libby Dam	Mixed benthic production; low TDG risk; less likelihood of low winter flow for burbot; flow benefits for sturgeon. Low probability of involuntary spill with TDG impacts.	High benthic production; somewhat higher TDG risk; greater likelihood of low winter flow for burbot; flow benefits for sturgeon. Some probability of involuntary spill with TDG impacts.	Productivity similar to LS1; less likelihood of low winter flow for burbot; higher flow benefits for sturgeon.	Productivity similar to LV1; greater likelihood of low winter flow for burbot; higher flow benefits for sturgeon.	Benthic biomass would range between LS1 and LS2. Possible TDG impacts to aquatic life in 25% of years, especially at spill levels above 2-3kcfs	Benthic biomass would range between LS1 and LS2. Possible TDG impacts to aquatic life in 50% of years, especially at spill levels above 2-3kcfs.	Mixed benthic production; relatively high TDG risk; less likelihood of low winter flow for burbot; no flow benefits for sturgeon.	Relatively high benthic production; highest TDG risk; greater likelihood of low winter flows for burbot; no flow benefits for sturgeon.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Kootenay Lake to confluence with Columbia River	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possibly higher washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Biological effects would range between LS1 and LS2.	Biological effects would range between LV1 and LV2	Possibly lower washout of nutrients and plankton; possible fish stranding in Duncan delta (Note: Potential for fish stranding a result of low lake levels that may not be significantly affected by the different alternatives)	Lower washout of nutrients and plankton; possible fish stranding in Duncan delta.
Sensitive, Threatened and Endangered Species								
	No likely effect on terrestrial species exc. bald eagle; moderate flow benefits for sturgeon, moderate flexibility for research, monitoring, & evaluation (RM&E) of sturgeon responses; relatively low likelihood of winter low flows for burbot; minimum flows maintained for bull trout. Low probability of involuntary spill with TDG impacts.	No likely effect on terrestrial species exc. bald eagle; flow benefits for sturgeon same as LS1, slightly higher flexibility for RM&E of sturgeon responses than LS1; relatively high likelihood of low flows in winter for burbot; minimum flows maintained for bull trout. Some probability of involuntary spill with TDG impacts.	No likely effect on terrestrial species exc. bald eagle; high flow benefits for sturgeon, high flexibility for RM&E of sturgeon responses; same winter flows as LS1 for burbot; minimum flows maintained for bull trout. No TDG evaluation because mechanism to pass flows above powerhouse capacity not known.	No likely effect on terrestrial species exc. bald eagle; highest flow benefits for sturgeon, highest flexibility for RM&E of sturgeon responses; same winter flows as LV1 for burbot; minimum flows maintained for bull trout. No TDG evaluation because mechanism to pass flows above powerhouse capacity not known.	Most biological effects of flow would range between LS1 and LS2. Higher flow benefits for sturgeon than LS1 or LV1, moderate flexibility for RM&E of sturgeon responses. TDG impacts to fish below Libby Dam in years of spill (about 25% of years), especially when spill exceeds 2-3 kcfs.	Most biological effects of flow would range between LV1 and LV2. Higher flow benefits for sturgeon than LS1 or LV1, moderate flexibility for RM&E of sturgeon responses. TDG impacts to fish below Libby Dam in years of spill (about 50% of years)—especially when spill exceeds 2-3 kcfs.	No likely effect on terrestrial species exc. bald eagle; no flow benefits for sturgeon; same winter flows as LS1 for burbot; no minimum flows for bull trout.	No likely effect on terrestrial species exc. bald eagle; no flow benefits for sturgeon; same winter flows as LV1 for burbot; no minimum flows for bull trout.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Vegetation and Wildlife								
Lake Koocanusa	Little or no riparian vegetation below full reservoir level. Minimal effect on wildlife.	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.	Effects would range between LS1 and LS2.	Effects would range between LV1 and LV2	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.
Kootenai River downstream from Libby Dam	Some riparian vegetation enhancement due to fish flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows; possible enhancement due to lower winter flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows; possible enhancement due to lower winter flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Effects to wildlife and vegetation would range between LS1 and LS2.	Effects to wildlife and vegetation would range between LV1 and LV2.	Little or no benefit to riparian vegetation; possible loss, with corresponding effects on wildlife.	Little or no benefit to riparian vegetation; possible loss, with corresponding effects on wildlife.
Kootenay Lake to confluence with Columbia River	Little or no change in existing lakeshore vegetation, which should remain extensive.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.
Recreation								
Lake Koocanusa in United States	1,340 boat ramp days May-Sep; 107 swimming days Jun-Aug; 45 camping days above elev. 2439' May-Sep; 113 camping days above 2409' May-Sep	1,467 boat ramp days May-Sep; 150 swimming days Jun-Aug; 65 camping days above elev. 2439' May-Sep; 126 camping days above 2409' May-Sep	1,351 boat ramp days May-Sep; 92 swimming days Jun-Aug; 42 camping days above elev. 2439' May-Sep; 112 camping days above 2409' May-Sep	1,454 boat ramp days May-Sep; 142 swimming days Jun-Aug; 61 camping days above elev. 2439' May-Sep; 124 camping days above 2409' May-Sep	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	1,627 boat ramp days May-Sep; 217 swimming days Jun-Aug; 102 camping days above elev. 2439' May-Sep; 122 camping days above 2409' May-Sep	1,665 boat ramp days May-Sep; 221 swimming days Jun-Aug; 104 camping days above elev. 2439' May-Sep; 130 camping days above 2409' May-Sep

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Lake Koocanusa in Canada	352 boat ramp days May-Sep, and 29 swimming days Jun-Aug.	414 boat ramp days May-Sep, and 51 swimming days Jun-Aug	343 boat ramp days May-Sep, and 24 swimming days Jun-Aug	404 boat ramp days May-Sep, 24 swimming days Jun-Aug	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	503 boat ramp days May-Sep, and 131 swimming days Jun-Aug	522 boat ramp days May-Sep, and 133 swimming days Jun-Aug
Kootenai River downstream of Libby Dam	May-Sep: 77 shore-fishing days and 88 boating days.	May-Sep: 50 shore-fishing days and 101 boating days.	May-Sep: 80 shore-fishing days and 88 boating days.	May-Sep: 54 shore-fishing days and 105 boating days.	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	May-Sep 74 shore-fishing days and 85 boating days.	May-Sep: 48 shore-fishing days and 115 boating days.
Kootenay Lake to confluence with Columbia River	135 days in preferred range May-Sep; 52 boat moorage days Jan-May; 83 fishing days above elev. 1744' May-Sep; 77 swimming days below lake elev. 1749' Jun-Aug	132 days in preferred range May-Sep; 52 boat moorage days Jan-May; 90 fishing days above elev. 1744' May-Sep; 76 swimming days below lake elev. 1749 Jun-Aug	134 days in preferred range May-Sep; 52 boat moorage days Jan-May; 82 fishing days above elev. 1744' May-Sep; 76 swimming days below lake elev. 1749 Jun-Aug	132 days in preferred range May-Sep; 52 boat moorage days Jan-May; 89 fishing days above elev. 1744' May-Sep; 75 swimming days below lake elev. 1749' Jun-Aug	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	142 days in preferred range May-Sep; 51 boat moorage days Jan-May; 79 fishing days above elev. 1744' May-Sep; 84 swimming days below lake elev. 1749' Jun-Aug	139 days in preferred range May-Sep; 52 boat moorage days Jan-May; 86 fishing days above elev. 1744' May-Sep; 82 swimming days below lake elev. 1749' Jun-Aug
Environmental Health								
Lake Koocanusa	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 87% of time May, & 32% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 60% of time May, and 13% of time June	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 88% of time May, & 37% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 62% of time May, & 18% of time June	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 83% of time May, & 14% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 56% of time May, & 7% of time June
Cultural Resources								
Lake Koocanusa in United States	268 sites possibly exposed to erosion, looting, and vandalism	247 sites possibly exposed to erosion, looting, and vandalism	Similar to LS1	Similar to LV1	Similar to LS1	Similar to LV1	Similar to LS1 Note: This exposure is due to FC operations and not a factor of fish flows	Similar to LV1
Kootenai River below Libby Dam	Possible erosion at 6 sites within 5 miles of Libby Dam	Same as LS1.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Lowest likelihood of erosion at sites downstream from dam.	Relatively low likelihood of erosion at sites downstream from dam.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Indian Sacred Sites								
	During informal consultations with the CSKT, they have chosen not to discuss sacred sites at Libby Dam-Lake Koocanusa. Therefore, the possible effects on TCPs are not assessed in this analysis.	Same as LS1.	Same as LS1.	Same as LS1.	Same as LS1	Same as LS1.	Same as LS1.	Same as LS1.
Other Affected Tribal Interests								
	No impacts	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Socioeconomics								
Lake Koocanusa	Adverse impacts on employment and income from recreation and tourism.	Potential positive effects on employment and income from recreation/ and tourism.	Adverse socioeconomic impacts slightly greater than LS1.	Socioeconomic benefits slightly lower than LV1.	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Positive effects on employment and income from recreation/tourism.	Positive effects on employment and income from recreation/tourism.
Kootenai River downstream of Libby Dam	Avg. annual flood damages of $21,780; 455,600 kW-hr of ag. pumping; moderate ag. losses from high groundwater (i.e. seepage).	Avg. annual flood damages same as LS1. 452,500 kW-hr of ag. pumping; relatively high ag. losses from high groundwater.	Avg. annual flood damages same as LS1. 456,100 kW-hr of ag. pumping; ag. losses from high groundwater similar to LS1.	Avg. annual flood damages same as LS1. 453,000 kW-hr of ag. pumping; highest ag. losses from high groundwater.	Avg. annual flood damages same as LS1. ag. pumping costs and losses from high groundwater between LS1 and LS2. Also likely TDG impacts to game fish in 25% of years, affecting recreation economy.	Avg. annual flood damages same as LS1. ag. pumping costs and ag. losses from high groundwater between LV1 and LV2. Also likely TDG impacts to game fish in 50% of years, affecting recreation economy.	Avg. annual flood damages same as LS1. 457,100 kW-hr of ag. pumping; lowest ag. losses from high groundwater.	Avg. annual flood damages of $22,950 in Idaho. 455,300 kW-hr of ag. pumping; ag. losses from high groundwater higher than LS, but tend to be lower than fish flow alternatives.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Kootenay Lake	Moderate likelihood of flood damages around Kootenay Lake.(Damages would occur below established zero-damage elevation)	Likelihood of flood damages around Kootenay Lake similar to LS1	Highest likelihood of flood damages around Kootenay Lake.	Likelihood of flood damages around Kootenay Lake similar to LS2	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Lowest likelihood of flood damages around Kootenay Lake.	Relatively low likelihood of flood damages around Kootenay Lake.
Municipal Water and Wastewater Treatment								
	No impacts identified.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Transportation								
	No impacts identified.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Dam Structural Condition								
	Minor add'l deterioration of spillway surface. Repairs would remain relatively low urgency	Same as LS1	No analysis since mechanism to achieve add'l 10 kcfs of flow not known	Same as LS2	Accelerated deterioration of spillway surface. Repairs would become a higher priority maintenance activity.	Same as LSB	Lowest rate of add'l deterioration of spillway surface.	Rate of deterioration of the spillway surface would be low, but slightly higher than LS1 or LV1.

Table 2-5. Summary comparison of the no action and preferred alternatives at Hungry Horse Dam.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Hydrology and Flood Control		
Hungry Horse Reservoir	Hungry Horse Reservoir would continue to have deeper winter flood control drafts in slightly below average to slightly above average water years. The average winter draft would be to elevation 3501 feet. The average June 30 refill would be to elevation 3558.17 feet.	Hungry Horse Reservoir would have shallower winter flood control drafts in slightly below average to slightly above average water years. The average winter draft would be to elevation 3512 feet. This would allow for a slight improvement in probability of refill; the average maximum refill would be to elevation 3558.5 feet.
Hungry Horse Outflows	Due to deeper winter flood control drafts, average outflows would be higher under HS during the January to April period. Average outflows would be about: January – 4995 cfs February – 4930 cfs April – 5648 cfs May – 3423 cfs June – 3054cfs Average outflows for flow augmentation would be about: July – 5174 cfs August - 5474 cfs	Given shallower winter flood control drafts, more water would be released later in the spring in order to maintain the same level of flood protection. Average outflows would be about: January – 4151cfs February – 3906 cfs April – 3560 cfs May – 5637 cfs June – 4243 cfs Average out flows for flow augmentation would be about: July – 5302 cfs August – 5476 cfs Releases for flow augmentation are higher under HV because of the improved probability of refill.
Columbia Falls	During slightly below average to slightly above average water years, HS flows would be higher during the January to April period. Average outflows would be about: January – 6594 cfs February – 6486 cfs April – 12681 cfs May – 23874 cfs June – 23650 cfs Under both alternatives there would continue to be an 18% probability of reaching or exceeding flood stage at Columbia Falls (14 feet).	During slightly below average to slightly above average water years, HV flows would be higher in May and June. Average outflows would be about: January – 5751 cfs February – 5461 cfs April – 10592 cfs May – 26088 cfs June – 24839 cfs Under both alternatives there would continue to be an 18% probability of reaching or exceeding flood stage at Columbia Falls (14 feet).
Flathead Lake	Under HS, there is a 7% probability of exceeding Flathead Lake's full pool elevation of 2893 feet.	Under HV there is 10% probability of exceeding Flathead Lake's full pool elevation of 2893 feet.
Lake Pend Oreille	Due to the attenuation of flows in the river reaches downstream from Hungry Horse Dam and reregulation of flows through Flathead Lake and Kerr Dam, water surface elevations at Lake Pend Oreille would be essentially identical.	Same as HS.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Downstream from Albeni Falls Dam	Average outflows from Lake Pend Oreille would lower in June. Average outflows would be about: January – 17411 cfs February – 19434 cfs April – 28588 cfs May – 53,678 cfs June – 54518 cfs There would continue to be a 27% probability of exceeding the flood stage of 100,000 cfs below Albeni Falls Dam.	Average outflows from Lake Pend Oreille would be slightly lower in January to April period. The slight reduction in April flows could provide flood relief in the Cusick area when Calispell and Trimble Creeks are high. Average outflows would be about: January – 16981 cfs February – 18033 cfs April – 28020 cfs May – 53,536 cfs June – 56578 cfs There would continue to be a 27% probability of exceeding the flood stage of 100,000 cfs below Albeni Falls Dam.
Water Quality		
	Under simulated releases, there is less chance of HS exceeding TDG standards.	Under simulated releases, the chance of HV exceeding the 15 percent spill is 1 % in June. Overall, spill analysis indicates that implementation of HV could result in increases in TDG saturation levels from May through July. Changes in the saturation levels are not quantifiable with the available data, but appear to be minor. Based on modeling, HV operations would generally increase benthic biomass production in the Flathead River because the natural temperature regime and other physical properties of the river would be more closely mimicked.
Aquatic Life		
	Deep drafts implemented under HS would continue to limit food availability and habitat quality at Hungry Horse Reservoir and the Flathead River. Modeling results showed minimal differences between alternatives from Flathead Lake downstream.	Implementation of HV would likely benefit resident fish, especially those in Hungry Horse Reservoir and immediately downstream in the Flathead River. Hungry Horse releases would follow a more normative hydrograph and would be higher in March, May, and June. Reduced winter drafts would help achieve refill at Flathead Lake, especially in dry years. Higher late-spring releases would help meet Kerr Dam minimum outflow requirements, thus providing minor benefits to aquatic resources in Flathead Lake and downstream from Kerr Dam.
Sensitive, Threatened and Endangered Species		
	Deep drafts implemented under HS would continue to limit food availability and habitat quality at Hungry Horse Reservoir and the Flathead River. Modeling results showed minimal differences between alternatives from Flathead Lake downstream.	Implementation of HV would benefit bull trout through general improvements in biological conditions at Hungry Horse Reservoir and immediately downstream in the Flathead River. Below Flathead Lake, HV would result in a slightly more normative hydrograph and minor increases in TDG saturation levels. Neither alternative is likely to appreciably affect existing conditions within designated bull trout critical habitat HV may result in minor benefits to the fish prey base for bald eagles at Hungry Horse Reservoir and Flathead Lake and neither alternative is likely to affect bald eagle nesting, roosting, and feeding habitats.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Wildlife		
	Existing riparian and wetlands habitat would remain unchanged.	May provide minor benefits to riparian and wetland habitats and associated wildlife along Flathead Lake and immediately upstream on the Flathead River. Otherwise, existing wildlife habitats generally would not be affected.
Vegetation		
	Existing riparian and wetlands would remain unchanged.	May provide minor benefits to riparian areas and wetlands along Flathead Lake and immediately upstream on the Flathead River.
Recreation		
	Slightly more fishing and kayaking days on the Flathead River downstream from Hungry Horse Dam in the early summer due to optimal flows.	May result in minor improvements in boater access to Hungry Horse Reservoir and Flathead Lake owing to higher average water surface elevations during the recreation season and an increase in the usability of boat ramps. Slightly better aesthetics due to higher surface water elevations.
Environmental Health		
	No measurable effect on human or environmental health within the affected area.	Same as HS.
Cultural Resources		
	Some erosion and slumping would continue at archaeological sites within Hungry Horse Reservoir.	Likely would be a minor increase in the potential for winter erosion and ice impacts to cultural resources. HV also may provide minor benefits to cultural resources during the summer recreation season owing to the increased probability of reservoir refill. Once full, the reservoir helps protect cultural sites below the high water line which otherwise would be exposed to impacts from summer erosion and visitor use.
Indian Sacred Sites		
	No Indian sacred sites have been identified.	Same as HS.
Other Affected Tribal Interests		
	No effect on other interests	Same as HS.
Transportation		
	No effect on existing transportation systems	Same as HS.
Municipal Water and Wastewater Treatment		
	No effect likely on existing municipal water sources or treatment/disposal facilities.	Same as HS.
Socioeconomics		
	Existing levels of flood protection would continue.	Results in a minor (4%) increase in potential flood effects at Flathead Lake, primarily for damage to waterfront land and docks. HV would also result in a 12% increase in potential flood effects below Albeni Falls Dam, primarily for damages to agricultural and residential property.

Table 2-6. Summary comparison of alternative and benchmark combinations on the mainstem Columbia River.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Hydrology and Flood Control								
Grand Coulee Dam-upstream	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies no greater than LS+HS	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies same as LV+HV	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies no greater than LS+HS	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies same as LV+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Birchbank: 99% exceedance frequency 93.6 kcfs, 50% exceedance. frequency 162.5 kcfs; 1% exceedance frequency 250 kcfs	Birchbank: 99% exceedance frequency 95.1 kcfs, 50% exceedance frequency 167 kcfs; 1% exceedance frequency 251 kcfs
Lake Roosevelt	2nd half of April elevations (feet): Minimum 1208.0 Maximum 1280.0 Average 1244.0	2nd half of April elevations (feet): Minimum 1208.0 Maximum 1280.0 Average 1242.4	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Apr2 same as LV1+HV Lower Jan-May elevations during some years

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	Peak 1-day release exceedance frequencies for The Dalles no more than for LS+HS. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly lower than for LV1+HV, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LV+HV. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly higher than for LS1+HS, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LS+HS. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly lower than for LV2+HV, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LV+HV. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly higher than for LS2+HS, and above flood stage In 2 of the 10 years.	Similar to LS1+HS and LS2+HS. For peak daily releases at The Dalles, values would be between LS1+HS and LS2+HS. Peak 1-day elevations at Vancouver would fall between LS1+HS and LS2+HS.	Similar to LV1+HV and LV2+HV. For peak daily releases at The Dalles, values would be between LV1+HV and LV2+HV. Peak 1-day elevations at Vancouver would fall between LV1+HV and LV2+HV.	The Dalles: 99% exceedance frequency: 205 kcfs 50% exceedance frequency: 401 kcfs; 1% exceedance frequency: 670 kcfs	The Dalles: 99% exceedance frequency: 211 kcfs 50% exceedance frequency: 411 kcfs; 1% exceedance frequency: 670 kcfs
System Power								
Winter (Jan-Apr)	Monthly average winter generation (aMW): 16,556 System; 8,252 Federal; 3,812 non-Federal; Canadian monthly average generation 631 on Pend d'Oreille, 702 on Kootenay.	Monthly average winter generation (aMW): 16,220 System; 8,008 Federal; 3,718 non-Federal Canadian monthly average generation 616 aMW on Pend d'Oreille 626 on Kootenay	Monthly average winter generation (aMW): 16,555 system; 8,252 Federal; 3,812 non-Federal Canadian monthly average generation 631 on Pend d'Oreille, 702 on Kootenay	Monthly average winter generation (aMW): 16,219 System; 8,008 Federal; 3,718 non-Federal Canadian monthly average generation 616 on Pend d'Oreille, , 626 on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average winter generation (aMW): 16,556 System; 8,259 Federal; 3,813 non-Federal Canadian monthly average generation 631 on Pend d'Oreille, 704 aMW on Kootenay	Monthly average winter generation (aMW): 16,226 System; 8012 Federal; 3,718 non-Federal; Canadian monthly average generation 616 on Pend d'Oreille, 627 on Kootenay

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Spring/summer (May-Aug)	Monthly average generation (aMW): 16,993 System; 9,011 Federal; 4,272 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 922 aMW on Kootenay	Monthly average generation (a MW): 17,252 System; 9,237 Federal; 4,317 non-Federal; Canadian monthly average generation 794 aMW on Pend d'Oreille, 948 on Kootenay	Monthly average generation (aMW): 16,977 System; 9,009 Federal; 4,273 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 921 aMW on Kootenay	Monthly average generation (aMW): 17,235 System; 9,235 Federal; 4,317 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 947 aMW on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average generation (aMW): 16,716 System; 8,763 Federal; 4,219 non-Federal; Canadian monthly average generation 797 on Pend d'Oreille, 886 aMW on Kootenay	Monthly average generation (aMW): 16,993 System; 9,003 Federal; 4,269 non-Federal; Canadian monthly average generation 798 on Pend d'Oreille, 901 on Kootenay
Fall (Sept-Dec)	Monthly average generation (aMW): 11,500 System; 5,780 Federal; 2,821 non-Federal; Canadian monthly average generation 507 on Pend d'Oreille, 477 on Kootenay	Monthly average generation (aMW): 11,550 System; 5,805 Federal; 2,836 non-Federal; Canadian monthly average generation 510 on Pend d'Oreille, 483 on Kootenay	Monthly average generation (aMW): 11,493 System; 5,775 Federal; 2,820 non-Federal; Canadian monthly average generation 507 on Pend d'Oreille, 476 on Kootenay	Monthly average generation (aMW): 11,545 System; 5,803 Federal; 2,834 non-Federal; Canadian monthly average generation 509 on Pend d'Oreille, 483 on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average generation (aMW): 11,863 System; 6,805 Federal; 2,906 non-Federal; Canadian monthly average generation 504 on Pend d'Oreille, 580 on Kootenay	Monthly average generation (aMW): 11,888 System; 6,092 Federal; 2,910 non-Federal; Canadian monthly average generation 505 on Pend d'Oreille, 580 on Kootenay
Water Quality								
Grand Coulee Dam – upstream TDG	Existing seasonally-elevated TDG levels in the Columbia River at the international border and in Lake Roosevelt would continue, as would ongoing efforts to ameliorate them.	TDG levels in the Columbia River at the international border likely would be marginally higher than at present at times, primarily due to minor increases in involuntary spill at Canadian hydropower facilities on the Kootenay River.	Same as LS1+HS	Same as LV1+HV	Values would range between LS1+HS and LS2+HS.	Values would range between LV1+HV and LV2+HV.	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Temperature	Operational changes at Hungry Horse and Libby Dams are unlikely to affect Columbia River temperatures because of the large intervening distance involved.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Grand Coulee Dam – downstream TDG	Slightly increase spill cap exceedance index and the amount of spill in excess of the spill cap compared to benchmarks which indicates the potential to increase TDG levels.	Highest spill cap exceedance index and the amount of spill in excess of the spill cap.	Same as LS1+HS	Same as LS1+HS and has a higher spill cap exceedance index at Rock Island and Priest Rapids Dams than LV1+HV.	Values would range between LS1+HS and IS2+HS.	Values would range between LV1+HV and LV2+HV.	Spill cap exceedance index and spill in excess of spill cap would be lower than Standard FC alternative combinations.	Spill cap exceedance index and spill in excess of spill cap would be lower than VARQ FC alternative combinations.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Aquatic Life								
Grand Coulee Dam - upstream	The present habitat characteristics, species assemblages, and population dynamics at Lake Roosevelt generally would remain unchanged. Large annual flood control drafts would continue to limit natural reproduction of many fish species in the reservoir and would continue to facilitate entrainment. Nutrient flushing and low spring water surface elevations would continue to limit the growth of some species.	Minor increases in spring drawdowns at Lake Roosevelt could result in periodic, small reductions in present levels of spawning success for smallmouth bass, yellow perch, and shoreline spawning kokanee. Minor reductions in water retention times may result in small increases in the loss of nutrients from the reservoir which in turn may lead to minor decreases in growth rates for some species. Minor increases in entrainment would occur in some years.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	Continued similar influence on the timing and magnitude of flows in the Columbia River. The present habitat characteristics, presence/ absence and migration patterns of species generally would remain unchanged.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Sensitive, Threatened and Endangered Species								
Grand Coulee Dam - upstream	The present habitat characteristics, species presence, and population dynamics at Lake Roosevelt and upstream generally would remain unchanged. Large annual flood control drafts would continue to limit benthic productivity and may also continue to limit the juvenile-growth potential of bull trout in the reservoir. Bald eagle numbers and distribution would likely remain unchanged.	Minor increases in spring drawdowns at Lake Roosevelt could result in small reductions in present levels of benthic productivity. Primary impacts to bull trout would most likely be growth-related. The fish prey base for bald eagles would not likely be noticeably affected, and bald eagle numbers and distribution would likely remain unchanged.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	River flows and reservoir elevations would remain within the current range of operations. In general, related ongoing effects to threatened and endangered species would remain unchanged from those previously consulted upon and addressed in biological opinions.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LV1+HV
Anadromous Fish –Priest Rapids Dam	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly flow objectives met in 32-47 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.
Anadromous Fish -McNary Dam	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 3-42 of 52 years.	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Monthly flow objectives met in 3-42 of 52 years.	Monthly flow objectives met in 2-42 of 52 years.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Spill	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in slightly lower potential TDG levels and durations as compared to the VARQ FC alternative combinations.	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in a slight potential increase in TDG levels and durations as compared to the Standard FC alternative combinations.	Same as LS1+HS	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in the highest potential TDG levels and durations as compared to all other alternative combinations.	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this benchmark combination results in the lowest potential TDG levels and durations.	Same as LV1+HV
Vegetation								
	River flows and reservoir elevations would remain within the current range of river and reservoir operations, and; therefore, related effects on vegetation would be similar. Riparian and wetland areas within the influence of the Columbia River and its impoundments generally would remain unchanged.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Wildlife								
	Riparian and wetland habitats within the influence of the Columbia River and its impoundments generally would remain unchanged. Associated terrestrial wildlife populations also are not likely to be affected.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Recreation								
Grand Coulee Dam - upstream	Current levels of recreation access and scenic quality at Lake Roosevelt generally would remain unchanged. There would be no change in usable boat ramp days during the summer.	There would be a minor decrease (less than 5%, primarily in May) in average usable boat ramp days at Lake Roosevelt. Otherwise, there would be no change in the present function of boat ramps or marinas, particularly during the summer. A slight degradation in visual resources may be noticeable in May due to slightly lower reservoir elevations.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	No change in present levels and quality of boating and shoreside recreation.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Environmental Health								
Grand Coulee Dam - upstream	There would be no change in the timing, duration, or magnitude of annual flood control drawdowns at Lake Roosevelt. Similarly, there would be no change in the annual exposure of lake bed sediments, or in the exposure of humans and other organisms to contaminants present in those sediments. Preliminary results of an ongoing air quality study indicate that none of the samples taken at Lake Roosevelt study sites have exceeded established standards.	There would be slightly lower reservoir surface elevations and thus slightly increased exposure of lake bed sediments during the spring flood control draft in average to moderately dry water years. When compared to present conditions, the likelihood of measurable impacts to environmental and human health through inhalation, ingestion, or direct contact with contaminated bed-sediments is expected to be extremely low.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	There are no identified flow-related environmental health concerns below Grand Coulee. All alternative combinations would continue to similarly influence the timing and magnitude of flows in the Columbia River.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Cultural Resources								
Grand Coulee Dam – upstream	There would be no change in the timing, duration, or magnitude of annual flood control drawdowns at Lake Roosevelt. Similarly, there would be no change in the periodic exposure of cultural resources to wave action, erosion, displacement, weathering, or collection/looting.	There would be slightly lower reservoir surface elevations and thus slightly increased exposure of cultural resources during the spring flood control draft in average to moderately dry water years. When compared to present conditions, the likelihood of impacts to cultural resources is expected to be minor.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	There would be essentially no change in management or protection of cultural resources downstream from Grand Coulee Dam. Effects to cultural resources (primarily erosion and site exposure) from river flows and reservoir operations would be similar for all alternative combinations.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Indian Sacred Sites								
	No sacred sites have been identified.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Other Affected Tribal Interests								
	Tribal interests in fishing would be affected by all alternative combinations to the extent that salmon and steelhead survival and recovery are affected. The analysis for anadromous fish discusses how the flow objectives at McNary and Priest Rapids dams are achieved by the various alternative combinations. Fish flows from Libby and Hungry Horse in July and August are intended to assist salmon outmigration. Spring flow augmentation for Kootenai River white sturgeon also can assist in meeting flow objectives in the lower Columbia River. No discernible effect on lamprey is expected.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Socioeconomics								
Flood Damages	No increase in economic losses from floods to areas protected by major levee systems. Fish flows may cause minor increase in levee maintenance costs.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Agriculture	No impacts identified.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Hydropower	Annual hydropower values (billions): $4.946 System; $2.516 Federal; $1.211 non-Federal	Annual hydropower values (billions): $4.932 System; $2.504 Federal; $1.202 non-Federal	Annual hydropower values (billions): $4.944 System; $2.525 Federal; $1.212 non-Federal	Annual hydropower values (billions): $4.931 System; $2.508 Federal; $1.202 non-Federal	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Annual hydropower values (billions): $4.967 System; $2.533 Federal; $1.213 non-Federal	Annual hydropower values (billions): $4.948 System; $2.520 Federal; $1.203 non-Federal
Transportation and Navigation	No effects to Keller or Inchelium ferries	Keller Ferry north landing would be used more frequently.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV
Municipal Water and Wastewater Treatment								
	No effect on municipal water sources, wastewater treatment or disposal.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Transportation								
Grand Coulee Dam – upstream	The Keller and Inchelium Ferries would continue normal operations within the current range of reservoir levels. Lake Roosevelt end-of-April elevation would be less than 1248 feet approximately 60% of all years. Keller Ferry North landing must be used when elevation is below 1248 feet	The Keller and Inchelium ferries would continue normal operations within the current range. Lake Roosevelt end-of-April elevation would be less than 1248' approximately 70% of all years, therefore, the Keller Ferry's alternative north landing would have to be used more frequently than at present.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV
Grand Coulee Dam – downstream	No effect	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Chapter 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES: KOOTENAI RIVER BASIN

3.1 Introduction

This chapter describes the affected environment and evaluates the environmental consequences of implementing each of the alternatives for the Kootenai River basin as described in Chapter 2. The extent of the environmental analysis corresponds to the context and intensity of the impacts anticipated for each environmental component. Where the alternatives would have the same impacts on an environmental component, the analysis is presented once and summarized or referenced in subsequent analyses to eliminate redundancy.

This chapter is split into two sections: affected environment (description of each resource) and environmental consequences (effects of the different alternatives on each resource). In each of these sections, the discussion for each resource is generally arranged by river or reservoir reach as follows:

- Lake Koocanusa;
- Libby Dam to Kootenay Lake near Creston, British Columbia;
- Kootenay Lake to the confluence of the Kootenay River and the Columbia River.

Resource discussions that do not follow this pattern are:

- Sensitive, threatened and endangered species (discussed by species);
- Socioeconomics (discussed by county/state divisions); and
- Cultural resources, Indian sacred sites, and other affected Tribal interests (focusing on recognized tribal resources).

Potential impacts to hydropower generation on the Kootenai River are addressed as part of the system hydropower discussion in Section 5.3.2.

3.1.1 Resources Not Affected by the Alternatives

None of the alternatives and associated actions is expected to affect regional or local climates, geography, or geology in the Kootenai River basin nor would these resources rise to the level of needing analysis. Groundwater quality is not expected to be affected by any of the alternatives, based on monitoring of an extended spill event in 2002. These discussions are summarized as part of affected environment background information in the basin overview discussion.

3.2 Affected Environment

3.2.1 Basin Overview

The Kootenai River basin (Figure 3-1) encompasses 16,180 square miles (KTOI and MFWP 2004). About 70 percent of the basin lies within British Columbia; the remainder is in Montana and Idaho. Basin elevations range from more than 11,000 feet above sea level on many of the peaks along the Continental Divide to 1500 feet in the lowest valleys. In terms of runoff volume, the Kootenai River is the second largest Columbia River tributary and the basin ranks third in terms of watershed area at 8.96 million acres.

The Kootenay River[10] originates in Kootenay National Park, British Columbia, Canada. The river flows south within the Rocky Mountain Trench into Montana. At river mile (RM) 222 (48 miles south of the international boundary), Libby Dam impounds Lake Koocanusa, which is 90 miles long at full pool. Downstream of Libby Dam at the city of Libby (RM 204), the river turns to the northwest, then turns north near Bonners Ferry, Idaho (RM 153), and flows back into British Columbia at RM 106. The river enters Kootenay Lake about 25 miles north of the international boundary. The Duncan River in British Columbia, the other major tributary to Kootenay Lake, flows into the lake's north end and is regulated by Duncan Dam. Kootenay Lake drains through its West Arm near Nelson, British Columbia, and into the Columbia River near Castlegar, British Columbia. Corra Linn Dam is at the Kootenay Lake outlet, and Upper Bonnington, Lower Bonnington, South Slocan, and Brilliant Dams are between Corra Linn Dam and the Kootenay River confluence with the mainstem Columbia River.

In general, steep, forested mountain canyons and valleys dominate the Kootenai River basin. Tributaries to the Kootenai River tend to have very high channel gradients. Downstream from Canal Flats, British Columbia, the Kootenay River tends to have a low gradient, dropping less than 1,000 feet in elevation over the 300-mile distance between Canal Flats and Kootenay Lake. Valley bottoms are typically narrow, but the valley opens to include a broad floodplain in the Tobacco Flats area upstream from Eureka, Montana, and the Kootenai Flats area downstream from Bonners Ferry, Idaho. The valley in northern portion of Lake Koocanusa broadens to approximately two miles wide and broad flat areas occur at and just below full pool elevation (2459 feet). Landmark locations in the Kootenai River basin are listed in Table 3-1.

[10] The Canadian spelling is Kootenay and is used throughout the document to indicate river reaches, places, and facilities in Canada.

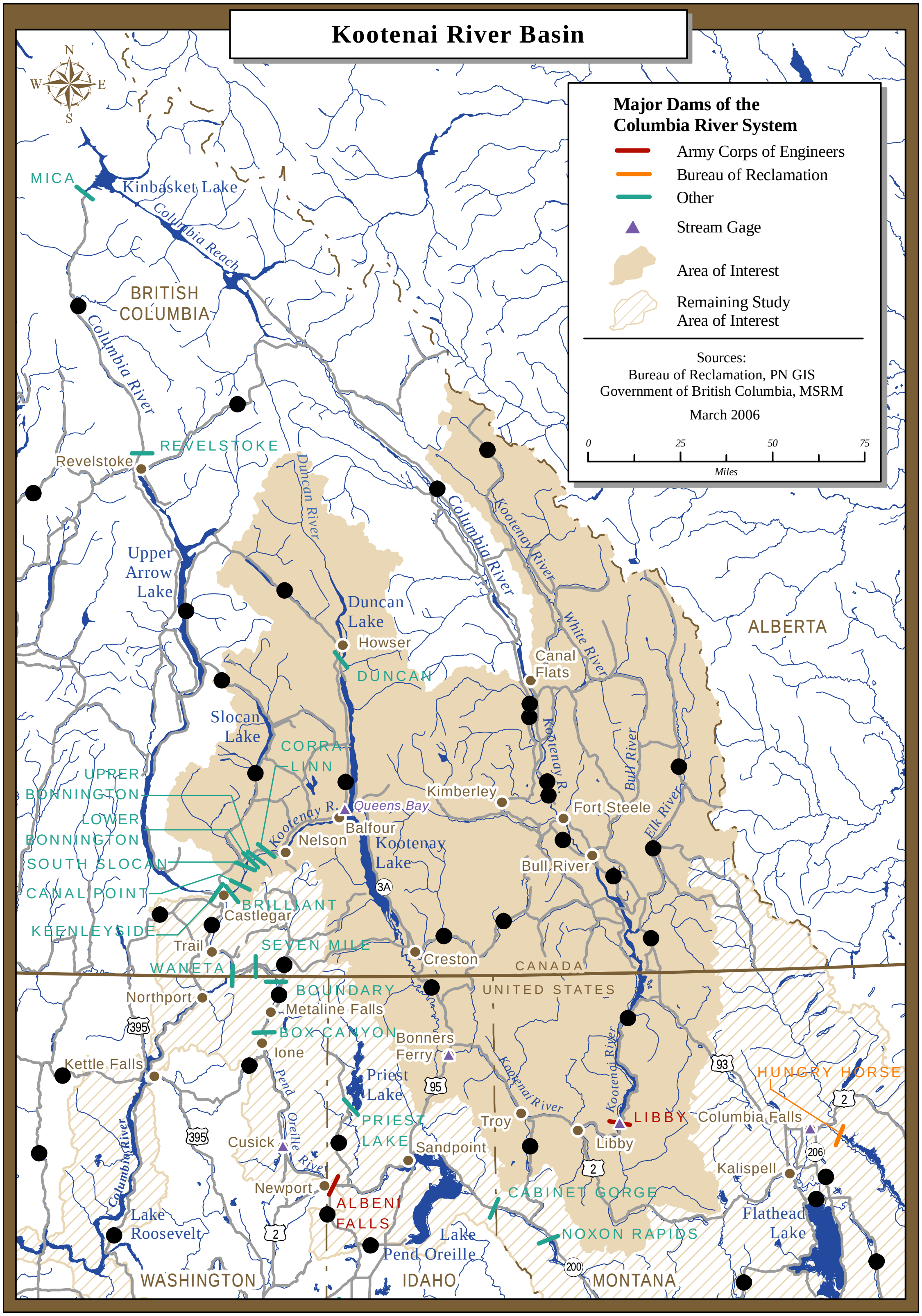

Figure 3-1. Map of the Kootenai River Basin

Table 3-1. Kootenai River basin landmarks

Landmark	River Mile
Kootenay National Park Boundary	431
Canal Flats, British Columbia	381
Fort Steele, British Columbia	331
Bull River Confluence	312
Elk River Confluence	286
International Boundary on Lake Koocanusa	271
Libby Dam, Montana	222
Libby, Montana	204
Kootenai Falls, Montana	193
Troy, Montana	186
Montana/Idaho Border	172
Bonners Ferry, Idaho	153
International Boundary on Kootenai River	106
Creston, British Columbia	91
Nelson, British Columbia	26
Grohman Narrows	23
Corra Linn Dam	16

Source: Pacific Northwest River Basins Committee, 1965

Geology

The majority of the Kootenai River basin is within the Columbia Mountains/ Okanogan Highlands physiographic province, a complex of high, glaciated mountains with narrow plateaus to the south. Topography is primarily controlled by bedrock structure modified by glacial erosion and sedimentation. The basin is characterized by high, rugged, forested northwest-trending mountain ranges separated by narrow linear valleys.

The Kootenai River downstream from Bonners Ferry, Idaho, lies in a glaciated trough that was once inundated by Glacial Lake Kootenay. Fine sands, silts, and glacial lake sediments underlie the valley floor to an unknown depth. The west side of the valley has steep rocky slopes cut by creeks that end on alluvial fans on the valley floor. A glacial terrace forms a plateau about 500 feet above the river on the east side of the valley. Upstream from Bonners Ferry, the Kootenai River flows through a valley that was eroded through terraces of glacial sediment into bedrock canyons (NPPC 2004).

The Kootenai River, throughout the study area, meanders across the valley floor; bends in the river have a tendency to migrate laterally and downstream over time. Historical records suggest that river movements have occurred very slowly. The Kootenai River below Bonners Ferry is depositional in nature with only minor areas of erosion. The river has formed a system of natural levees along its meandering course and along the tributary creeks where they merge with the river. These natural levees are typically 10 to 15 feet higher than the adjacent floodplain. Historically, the areas behind the levees have been poorly drained because the natural levees inhibited tributaries from entering the Kootenai River (Tetra Tech 2004).

Sediment

Libby Dam essentially traps the entire upstream supply of sediment. Coarse and fine sediment continues to enter the river below Libby Dam from the Fisher River, Yaak River, and numerous creeks. Even considering the amount of sediment contributed by tributaries below Libby Dam, the amount of suspended sediment transported by the regulated Kootenai River in the Kootenai Flats area is only about 15 percent of its former load at the USGS Copeland gage (RM 123) in Idaho (Tetra Tech 2004). This reduction is caused primarily by Libby Dam and Lake Koocanusa trapping sediments and reducing peak river flows. The reduction in sediment transport mirrors an analogous reduction in nutrient transport to areas downstream of Libby Dam (see Section 3.2.3).

Climate

The Kootenai River basin is influenced by a modified west coast marine and continental climate (Corps 1984). Pacific air masses help moderate temperatures, although continental Canadian systems periodically move into the area in the winter and bring subzero temperatures. Average annual temperature (Fahrenheit) is in the middle 50s, with the average high temperatures in the 80s in the summer and near freezing in the winter (WRCC 2006). Precipitation generally exceeds 20 inches per year throughout the Kootenai River basin. Weather systems from the Pacific bring moisture to the region, with snow accumulations of up to 300 inches per year in certain mountainous portions of the basin. Annual precipitation generally increases with elevation; most precipitation is snow. Rising spring temperatures lead to low elevation snowmelt starting in April or early May, followed by more basinwide melting by late May or early June, with a slow recession through the summer as high-elevation snowpack is depleted (Corps 1984).

3.2.2 Hydrology and Flood Control

Kootenai River basin hydrology is driven by snowmelt runoff. Mean annual streamflow since Libby Dam construction is 13,870 cubic feet per second (cfs), as measured at the USGS gage at Leonia, Idaho (USFS 2002). Highest flows tend to occur in May, June, or early July, but rain-on-snow events can cause short duration high flows during the winter months, particularly in portions of the river in Idaho and British Columbia that tend to be more influenced by runoff from lower elevation areas.

Lake Koocanusa

Libby Dam is operated for multiple uses. Full pool elevation for Lake Koocanusa (the Libby Dam reservoir) is elevation 2459 feet and minimum operating pool is elevation 2287 feet. Flood storage between full and minimum pool levels is about 5 million acre-feet. Space for water storage in Lake Koocanusa provides local flood control for the Kootenai River as well as system flood control for the Portland/Vancouver area on the mainstem Columbia River.

Figure 3-2 shows how Lake Koocanusa elevations change in a typical year. The reservoir typically reaches its peak elevation in early summer. Through the summer, reservoir elevations gradually decrease as dam outflows exceed reservoir inflows. In the fall, dam water releases draw the reservoir down (draft) for flood control. During winter months, the end-of-month target elevation for the reservoir (also known as the flood control rule curve) is determined by the size of the seasonal water supply forecast. The concept is to draft the reservoir to allow it to capture spring snowmelt runoff while still ensuring a high probability of reservoir refill by the end of the runoff period. In years

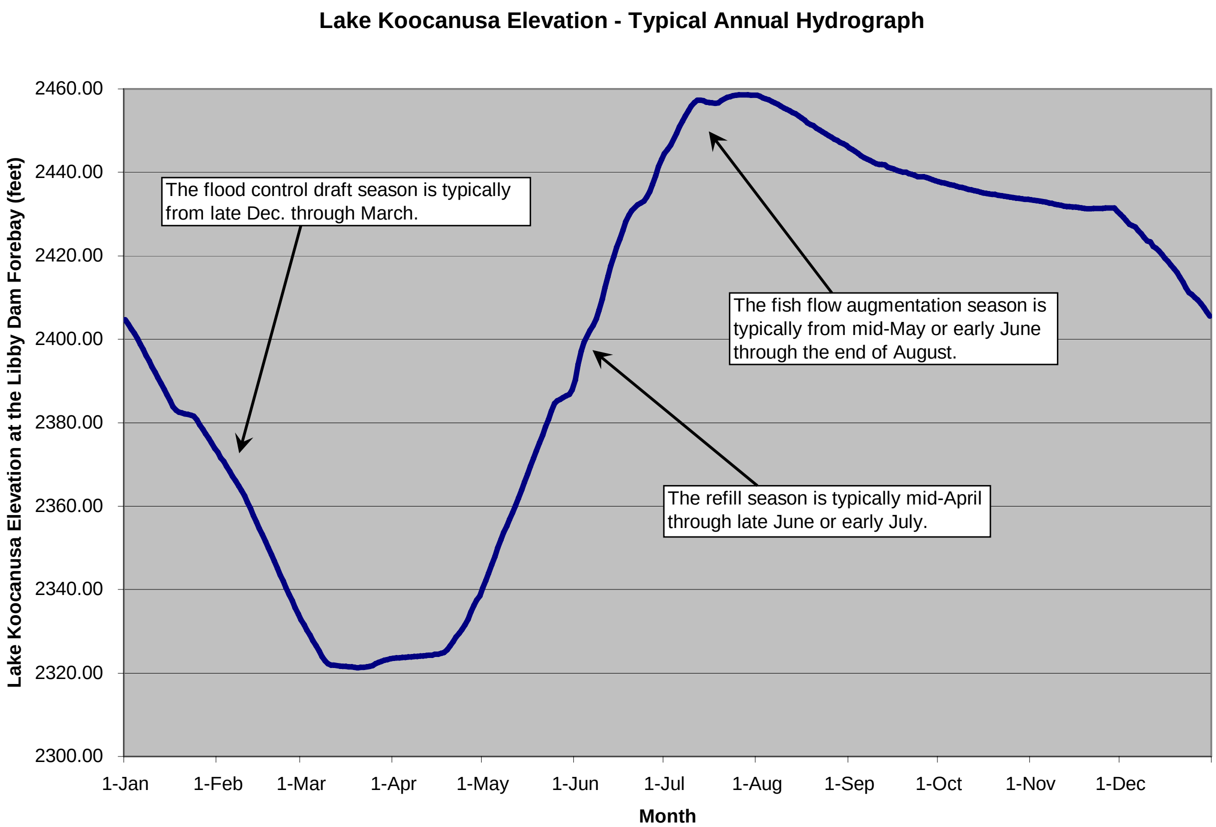

Figure 3-2. Lake Koocanusa elevations in a typical year.

with larger seasonal water supply forecasts, the reservoir would be drafted more deeply, while in drier years, the reservoir would be kept higher.

Operating under either Standard FC or VARQ FC, there may be some occasions where the actual Lake Koocanusa elevation would be higher than the flood control rule curve. For example, high runoff events during the winter from heavy rainfall or warm temperatures may require reducing dam outflows to moderate downstream river flows, resulting in an increase in reservoir elevation. After the end of the runoff event, the water that was stored during the runoff event would be released in an attempt to bring the reservoir back to the elevation defined by the flood control rule curve.

In another example specific to Libby Dam, the International Joint Commission (IJC) Order of 1938 prescribes maximum elevations for Kootenay Lake in Canada, located downstream from Libby Dam, from late summer through the end of March. There are times from January through March when releases from Corra Linn Dam (at the outlet to Kootenay Lake) are limited by the natural constriction at Grohman Narrows. If this limitation threatens to force Kootenay Lake above its upper limit elevation, the outflow from Libby Dam may need to be reduced to maintain Kootenay Lake at or below the prescribed elevation. In this instance, Lake Koocanusa elevation may be above flood control rule curve at the end of March. This limitation is acknowledged in the Columbia River Treaty (CRT), which states that operation of Libby Dam in the United States shall be in accordance with the 1938 IJC Order on Kootenay Lake.

Starting in the spring (typically in March or April), the reservoir begins to refill during the snowmelt runoff period. During refill, the dam is operated to manage downstream flows to minimize flooding, if necessary, while still providing for reservoir elevations at the end of the runoff period as close to full pool as possible. To the extent possible, Libby Dam is operated to maintain flow in the Kootenai River below flood stage (elevation 1764 feet) at Bonners Ferry, Idaho. In practice, Libby Dam is managed in real-time to respond to current conditions to meet multiple uses.

Libby Dam to Kootenay Lake near Creston, BC

Figure 3-3 shows predam and postdam hydrographs for the Kootenai River, with each period representing different eras on the Kootenai River in terms of dam presence or dam operations. The hydrographs show general trends in river flows during these discrete time periods. Since 1992, spring flows for sturgeon have been augmented, and with the 1995 NMFS Biological Opinion, Libby Dam outflows have been increased in summer months to benefit Columbia River salmon as well. Bull trout minimum flows year-round have also been in effect since 2000 (please note these flows are not discernable on the figure). Postdam releases for flood control and power production during the fall and winter produce flows substantially higher than predam conditions. Although the time periods shown vary in length, the flow trends shown are fairly representative of how

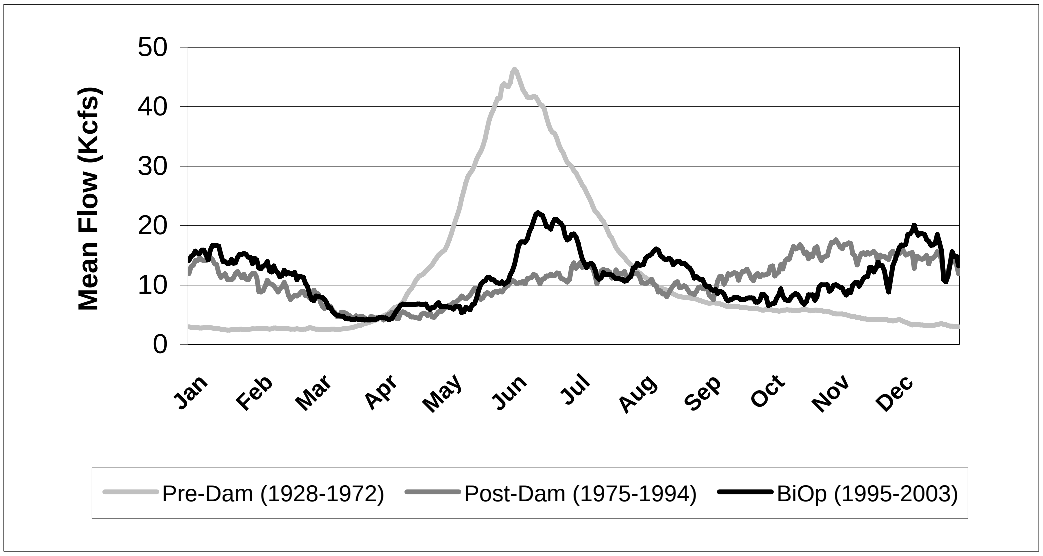

Figure 3-3. Kootenai River annual hydrograph based on daily average flows at Libby Dam: predam 1928-1972; postdam 1975-1994, and Biological Opinion 1995-2003

Libby Dam operations have changed the timing and magnitude of river flows. These flow changes are attributable to Libby Dam, given watershed conditions upstream of the dam have not changed in ways that would significantly alter the historic runoff pattern.

A levee system extends between Bonners Ferry and Kootenay Lake. It was begun in the 1920s, and is an integral part of the Kootenai flood control system. Its maintenance is the responsibility of diking districts. In British Columbia and most of the reach in Idaho, ramping rates have more influence on levee integrity than do higher flows, and the rate of channel migration in this reach has been slow both before and after Libby Dam construction (NHC 1999). In areas upstream of Bonners Ferry that are not influenced by the backwater of Kootenay Lake, erosion rates likely increase as river flows and water velocity rise. Some localized areas in this reach have experienced substantial erosion in the last several decades. Along the US portion of the Kootenai, levee condition is poor in places, but becoming stabilized by vegetation (M. Kaiser, Corps of Engineers, pers. comm.) due to curtailment of load following (fluctuations in dam releases that correspond to changes in power demand) and ramping rates, especially daily fluctuations, since the mid-1990s.

Kootenay Lake to the Confluence with the Columbia River

Kootenay Lake is a natural feature and a number of dams exist between the lake and the mouth of the Kootenay River near Castlegar. Corra Linn Dam, at the lake outlet, controls lake level for much of the year with the notable exception occurring during periods of high flows, such as during the peak runoff season, when Grohman Narrows, a natural constriction upstream from the dam near Nelson, regulates flows out of the lake.

Kootenay Lake levels are managed in accordance with the International Joint Commission (IJC) Order of 1938 that regulates allowable maximum lake elevations throughout the year. During certain high-flow periods when Grohman Narrows determines the lake elevation, Corra Linn Dam passes inflow in order to maximize the flows through Grohman Narrows. Regulation of lake inflows by Libby and Duncan Dams (on the Duncan River flowing into the North Arm of the lake) allows Kootenay Lake levels to be generally lower during the spring compared to predam conditions (Figure 3-4). Upper and Lower Bonnington Dams, South Slocan Dam, and Brilliant Dam, all run-of-river hydropower dams, exist in the 16 miles between Corra Linn Dam and the Columbia River.

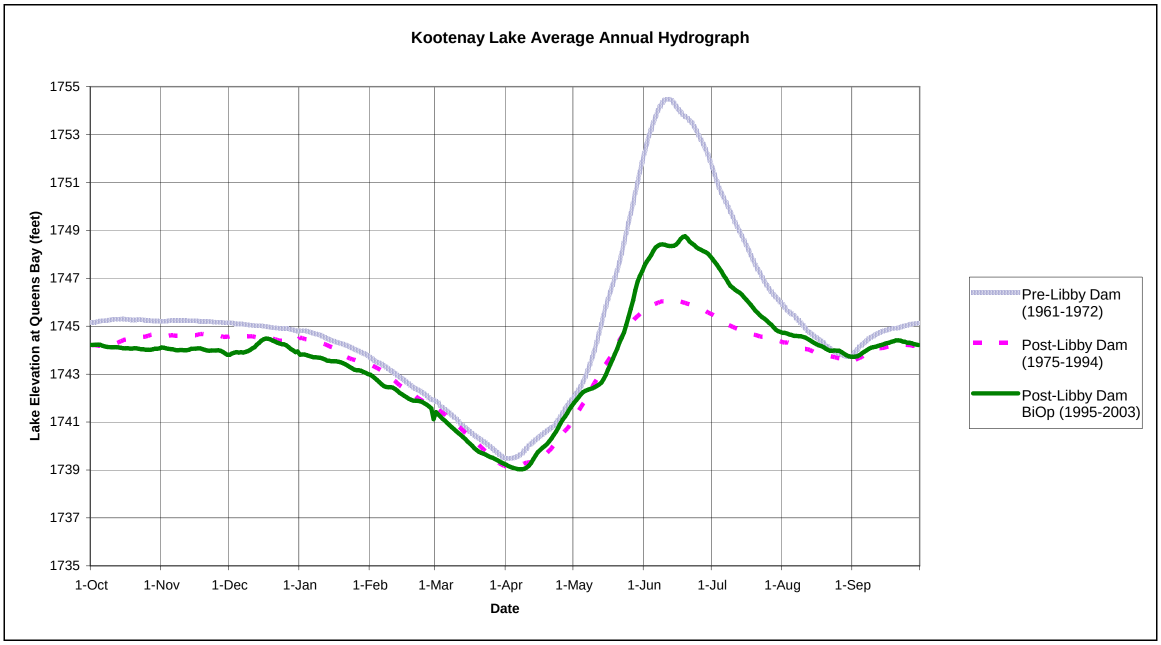

Figure 3-4. Kootenay Lake average annual hydrograph: predam 1961-1972; postdam 1975-1994, and Biological Opinion 1995-2003

3.2.3 Water Quality

Water quality data were collected downstream from Libby Dam by the USGS before and after dam construction (BPA *et al.* 1995). Since then, water quality data in the Kootenai River basin have been annually monitored by the USGS through the National Water Data System. The states of Montana and Idaho are currently preparing Total Maximum Daily Load (TMDL) plans for their respective portions of the Kootenai River. These plans are scheduled to be finished no earlier than 2007.

Lake Koocanusa

Upstream of Lake Koocanusa, the Kootenay River has generally good water quality prior to entering the United States. In the 1990s, zinc loading of the river due to acid rock drainage at the Cominco Ltd. Sullivan Mine at Kimberly, British Columbia, was reduced to reach safe levels and has largely remained at safe levels for most of the time since 1994. The mine closed in December 2001. Coal mining in the Elk River subbasin has contributed to elevated nutrient and selenium levels near the Elk River confluence with the Kootenay River (about 15 miles north of the international boundary).

Under Section 303(d) of the Clean Water Act, the Montana Department of Environmental Quality (Montana DEQ) lists Lake Koocanusa water quality as partially impaired for aquatic life support and coldwater fisheries (trout), primarily due to flow alteration and water level fluctuation resulting from operation of Libby Dam. Monitoring in the mid-1990s found elevated levels of lead, mercury, and selenium in samples taken near the international boundary (Kinne and Anders 1996), but sampling in 2003 found low levels of lead and mercury (selenium was not measured, Berkas *et al.* 2004). Lake Koocanusa has low algal productivity and nutrient concentrations (Pocket Water 1999). Relatively low nutrient concentrations are likely the result of substantial reduction in nutrient loading by Canadian municipal and industrial sources during the late 1970s. Also, the lake acts as a sink for nutrients. About 95 percent of total phosphorus and 25 percent of total nitrogen that enter the lake from upstream areas fall out in the lake due to sedimentation (Pocket Water 1999; see Section 3.2.1 for discussion of the reduction in sediment transport past Libby Dam). Total dissolved gas (TDG) levels in the lake are typically near 100 percent saturation.

In water year 2003, surface water temperatures in Lake Koocanusa ranged from near freezing in the winter to more than 68° F (20° C) in the late summer (Berkas *et al.* 2004). In the early summer, solar warming results in stratification of the reservoir that lasts through most of the fall. Dissolved oxygen levels in the reservoir were typically higher than 7 milligrams per liter and pH ranged from near neutral to 8.6 (as a result of primary production, the surface water within the reservoir tends to have relatively high pH, more alkaline, particularly during the summer). Nutrient levels were low with generally less than 0.1 milligrams per liter total nitrogen and less than 0.01 milligrams per liter total phosphorus. Total phosphorus levels near Wardner, British Columbia, are nearly three-fold higher than levels below Libby Dam, providing empirical evidence of the reduction in nutrients resulting from impoundment by Libby Dam (Holderman and Hardy 2004).

Libby Dam to Kootenay Lake near Creston, BC

Downstream from Libby Dam, the Montana Department of Environmental Quality (Montana DEQ 2005) lists the Kootenai River water quality under Section 303(d) of the Clean Water Act (CWA) as partially impaired for aquatic life support and coldwater fisheries (trout) due to flow alterations and thermal modifications resulting from dam operations. The Kootenai River fully supports primary contact (recreation), drinking water, agriculture, and industry.

The Idaho Department of Environmental Quality (Idaho DEQ 2005, M. Edmondson, Idaho DEQ, pers. comm. 2005) under Section 303 (d) of the CWA lists the Kootenai River as impaired for siltation and thermal modifications. It is listed as not supporting beneficial uses for aquatic life. The Kootenai River is listed as supporting primary contact for recreation (University of Idaho 2005). There appeared to be no assessment for drinking water supply, agriculture, industrial water supply, wildlife habitats, or aesthetics.

Lake Koocanusa acts as a nutrient sink (Daley *et al.* 1991), resulting in low nutrient levels in the Kootenai River and into Kootenay Lake. Prior to construction of Libby Dam, a fertilizer plant located in Kimberly, British Columbia, discharged high levels of phosphorus that contributed to algal blooms. In the mid-1970s, decreases in phosphorus loading from the fertilizer plant and the construction of Libby Dam both contributed to substantial reductions in nutrient levels of the river. Downstream from Libby Dam, nutrient levels near Bonners Ferry tend to be similar or slightly lower than levels further upstream (Holderman and Hardy 2004). Likely as a result of low nutrient levels, chlorophyll levels and primary productivity are very low in the river downstream from the dam. In 2005, a nutrification experiment was begun in the Kootenai River in Idaho by the Kootenai Tribe of Idaho and BPA. Nutrients were added to the river near the Montana state line, with some observed increases in primary productivity as far downriver as Bonners Ferry.

In general, contaminant levels are low but some measurements in Montana and Idaho in the mid-1990s found elevated levels of mercury, lead, and selenium (Kinne and Anders 1996) and occasional point measurements in 2002 and 2003 measured levels of copper, lead, and mercury in the river that approach standards for the chronic effects to aquatic life (Montana DEQ 2004) at sites in British Columbia, Montana, and Idaho (Holderman and Hardy 2004). Sampling in 2003 found low levels of these constituents (Berkas *et al.* 2004). Possible sources of pollution to the lake include tailings from mines throughout the watershed, runoff from municipalities and agricultural areas, and forestry operations. Selected water quality parameters for the Kootenai River downstream from Libby Dam are shown in Table 3-2.

Table 3-2. Summary of Selected Water Quality Measurements for the Kootenai River downstream from Libby Dam

Median Measurements for the Kootenai River below Libby Dam (1967-2003)				
Dissolved Solids (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Nitrite plus Nitrate (mg/L of N)	Total Phosphorus (mg/L)	Suspended Sediment (mg/L)
139	10.8	0.10	0.008	2

Source: Berkas *et al.* 2004

In the Libby and Troy area, numerous wells and septic systems are located adjacent to the Kootenai River. There are approximately 1,000 privately held parcels adjacent to the Kootenai River channel between the mouth of the Fisher River (RM 218) and the Idaho border (RM 172). Two-thirds of these parcels are currently developed. Many of the developed parcels have private drinking water wells, many of them shallower than 60 feet. Additionally, there are at least 11 active public drinking water wells flanking the Kootenai River in Montana. These systems access subsurface aquifers with an unknown degree of continuity with the river.

Groundwater monitoring completed by the Corps in 2002 (Easthouse 2004) has demonstrated that water levels in wells near the Kootenai River in the Libby/Troy area fluctuate in concert with river stage. Measurements of groundwater quality in 2002 occurred during Libby Dam releases as high as 40 kcfs. Monitoring of water quality in the wells did not reveal any correlation between high river flows and adverse effects on groundwater quality, as evidenced by measurements of temperature, turbidity, coliform bacteria, potassium, ammonia nitrogen, and total nitrogen, as well as supplemental microscopic particle and stable isotope analysis.

Dissolved Gas

Water may be spilled when outflow requirements exceed generating capacity at dams, creating elevated total dissolved gas (TDG) downstream from the dam. High TDG levels in water may persist for many miles downstream from their source. Elevated TDG can harm or kill aquatic organisms through a condition similar to “the bends” in human divers. Such gas bubble disease is a condition caused when dissolved gas in supersaturated water comes out of solution in the body fluids or tissues of aquatic organisms, causing bubbles to form and block the bloodstream or damage tissues.

In Montana and Idaho, the TDG standard is 110 percent. Higher TDG levels (especially over 120 percent saturation) may have detrimental consequences, depending on a number of conditions including duration of exposure, water temperature, species of fish, life stage of the fish, depth of the fish below the surface (generally below about 1 to 2 meters depth, fish are much less susceptible to harm), and other stressors. Symptoms may not appear right away, and fish may recover from relatively short-term exposures. See Corps (2000a) for more details on the effects of high TDG on fish and other aquatic organisms.

TDG in Libby Dam powerhouse outflow is generally at 110 percent saturation or less. Libby Dam can spill up to approximately 1 kcfs via the spillway without exceeding the Montana TDG standard in some areas immediately downstream of the dam's spillway. At higher spill levels, TDG saturation levels in some areas below the dam quickly increase to about 120 percent saturation with about 2.5 kcfs of spill, and plateaus at between 132 and 134 percent saturation at more than 7 kcfs of spill. Spill releases via the low-elevation sluiceway outlets generally produce TDG levels higher than 110 percent at any release rate.

TDG levels from spillway releases decrease as the water flows downstream and gas re-equilibrates with the air or the spilled water mixes with tributary inflow and powerhouse releases. Spillway and powerhouse releases appear to fully mix by approximately 8 miles downstream of the dam (see Table 3-3 and Section 3.3.2 for more details).

Table 3-3. Peak total dissolved gas levels at observed during the 2002 spill event (Coastal and Hydraulics Laboratory 2003)

		Spill Rate (cfs)			
Location (Distance from Libby Dam)	**Powerhouse Only**	**2,000**	**5,000**	**7,000**	**10,000**
Immed. downstream	101-106%	126%	133%	132%	134%
Thompson Bridge (0.4 mi. downstream)	101-105%	116%	123%	123%	125%
Old Haul Bridge (8.6 mi. downstream)	104-106%	110%	111%	113%	114%
Above Kootenai Falls (27.4 mi. downstream)	104%	104-106%	107-108%	109%	110%
Below Kootenai Falls (30.2 mi. downstream)	116%	117%	112%	116%	118%

Notes: >TDG levels are the maximum levels observed during monitoring during spill in 2002. In general, the maximum TDG level at each transect was observed at stations close to the left bank (looking downstream) of the river.
>For all spill rates, powerhouse outflows were provided at the maximum possible rate (about 25 kcfs).

Operators attempt to avoid involuntary spill whenever possible. Libby Dam spilled most recently in 2005 (during powerhouse maintenance), 2002 (via the spillway for flood control purposes)[22] and 1985 (via the sluiceways as a test of dam equipment).

Kootenai Falls[23], near Troy, Montana, re-sets TDG levels in the river and TDG loading below falls is typically 115 to 117 percent regardless of the TDG levels upstream from the falls (Coastal and Hydraulics Laboratory 2003). TDG saturation in the Idaho portion

[22] The 2002 spill event started as a planned test of spillway flows, but the test was overtaken by a flood control operation that required higher spill volumes than planned. The result was much higher TDG levels for longer durations than what would have occurred under the planned test.
[23] Natural features such as waterfalls and rapids help to dissipate gases into the atmosphere.

of the river is not affected by Libby Dam operations due to the distance from the dam and the effect of Kootenai Falls.

Temperature

Since the reservoir acts as a thermal buffer, average water temperatures in the Kootenai River are typically warmer in the winter and colder in the summer than they were before Libby Dam was built. Libby Dam is equipped with selective withdrawal gates, allowing for some control of the temperature of dam releases when the reservoir is stratified, usually in the summer and fall. The gates allow water to be withdrawn from various depths and mixed to achieve desired downstream temperatures. Temperatures of dam releases vary within a range over the year in accordance with an agreement with the state of Montana. Current operations manage for 46° F to 54° F (8 to 12° C). In the winter and often well into spring the reservoir temperatures are relatively uniform , so use of the selective withdrawal gates to manage downstream water temperatures is not effective.

As the water flows downstream, temperature is influenced heavily by solar radiation, air temperature and wind. These factors are magnified by low flows in the river, and large water surface area relative to water depth. However, dam releases are still believed to have some influence on water temperatures downstream. For instance, heat stored in Lake Koocanusa has been implicated (Paragamian *et al.* 2000) as a cause of warmer winter river temperatures downstream, and reduced ice formation, compared to pre-dam conditions.

The trigger for sturgeon spawning flow releases is water temperatures of approximately 50° F (10° C), at Bonners Ferry, Idaho, which usually occurs in May. For the sturgeon flows, the Corps attempts to provide the warmest temperatures possible in May and June to assist sturgeon spawning. However, the reservoir may not be stratified until later in June, and release of water cooler than 50° F (10° C) can cause water temperature in the river near Bonners Ferry to drop. The Corps has recently been working to withdraw water from closer to the reservoir surface, while avoiding vortexing that causes cavitation (vacuum bubbles) that can damage turbines and other surfaces in the draft tubes.

Kootenay Lake to the Confluence with the Columbia River

Like Lake Koocanusa, Kootenay Lake is an oligotrophic (nutrient poor) system. Prior to construction of Libby Dam, a fertilizer plant located in Kimberly, British Columbia, discharged high levels of phosphorus that contributed to algal blooms. In the mid-1970s, decreases in phosphorus loading from the fertilizer plant and Libby Dam contributed to substantial reductions in nutrient levels of the lake. Nutrient levels declined to such a level that in 1992 the British Columbia Ministry of Water, Land, and Air Protection (then BC Ministry of Environment, Lands and Parks) began fertilizing Kootenay Lake with phosphorus to boost fish production (Ashley and Thompson 1993). The Columbia Basin Fish and Wildlife Compensation Program has continued lake fertilization since 1995.

Dissolved Gas

Water may be spilled at British Columbia dams downstream of Libby when outflow requirements exceed generating capacity at the dams.

3.2.4 Aquatic Life

Fish species diversity in the Kootenai River basin is relatively low. Species found within the basin are listed in Table 3-4.

Table 3-4. Fish Species of the Kootenai River Basin

Species	Native/Introduced	Location
Redband trout, *O. mykiss gairdneri*	Native	Throughout
Westslope cutthroat trout, *O. clarki lewisi*	Native	Throughout
Kokanee salmon, *O. nerka*	Native[1]	Throughout
Bull trout, *Salvelinus confluentus*	Native	Throughout
Mountain whitefish, *Prosopium williamsoni*	Native	Throughout
Burbot, *Lota lota*	Native	Throughout
White sturgeon, *Acipenser transmontanus*	Native	Kootenai Falls through Kootenay Lake
Lake chub, *Couesius plumbeus*	Native	Kootenai River
Sandroller, *Percopsis transmontanus*	Native	Kootenai River
Slimy sculpin, *Cottus cognatus*	Native	Kootenai River
Torrent sculpin, *Cottus rhotheus*	Native	Kootenai River
Redside shiner, *Richardsonius balteatus*	Native	Throughout
Peamouth chub, *Mylocheilus caurinus*	Native	Throughout
Northern pikeminnow, *Ptychocheilus oregonensis*	Native	Throughout
Largescale sucker, *Catostomus macrocheilus*	Native	Throughout
Longnose sucker, *Catostomus catostomus*	Native	Throughout
Torrent sculpin, *Cottus rhotheus*	Native	Kootenai River
Slimy sculpin, *Cottus cognatus*	Native	Kootenai River
Longnose dace, *Rhinichthys cataractae*	Native	Kootenai River
Rainbow trout, *Oncorhynchus mykiss*	Introduced	Throughout
Brook trout, *S. fontinalis*	Introduced	Lake Koocanusa
Brown trout, *Salmo trutta*	Introduced	Kootenai Falls through Kootenay Lake
Northern pike, *Esox lucius*	Introduced	Lake Koocanusa
Yellow perch, *Perca flavescens*	Introduced	Lake Koocanusa
Largemouth bass, *Micropterus salmoides*	Introduced	Tributaries to Lake Koocanusa; Kootenay Lake
Brown bullhead, *Ictalurus nebulosus*	Introduced	Kootenai River

Species	Native/Introduced	Location
Pumpkinseed sunfish, *Lepomis gibbosus*	Introduced	Kootenai River

[1] Kokanee are native to Kootenay Lake but did not occur in the Kootenai River above Kootenai Falls until their introduction to Lake Koocanusa in the late 1970s. Entrained kokanee from Lake Koocanusa represent the large majority of kokanee occurring in the Kootenai River below Libby Dam.

Sources: NPPC 2004; BPA *et al.* 1995

Lake Koocanusa

Water level fluctuations greatly influence biological production and available fish habitat in Lake Koocanusa. During the late spring and early summer, an objective for dam operations is to fill the pool to an elevation of 2459 feet. In the late winter and early spring, drawdown for flood control can draft the reservoir to elevations as low as 2287 feet. For the period between 1974 and 1999, average peak reservoir elevation was about 2450 feet and average minimum reservoir elevation was about 2340 feet (Corps 2004c). See Appendix A for more details about water management. Average reservoir depth is 126 feet and maximum depth is 350 feet (Dalbey *et al.* 1998). Reservoir water level management can be an important tool for fisheries management.

Biological production is based on primary productivity—plant growth—which is dependent on nutrients and sunlight. Primary production by reservoir phytoplankton (microscopic drifting plants) refers to the conversion of light and nutrients into organic carbon and resulting phytoplankton growth and biomass. Fluctuation of the reservoir increases or decreases the surface area which receives the sunlight, thus affecting production of phytoplankton, which, by serving as food for zooplankton (tiny drifting animals), form the base of the food web.

Zooplankton are drifting animals that consume primarily phytoplankton and, in turn, are eaten by animals higher in the food web. Once produced, zooplankton survive in the reservoir for an indefinite period until they are eaten by predators (*e.g.*, fish and other invertebrates), die from natural causes and sink, or are lost through the dam. Enough individuals survive through fall and winter that zooplankton provide the primary winter food for fish species that do not prey on fish (including westslope cutthroat trout and juvenile bull trout). Zooplankton are the primary food supply of kokanee throughout their lives. In Lake Koocanusa, *Cyclops, Diaptomus,* and *Daphnia* are the dominant zooplankton genera, with *Bosmina* another notable genus (Richards 1997).

Lake Koocanusa inundated 43 percent of total potential habitat encompassing 109 miles of the Kootenai River and 40 miles of tributary streams (Dalbey and Marotz 1997) and converted riverine spawning, juvenile rearing, migratory passage, and resident habitat to a lake environment. This has created abundant silt- and mud-dominated substrates in the reservoir. The varial (drawdown) zone in the reservoir lacks shoreline vegetation. With the change in habitat types, the fish assemblage has also shifted. Westslope cutthroat trout, mountain whitefish, and rainbow trout abundances have declined from early post-impoundment levels, while northern pikeminnow and peamouth chub numbers have substantially increased (Dalbey and Marotz 1997). Shifts in species assemblage may be related to competition and habitat changes since dam construction. For example, peamouth chub population increases may be related to their exploitation of the habitat provided by the unvegetated varial zone of the reservoir (Dalbey *et al.* 1998). Kokanee salmon introduced to the reservoir in the 1970s have become abundant and self-sustaining due to exploitation of the niche provided by the reservoir environment. Genetically pure stocks of fluvial and adfluvial westslope cutthroat trout occur in the headwaters of Lake Koocanusa.

Studies have documented kokanee, largescale sucker, burbot, cutthroat trout, and several other fish species passing through turbines in Libby Dam (known as entrainment; Skaar *et al.* 1996). Kokanee, which represent the vast majority (97.5 percent according to Skaar *et al.* 1996) of entrained fish, are particularly vulnerable to entrainment through hydropower dams since they are pelagic, spending much of their lives within 70 feet of the water surface. At Libby Dam, the release rate, depth of withdrawal, and forebay fish density all influence the rate of entrainment (Skaar *et al.* 1996). On a seasonal basis, kokanee entrainment rates are highest in the spring (late April-early July) when dam outflow and forebay fish densities are high and withdrawal depth is the shallowest of the year (Skaar *et al.* 1996). As the withdrawal depth decreases, kokanee entrainment rates would be expected to increase. Bull trout feed on kokanee in Lake Koocanusa and may be entrained as they follow kokanee into the turbine intakes.

While entrained fish may be killed or injured as they pass through the turbines, many survive. For example, since their introduction into Lake Koocanusa, entrained kokanee have colonized the Kootenai River downstream of Libby Dam. Entrained kokanee are also a food source for resident fish downstream of the dam (such as bull trout, pikeminnow, and rainbow trout).

Libby Dam to Kootenay Lake near Creston, BC

Construction of Libby Dam created a barrier to upstream fish passage, separating two different aquatic environments, a regulated river downstream from the dam and a fluctuating reservoir upstream from the dam, each with its distinctive fish community. Some downstream passage of fish occurs through the powerhouse. Since dam construction, surveys indicate that the mainstem Kootenai River fish community has shifted from primarily whitefish and trout to primarily suckers, peamouth chub, and northern pikeminnow (NPPC 2004). The Kootenai River downstream from Libby Dam has developed into a good rainbow trout fishery. Large Gerrard (Kamloops) rainbow trout can be caught below the dam where they feed on kokanee that were entrained in the penstocks. Kootenai Falls constitutes a barrier to most upstream fish migration, although tracking data indicates that some bull trout can ascend the falls (Hoffman *et al.* 2002). Some downstream fish movement past the falls occurs.

In recent decades, estimates of westslope cutthroat numbers indicate substantial declines in Montana and Idaho (NPPC 2004). Redband trout provide an important fishery in Idaho (NPPC 2004). Mountain whitefish are still fairly common in the river, but their numbers have declined substantially since dam construction, particularly in Idaho (Partridge 1983, Paragamian 1994). Downstream from Bonners Ferry, northern pikeminnow, largescale suckers, and redside shiners become the dominant fish species, supplanting mountain whitefish dominance in the river as it exits the Kootenai River canyon near the Montana-Idaho border (Holderman and Hardy 2004). Recent surveys found most adult rainbow trout and mountain whitefish associated with pools and riffles, with juvenile fish also commonly observed in rapids and runs (Hoffman *et al.* 2002). In recent years during the spring, the river between the dam and Kootenai Falls has experienced growth of abundant mats of diatomaceous algae blanketing the river bottom. The cause of the observed diatom growth is unknown.

In the Kootenai River downstream from the dam, construction and operation of Libby Dam has altered the natural hydrograph. In particular, dam releases during the winter are higher than predam conditions and releases during the spring freshet are lower. Recent changes in spring and summer dam operations provide for higher flows in the spring for sturgeon, and steady, but typically higher than predam flows through the summer for bull trout and salmon (NMFS 2000a; USFWS 2000). In addition to flow changes, the effects of the dam releases on water temperatures may affect habitat suitability for certain native fishes like white sturgeon and burbot.

Spill events such as that which occurred in 2002 can cause gas bubble disease in fish in the river in the vicinity of Libby Dam. The 2002 spill event resulted in spill releases between 4 and 15.6 kcfs lasting for 12 days. Within 5 days of the high spill releases in 2002, more than half of fish sampled along the left bank of the river for two miles downstream of the dam had symptoms of gas bubble disease. At the peak of the 2002 spill, the incidence of gas bubble disease increased to about 80 percent of all fish along the left bank, and to slightly more than 50 percent of all fish within 2 miles of the dam. Mountain whitefish appeared most susceptible and experienced rates of gas bubble disease of more than 90 percent by the end of the 2002 spill. Slightly less than 80 percent of rainbow and bull trout along the left bank of the river showed signs of gas bubble disease by the end of the spill. After the spill ended, fish appeared to recover from gas bubble disease, but showed signs of injury such as split fins which may increase susceptibility to fungal and bacterial infections. The Montana Department of Fish, Wildlife, and Parks performed the monitoring and did not monitor or estimate direct or delayed mortality resulting from spill and elevated TDG levels for the 2002 spill event (Dunnigan *et al.* 2003), During early portions of the spill event, field crews observed two severely injured adult bull trout which later died; observed injuries included abrasions and hemorrhages that indicate these fish likely were not injured by high TDG levels but rather may have been entrained by spill or subjected to extreme turbulence in the spillway stilling basin (E. Lewis, Corps, pers. comm. 2003).

Fluctuating outflows from Libby Dam create areas along the river shoreline that may experience periodic inundation and dewatering. This area is called the varial zone and is dependent on local river channel configuration and the schedule of dam releases. Since the late 1990s, Libby Dam operations have curtailed rapid flow fluctuations associated with daily power peaking (called load following) and have committed to summer and winter ramping rates intended to allow mobile invertebrates to move towards the channel and avoid desiccation as flows drop.

Downstream of Bonners Ferry, off-channel areas are very limited. The most notable side channel habitat occurs along the left bank (looking downstream) at Shorty's Island in the vicinity of RM 143.

Mean density of aquatic insects, an important food for fish, at sample sites above and below the dam in 2000-2001 was 914 organisms per square meter, low compared to other oligotrophic rivers in the Pacific Northwest (Holderman and Hardy 2004).

Between Libby Dam and Bonners Ferry, Idaho, Hauer and Stanford (1997) found chironomid larvae to be the most abundant aquatic insects in the Kootenai River. Other notable zoobenthos (Hauer and Stanford 1997) included mayflies; stoneflies, caddisflies, and abundant blackfly larvae. Oligochaetes (aquatic worms) and snails occur frequently in benthic samples, although snail distribution is patchy (Hauer and Stanford 1997). Compared to a similar study completed in 1979 through 1982 (Perry and Huston 1983, Hauer and Stanford 1997) found that abundance of caddisflies, blackfly larvae, and mayflies had decreased substantially. While stonefly abundance remained similar to the earlier work, diversity and density of stonefly populations in the Kootenai River remained low relative to the Flathead and Fisher Rivers (Hauer and Stanford 1997). Zoobenthos changes since implementation of more gradual ramping rates have not been studied.

Kootenay Lake to the Confluence with the Columbia River

The fish community in Kootenay Lake is similar to that in Lake Koocanusa, with the notable addition of white sturgeon in Kootenay Lake. Prominent zooplankton in Kootenay Lake include copepods, cladocerans, and the introduced freshwater shrimp *Mysis relicta*.

Kootenay Lake habitat is typical of a nutrient-poor lake environment. Lake level fluctuations due to natural runoff patterns and water management at Corra Linn Dam influence riparian vegetation, but the riparian zone of the lake is well-vegetated and largely undeveloped. Seasonal fluctuations of Kootenay Lake are much less pronounced than those in Lake Koocanusa. A fertilization program in recent years has enhanced overall lake productivity (Wright *et al.* 2002).

3.2.5 Sensitive, Threatened, and Endangered Species

To better cover how the action would affect pertinent species throughout their range within the project area, the following discussion of sensitive, threatened, and endangered species is arranged by species, not by geographic region.

Within the basin, the Kootenai River white sturgeon is listed as endangered, and Columbia River bull trout, and bald eagle are listed as threatened under the ESA. Federally listed endangered and threatened species occurring in the Kootenai River basin are shown in Table 3-5.

Table 3-5. Federally Listed Threatened and Endangered Species in the Kootenai River Basin

Name	Status	Date Listed
White sturgeon *Acipenser transmontanus*	Endangered	1994
Columbia River bull trout *Salvelinus confluentus*	Threatened	1998
Bald eagle *Haliaeetus leucocephalus*	Threatened	1995
Grizzly bear *Ursus arctos horribilis*	Threatened	1975
Gray wolf *Canis lupus*	Threatened	1967
Woodland caribou *Rangifer tarandus caribou*	Endangered	1983
Canada lynx *Lynx canadensis*	Threatened	2000

White Sturgeon

The Kootenai River population of white sturgeon (*Acipenser transmontanus*) was federally listed as endangered under the ESA in September 1994 (USFWS 1994). In 1999, the USFWS and the Kootenai River White Sturgeon Recovery Team released the final recovery plan for the Kootenai River white sturgeon (USFWS 1999). Kootenai River white sturgeon occur in the river downstream from Kootenai Falls and in Kootenay Lake. No white sturgeon are known to occur upstream from the falls. In 2001, the Kootenai River from RM 141.4 (just downstream from Shorty's Island) to RM 152.6 (just upstream from the Highway 95 bridge) was designated as critical habitat for Kootenai River white sturgeon (USFWS 2001). On February 8, 2006, the USFWS published an interim rule to designate additional critical habitat for sturgeon, extending the existing critical habitat 6.9 miles from the highway bridge upstream into the braided reach (USFWS 2006). The new critical habitat rule became effective March 10, 2006.

In the spring, white sturgeon migrate upstream from Kootenay Lake to the spawning reach located between Bonners Ferry and Shorty's Island. Once there, spawning white sturgeon release eggs which sink and adhere to bottom substrates (clean gravel or cobble with interstices appears to be the ideal substrate) where they remain until hatching. The sac fry depend on gravel substrates for cover until the yolk sac is absorbed, at which time they enter the water column in search of food.

The lack of recruitment of young fish to the adult population is a primary reason for the protection of white sturgeon in the Kootenai River. Since Libby Dam was finished in 1973, sturgeon have produced substantial numbers of offspring only once--in 1974. In the 2006 Biological Opinion, the USFWS described habitat attributes that are based on the best available scientific information regarding what is necessary to adequately provide for successful Kootenai sturgeon spawning, and natural in-river reproduction (Table 3-6). Habitat attributes that are believed to be related to white sturgeon recruitment and could be affected by Libby Dam operations include flow timing and duration, velocity, temperature fluctuation, depth at spawning sites, substrate, and minimum frequency of occurrence. Pursuant to the 2006 USFWS Biological Opinion, these specific attributes may be altered or adjusted through coordination with the USFWS.

Table 3-6. Habitat Attributes Currently Believed to be Necessary for Successful White Sturgeon Spawning and Natural Reproduction in the Kootenai River (from USFWS 2006b).

Habitat Attribute	Measure	Objective
Area: RM 141.4 to RM 159.7		
Timing of Augmentation Flows	May into July (triggered by sturgeon spawning condition), in all years except for Tier 1.	Provide conditions for normal migration and spawning behavior.
Duration of Peak Augmentation Flows for Adult Migration and Spawning	Maximize peak augmentation flows with available water for as many days as possible, up to 14 days during the peak of the spawning period with pulses, in all years except for Tier 1 (pulses refer to slight reductions in flow during this 2 week period to initiate sturgeon spawning).	Through in-season management, provide peak augmentation flows that lead to a biological benefit for sturgeon to maximize migration and spawning behavior via a normalized hydrograph.
Duration of Post-peak Augmentation Flows for Incubation and Rearing	Maximize post-peak augmentation flows with available water for as many days as possible, up to 21 days, in all years except for Tier 1.	Through in-season management, provide post-peak augmentation flows that lead to a biological benefit for sturgeon to maximize embryo/free embryo incubation and rearing via descending limb of a normalized hydrograph.
Minimum Flow Velocity	3.3 ft/s and greater in approximately 60% of the area of rocky substrate in the area of RM 152 to RM 157 during post-peak augmentation flows.	Provide conditions for spawning and embryo/free embryo incubation and rearing.
Temperature Fluctuation	Optimize temperature releases at Libby Dam to maintain 50 degrees F with no more than a 3.6 degree F drop.	Provide conditions for normal migration and spawning behavior via a normalized thermograph.

Habitat Attribute	Measure	Objective
Depth at Spawning Sites	Intermittent depths of 16.5 to 23 ft or greater in 60% of the area of rocky substrate from RM 152 to RM 157 during peak augmentation flows.	Provide conditions for normal migration and spawning behavior.
Substrate Extent/Spawning Structures	Approximately 5 miles of continuous rocky substrate; create conditions/features that improve the likelihood of recruitment success.	Provide habitat for embryo/free embryo incubation and rearing.
Minimum Frequency of Occurrence	To facilitate meeting the attributes via: powerhouse plus 10 kcfs flow test: the flow test will occur 3 or more times during the next 10 years; 3 times within the next 4 years if conditions allow, and other options are not available to meet this measure. Habitat improvement projects and other options: through adaptive management, as noted in RPA Action 6, implement the habitat projects and other available options no later than 2010 and continuing through the term of the proposed action.	Maximize the probability that habitat attributes necessary for successful in-river sturgeon spawning and recruitment will be provided multiple times during the term of the proposed action.

The Corps has been augmenting flows from Libby since the early 1990s and available data indicate that sturgeon spawning has occurred on an almost annual basis, however, successful recruitment to at least age 1 has not occurred.[24] Characteristics of flow are likely important factors in creating the necessary river conditions for successful sturgeon spawning and recruitment. Since the 2000 USFWS FCRPS Biological Opinion, biologists, including members of the KRWSRT, have reached general consensus that flow augmentation alone is not sufficient to address the biological requirements of the sturgeon. Successful sturgeon recruitment is likely the result of the coincidence of a number of biological and physical variables or ecosystem factors, during critical periods. The 2006 USFWS Biological Opinion (USFWS 2006b) addresses these issues in more detail, and leaves the mechanism for attaining of these habitat attributes to the action agencies.

In 2000, the Idaho Department of Fish and Game (IDFG) estimated that that there were about 760 adult sturgeon remaining in the Kootenai River population (Paragamian *et al*. 2005). This is down from an estimated 5,000 to 6,000 adults in the early 1980s. These adults are now being lost to natural causes at the rate of 9 percent per year, leading to a 2005 population estimate of fewer than 500 adults (Paragamian *et al*. 2005). Based on

[24] Successful recruitment is defined in the Kootenai River White Sturgeon Recovery Plan (Duke *et al*. 1999) as natural production in at least 3 different years within a 10-year period. To be successful, the natural production must include at least 20 juveniles from each year class when sampled at more than 1 year of age. These criteria apply to downlisting from endangered to threatened status; criteria have not been developed for removing sturgeon from the threatened species list.

recently revised aging information, females are not expected to reach sexual maturity until approximately age 30. Thus, there is increasing urgency in restoring the spawning and incubation habitat to again allow the sturgeon to recruit naturally and to begin rebuilding a healthy population structure.

The Kootenai Tribe of Idaho has conducted aquaculture of Kootenai River white sturgeon since 1990, with a dedicated conservation aquaculture program in operation since 1993. Even if successful wild recruitment occurred immediately, the progeny of fish spawned under a conservation aquaculture program would comprise the great majority of the next generation of sturgeon in the Kootenai River. A hatchery located at Bonners Ferry released over 20,000 fish aged 1 to 4 between 1992 and 2002. Most releases were 2-year-old juveniles, but the hatchery has also provided larvae and embryos for release to address specific monitoring objectives. The releases are thought of as a “safety net” to maintain the population until wild spawning results in significant and consistent recruitment. With current levels of hatchery production, the population is projected to stabilize at about 3,000 adults (Paragamian *et al*. 2005).

The USFWS 2006 FCRPS Biological Opinion RPA recommends continued implementation of VARQ FC to improve the probability of storing water in Lake Koocanusa for releases to achieve the habitat attributes described in Table 3-6. Studies are ongoing to quantify benefits of spring flow enhancement on sturgeon spawning and recruitment. To date, annual monitoring by researchers has observed sturgeon eggs from spawning events, but has not found meaningful correlation between the sturgeon flow augmentation that has been provided since 1992 and substantial recruitment of juvenile sturgeon (e.g., the observed eggs are not producing larvae that survive).

In addition to the altered hydrograph due to Libby Dam operations, a variety of other ecosystem factors may affect the recovery of the sturgeon. For example, there have been numerous environmental changes in the Kootenai River that likely affect sturgeon recruitment, and the aquatic ecosystem as a whole. These changes are due in part to the construction of Libby Dam, levee construction, and floodplain development and include river level fluctuations, floodplain alterations, water pollution, depleted nutrient levels, predation, and sediment contamination. Changes in channel form since dam construction are minimal, but the rate of channel shifting is likely lower than under pre-dam conditions due to reduced sediment supply and stream power (Tetra Tech 2004). Refer to the recent designation of critical habitat for sturgeon (USFWS 2006a) and the 2006 USFWS Biological Opinion on Libby Dam Operations (USFWS 2006b) for more details on other factors affecting sturgeon.

Bull Trout

Columbia River bull trout (*Salvelinus confluentus*) was federally listed by the USFWS as threatened on June 10, 1998 (USFWS 1998). Bull trout populations are composed of a migratory component that migrates within the Columbia River system and its large tributaries (fluvial), a component that migrates between river and lake habitats (adfluvial), and a resident, nonmigratory component (Goetz 1989).

Lake Koocanusa's subpopulation represents one of the strongholds of the Columbia River Distinct Population Segment (DPS) (USFWS 2000; BPA *et al.* 1999). Libby Dam now isolates this bull trout subpopulation from the Kootenai River subpopulation downstream, but downstream passage through the turbines occurs as indicated by fish that migrated from the Wigwam River in British Columbia to O'Brien Creek below Kootenai Falls (Hoffman *et al.* 2002). Based on the robust status of the Lake Koocanusa subpopulation, entrainment by the dam does not appear to regulate bull trout numbers above the dam. The migratory adfluvial form of bull trout utilizes the reservoir as year-round habitat as subadults and adults. The only known spawning and rearing area above the dam in the United States is located in the Grave Creek drainage. In British Columbia, spawning by migratory bull trout also occurs in the Wigwam River, White River, Bull River, St. Mary, and Lussier river drainages, and Skookumchuck, Gold, Kikomun, and Findlay Creeks (NPPC 2004a). Redd counts in the Wigwam River and Grave Creek have steadily increased since 1994. In 2004, the state of Montana, via section 4(d) of the Endangered Species Act, instated a limited harvest of bull trout in Lake Koocanusa (MFWP 2004).

The Kootenay River upstream from Lake Koocanusa in British Columbia also likely supports migratory bull trout. Critical habitat for bull trout, which was designated in September, 2005, includes some tributaries of the river and lake, but does not include any portion of Lake Koocanusa or the mainstem Kootenai River.

The bull trout subpopulation below Libby Dam appears to number a few hundred adults and is considered to utilize a fluvial life history. Downstream from Libby Dam, bull trout utilize the mainstem river as subadults and adults. Libby Dam is a barrier to upstream bull trout migration. Although tracking studies have confirmed movement of one bull trout upstream over Kootenai Falls (Hoffman *et al.* 2002), the falls also presents a substantial barrier to upstream migration for bull trout and other resident fish species. Quartz, Pipe, and Libby Creek drainages are the most important spawning tributaries between the dam and Kootenai Falls (NPPC 2004). Downstream from Kootenai Falls, O'Brien Creek is considered the best spawning tributary (NPPC 2004).

Since dam construction, reduction of seasonal peak flows may have contributed to delta formation at the mouths of some tributaries in Montana and Idaho. These depositional areas may eventually impede upstream movement of bull trout spawners during low flows. Migrant bull trout may be especially sensitive because their fall spawning run coincides with low tributary flows and reduced water depths. A delta at the mouth of Quartz Creek is of particular concern because of that stream's importance to migratory bull trout reproduction (NPPC 2004).

Minimum flows for bull trout below Libby Dam were established in the 2000 USFWS Biological Opinion and carried forward in the 2006 USFWS Biological Opinion. The intent of establishing a minimum flow above the base flow for each dam was to provide additional habitat for the species during the productive summer months. The specific flows (6, 7, 8, or 9 kcfs) correspond to certain tiered volumes for sturgeon at Libby, and are based on water availability and the intent of maintaining wetted perimeter in the Kootenai River.

Bald Eagle

Bald eagle (*Haliaeetus leucocephalus*) were reclassified as threatened under the ESA in the lower 48 States on July 12, 1995 (USFWS 1995), and were proposed for removal from the ESA list of endangered and threatened species on July 6, 1999 (USFWS 1999). In general, bald eagle numbers along the Kootenai River are stable or on the rise. Migratory and wintering bald eagles occur in the vicinity of Libby Dam and Lake Koocanusa primarily in late fall to early spring (BPA *et al.* 1995). Recent estimates count 17 bald eagle nesting territories along the Kootenai River corridor and its tributaries in Montana (USFS 2002). Bald eagles are common along the Kootenai River corridor throughout the year and likely exceed the Pacific Bald Eagle Recovery Plan target of three eagle nesting territories above and below Libby Dam (USFWS 1986).

Other Federally-Listed Threatened and Endangered Species

Other threatened or endangered wildlife species that may occur in the Kootenai River Basin include the grizzly bear, gray wolf, woodland caribou, and Canada lynx. Effects of operation of the Federal Columbia River Power System on these species have been addressed in consultations pursuant to Section 7 of the ESA. Generally, these species are not present in, nor directly dependent on, aquatic habitat that may be altered by the alternatives evaluated, and therefore are considered not likely to be adversely affected.

Other Sensitive Species or Species of Concern

Kootenai River burbot is listed as endangered by the state of Idaho. Redband trout and westslope cutthroat trout are listed as rare/imperiled in Idaho and species of concern in Montana. The northern leopard frog is a species of special concern in Idaho and red-listed[25] in British Columbia. The South Arm of Kootenay Lake kokanee salmon population is critically depressed and may be functionally extirpated.

[25] Red-listed species are extirpated, have been legally designated as Endangered or Threatened under the British Columbia Wildlife Act, or are candidates for such designation.

Lower Kootenai River Burbot

There is a remnant population of burbot that lives in Kootenay Lake and migrates up the Kootenai River to spawn in Idaho. While burbot in Montana are relatively common[26], the burbot numbers in Kootenay Lake and the lower Kootenai River in Idaho have experienced a steep decline over recent decades. Fewer than 300 adults have been captured in monitoring efforts that began in 1993. Burbot are designated as endangered by the state of Idaho and red-listed in British Columbia.

Burbot harvest in both nations has been substantially restricted. However, burbot have not recovered as expected of an animal with such remarkable fecundity. Poor habitat conditions may play a role in continuation of the burbot's depressed status.

Studies indicate that burbot in this population are either not capable of sustained migration against even moderate currents, or their migrations are deterred behaviorally by moderate flows. In nine years of monitoring, burbot reached the Bonners Ferry spawning reach only during the drought of 2000/2001 when December and January flows in the Kootenai River below Bonners Ferry were unusually low and frequently in the 6 to 8 kcfs range. Historically during this time period, unregulated flows were typically in the 4 to 6 kcfs range, but since the commencement of operation of Libby Dam, flows typically range from 16 to 18 kcfs. Based on monitoring results, high flows during the winter migration and spawning period may adversely affect spawning success of burbot.

The winter high flows are also associated with an increase in winter water temperatures from near 2° F (1° C) to 8° F (4° C). These higher water temperatures may inhibit burbot spawning since burbot appear to prefer colder waters during spawning season and have been observed spawning under the ice.

There is an ongoing broad-based effort to conserve this population of burbot through an international candidate conservation agreement. Responding to a petition by American Wildlands and the Idaho Conservation League, the USFWS conducted a status review to determine if lower Kootenai burbot was warranted for listing as threatened or endangered and found that listing is not warranted because lower Kootenai burbot does not represent a distinct population segment and is therefore not a listable unit (USFWS 2003b). Together with the Idaho Department of Fish and Game, the Kootenai Tribe of Idaho (KTOI), and other stakeholders in the basin, the Corps has signed a Memorandum of Understanding to establish processes to coordinate burbot conservation activities, which may include, when possible, utilizing existing operational flexibility at Libby Dam to decrease dam releases during the burbot migration and spawning period.

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[26] Genetic analyses indicate that burbot from the lower Kootenai River are genetically distinct from burbot in Montana (NPPC 2001b).

South Arm Kootenay Lake Kokanee Salmon

Native kokanee salmon from the South Arm of Kootenay Lake that historically spawned in Idaho tributaries have experienced dramatic declines over the last several decades (NPPC 2004, Ashley and Thompson 1993, Partridge 1983). Runs that numbered in the thousands of fish as recently as the early 1980s may now be functionally extinct (Anders 1993). Observations since 1996 in several Idaho tributaries found few kokanee returns to Long Canyon and Boundary Creeks, and no spawners in Trout, Smith, and Parker Creeks (NPPC 2004). Kokanee stocks in the North and West Arms of Kootenay Lake also experienced population declines in the late twentieth century. Fertilization experiments since the early 1990s have coincided with increases in numbers and condition of spawning kokanee utilizing North Arm tributaries (Anders 1993) but South Arm kokanee remain very rare.

Reasons for the decline of kokanee in the South Arm of Kootenay Lake are unknown. The positive relationship between fertilization in the North Arm and increased escapement of North Arm kokanee indicates that reduced nutrient inputs may play a role in the status of kokanee in the South Arm. Starting in 2005, the Kootenai Tribe of Idaho, IDFG, and BPA propose to add liquid nitrogen and phosphorus to the Kootenai River from late June through September, which may improve lake productivity and kokanee numbers (BPA 2005).

Columbia River Redband Trout

NPPC (2004) provides detailed information on redband trout (O. mykiss gairdneri) a subspecies of rainbow trout (O. mykiss) in the Kootenai River basin. Redband trout currently occur throughout the Kootenai River basin, with genetically pure stocks in several tributaries. In the Kootenai mainstem, stocks have mixed with introduced hatchery rainbow trout. Studies have shown that stocks include resident, adfluvial, and fluvial life history forms. Although their historical range did not likely extend upstream of the approximate location of Libby Dam (Hensler *et al*. 1996), redband trout are currently present in Lake Koocanusa and annually stocked from Murray Springs State Fish Hatchery. Columbia River redband trout generally spawn between March and June.

This species is classified as of special concern by all states in its historic range, as well as by USFWS and AFS (Muhlfeld 2005). Causes of decline include habitat loss and fragmentation, range restriction, overharvest, and hybridization and competition with non-native species (Williams *et al.* 1989; Behnke 1992; Lee *et al.* 1997; Perkinson 1993; Muhlfeld 1999).

Detailed status and life history of the Columbia River redband trout in Montana is found in Muhlfeld (2005).

To the extent that dam operation affects their food resources in Lake Koocanusa or the Kootenai River, redband trout may be affected.

Westslope Cutthroat Trout

NPPC (2004) provides detailed information on westslope cutthroat trout (*Oncorhynchus clarki lewisi*) a subspecies of cutthroat trout in the Kootenai River basin. Westslope cutthroat trout are widespread throughout the Kootenai River basin. Resident, adfluvial, and fluvial life history forms occur in the basin. Genetically pure stocks exist in several tributaries, notably in the headwaters of Lake Koocanusa. Downstream from Kootenai Falls, westslope cutthroat trout were likely never common in the mainstem or tributaries downstream of migration barriers due to the presence of native redband trout.

Libby Dam may have impacted westslope cutthroat to the extent that flow fluctuations or low nutrient levels have impacted aquatic insects in the Kootenai River. Westslope cutthroat have likely been affected by other factors such as habitat modifications. Westslope cutthroat are no longer stocked in Lake Koocanusa as part of the hatchery mitigation program for impoundment by Libby Dam, but would be subject to effects on invertebrates from reservoir fluctuations there.

Detailed status and life history of the westslope cutthroat trout are found in Gardner (2005).

Northern Leopard Frog

The northern leopard frog (*Rana pipiens*), southern mountain population is protected under the Canadian Species at Risk Act. Historically, the northern leopard frog has had a limited distribution in British Columbia. It also occurs in northern Idaho. It may have occurred near the headwaters of the Kootenay and Columbia River valleys and also in the vicinity of Creston, British Columbia at the southern end of Kootenay Lake (Environment Canada 2004). A population was known at Osoyoos and the species was introduced onto Vancouver Island (Environment Canada 2004). However, in the last 30 years, the species has declined dramatically in the Province and has been found, in very low numbers, only at the Creston Valley Wildlife Management Area, in the southern part of its historic range in British Columbia (Environment Canada 2004). A survey in 2000 found 16 egg masses, indicating that the breeding population is very small (Environment Canada 2004). Northern leopard frogs typically breed in shallow, temporary ponds located in an open area and lacking fish (Environment Canada 2004). In the summer, frogs are found in a variety of habitats, but preferred habitat appears to be in vegetation between 6 and 12 inches tall (Environment Canada 2004). Well-oxygenated water bodies that do not freeze solid are preferred for overwintering (Environment Canada 2004).

In British Columbia, the alteration of waterways and the introduction of game fish are thought to have contributed to the decline of the frog (Environment Canada 2004).

Disease, the use of pesticides, and possibly increased ultraviolet radiation due to the thinning of the ozone layer are also causes of concern to the species (Environment Canada 2004).

Detailed status and life history on the northern leopard frog may be found at MFWP (2005) and BCMWLAP (2005).

3.2.6 Wildlife

Wildlife in the Kootenai River basin and, in particular, the riparian habitats of the Kootenai River comprises a variety of species (IBIS 2005). Those species associated with riparian habitats, the primary habitat affected by this project, include amphibians, birds, reptiles, and mammals. Appendix N provides a detailed list of wildlife species found in the Kootenai River basin.

The existing riparian wildlife habitat is a direct result of decades of controlled flows and land use practices that rely on levees and dikes to control flooding. As a result of these practices, the riparian habitat is fragmented laterally along portions of the river margin and wildlife corridors to upland habitats have also been fragmented. Wildlife species that are closely associated with these riparian habitats have likely been displaced over time, or seen their numbers decrease because of dwindling habitat.

To highlight the importance of an aquatic system for terrestrial species, Figure 3-5 shows that the more complex a habitat is, the greater number of terrestrial species will exist (IBIS 2005).

Those areas along the Kootenai River with the greatest level of habitat complexity, including the areas just below Libby Dam and in the braided section upstream of Bonners Ferry, are the areas with the greatest wildlife diversity outside of the Kootenai National Wildlife Refuge and Creston Valley Wildlife Management Area. In the areas where minimal riparian habitat exists and/or areas where land use practices preclude complex habitats from forming, one would expect to find less wildlife diversity and abundance occurs.

Figure 3-6 shows the number of breeding wildlife species associated with a particular habitat’s structure condition. It has been suggested that the riparian habitats along the Kootenai River between Libby Dam and Creston Wildlife Management Area are lacking early and mid-seral stage trees and, where found are primarily single-story, large cottonwoods stands (Marotz 2005). Figure 3-6 suggests that greatest diversity of breeding wildlife species in the Kootenai River basin would likely stem from two types of structural conditions: mid to large tree multi-story moderately closed and grass/forb, to small tree multi-story open. Because these two conditions are lacking in the basin, fewer wildlife species are expected to occur.

Influences on wildlife distribution and use of the basin include land use and forestry practices, transportation corridors, recreation use and natural disturbances. Between Lake Koocanusa and Kootenay Lake, wildlife diversity and abundance are dependent upon the amount and quality of available riparian habitat, which is affected by Libby Dam operations.

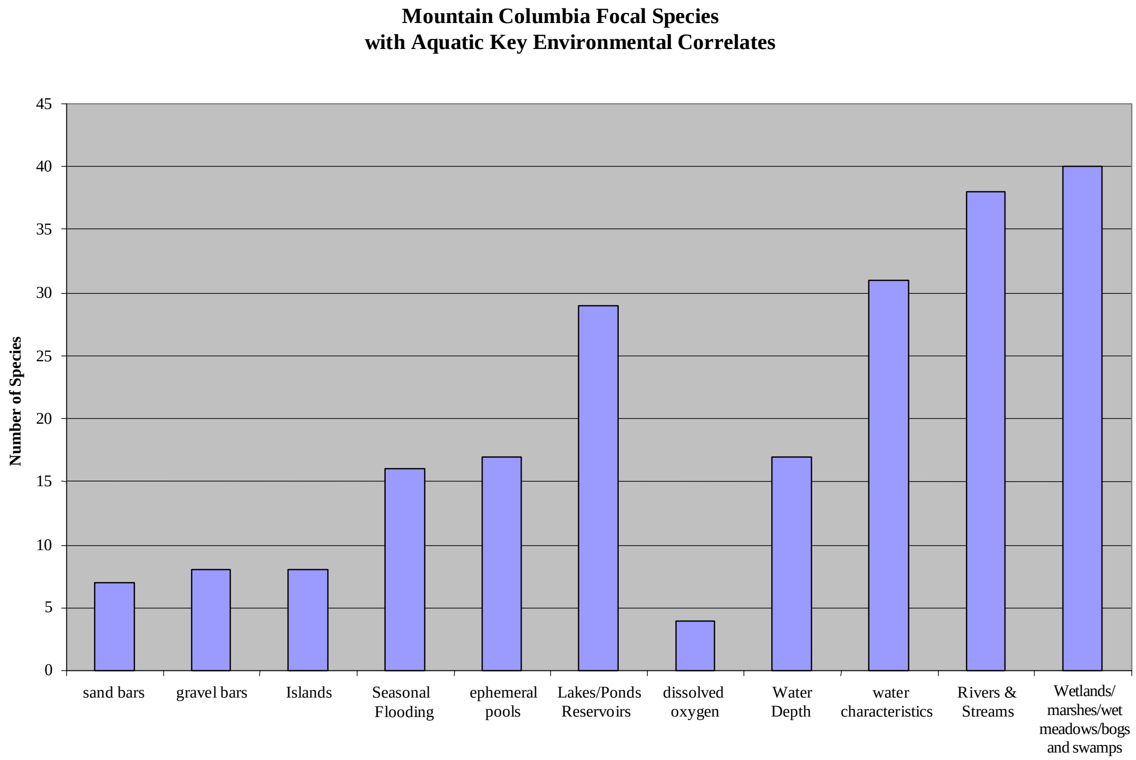

Figure 3-5. The number of species associated with a particular aquatic attribute or grouping of attributes likely to be found in the Kootenai River Basin (IBIS 2005).

3.2.7 Vegetation

Lake Koocanusa

Mixed conifer forests composed mostly of ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), and spruce (*Picea* spp.) surround Lake Koocanusa (BPA *et al.* 1995). The eastern shore of the lake has one of the largest blocks of grassland habitat in the basin, but other grassland areas are scattered throughout the basin (NPPC 2004). Due to fluctuating water levels, Lake Koocanusa lacks well established riparian zones and backwater areas. As with other portions of the basin, alpine and high meadow areas occur at higher elevations in surrounding mountain ranges.

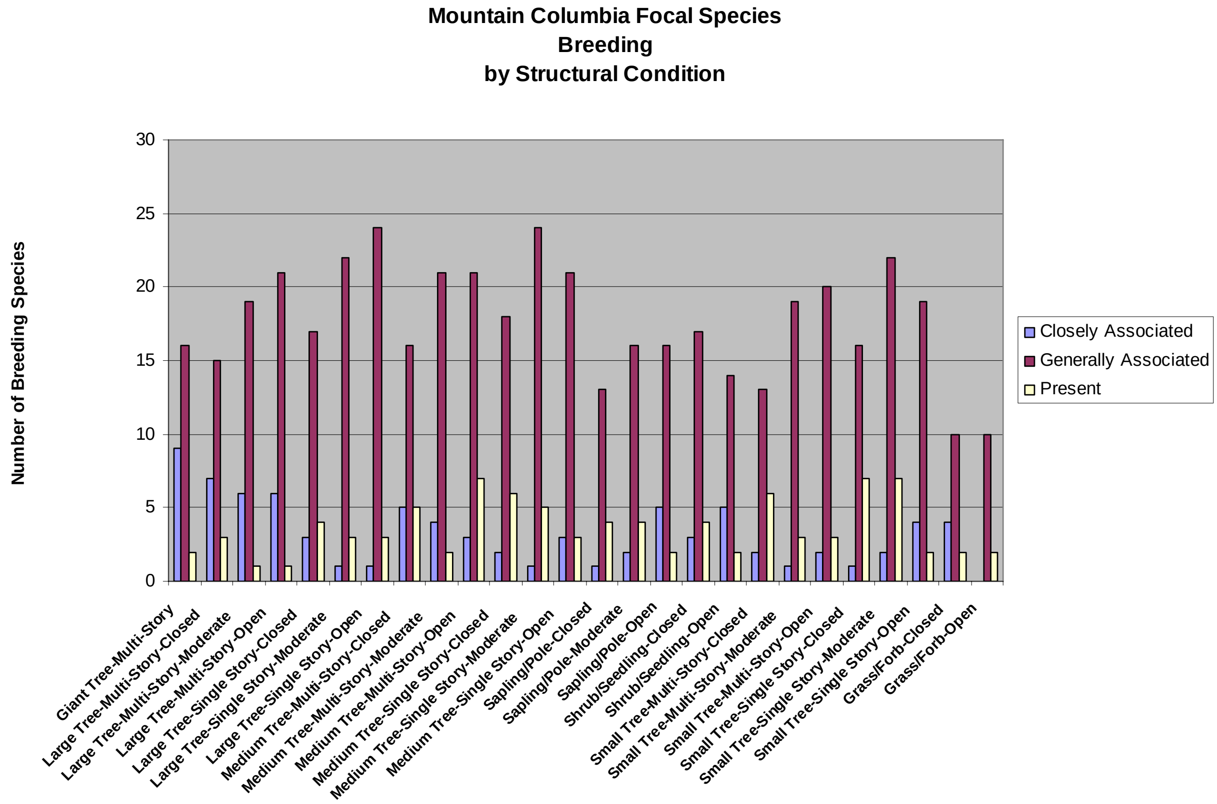

Figure 3-6. Number of breeding focal species likely to be found within a particular structural condition in the Kootenai River Basin (IBIS 2005).

Libby Dam to Kootenay Lake near Creston, BC

Upland forests downstream of Libby Dam are similar to those around Lake Koocanusa. The riparian zones along the Kootenai River between Libby Dam and Bonners Ferry, Idaho, can be characterized as deciduous shrub and deciduous tree communities with black cottonwood (*Populus trichocarpa*), quaking aspen (*Populus tremuloides*), and red alder (*Alnus rubra*). Downstream from Bonners Ferry, the deciduous riparian community has been largely eliminated by diking and agricultural activities. Most of the valley between Bonners Ferry and Kootenay Lake has been converted to row crops, pastureland, orchards, and other agricultural cover types.

Sporadic wetland areas occur along the river in Montana and Idaho upstream from the Moyie River confluence. From there, the valley opens into the Kootenai Flats area, where National Wetland Inventory maps show 1,373 acres of inland marsh, swamp, or wet meadow (palustrine) wetlands and 2,500 acres of riverine wetlands along the river, including 800 acres of wetland that have been rehabilitated on the Kootenai National Wildlife Refuge (NPPC 2004; note that the refuge wetlands are separated from the Kootenai River by levees). Near Kootenay Lake, areas adjacent to the river include broad expanses of natural and managed wetland habitats, including the 17,000-acre Creston Valley Wildlife Management Area. Wetland habitats in the Creston area are primarily palustrine emergent and scrub-shrub systems. The Creston Valley Wildlife Management Area includes wetlands of international importance listed under the Ramsar Convention of 1971.

Kootenay Lake to the Confluence with Columbia River

Vegetation communities around Kootenay Lake are adapted to wetter conditions than those surrounding Lake Koocanusa, with mixed conifers composed of primarily western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*), Douglas fir, and lodgepole pine (*Pinus contorta*) (Mackinnon *et al.* 1992).

Unlike Lake Koocanusa, Kootenay Lake riparian areas are extensive. Except for the vicinity of cities and towns such as Nelson, Kaslo, Crawford Bay, and Balfour, the shoreline of Kootenay Lake is generally undeveloped with characteristic riparian areas of willows (*Salix* spp.), dogwood (*Cornus stolonifera*), and birch (*Betula papyrifera*) communities (Wetlands International 2002) that transition into conifer forests. Tributaries entering the lake provide deltas with broad areas of willow-dominated riparian areas (a good example is the Kokanee Creek delta in Kokanee Creek Provincial Park) that provide habitat for a wide variety of birds and wildlife. Typical annual lake level fluctuations of approximately 10 feet influence shoreline characteristics but do not preclude establishment and function of riparian areas. Prominent palustrine and lacustrine wetland areas occur at the mouths of the Kootenay and Duncan Rivers and in the vicinity of Crawford Bay.

3.2.8 Recreation

Lake Koocanusa

Lake Koocanusa is an important regional recreational resource on both sides of the United States/Canadian Border. The lake is relatively undeveloped compared to nearby large lakes, with less transportation access and fewer recreational facilities. This is due, in part, to the large seasonal fluctuation in pool elevation that accompanies operation of Libby Dam, which can result in a 160-foot fluctuation in water surface elevations through the year (BPA *et al.* 1995). Two provincial parks and two recreational areas are located along the lake in British Columbia.

A variety of developed and less well developed recreational sites are located on both sides of the United States/Canadian border along Lake Koocanusa. Recreational activities at these sites include fishing, boating, camping, and swimming. Several businesses on Lake Koocanusa rent houseboats.

Fishing on Lake Koocanusa is reported to be the primary activity at the lake, with 45 percent of visitors reporting that fishing or related activities were the main reason for visiting (BPA *et al.* 1995). Most fishing on the lake requires the use of a boat and most boating on the lake is associated with fishing (Shapiro 1985). The lake is available for fishing year round, including summer angling for game fish and winter ice-fishing. Game fish present include cutthroat trout, bull trout, rainbow trout, kokanee, mountain whitefish, and burbot (BC Adventure 2004).

There are 13 boat launches on the United States side of the lake, managed by the US Forest Service and the Corps, and five improved boat launches on the Canadian side of the border, managed by the BC Provincial Parks and private owners. Additionally, there are two private campground/marinas on the United States side of the lake. Moorage slips, rental cabins, a care and convenience store, rental boats, and service shop are all available. In Canada, a commercial campground, boat launch, marina and store are located on the west shore of the reservoir, opposite Kikomun Creek. Table 3-7 lists the minimum lake elevation for boat ramp operations on Lake Koocanusa.

Table 3-7. Lake Koocanusa Minimum Usable Boat Ramp Elevations

Boat Ramp	Minimum Usable Boat Ramp Elevation (feet)	Minimum Usable Boat Ramp Elevation (feet below full pool)
U.S. Ramps		
Tobacco River	2449	10
Gateway Boat Camp	2445	14
Warland Flats	2444	15
Tobacco Plains	2433	26
Koocanusa Lake Campsite and Resort	2420	39
Mariner's Haven	2420	39
McGillivray	2385	74
Rocky Gorge	2370	89
Rexford Bench Complex	2341	118
Lake Koocanusa Resort and Marina	2334	125
Peck Gulch	2310	149
Souse Gulch	2310	149
Barron Creek	2282	177
Canadian Ramps		
Englishman Creek	2458	1
Newgate Sandy Shores Resort	2439	20
Koocanusa Marina	2430	29
Golden Ears (Gold Creek Bay)	2427	32
Kikomun Creek Provincial Park	2396	63

Lake Koocanusa Full Pool Elevation (ft): 2459

Swimming and picnicking are popular activities on Lake Koocanusa, each accounting for 25 percent of recreation participation at the lake (BPA *et al.* 1995).

Camping along Lake Koocanusa is a popular activity that accompanies many boating, fishing, swimming and picnicking activities. The Corps and USFS operate and maintain eleven campgrounds on the United States side of the lake. There are six camping areas on the Canadian side of the lake, managed by BC Provincial Parks and private owner/operators.

The Libby Dam visitor center affords tourists a view of the lake. Several highways in the area are identified as scenic drives. State Highway 37 is a scenic byway following the Kootenai River along Lake Koocanusa.

Approximately half of Lake Koocanusa recreational visitors are from Montana; out-of-state visitors tend to come from Washington, British Columbia, and Alberta. The peak recreation season is from June through August (BPA *et al.* 1995). Over the last 10 years visitation at these facilities increased to an average of 50,915 visitor days per year (D. Wernham, pers. comm. Dec 2004). Visitation for the entire Kootenai National Forest in 2002 was estimated at 1.1 million total visitors (USFS 2003). The most recent consolidated estimate of visitor days for water related recreation activities at Libby Dam and Lake Koocanusa was 175,400 visitor days per year (calculated from 1987-1993) (BPA 1995 *et al.* Appendix J).

Libby Dam to Kootenay Lake near Creston, BC

Recreational opportunities along the river are primarily fishing, boating, camping, sightseeing, and wildlife viewing.

Downstream from Libby Dam, boating opportunities on the Kootenai River are mostly related to float boating for fishing. The Kootenai is a big river and fly fishing from a boat is a popular method of fishing the river. Between Libby Dam and Kootenay Lake, there are a total of eight improved boat ramps and several unimproved boat ramp and fishing access points. Kayaking and rafting are popular activities at Kootenai Falls and downstream between the Yaak River confluence and the Highway 2 bridge in Bonners Ferry (BSF 2004).

Sport fishing opportunities primarily focus on rainbow and cutthroat trout. Local guide services, outfitters, and gear shops are a growing part of the recreational economy (BPA *et al.* 1995). In 2004, there were more than five river outfitting services listed in Libby and Troy, Montana. Some wadeable areas exist at certain times of the year (BSF 2004). This reach of the river is a blue-ribbon rainbow trout fishery and is a popular draw for anglers. Westslope cutthroat, whitefish, and the occasional brown trout are found in this reach. Fishing for white sturgeon, bull trout, and burbot is prohibited.

There are four maintained campgrounds located along the river from Libby Dam, downstream to the Canadian border.

The estimated number of visitor days for the three Corps facilities on the Kootenai River averaged 6,786 visitor days per year from 1988-1994. Over the last 10 years visitation at these facilities increased to an average of 13,121 visitor days per year (D. Wernham, pers. comm. Dec 2004).

Kootenay Lake

Kootenay Lake provides several river and lake-related recreational opportunities. Many recreational activities take place at Kootenay Lake, including boating, fishing, swimming, camping, and sightseeing. Several privately-operated resorts and marinas also exist along the lake, primarily in the vicinities of Nelson, Balfour, Kaslo, and the eastern shore south of Kootenay Bay. Several marine parks, accessible only by boat, are located on the south arm of the lake.

Boating activity includes houseboating, sailing, kayaking, cruising, sightseeing and fishing. Boating related services include charter services, rentals, and boat access to the lake. In addition, there are several smaller improved boat ramp access points and campground areas along the shoreline of the lake. Overall, there are eleven recreational facilities on Kootenay Lake that provide boat access, docking, and fueling for recreational boaters. Downstream from the lake, there are several reaches of river and rapids for kayaking. Brilliant Dam operators manage flows in coordination with the boating community (TekCominco 2001).

At Kootenay Lake, fishing takes place for Gerrard rainbow trout, Yellowstone cutthroat trout, kokanee, Dolly Varden, bull trout, and largemouth bass. Duck Lake, a managed impoundment near the south end of Kootenay Lake in the Creston Valley Wildlife Management Area, provides boating and fishing opportunities unique to the area with its sheltered waters and fishery for bass and other warmwater fish species.

Swimming is common at several of the campsites, resorts, marinas, beaches, and pocket beaches along the shoreline of the lake.

The lake has twelve campgrounds and resorts owned and operated by BC Provincial Parks or private operators. From 1996 to 2001, annual average park visits for the BC Parks, Kootenay District was slightly less than 2.0 million visitors per year. Camping and day use numbers continue to increase and boating use has increased substantially in the area (CRN 2004).

3.2.9 Environmental Health

Lake Koocanusa

Air Quality

Air quality in the Kootenai River basin is generally good, with exceptions. For example, airborne dust from the drawdown zone of Lake Koocanusa is an issue in the Eureka/Rexford area along the lake (David Evans and Associates 1996). On two occasions during a 25-month monitoring period in the mid-1990s at Eureka, dust concentrations exceeded the Environmental Protection Agency (EPA) 24-hour maximum standard concentration for particulates (PM10 or particulates with a diameter of 10 millimeters (mm) or less) of 150 micrograms per cubic meter (µg/ m^3), Both events were attributed to highway construction. EPA has no 1-hour PM10 standard, but short term events that were likely associated with dust from the exposed lake bed resulted in maximum 1-hour PM10 concentrations between 497 and 1,567 µg/m^3. Wind speeds required to initiate a dust event appear to be in the range of about 15-20 miles per hour, although average wind speeds during an event may be much lower (less than 10 miles per hour). Observed events were associated with dry periods and steady winds often from the southeast to northwest. Lake elevations during recorded major and minor events were 2404 feet or lower. All of the events observed by David Evans and Associates (1996) were during the January-May time frame.

Libby Dam to Kootenay Lake near Creston, BC

Sediment Quality

Limited sediment sampling at various places in Idaho has detected arsenic, chromium, copper, iron, lead, manganese, selenium, and zinc in bottom sediments (Kruse, pers. 2004 comm.), but the levels do not approach consensus-based sediment quality guidelines pursuant to Ingersoll *et al.* (2000). Sediment sampling by USGS in 1981 and 1982 near Copeland, Idaho, (downstream from Bonners Ferry) detected very low levels of organochlorine pesticides (including Chlordane, Aldrin, and P,P'-DDT and its byproducts) and PCBs that were well below consensus-based sediment quality guidelines pursuant to Ingersoll *et al.* (2000) and Johnson (2000).

3.2.10 Cultural Resources

Cultural resources include archaeological and historical sites and districts that contain physical objects, structures, buildings, deposits or features that are traceable on the ground and possess qualities of significance in American prehistory, history, and culture. These elements are all referred to as here as "historic properties." The historic properties analyzed here have been evaluated under Criterion D for eligibility for listing in the National Register of Historic Places. This analysis does not include Traditional Cultural

Properties (TCP) that may be eligible for the National Register under Criterion A or Criterion C. TCP information is proprietary and only available through consultation with affected Indian tribes, in this case, the Kootenai Indian people. To date, the Confederated Salish and Kootenai Tribes (CSKT) have chosen not to share TCP information outside of their own groups, but have agreed to look at possible National Register eligibility of recorded archaeological sites and localities under Criteria A and C.

Prehistory

Lake Koocanusa

Indigenous Peoples

The Kootenai River valley between Tobacco Plains and Libby, Montana, was traditionally used by the Kootenai Indian people (Turney-High 1941; Smith 1984b). There are also numerous ethnographic and historical accounts of Blackfeet raids into this area. Survivors of the Libby-Jennings Band of Kootenai now reside on the Flathead Reservation as the Confederated Salish and Kootenai Tribes, as part of the Kootenai Tribe of Idaho, or with Kootenay bands in Canada. The various Kootenai bands within this region continue to maintain strong ethnic and community identity.

Since at least the early nineteenth century, the Kootenai people used the area around what is now Lake Koocanusa for short-term seasonal occupations related to resource procurement such as trapping, plant harvesting, fishing, and especially deer and elk hunting (CSKT Preservation Department 2003). They also used the area extensively as a travel route between major settlements and seasonal resource procurement areas.

Historic Euro-American Period

For the middle Kootenai River region, Euro-American contact began with the fur trade. Activities of the Northwest Fur Trading Company and the Hudson's Bay Company early in the nineteenth century led to the establishment of a series of short-term trading posts historically called "Kootenay House" (Chance 1995). At least one of these posts was located within what is now Lake Koocanusa on the Tobacco Plains. Also, the cabin of late 19th century trader Sophie Morigeau (24LN521) is located within the same general area of the affected zone.

"Gold fever" inspired sporadic steamboating and temporary nineteenth century mining camps along the Kootenai River and the Caribou country farther north in Canada. Stable settlements at Jennings and Rexford emerged with the coming of the railroad in the late nineteenth century. Pioneer settlements connected with the timber industry did not begin in this area until early in the twentieth century. The historic settlement of Rexford, Montana, was inundated by Lake Koocanusa in 1972.

It is likely that Libby Dam itself is eligible for listing in the National Register of Historic Places for the design work of Paul Thiry, a noted regional architect.

Historic Properties

The inventoried historic properties known to be within the drawdown zone of Lake Koocanusa include at least 418 archaeological and historic properties. In 1985, the Forest Service secured a concurrence Determination of Eligibility with the Montana SHPO for Lake Koocanusa, called the Middle Kootenai River Archaeological District.

Traditional Cultural Properties

Studies of traditional Kootenai place names and traditional use areas at Libby Dam—Lake Koocanusa have been conducted since 1998 by the Confederated Salish and Kootenai Tribes of the Flathead Nation (CSKT 2003), under a five-year contract with the Corps and BPA. This data was gathered by tribal staff using interviews with tribal elders and field visits to culturally important areas, along with anthropological and historical source documents. This specific information is confidential, but has been provided in summary form to the Corps.

Current Cultural Resources Management at Libby Dam

The cultural resources of Lake Koocanusa are jointly managed by Kootenai National Forest and the Corps as a provision of Action Plan "O" [Cultural Resources] (1988) under the 1966 Memorandum of Understanding for reservoir construction and operation at Libby Dam, Montana. Current Libby reservoir compliance with Section 106 National Historic Preservation Act is under the Bonneville Power Administration's Intertie Development and Use Programmatic Agreement of 1991. The Corps prepared an Historic Properties Management Plan in 1987 (Corps 1987) and this is currently in the process of being updated.

The earliest professional archaeological surveys were conducted in the Canadian Kootenay River valley (Borden 1956) in 1954. Before the Libby Dam reservoir filled in 1973, forming Lake Koocanusa, cultural resources surveys and investigations were undertaken in the 42-mile Canadian section of the reservoir area (Choquette 1971). Efforts were made by the Provincial Government of British Columbia to recover significant heritage information from cultural resource sites prior to inundation by the reservoir (Choquette 1973). Since that time, the reservoir has been monitored and culturally sensitive features have been recovered by B.C. Hydro in consultation with bands of the Ktunaxa Nation.

Even though Libby Dam began holding back water in 1972, the baseline inventory survey and site evaluation of cultural resource sites within the drawdown zone of Lake Koocanusa (the reservoir behind Libby Dam) was not completed until 1981 (Thoms 1984). This inventory survey produced 249 prehistoric sites found between elevations 2342 and 2459 feet within the 48 mile long drawdown area of Lake Koocanusa inside the United States. It did not include the 42 mile length of the Canadian portion of the reservoir. It is not likely that future reservoir drawdown will permit examination of inundated lands to minimum pool elevation of 2287 feet. Although radiocarbon chronology has not been well developed due to lack of sufficient datable materials, geochronology and use of volcanic tephra establishes that prehistoric sites at Lake Koocanusa date back between 8,000 and 9,000 years before present. Most archaeological sites are represented by brief occupations in a riverine setting. These are characterized primarily by concentrations of fire-modified rock. Occupational features and finished tools are generally rare and indicate small, seasonally transient populations engaged in a seasonal subsistence round. Annual monitoring of the drawdown area by Kootenai National Forest between 1985-2003 has identified an additional 169 archaeological sites (USFS 2003), for a total of at least 418 known cultural resources. Ninety-nine of these sites are contributing members of the Middle Kootenai River Archaeological District, determined eligible for the National Register by Kootenai National Forest in 1985. Among the National Register-eligible archaeological sites only one, 24LN1054, possesses an unusually large density of cultural materials including features, diverse artifact types and highly varied lithic materials. All of these prehistoric sites are subject to the effects of fluctuating water within the drawdown area due to annual reservoir operations.

Libby Dam to Kootenay Lake near Creston, BC

Munsell and Salo (1979) identify 43 prehistoric and 9 historic sites in the 10 miles downstream from Libby Dam. These sites comprise the Libby-Jennings Archaeological District. VARQ FC operations alternatives have the potential to affect six archaeological sites (24LN10, 24LN1020, 24LN1025, 24LN1046, 24LN1048, 24LN1050) in the first five miles below the dam. About 30 miles downstream from Libby Dam is the Kootenai Falls Archaeological District, but at that point erosional effects would be confined to the existing Kootenai River channel.

The segment of the Kootenay River valley between the international boundary and Kootenay Lake includes several Indian reserves of the Creston Band of the Ktunaxa Nation. Historically, the Lower Kootenay people relied more heavily upon fishery resources for their subsistence (Smith 1984b) than the Upper Kootenay, so there is a close connection between native fish and use by the Indians.

Kootenay Lake

Archaeological resources in the West Kootenay region are not well documented but known to exist (Borden 1956). Early Period isolated archaeological finds are reported in southeastern British Columbia and help to define five early cultural traditions that existed there (Carlson 1996). These suggest several millennia of aboriginal land use, but archaeological sites with stratified deposits are very rare and few have been investigated.

The archaeological culture history of the Kootenay Lake region has not yet been established.

3.2.11 Indian Sacred Sites

The Corps currently has no data concerning sacred sites according to the definition set forth by Executive Order 13007 for the Libby Dam—Lake Koocanusa shoreline. About 30 miles downstream, Kootenai Falls is identified as a sacred site to the Kootenai Indian people.

3.2.12 Other Affected Tribal Interests

The United States has a fiduciary responsibility to protect and maintain rights reserved or granted to Indian Tribes by treaties, statutes, and executive orders. This responsibility is sometimes further interpreted through court decisions and regulations. This trust responsibility requires that Federal agencies take reasonable actions to protect trust assets when administering programs under their control.

The Confederated Salish and Kootenai Tribes, Kootenai Tribe of Idaho, and Blackfeet Indian Nation include all the federally recognized Indian tribes historically associated with the Lake Koocanusa area. While much of the surrounding area retains resources that support hunting, fishing, and gathering activities, the reservoir drawdown area has already been inundated since 1972 and may no longer support such traditional uses.

As noted in Section 3.2.10, several Indian reserves of the Creston Band of the Ktunaxa Nation are located along the Kootenay River near Creston, BC. Water rights in British Columbia recognize those of Indians. In 1884 the Kootenay Agency confirmed allotted water rights to Indians in the following terms: “All water flowing through this Reserve is allotted to the use of the Indians.”

3.2.13 Socioeconomics

The following discussion of socioeconomics is organized by county/state or regional district/province divisions.

The Kootenai River basin is dominated by Federal and provincial forested and mountainous reserves including Kootenai National Forest (US), Panhandle National Forest (US), Flathead National Forest (US), Kootenay National Park (Canada), Purcell Wilderness (Canada), and many other smaller parks and private and public forest lands. Historically, miners settled this basin, followed by timber workers and the supporting communities that grew up around these natural resource industries. As the natural resource base has declined, other industries have become more important, particularly tourism.

Selected data on demographics, employment, and income are presented in the following paragraphs. Appendix F contains the full socioeconomic report.

Demographics

The Kootenai River basin includes portions of the East and Central Kootenay Regional Districts (RD), British Columbia; Lincoln County, Montana; and Boundary County, Idaho. Cities and towns located adjacent to the Kootenai and Columbia Rivers are Cranbrook, Kimberley, Creston, Nelson, and Castlegar, British Columbia; Eureka, Libby, and Troy, Montana; and Bonners Ferry, Idaho. The Kootenai Tribe of Idaho Headquarters is located at Bonners Ferry, Idaho. Table 3-8 summarizes selected demographics in British Columbia, Montana, and Idaho.

Employment and Income

The Kootenai River basin has a historically strong natural resources industry including timber and mining. Tourism and recreation have become important components of the regional economy and government employment is also important. Agriculture is less

Table 3-8. Selected Demographic and Socioeconomic Information

	Population Estimate[1]	Population Projection for 2025	Median Per Capita Income[2]	State/ Province Income[2] (%)	Below Poverty Line[2] (%)	Minority Population[2] (%)
State / Province						
British Columbia	4,146,580		$22,095	not applicable	no data	26.0
Montana	917,621		$17,151	not applicable	14.6	9.4
Idaho	1,366,332		$17,841	not applicable	11.8	4.8
City / County / Regional District (RD)						
East Kootenay RD	59,334	65,410-75,280	$21,732	98.4	no data	7.0 (First Nation)
Cranbrook	24,275		$28,975	131.1	no data	8.0
Kimberley	6,484		$29,679	134.3	no data	4.0
Central Kootenay RD	59,388	56,500-73,350	$19,008	86.0	no data	5.0 (First Nation)
Creston	4,795		$23,935	108.3	no data	4.0
Nelson	9,298		$25,041	113.3	no data	5.0
Castlegar	7,002		$31,601	143.0	no data	5.0
Lincoln County, MT	18,835	19,000-21,000	$13,923	81.2	19.2	3.9 (Native American & Hispanic)
Eureka	1,009		$12,619	73.6	22.9	3.2
Libby	2,606		$13,090	76.3	16.3	4.5
Troy	963		$10,620	61.9	27.5	4.2
Boundary County, ID	10,173	12,000	$14,636	82.0	15.7	4.8 (Native American & Hispanic)
Bonners Ferry	2,647		$13,343	74.8	20.0	4.3

[1]U.S. State and county population estimates are for 2003 from U.S. Census Annual Population Estimates, Release Date: April 9, 2004. U.S. city/town population estimates are for 2003 from U.S. Census Annual Population Estimates FRO Incorporated Places, Release Date: June 24, 2004. Canadian Province, Regional District, and city/town population data are for 2003 from BC Stats Community Facts, release date October 06, 2004.
[2]Canadian income and minority population data are for 2000 from the 2001 Census
U.S. data on income, poverty, and minority population are for 1999 from the 2000 census.

important. The population base is small and does not support a large number of manufacturing industries, but a few are important and are summarized in Table 3-9 for British Columbia, Montana, and Idaho. Table 3-10 summarizes employment by industry for the U.S. portion of the basin.

Table 3-9. Percent of Income of Various Industries in Kootenai River Basin - Canada

	Cranbrook-Kimberley Region	Castlegar Region	Nelson Region	Creston Region
Forestry	14	25	13	10
Mining	9	6	2	2
Fishing	0	0	0	0
Agriculture	1	0	1	7
Tourism	8	3	7	5
High Tech	0	1	2	0
Public Sector	25	23	30	23
Const	6	9	8	5
Other	5	3	2	2
Transfer Payments	18	18	19	29

Source: BC Ministry of Management Services 2004

Table 3-10. Percent Employment by Industry - U.S. Portion of Kootenai River Basin

	Lincoln County, MT	Boundary County, ID	Average (U.S. portion of basin)
Agriculture	6.8	14.2	10.5
Forestry And Fishing	7.4	6.6	7.0
Mining	0.5	0.2	0.4
Construction	7.3	7.4	7.4
Manufacturing	9.5	9.7	9.6
Retail Trade	11.7	10.1	10.9
Transportation/Warehousing	3.0	3.2	3.1
Information	1.4	0.8	1.1
Finance/Insurance	2.2	1.1	1.7
Real Estate	4.5	2.7	3.6
Professional/Technical	3.4	3.8	3.6
Education	0.4	1.4	0.9
Health Care/Social Assistance	9.9	11.7	10.8
Recreation/Entertainment	2.0	0.9	1.5
Accommodation/Restaurant	6.7	3.3	5.0
Other Services	6.9	1.7	4.3
Government	16.5	21.3	18.9

Source: Bureau of Economic Analysis Regional Economic Information System, May 2004.
Employment data is for 2002 – Total full-time and part-time employment by industry.

Flood Impacts

In the United States portion of the basin, economic losses from flooding have historically occurred along the Kootenai River, between Bonners Ferry, Idaho, and the international border. This area is downstream from Libby Dam and is referred to informally as Kootenai Flats. Historically, high water from rain-on-snow events and snowmelt runoff would cover portions of the floodplain every year and less frequent events would flood the entire valley (more than 60,000 acres).

Bonners Ferry and Kootenai Flats floodplain land use and infrastructure with flood protection includes:

- 35,000 acres of agricultural cropland in the United States
- 17,000 acres of agricultural cropland in Canada
- 190 acres of commercial and residential development in Bonners Ferry, Idaho
- Other transportation and public infrastructure

The National Weather Service considers elevation 1764 to be the flood stage at Bonners Ferry, Idaho.

In Canada, flooding from Kootenay Lake is a concern. The 1972 Columbia River Treaty Flood Control Operating Plan (FCOP) states that “damage commences at Nelson when Kootenay Lake reaches elevation 1755 feet and the major damage stage is elevation 1759 feet” (based on lake elevation at Queens Bay; Corps 1972). Since 1972, encroachment around Kootenay Lake has occurred, and a 2004 study involving interviews with Kootenay Lake stakeholders identified water levels as detrimental when above elevation 1750 feet (BC Hydro *et al.* 2004). The report identifies lake elevation identified below elevation 1752 feet as preferred. Recent surveys of the West Arm of Kootenay Lake (near Nelson, BC) estimate damages of $5 to $15 million (CDN) at a lake level of 1755 feet, $2 to $5 million at a lake level of 1752 feet, and up to $2 million at a lake level of 1750 feet (H. Brownlow, BC Hydro, pers. comm., August 10, 2005).

Navigation

The Canadian Ministry of Highways operates a ferry crossing Kootenay Lake between Balfour and Kootenay Bay, 20 miles east of Nelson on Highway 3A. Year-round daily service is offered for car, truck, and foot passengers. Recreational vessels also use Kootenay Lake, primarily during the late spring, summer, and early fall.

Agriculture and Irrigation

East and Central Kootenay RDs, Canada

The East Kootenay RD is primarily a ranching area, although farming is also carried out. Total farm sales receipts from the East Kootenay RD in 2001 were approximately $15 million. Hay, much of which is irrigated, is the largest crop and is produced for cattle use. Alfalfa, oats, and barley are other crops produced in the area. Approximately 221,000 square feet of greenhousing is also present in the RD.

The Central Kootenay RD has a major area of prime farmland around Creston. Field vegetables and tree fruits include potatoes, peas, beans, apples, and berries. The dairy industry is important in this area. Total farm sales receipts in the Central Kootenay RD were approximately $26,000,000 Canadian in 2000 (U.S. equivalent $34,068,000; BC Ministry of Management Services 2004).

Lincoln County, Montana

Approximately 54,000 acres are farmed in Lincoln County, with about 4,700 acres irrigated (about 9 percent). Major agricultural products include livestock and poultry such as beef cows, milk cows, hogs and pigs, sheep and lambs, and chickens. Hay and pastureland is the other dominant crop, with small amounts of oats and barley grown for grain. A total of 15 acres is in vegetable or fruit production in the county. The market value of the county's agricultural products sold in 2002 was $2,516,000. Net cash income is the cash earnings realized within a calendar year from the sales of farm production and the conversion of assets, both inventories (in years in which reduced) and capital consumption, into cash. Net cash farm income is a solvency measure representing the funds that are available to farm operators to meet family living expenses and make debt payments. The county's 2002 net cash farm income totaled a loss of $478,000, with an average loss of $1,589 per farm (NASS 2002). A summary of Lincoln County agricultural and irrigation information is presented in Table 3-11.

Boundary County, Idaho

Approximately 76,000 acres are farmed in Boundary County with about 2,750 acres irrigated (less than 4 percent). Major agricultural products include wheat and beef and milk cows. Hay and alfalfa are also dominant crops with oats and barley for both grain and forage. Specialty crops include hops and tree fruits (apples). The market value of the county's agricultural products sold in 2002 was $2,822,000. The county's 2002 net cash farm income totaled $6,545,000, an average of $15,115 per farm (NASS 2002). A summary of Boundary County agricultural and irrigation information is presented in Table 3-11. Approximately 2,200 acres are farmed by the Kootenai Tribe and include grain and hay crops.

Table 3-11. Agricultural and Irrigation Summary Statistics - U.S. portion of Kootenai River Basin

County, State	Land In Farms	Total Cropland	Harvested Cropland	Irrigated Acres (%)[1]	County's Net Cash Farm Income
Boundary, ID	76,506	47,706	40,440	2,750 (7)	$6,545,000
Lincoln, MT	54,236	18,696	9,188	4,762 (52)	-$478,000

[1] Percent of harvested cropland
Source: NASS 2002

Municipal and Industrial Water Supply

The Kootenai River and the reservoirs are used to provide municipal and industrial (M&I) water supply for several communities and private landowners. Table 3-12 summarizes municipal, domestic, and industrial water withdrawals in the United States portion of the Kootenai River basin in 2000 (USGS 2000).

Table 3-12. Selected Statistics for M&I Water Supply – United States portion of Kootenai River Basin

	Lincoln County, MT	Boundary County, ID
Total Population (x1,000)	18.84	9.87
Total Population Served By Public Supply (x1,000)	7.19	6.81
Total Public Supply Fresh Surface Water Withdrawals (Million Gal/D)	0.46	1.00
Total Domestic Self-Supply Fresh Surface Water Withdrawals (Million Gal/D)	0.04	0.00
Total Industrial Self-Supply Fresh Surface Water Withdrawals (Million Gal/D)	13.77	0.20

Source: http://water.usgs.gov/watuse/ May, 19, 2005

Tribal Socioeconomics

The recognized Native American Tribes and Bands located in the Kootenai River basin are the Kootenay and Tobacco Plains Bands in British Columbia, and the Kootenai Tribe of Idaho in northern Idaho. The reserves and reservations are all along the Kootenai River. The Tobacco Plains Reserve is near Grasmere and encompasses approximately 10,800 acres. The reserve is in the rolling hills and flat areas in the Kootenay River valley and the primary industries are forestry and agriculture. Commercial development includes a restaurant, gas station, and duty-free shop (BCFN 2005).

The Lower Kootenay Indian Band Reserve is near Creston and covers approximately 6,000 acres. Agriculture is the primary economic activity, crops include fruit, corn, wheat, and barley. Other development includes recreational guiding and outfitting and tribal operations such as the elementary school and other administrative activities. The Lower Kootenay Indian Band holds an annual Pow Wow which is a tourist attraction (BCFN 2005).

The Kootenai Tribe of Idaho reservation is north of Bonners Ferry along the Kootenai River. The Kootenai River Inn and Casino is the major employer. The tribal business/administration operations and the fish hatchery also employ many tribal members. Approximately 2,200 acres are farmed for hay, grains, and livestock; none of the agricultural lands are irrigated. Currently, their agricultural lands are subject to spring flooding and poor drainage. (P. Perry, Kootenai Tribe, pers. comm. 10/2004).

3.2.14 Municipal Water and Wastewater Treatment

Lake Koocanusa

Upstream from Libby Dam in Canada, towns draw water from a mix of surface and groundwater sources. Major municipalities discharging secondary treated waste to the Kootenay River or its tributaries include Kimberly, Fernie, Sparwood, and Elkford, British Columbia.

Eureka, Montana, obtains water from wells associated with alluvium of the Tobacco River and is serviced by a sanitary sewer system with treatment lagoons southwest of town (Montana DEQ 2001a).

Libby Dam to Kootenay Lake near Creston, BC

The municipal water supply for Libby, Montana, comes from a diversion dam on Flower Creek and meets all Federal and state water quality standards (Energy Laboratories 2003). In addition to standard water quality constituents, Libby's municipal water has been tested to show no contamination from asbestos (Energy Laboratories 2003). Libby discharges secondary treated effluent from wastewater treatment to the Kootenai River.

Troy, Montana, obtains its municipal water from wells and provides municipal sanitary sewer service with discharge of secondary treated effluent to the Kootenai River.

The primary municipal water source for Bonners Ferry is Myrtle Creek. However, a large forest fire in the Myrtle Creek watershed in 2004 required a withdrawal of a portion of municipal water from the Kootenai River, the city's backup water source. Secondary treated effluent from the city's wastewater treatment plant on the north bank of the river about 1-mile downstream from the Highway 95 bridge is discharged into the Kootenai River.

Kootenay Lake to Confluence with Columbia River

Creston, British Columbia, obtains its municipal water from wells and reservoirs. Creston operates a wastewater plant that provides secondary treatment and discharges effluent to the Kootenay River.

Nelson, British Columbia, obtains its municipal water from reservoirs via gravity feed. The city of Nelson sewage treatment plant is 2 miles from the city center at Grohman Creek and discharges to Kootenay Lake.

3.2.15 Transportation

The British Columbia Ministry of Transportation operates a free ferry traversing Kootenay Lake from Balfour to Kootenay Bay. This ferry runs year-round. Ferry access into the West Arm of the lake and the Balfour terminal is extremely difficult at lake elevations below 1739 feet. High lake levels do not adversely affect ferry operation.

3.2.16 Dam Structural Condition

Libby Dam is safe and is fully capable of continued operation. In the past, concrete patch repairs were made to portions of the spillway face. These repairs were made under the assumption that, based on water management designed to avoid the excessive levels of dissolved gas in the river downstream of the dam, the spillway would be infrequently used. Due to concerns about creating damaging levels of dissolved gas downstream of Libby Dam, dam operations have intentionally attempted to avoid spill of any water since the mid-1980s[27]. More recent use of the spillway occurred during the 2002 spill event and during powerhouse maintenance in the winter of 2005.

The patched areas of the spillway face have reached the end of their design life and must be repaired. During and after the spill in 2002, engineers evaluated the areas needing repairs and found that portions of the patching had come loose and some chipping and flaking of the patches occurred. The spillway is available for infrequent use (i.e. similar to historical spillway use frequency) in its current condition, and repairs necessary to restore a smooth spillway surface and minimize future maintenance requirements are planned to be accomplished in future, funding dependent. A more frequent spillway use schedule, such as that recommended under the 2006 USFWS biological opinion RPA, will accelerate the deterioration of the previously repaired areas and possibly extend the damage, thereby increasing future repair costs. The worsened conditions could induce even more deterioration and damage during periods of prolonged high rate spills.

[27] The most recent opening of the sluices occurred in September 1985 for a test of the emergency closure gates, during which fish with GBD symptoms were observed downstream of the dam.

Also, the Corps monitored the spillway gates during the 2002 spill event and determined that they are fully functional and safe for use under the full range of possible spill operations for either flood control or fish flow augmentation.

3.3 Environmental Consequences

Six alternatives are analyzed for Libby operations; all incorporate fish flows:

- Alternative LS1 (No Action Alternative)
- Alternative LV1
- Alternative LS2
- Alternative LV2
- Alternative LSB
- Alternative LVB (Preferred Alternative)

In response to the issuance of the 2006 USFWS Biological Opinion on the effects of the operations of Libby Dam (following release of the draft EIS), Alternative LVB was added to provide for up to 10 kcfs above powerhouse capacity using Libby's spillway to benefit endangered Kootenai River white sturgeon. This alternative is the preferred alternative for Libby operation. As explained in Sec. 2.2, this alternative relies on spill at Libby at this time, but would not necessarily result in 10 kcfs being provided above powerhouse capacity every year. For the sake of comparability, a standard flood control alternative (LSB) with up 10 kcfs above powerhouse capacity via the spillway was also considered; however, it is not the preferred alternative.

In addition, two benchmarks without fish flows are evaluated; they are not alternatives for purposes of this EIS, but they provide a baseline against which to evaluate the alternatives for effects of the fish flows. They are:

- Benchmark LS
- Benchmark LV

Details on these alternatives and benchmarks are provided in Section 2.2.

This analysis addresses the effects of the alternatives at Libby and focuses on impacts relative to the no-action alternative. Significance is considered in that context. The relative impacts of the alternatives are not considered significant unless specifically stated as such.

This section evaluates the potential effects of the alternatives on the Kootenai River and its surroundings between the upstream extent of Lake Koocanusa and the mouth of the

Kootenay River in Canada. The discussions are generally arranged by river reach (headwaters to downstream) or reservoir as follows:

- Lake Koocanusa;
- Libby Dam to Kootenay Lake near Creston, British Columbia;
- Kootenay Lake to the confluence of the Kootenay River and the Columbia River.

Resource discussions that do not follow this pattern are threatened and endangered species (discussed by species) and socioeconomics (discussed by county/state divisions). Cultural resources, Indian sacred sites, and other affected Tribal interests follow a more generalized approach focusing on recognized tribal resources.

Potential impacts to hydropower generation on the Kootenai River are addressed as part of the system hydropower discussion in Section 5.3.2.

3.3.1 Hydrology and Flood Control

For each of the alternatives, the Corps' Streamflow Synthesis and Reservoir Regulation (SSARR) computer model and the Autoreg pre/post-processing program were used to simulate conditions in the Kootenai River system over a period of record between 1948 and 1999. Using historic unregulated streamflow records, reservoir storage-elevation relationships, rating curves for hydraulic capacity, and streamflow routing procedures, the computer model simulated operation of the Kootenai River system according to a variety of rules. Typical rules include drafting a reservoir according to a specified rule curve, imposing maximum and/or minimum flow requirements, or providing an outflow over a specified period of time.[28] The simulations were conducted using a daily time step, providing daily output values for reservoir elevation, dam releases, and river flows and stages. See Appendix I for a discussion of how the modeling assumptions for Libby Dam operations relates to modeling of Hungry Horse Dam operations, system power, and system flood control that is discussed in Chapters 4 and 5.

Alternative operations simulated in the hydroregulation study included both VARQ FC and Standard FC and various fish flow operations LS1, LV1, LS2 and LV2. VARQ FC and Standard FC operate to different draft requirements in the winter and different dam release protocols during the refill period. Fish flow operations were standardized to a

[28] Concerning operations of Duncan Dam, the refill date and minimum/maximum discharge from Duncan Dam were included in the modeling. However, flow targets for the lower Duncan River in the Duncan Dam Water Use Plan were not part of the EIS modeling effort. Meeting the Water Use Plan flow conditions could affect Libby Dam operations, since compliance with the IJC order on Kootenay Lake is still required. In some years, the amount of "trapped storage" in Lake Koocanusa would increase as a result of maintaining minimum flows on the Duncan River. This would probably be most pronounced under the Standard FC alternatives, since storage requirements for Standard FC are greater than for VARQ FC.

template in order to allow valid comparisons between the simulations. The fish flow template included:

- Release of tiered “sturgeon” volumes in the May/June period at a specified maximum threshold
- A ramp-down to bull trout minimum flows following the sturgeon flow augmentation
- Salmon flow augmentation during July and August to draft Lake Koocanusa to 2439 feet by the end of August

If the sturgeon flows ended during the last week of June, the simulations avoided a double-peak operation by smoothing the transition between sturgeon and salmon flows instead of dropping to bull trout flows between higher sturgeon and salmon flow augmentation periods. The strict fish-flow template differs from real-time fish flow operations in that it applies roughly the same fish flow timing and magnitude to all years in a very similar manner. In actual operations, the fish-flow operation would likely differ from the fish-flow template in any given year (i.e., different timing, different magnitude and shape of releases) since real-time operations would have more flexibility to adjust to observations of parameters such as reservoir inflow forecasts, water temperatures, and sturgeon behavior. For example, the modeled sturgeon flows always utilized the peak outflow capacity available for the alternative (either powerhouse capacity or 10 kcfs above powerhouse capacity). In practice, sturgeon operations called for by the USFWS have not always been at full powerhouse capacity.

See Appendix B for complete details on the analysis framework and assumptions for the computer simulations. Appendix I discusses the relationship of the Libby Dam modeling to other modeling efforts discussed later in this EIS.

For alternatives LS1, LV1, LS2 and LV2, as well as benchmarks LS and LV, flow/stage-frequency curves and flow/stage-duration curves were generated using the simulated daily reservoir elevations, dam releases, and river flows and stages provided by the SSARR simulations. Alternative LSB would produce flows, stages and elevations intermediate to LS1 and LS2. Similarly, Alternative LVB would produce river and lake conditions intermediate to LV1 and LV2. Additionally, frequency curves for the non-fish-flow LS and LV benchmark operations made use of a previously investigated hypothetical 0.5-percent-chance exceedance flood from Libby Dam to Bonners Ferry. (This was limited to the LS and LV benchmark operations since the 0.5-percent-chance exceedance regulation is based solely on flood control objectives.) The frequency and duration curves allow comparison of the effects of different alternatives on hydrologic conditions at the following four locations in the basin:

- Elevation of Lake Koocanusa
- Outflows at Libby Dam

- River stage at Bonners Ferry
- Elevation of Kootenay Lake

These locations are arranged in order from upstream to downstream. The effects at upstream locations play a large role in the effects at locations further downstream. For example, Libby Dam releases generally account for a large part of flows and resulting stages at Bonners Ferry. See Appendix B for detailed discussion of the results. Highlights are presented below.

Lake Koocanusa

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

Figure 3-7 shows the elevation-duration curves for Lake Koocanusa for the months of January through April (during the flood control draft season). These curves summarize the percentage of time that simulated reservoir elevations were exceeded for the given month or months over the 1948-1999 period of record. In general, higher curves indicate higher reservoir elevations for that time period. From January through April, the simulated reservoir elevations would be dependent exclusively on flood control operations. This means that all VARQ FC alternatives (LV1, LV2, LVB), and the LV benchmark operation are equivalent to each other, as would be all Standard FC alternatives (LS1, LS2, LSB) and the LS benchmark operation. Under the Standard FC alternatives (LS1, LS2, LSB) and LS benchmark operation, the median reservoir elevation would be about 2370 feet between January and April.

As Libby Dam captures snowmelt runoff between May and July, the reservoir fills and the reservoir surface elevation increases. Figure 3-8, Figure 3-9, Figure 3-10 show elevation-duration curves for Lake Koocanusa for the months of May, June, and July, respectively. Table 3-13 shows reservoir elevations that model simulations indicate would be exceeded about 50 percent of the time for the months of May, June, and July (these elevations represent the median reservoir elevation over the period of record). Table 3-14 shows end-of-month average elevations for Lake Koocanusa between May and September. Table 3-15 shows the percentage of years that Lake Koocanusa would approach the full pool elevation of 2459 feet.

For LS1, the reservoir would exceed elevations of about 2371 feet in May, 2415 feet in June, and 2440 feet in July about 50 percent of the time. Model simulations of LS1 show that it would be possible to refill the reservoir within 1 foot of full before the end of July in 6 percent of the years, and within 5 feet of full before the end of July in 12 percent of the years.

Model simulations of the LS benchmark operation show that it would be possible to refill the reservoir within 1 foot of full before the end of July in 92 percent of the years, and within 5 feet of full before the end of July in 98 percent of the years. These refill percentages are higher than any alternative and the same as the LV benchmark operation. Due primarily to the fish flows under LS1, reservoir elevations in May, June, and July would be consistently lower than either the LS or LV benchmark operation. The range of simulated reservoir elevations in July would be much wider for LS1 than for the LS benchmark operation. Compared to the LS benchmark operation, LS1 would result in median pool levels that would be about 1 foot lower in May, 9 feet lower in June, and 19 feet lower in July.

(LV1) VARQ FC w/ fish flows to powerhouse capacity)

From January through April, VARQ FC would result in consistently higher reservoir elevations than Standard FC. During this time period, the median reservoir elevation for all the VARQ FC alternatives (LV1, LV2, LVB) and the LV benchmark operation would be about 2396 or 26 feet higher than LS1.

For LV1, the reservoir would exceed elevations of about 2398 feet in May, 2427 feet in June, and 2446 feet in July about 50 percent of the time. Model simulations of LV1 show that it would be possible to refill the reservoir within 1 foot of full before the end of July in 12 percent of the years, and within 5 feet of full before the end of July in 31 percent of the years. Under LV1, reservoir elevations in May, June, and July would be consistently higher than LS1 and as high or higher than any of the alternatives. Compared to LS1, LV1 would result in median pool levels that are about 27 feet higher in May, 12 feet higher in June, and 6 feet higher in July.

Similar to the LS benchmark operation, model simulations of the LV benchmark operation show that it would be possible to refill the reservoir within 1 foot of full before the end of July in 92 percent of the years, and within 5 feet of full before the end of July in 98 percent of the years. With the VARQ FC operation and the absence of fish flows under the LV benchmark operation, reservoir elevations in May and June would be the highest of any of the alternatives. In July, reservoir elevations under the LV and LS benchmark operations would be similar. The range of simulated reservoir elevations in July under LV1 would be wider than for the LV benchmark operation (which would have a similar range as the LS benchmark operation). Compared to the LV benchmark operation, LV1 would result in median pool levels that would be about 1 foot lower in May, 11 feet lower in June, and 12 feet lower in July.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

For LS2, the reservoir would exceed elevations of about 2370 feet in May, 2411 feet in June, and 2440 feet in July about 50 percent of the time. Model simulations of LS2 show that it would be possible to refill the reservoir within 1 foot of full before the end of July in 6 percent of the years, and within 5 feet of full before the end of July in 10 percent of the years. Under LS2, reservoir elevations in May, June, and July would be the lowest of any of the alternatives. Compared to LS1, LS2 would result in median pool levels that would be similar in May and July, and about 4 feet lower in June. In some years, flexibility available due to the increased release capacity under LS2 could allow water managers to reach a higher peak reservoir elevation or reach the peak reservoir elevation about a week earlier in the year. In terms of the timing of reservoir refill, reaching full pool earlier would likely result in a dramatic increase in dam releases as the reservoir reached full pool. Early refill is not something that could be counted on as a normal benefit of additional flow capacity.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Model simulations of LV2 show that it would be possible to refill the reservoir within 1 foot of full before the end of July in 10 percent of the years, and within 5 feet of full before the end of July in 31 percent of the years. Under LV2, reservoir elevations in May, June, and July would tend to be higher than LS1 and similar, but slightly lower than LV1. Compared to LS1, LV2 would result in median pool levels that are 27 feet higher in May (the same as LV1), 10 feet higher in June, and 5 feet higher in July. Similar to LS2, additional release capacity could provide flexibility to refill the reservoir earlier or to reach higher peak elevations in some years, but these effects could not be counted on as a normal benefit of additional flow capacity.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Average reservoir elevations and outflows under alternative LSB would fall within the range exhibited by alternatives LS1 and LS2. Ability to spill is dependent upon adequate reservoir elevation (typically 2415, which is 10 feet above the spillway crest elevation of 2405 feet), and sufficient inflow to maintain outflows up to 10 kcfs above powerhouse capacity. Implementation of these flows for sturgeon is also dependent on ability to release to maintain temperatures of at least 50^{o} F with less than 3.6^{o} F drop. Therefore, dam releases above powerhouse capacity would not be achieved every year, as was assumed for LS2, and the magnitude and duration of flow above powerhouse capacity would vary year to year. For this reason, LSB would exhibit intermediate reservoir elevations and outflows, on average, compared to LS1 and LS2. Under LSB, adequate reservoir elevation and inflows for spill would likely occur in about 25 percent of years, so reservoir elevations and dam outflows would tend to be closer to LS1 conditions in most years. Because LSB includes fish flows, average spring and summer reservoir elevations, and reservoir refill capability, would be less than for benchmark LS. Outflows would be less in fall and winter and greater in spring and summer for alternative LSB compared to benchmark LS.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Average reservoir elevations and outflows under alternative LVB would fall within the range exhibited by alternatives LV1 and LV2. Ability to spill is dependent upon adequate reservoir elevation (typically 2415, which 10 feet above the spillway crest elevation of 2405 feet), and sufficient inflow to maintain outflows up to 10 kcfs above powerhouse capacity. Implementation of these flows for sturgeon is also dependent on ability to release to maintain temperatures of at least 50^{o} F with less than 3.6^{o} F drop. Therefore, dam releases above powerhouse capacity would not be achieved every year, as was assumed for LV2 and the magnitude and duration of flow above powerhouse capacity would vary year to year. For this reason, LVB would exhibit intermediate reservoir elevations and outflows, on average, compared to LV1 and LV2. Under LVB, adequate reservoir elevation and inflows for spill would likely occur in about 50 percent of years. Thus, in any given year under LVB, reservoir and outflow conditions similar to LV1 or LV2 would be equally likely to occur. Because LVB includes fish flows, average spring and summer reservoir elevations, and reservoir refill capability, would be less than for benchmark LV. Outflows would be less in the fall and winter and greater in spring and summer for alternative LVB compared to benchmark LV.

Summary

In general, elevations of Lake Koocanusa would more likely be higher during all months with VARQ FC alternatives compared to the corresponding Standard FC alternatives. The relative increase in lake elevation is most pronounced in winter and spring. While elevations during the winter and early spring are not affected by fish flows, the addition of fish flows would tend to decrease lake elevations achieved during the late spring and summer months (i.e., the fish flow season, as well as the recreation season).

Table 3-13. Median Elevation of Lake Koocanusa During January-April, May, June, and July. Reservoir elevations under LVB would be within the range exhibited by LV1 and LV2; elevations under LSB would fall within the range of LS1 and LS2.

	Median Reservoir Elevation (feet)			
Alternative	January-April	May	June	July
LS1	2370	2371	2415	2440
LV1	2396	2398	2427	2446
LS2	2370	2370	2411	2440
LV2	2396	2398	2425	2445
Benchmark				
LS	2370	2372	2424	2458
LV	2396	2399	2438	2458

Table 3-14. Lake Koocanusa Month-End Average Stage (feet). Average stages for LVB would be somewhere between those for LV1 and LV2, and stages for LSB would fall between those for LS1 and LS2.

	Month-End Average Stage (feet)				
Alternative	May	June	July	August	September
LS1	2393	2431	2443	2438	2435
LV1	2406	2440	2448	2439	2436
LS2	2391	2429	2442	2437	2434
LV2	2404	2439	2447	2439	2436
Benchmark					
LS	2400	2449	2459	2459	2438
LV	2410	2450	2459	2459	2438

Table 3-15. Simulated Likelihood of Reservoir Refill. Refill likelihood for LVB would fall between LV1 and LV2, while refill likelihood for LSB would fall between LS1 and LS2.

Alternative	**Percent of years filling to 2458 feet (1 foot from full pool) elevation before July 31**	**Percent of years filling to 2454 feet (5 feet from full pool elevation by July 31)**
LS1	6	12
LV1	12	31
LS2	6	10
LV2	10	31
Benchmark		
LS	92	98
LV	92	98

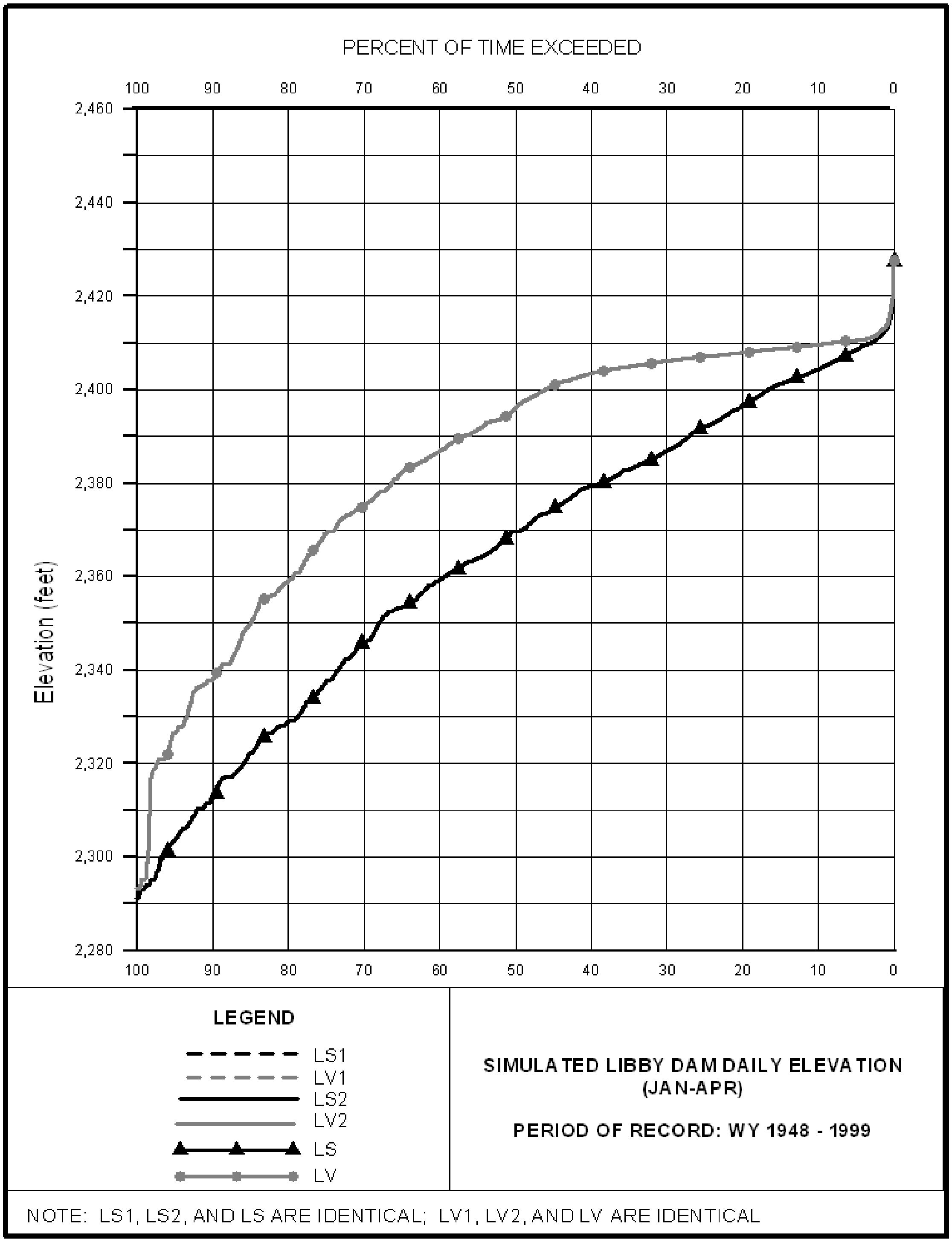

Figure 3-7. Elevation-Duration Analysis–Lake Koocanusa Daily Elevation (January-April). Alternative LVB would be the same as LV, LV1 and LV2; Alternative LSB would be the same as LS, LS1 and LS2.

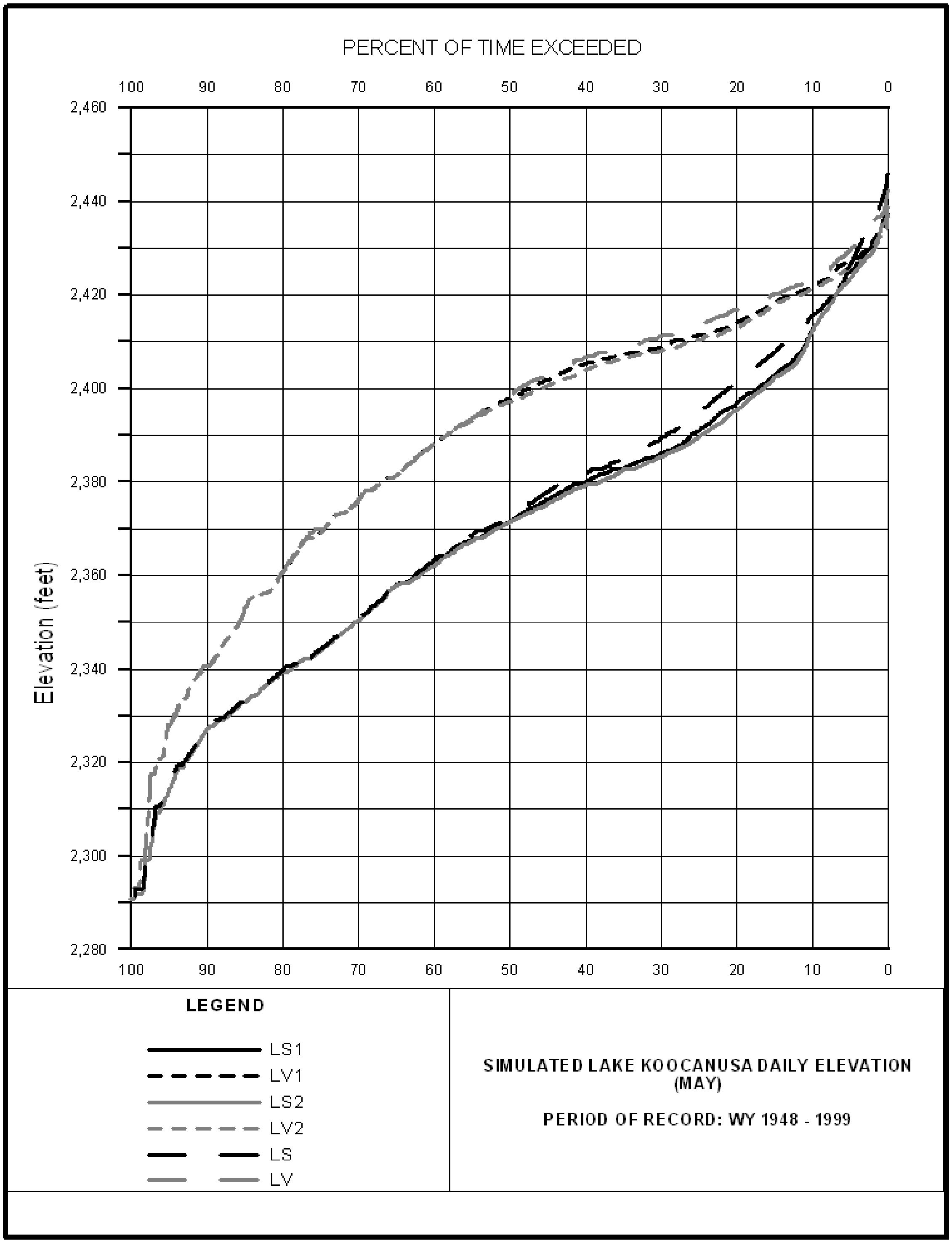

Figure 3-8. Elevation-Duration Analysis–Libby Dam Daily Elevation (May). Alternative LVB would fall between LV1 and LV2; alternative LSB would fall between LS1 and LS2.

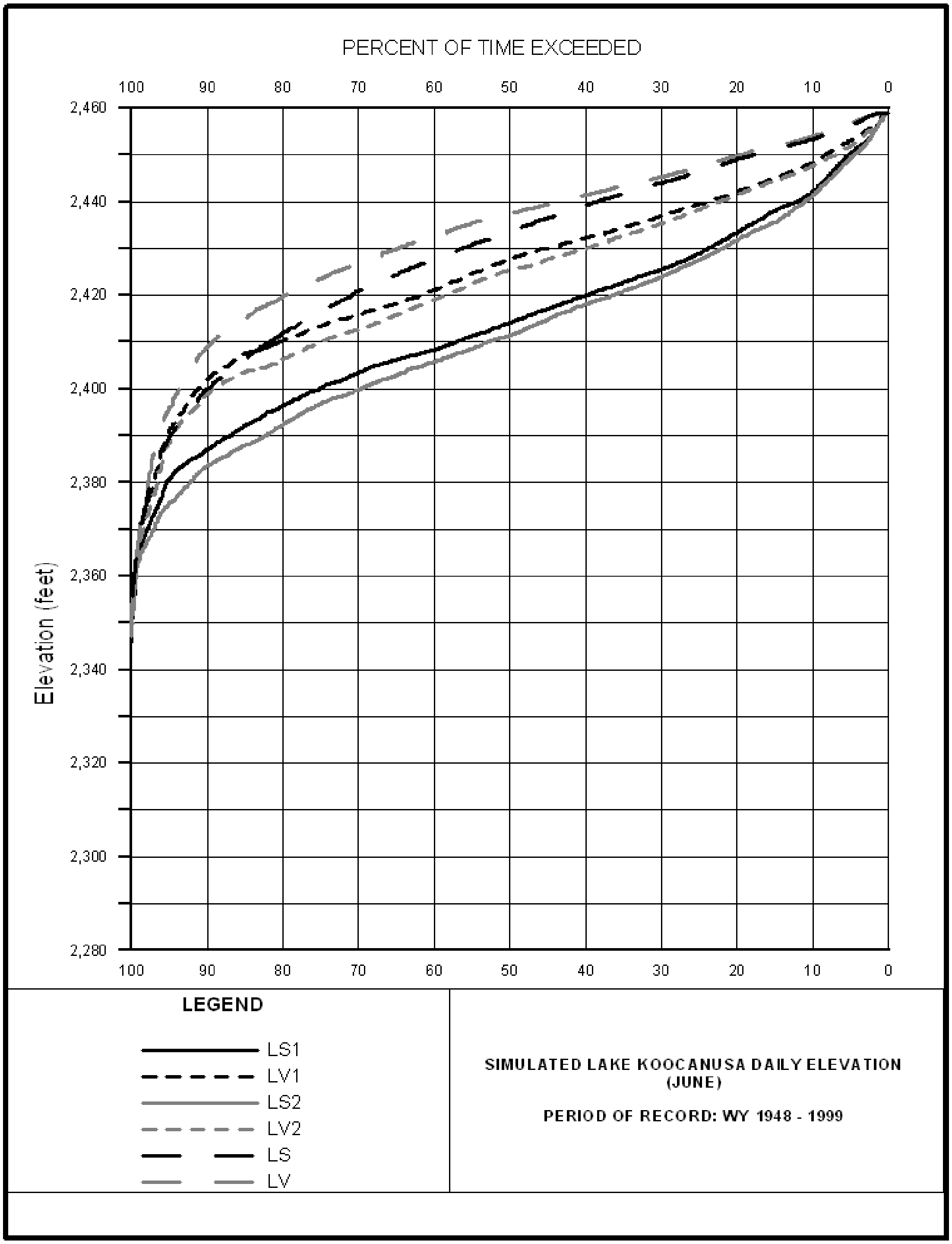

Figure 3-9. Elevation-Duration Analysis–Libby Dam Daily Elevation (June). Alternative LVB would fall between LV1 and LV2; alternative LSB would fall between LS1 and LS2.

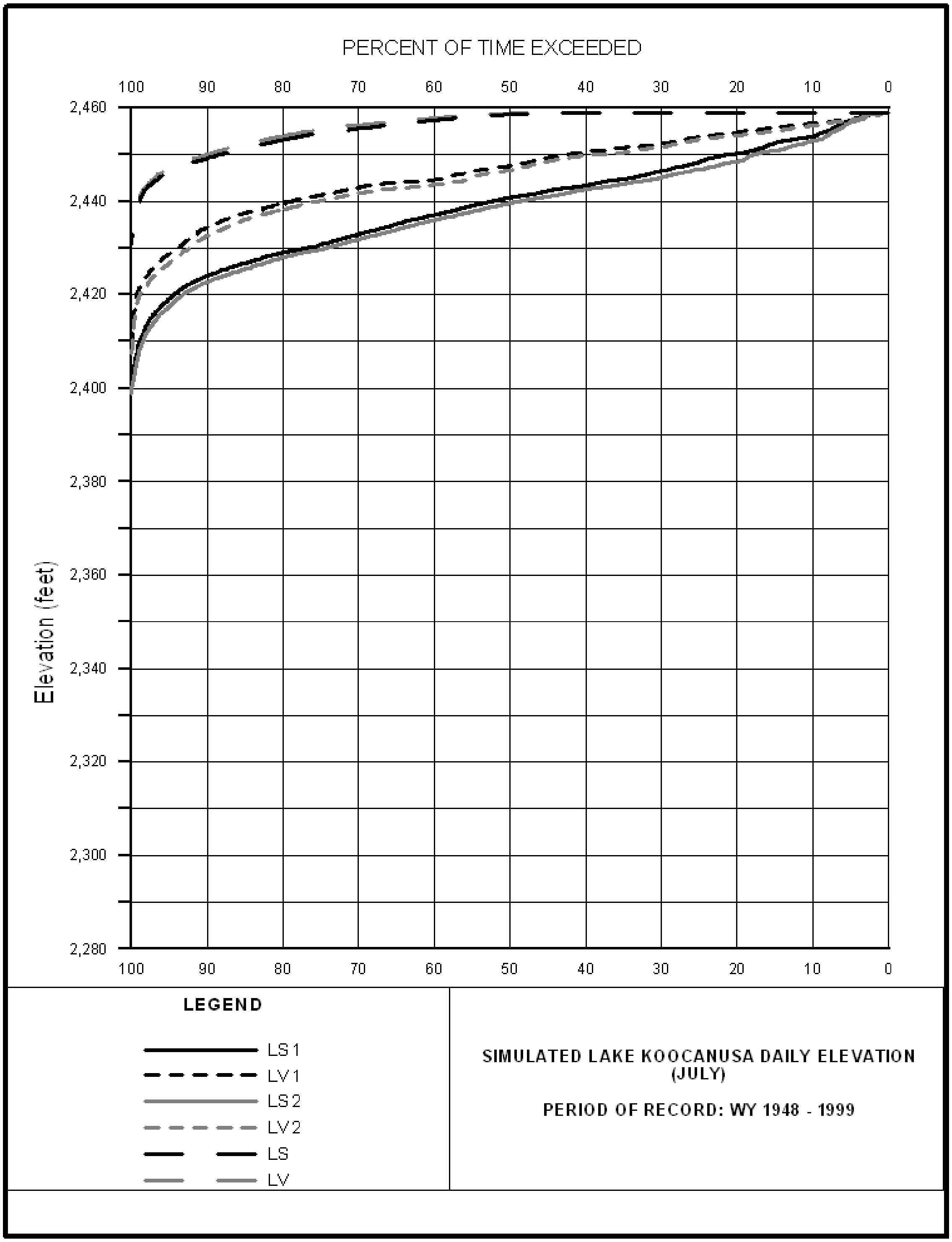

Figure 3-10. Elevation-Duration Analysis–Libby Dam Daily Elevation (July). Alternative LVB would fall between LV1 and LV2; alternative LSB would fall between LS1 and LS2.

Libby Dam to Kootenay Lake near Creston, BC

Libby Dam

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

Table 3-16 (Monthly Average Outflow from Libby Dam) shows monthly average outflow from Libby Dam during the winter and summer. Under LS1, average dam releases would be highest in January and have a secondary peak in June.

Figure 3-11 shows the flow-frequency curves for Libby Dam peak releases during the months of May through July, when the annual peak release at the dam would likely occur. Under LS1, peak dam releases would be essentially at the powerhouse capacity of about 25 kcfs. This is expected since the model simulations include sturgeon flow releases at powerhouse capacity in all but 3 years out of the 1948-1999 period of record. Comparing peak releases under LS1 with the LS and LV benchmark operations, fish flows would serve to reduce the frequency of involuntary flood control spills that would result in peak releases above powerhouse capacity.

Simulations indicate that average flows during May, June, and August for LS1 would be distinctly higher than those under the LS benchmark operation. However, in about 15 percent of years, peak releases under the LS benchmark operation would be higher than those under LS1, indicating years when, for flood control purposes, involuntary spill would be implemented. Average July flows provided for salmon flow augmentation under LS1 would be lower than those provided with the LV benchmark operation.

Since Libby Dam releases generally account for a large component of flows and resulting stages at Bonners Ferry, the general pattern for Libby Dam releases is similar to patterns for river stage at Bonners Ferry further downstream.

Table 3-16. Monthly Average Outflow from Libby Dam (kcfs). LVB would fall between LV1 and LV2; LSB would fall between LS1 and LS2.

Alternative	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
LS1	20.4	13.8	7.5	5.7	9.8	18	14.1	13.6	8.6	6.9	6.4	16.9
LV1	12.6	9.7	5.7	6.4	14.3	18.3	17	16.1	9.0	7.0	6.4	17.1
LS2	20.4	13.8	7.5	5.7	10.9	17.9	13.7	13.2	8.6	6.8	6.3	16.8
LV2	12.6	9.7	5.7	6.4	15.3	18.3	16.5	15.7	8.9	7.0	6.4	17.1
Benchmark												
LS	20.6	13.8	7.5	5.7	6	9.2	14.9	9.7	22.3	7.4	6.7	17.7
LV	12.7	9.7	5.7	6.4	12	13.8	15.4	9.8	22.3	7.4	6.6	17.7

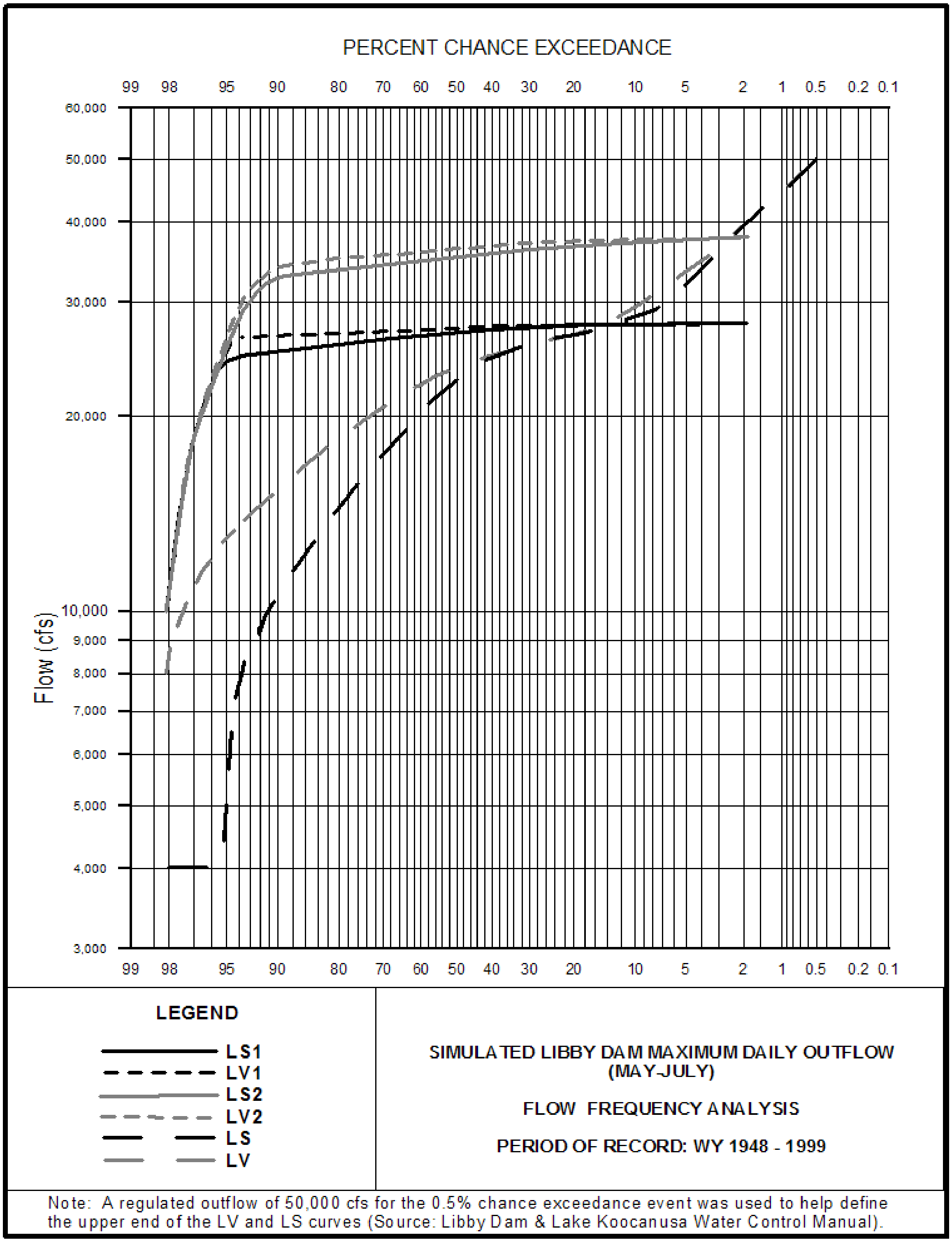

Figure 3-11. Flow-Frequency Analysis–Libby Dam Maximum Daily Outflow (May-July). LVB would fall between LV1 and LV2; LSB would fall between LS1 and LS2.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Average dam releases under LV1 would be highest in June. Compared to LS1, releases during the winter would be substantially lower for LV1, primarily due to relatively lower flood control draft requirements under VARQ FC. Compared to LS1, average releases during the fish-flow season of May through August would be higher with LV1. LV1 would have the highest average outflows during July and August of any alternative because VARQ FC and limiting sturgeon flows to powerhouse capacity would help better ensure high peak reservoir elevations that would then be available for release during salmon flow augmentation.

Under LV1, peak dam releases would be similar to those under LS1, with slightly higher peak releases in drier, high percent-exceedance years. Since powerhouse capacity increases with reservoir elevation up to 2420 feet, the difference in peak dam release is likely related to the higher reservoir levels resulting from VARQ FC during dry years. When compared to the LV benchmark operation, the fish flows in LV1 would serve to substantially reduce the frequency of spill for flood control that would result in peak releases above powerhouse capacity.

Similar to LS1, average flows for LV1 during May through August include fish flow augmentation, so flows would tend to be higher than with the LV benchmark operation. Peak releases also tend to be higher under LV1 than LS1, a difference that is most pronounced in drier, high percent-chance-exceedance years. Even without fish flows, the variable flows released during refill under the VARQ FC alternatives would result in average flows in May that are higher than either Standard FC alternative. Except for rare years with flood control spill operations under the benchmark operation, peak releases for LV1 would tend to be distinctly higher than those under the benchmark.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

Winter flows with LS2 would be the same as LS1. During the fish flow season of May through August, average flows with LS2 would be slightly higher than LS1 in May, but lower in June through July. Compared to all of the VARQ FC alternatives, average releases during the fish flow season would be lower with LS2.

As with LS1 and LV1, LS2 shows peak dam releases which closely correspond to the maximum sturgeon flow releases, in this case near 35 kcfs. Compared to LS1, peak releases would be roughly 10 kcfs higher.

In rare (low percent chance exceedance) years, peak releases under LS2 would be lower than those under the LS benchmark operation due to flood control spill operations under the benchmark. Average July flows provided as salmon flow augmentation under LS2 are lower than those provided under the other alternatives, as well as both the LV and LS benchmark operations.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Winter flows with LV2 would be the same as the LV1. LV2 would produce the highest average flows during May and June, likely due to a combination of VARQ FC releases for flood control and sturgeon flow augmentation that utilizes the additional flow capacity. In July and August, average flows would be higher than all Standard FC alternatives, but lower than LV1.

Under LV2, peak dam releases would be similar to those under LS2 and roughly 10 kcfs higher than LS1. Similar to the relationship between LV1 and LS1, peak releases under LV2 are slightly higher than those for LS2 during drier, high percent exceedance years, again likely due to higher reservoir levels resulting from VARQ FC in drier years.

In rare (low percent chance exceedance) years, peak releases under LV2 would be lower than those under the LV benchmark operation due to flood control spill operations.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Winter flows under LSB would be similar to LS1 and LS2. In May and June, flows under LSB would fall between LS1 and LS2, since spill would not be achievable every year and it may not be possible to provide the full 10 kcfs above powerhouse capacity. When spill of 10 kcfs could be achieved, its effect would be similar to LS2, depending on duration. Flows under LSB would, on average, be less in fall and winter, greater in spring and summer, and less in September, than under benchmark LS.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Winter flows under LVB would be similar to LV1 and LV2. In May and June, flows under LVB would fall between LV1 and LV2, since spill would not be achievable every year and it may not be possible to provide the full 10 kcfs above powerhouse capacity. When spill of 10 kcfs could be achieved, its effect would be similar to LV2, depending on duration. Flows under LVB would, on average, be less in fall and winter, greater in spring and summer, and less in September, than under benchmark LV.

Bonners Ferry

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

Bonners Ferry is the control point for local flood control below Libby Dam. The highest river stages at Bonners Ferry generally occur during the months of May, June, and July.

Specific to those months, stage-frequency curves of peak river stage at Bonners Ferry for all alternatives are provided in Figure 3-12.

To the extent possible, Libby Dam outflow is managed to avoid river stages in excess of the current flood stage of 1764 feet elevation at Bonners Ferry, so all alternatives would tend to plateau at 1764 feet. Due to the flood stage constraint, the differences between the alternatives diminish as one moves to the right on the frequency curves toward rarer, lower percent-chance-exceedance events. The likelihood of exceeding the current 1764-foot flood stage is the same for all alternatives. Above flood stage, there would be no differences in frequency of stages between any of the alternatives. Over the 1948-1999 period of record, simulations of LS1 and all other alternatives indicate peak river stages at Bonners Ferry would have exceeded flood stage in slightly less than 3 percent of the years.

Total number of days exceeding flood stage are rare, as indicated in Figure 3-13. Compared to the LS2 (with 10 kcfs of additional fish flow capacity), daily stages below about 1758 feet are more common with LS1, while daily stages above about 1758 feet are more common with LS2. This is likely due to a longer period high flow during the sturgeon pulse with LS1 (i.e., the time required to release the sturgeon volume would last longer if the peak release is limited to the powerhouse capacity rather than 10 kcfs above the powerhouse capacity under LS2). Stage-duration figures for seven-day and fifteen-day average river elevation (Figure 3-14 and Figure 3-15) show that average river stages between about 1756 feet and just below 1764 feet lasting for 1 or 2 weeks would be least likely under LS1 compared to the other alternatives.

The addition of fish flows would not affect the likelihood of exceeding flood stage at Bonners Ferry, but, rather, the likelihood of peak stages between 1756 feet and 1764 feet under LS1 is higher than either the LV or the LS benchmark operations.

Higher below-flood-stage peak river elevations that are due to the addition of fish flows may impact the integrity of levees in British Columbia and most of the river reach in Idaho. However, ramping rates, which would remain the same under all alternatives, would likely have a greater influence on levee integrity than the river stages themselves (NHC 1999). Localized bank erosion would continue at the current low rate. Bank erosion related to water velocity, which is an issue primarily upstream of Bonners Ferry, would be unchanged from current conditions.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

The likelihood of exceeding flood stage would be the same as for the other alternatives. Compared to LS1, LV1 would tend to increase the likelihood of peak Bonners Ferry river stages between 1756 and 1764 feet. For example, for any fixed percent chance exceedance between 30 percent and 90 percent, the peak stage would be about one foot higher under LV1 compared to LS1. Compared to Alternatives LS2 and LV2, peak river stages under LV1 would tend to be lower.

Looking at the daily stage-duration curve (Figure 3-13), the likelihood of daily stages below about 1759 feet at Bonners Ferry under LV1 would be as high as, or higher than, any alternative. The likelihood of seven-day and fifteen-day average stages between 1756 feet and just less than 1764 feet would also be higher under LV1 than under LS1 (Figure 3-14 and Figure 3-15). Above 1759 feet, LS2 and LV2 would be more likely to produce higher daily Bonners Ferry stages than LV1. Seven-day or fifteen-day average stages above 1756 would tend to be more likely under LS2 and LV2 than LV1. For a given likelihood, daily, seven-day duration, and fifteen-day duration Bonners Ferry stages under LV1 would be expected to be about 1 foot higher than LS1.

For stages below flood stage, the addition of fish flows would tend to increase the peak stage at Bonners Ferry for any given year. The fish flows also appear to provide a slight flood control benefit by slightly decreasing the likelihood of exceeding flood stage at Bonners Ferry. In any event, the likelihood of exceeding a Bonners Ferry stage of 1765 feet would be the same with or without fish flows. The fish flows increase the likelihood of river stages above 1754 feet, but do not appear to influence the likelihood of river stages below about 1754 feet. In general, the provision of fish flows in LV1 would result in river stages that would be as high or higher than both the LS and LV benchmark operations.

Levee integrity effects would be expected to be generally similar to LS1, with the possibility of slightly greater bank erosion upstream of Bonners Ferry due to marginally higher flows and water velocities during the spring freshet that would occur due to the VARQ FC operation.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

The likelihood of exceeding flood stage at Bonners Ferry under LV2 would be the same as the other alternatives. At lower river elevations, peak stages at Bonners Ferry under LS2 would be the second highest of any alternative (peak stages under only LV2 are higher). Peak Bonners Ferry stages under LS2 would be at or just below flood stage for almost half of years, meaning that the likelihood of stages close to flood stage under LS2 would be higher than under alternatives with lower fish flow capacity (LS1, LV1) or the LS or LV benchmark operations without any fish flows.

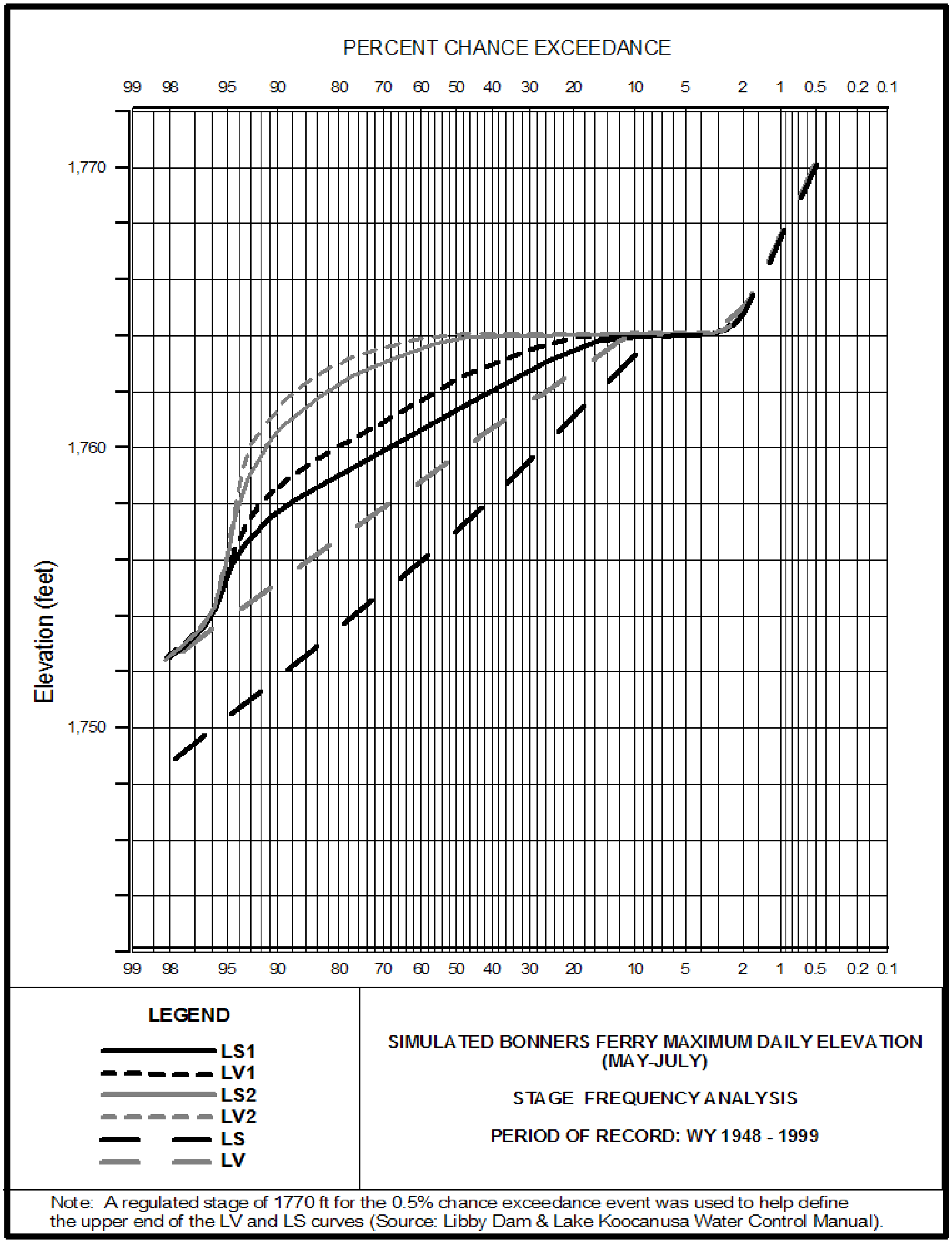

Figure 3-12. Stage-Frequency Analysis–Bonners Ferry Maximum Daily Elevation (May-July). Values for LVB would fall between LV1 and LV2; those for LSB would fall between LS1 and LS2.

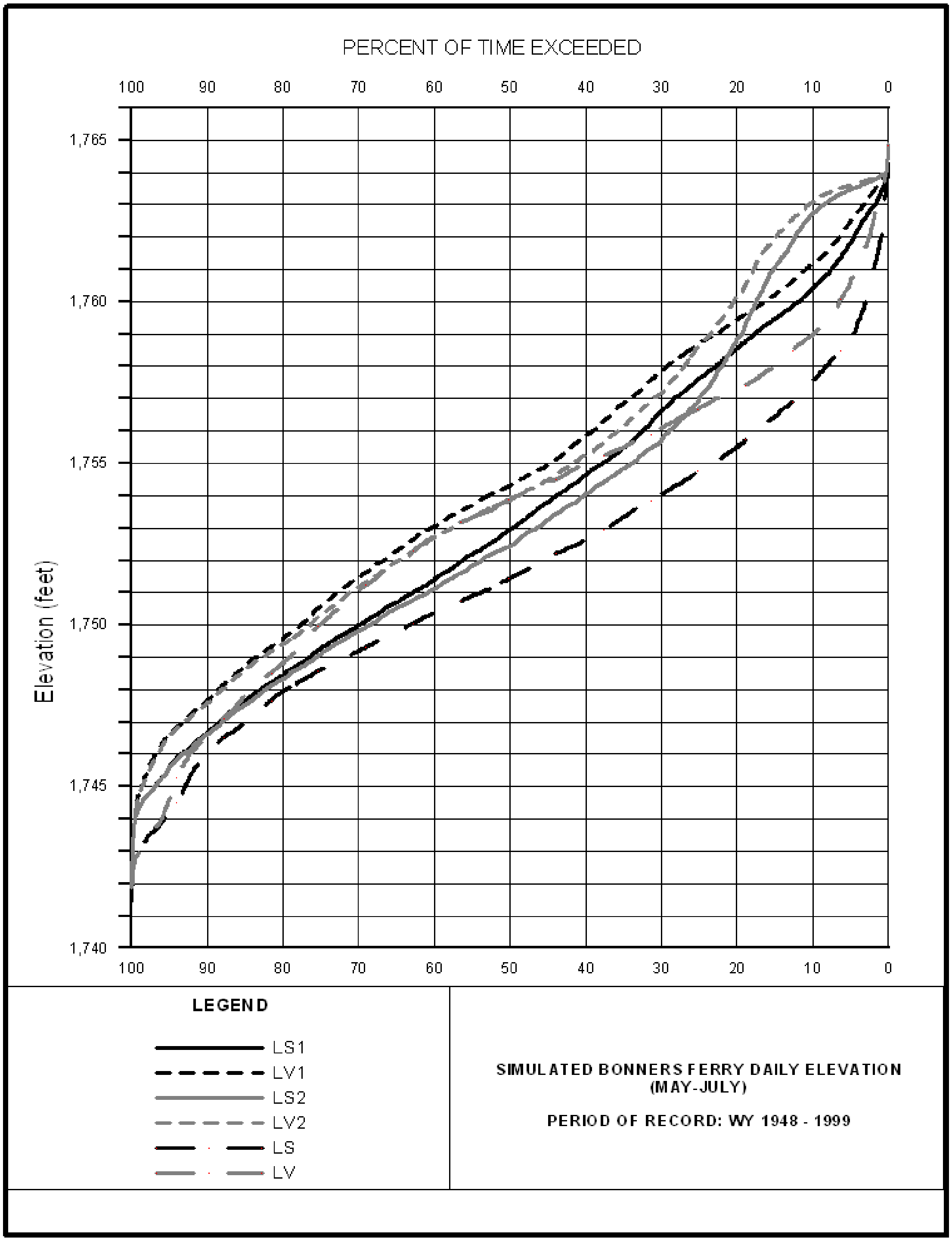

Figure 3-13. Stage-Duration Analysis–Bonners Ferry Daily Elevation (May-July). LVB would result in values between LV1 and LV2, while LSB would have values between LS1 and LS2.

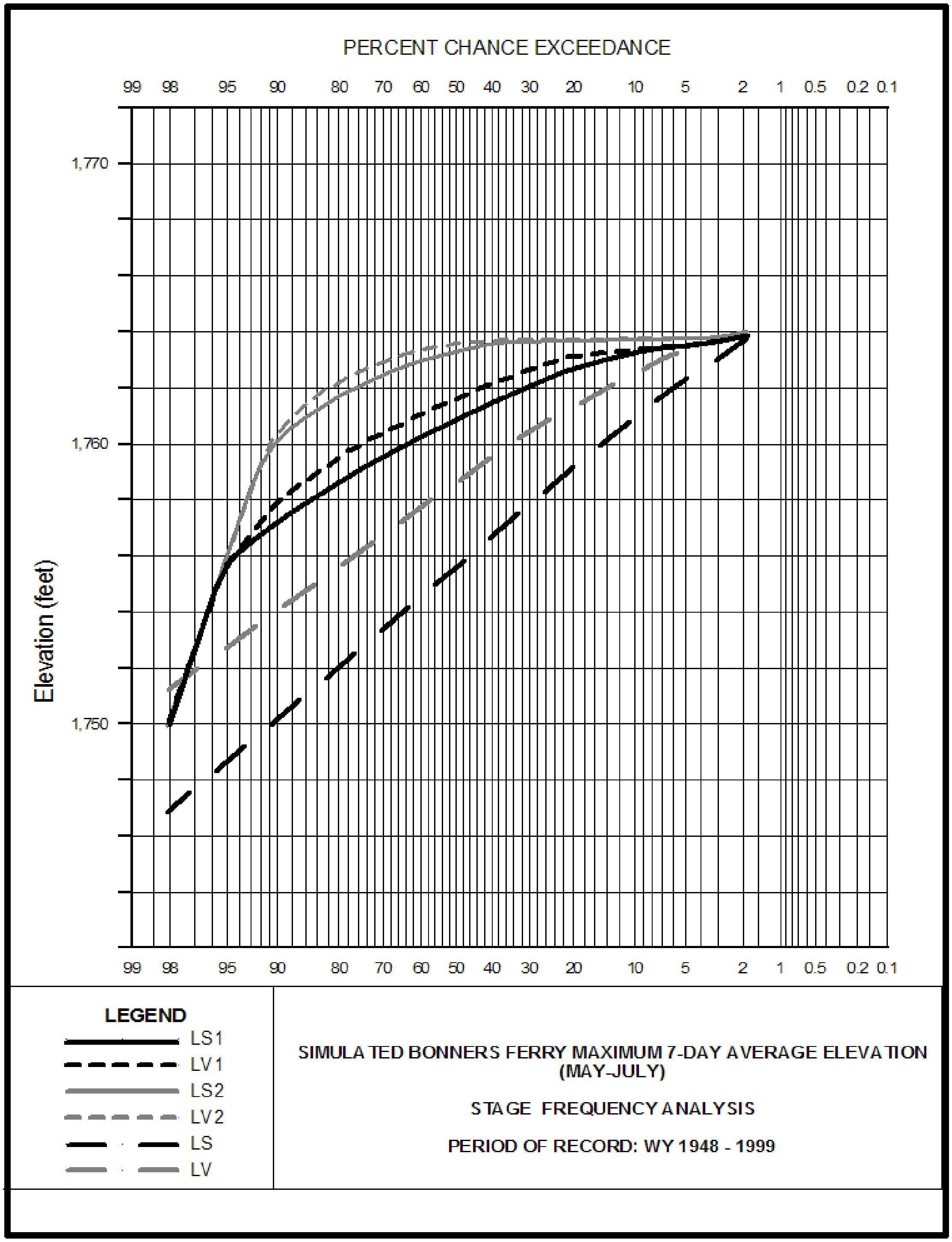

Figure 3-14. Stage-Frequency Analysis–Bonners Ferry Seven-Day Average Elevation (May-July). LVB would fall between LV1 and LV2, and LSB would fall between LS1 and LS2.

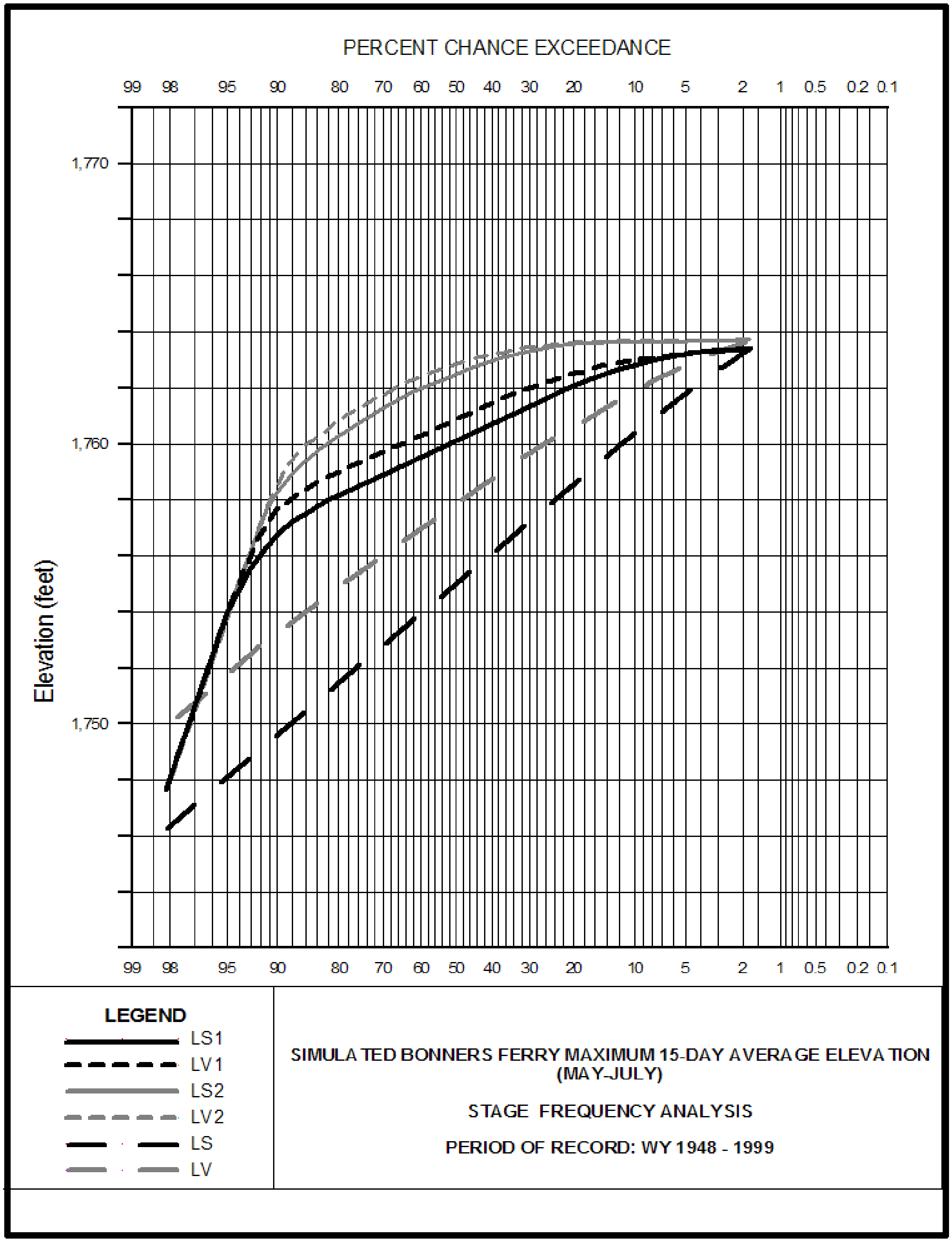

Figure 3-15. Stage-Frequency Analysis–Bonners Ferry Fifteen-Day Average Elevation (May-July). LVB would fall between LV1 and LV2, and LSB would fall between LS1 and LS2.

Looking at the daily stage-duration curve (Figure 3-13), LS2 has the interesting feature of having the lowest river stages among all the alternatives with fish flows about 80 percent of the time. However, the remaining 20 percent of the time, daily river stages under LS2 would be quite high (above about 1758 feet), second only to LV2. The likelihood of seven-day and fifteen-day average stages above 1756 feet would be higher than either LS1 or LV1, but generally lower than LV2. For a given likelihood, the seven-day and fifteen-day average stage would tend to be between 0 and 3 feet higher than under LS1.

Levee integrity effects downstream of Bonners Ferry would be expected to be similar to LS1. Flows and water velocities in the river reach upstream of Bonners Ferry would be higher under LS2 than LS1, which could result in more bank erosion in the braided reach under LS2.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

The likelihood of exceeding flood stage at Bonners Ferry under LV2 would be the same as the other alternatives. At lower river elevations, peak stages at Bonners Ferry under LV2 would be the highest of any alternative in any given year. Like LS2, peak Bonners Ferry stages under LV2 would be at or just below flood stage for almost half of years.

For stages below about 1759 feet, the likelihood of reaching or exceeding any given Bonners Ferry river stage under LV2 would be higher than any of the other alternatives except LV1. Above 1759 feet, the likelihood of Bonners Ferry river stages under LV2 would be the highest of any alternative. The likelihood of seven-day and fifteen-day average stages above 1756 feet would be as high or higher than any other alternative. For a given likelihood, the seven-day and fifteen-day average stage would tend to be between zero and 3.5 feet higher than under LS1.

Levee integrity effects would be expected to be generally similar to LS2, with the possibility of slightly greater bank erosion upstream of Bonners Ferry due to marginally higher flows and water velocities during the spring freshet that would occur due to the VARQ FC operation.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Bonners Ferry stages under LSB would fall between LS1 and LS2, since spill would not be achievable every year and it may not be possible to provide the full 10 kcfs above powerhouse capacity. When spill of 10 kcfs could be achieved, its effect would be similar to LS2, depending on duration. Effects on levee integrity under LSB would be intermediate between LS1 and LS2.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Bonners Ferry stages under LVB would fall between LV1 and LV2, since spill would not be achievable every year and it may not be possible to provide the full 10 kcfs above powerhouse capacity. When spill of 10 kcfs could be achieved, its effect would be similar to LV2, depending on duration. Effects on levee integrity under LVB would be intermediate between LV1 and LV2.

Kootenay Lake to the Confluence with the Columbia River

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

From a flood control perspective, impacts of Libby Dam operations on the level of Kootenay Lake are of greatest importance in May, June, and July when the lake typically reaches its maximum elevation of the year. For this specific period, stage-frequency curves of maximum Kootenay Lake elevation for all alternatives are provided in Figure 3-16.

The frequency curve for LS1 falls in the middle of all of the alternatives and is similar to the frequency curve for LV1. In general, the differences between LS1 and the other alternatives would be greatest in drier, low percent chance exceedance years. Differences between the alternatives would diminish for wetter, rarer years as the curves for all alternatives converge near a peak lake elevation of 1754 feet. This peak elevation would be about 0.5 feet higher than that seen for the non-fish-flow benchmark operations (LS, LV).

The level of Kootenay Lake is typically lowest at the end of March, and, as shown in Figure 3-17, would be the same under all of the alternatives. As Kootenay Lake captures snowmelt runoff between May and July, the lake fills and the water surface elevation increases. Figure 3-18, Figure 3-19, Figure 3-20 show elevation duration curves for Kootenay Lake for the months of May, June, and July, respectively.

Table 3-17 shows lake elevations that model simulations indicate would be exceeded about 50 percent of the time for the months of May, June, and July (these elevations represent the median lake elevation for each month over the period of record). For LS1, the lake would exceed elevations of about 1744.1 feet (May), 1748.4 feet (June), and 1744.4 feet (July) about 50 percent of the time. In general, lake levels under LS1 would fall within the middle of the range of lake levels for the various alternatives. In July, the range of differences between lake elevations under the various alternatives would be very small. Differences between lake elevations in May and June under the six alternatives would also be relatively small in June. Table 3-18 depicts Kootenay Lake average end-of-month elevations for each alternative. While average end-of-month elevations under the non-fish-flow benchmark operations may differ slightly from those under the alternatives, the average end-of-month elevations are the same among the different alternatives.

Compared to the LS benchmark operation, the addition of fish flows in LS1 would tend to increase spring and summer elevations on Kootenay Lake, with differences decreasing for rare, low-percent exceedance events. As with all of the alternatives, the maximum elevation of Kootenay Lake would remain below 1755 feet under LS1.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Under LV1, the likelihood of a given Kootenay Lake peak elevation would be similar, but slightly higher than that for LS1, but lower than either LS2 or LV2. The slight difference between LV1 and LS1 would diminish further at higher peak lake elevations as the curves converge for rare, low percent chance exceedance events. From May through July, LV1 would consistently produce higher lake levels than any of the Standard FC alternatives (LS1, LS2, LSB) and the LS benchmark operation, except for lake elevations above about 1749 feet in June, where LS2 would result in slightly higher lake elevations. The lake level difference between VARQ FC and Standard FC would be most pronounced in May, likely due to increased Libby Dam release during refill under VARQ FC. For LV1, the lake would exceed elevations of about 1745 feet (May), 1748.5 feet (June), and 1745.2 feet (July) about 50 percent of the time. The effects of the fish flows under LV1 would result in median lake elevations slightly higher than under the LV benchmark operation, with the most pronounced difference in June. Fish flows would have a minimal influence on average end-of-month elevations (Table 3-18).

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

Under LS2, the likelihood of a given Kootenay Lake peak elevation is higher than for any alternative except for LV2. The difference between LS2 and LV2 diminishes at higher peak lake elevations as the curves converge for rare, low percent chance exceedance events. In May and June, LS2 generally produces lake elevations that are similar, but slightly higher to those produced by LS1. A notable exception to this tendency occurs for lake elevations above about 1749 feet in June, when LS2 elevations are more similar to those under LV1 and LV2 than LS1. In July, LS2 would produce lake elevations similar to those produced by LS1. For LS2, the lake exceeds elevations of about 1744.1 feet (May), 1748.5 feet (June), and 1744.5 feet (July) about 50 percent of the time. In May and June, the median lake elevation is higher with this alternative than with LS benchmark operation, but the average end-of-month elevations are similar.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

LV2 produces the highest likelihood of any given peak stage on Kootenay Lake. In general, the difference between the likelihood of a given peak stage is close to that for

LS2, particularly for peak stages above about 1752 feet as the frequency curves converge for rare, low percent-chance-exceedance events. From May through July, LV2 generally produces lake elevations that are as high or higher than any other alternative. Exceptions occur at peak lake elevations below about 1748 feet in June and above about 1743 feet in July where LV1 peak lake levels are higher. For LV2, the lake exceeds elevations of about 1745.0 feet (May), 1748.6 feet (June), and 1745.0 feet (July) about 50 percent of the time. Median lake elevations are higher with this alternative than with LV benchmark operation. Average end-of-month elevations are similar between LV2 and the benchmark.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Kootenay Lake elevations under LSB would fall between LS1 and LS2, since spill would not be achievable every year and it may not be possible to provide the full 10 kcfs above powerhouse capacity. When spill of 10 kcfs could be achieved, its effect would be similar to LS2, depending on duration.

Table 3-17. Kootenay Lake Median Elevation (feet) in May, June, and July. The median elevation for LVB fall between LV1 and LV2; similarly, the median elevation for LSB would fall between LS1 and LS2.

Alternative	May	June	July
LS1	1744.1	1748.4	1744.4
LV1	1745.0	1748.5	1745.2
LS2	1744.1	1748.5	1744.5
LV2	1745.0	1748.6	1745.0
Benchmark			
LS	1743.8	1746.2	1744.5
LV	1744.8	1747.5	1745.0

Table 3-18. Kootenay Lake Month-End Average Stage (feet). The month-end average stage for LVB would be within the range between LV1 and LV2; similarly, the month-end average stage for LSB would fall between LS1 and LS2.

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LS1	1744	1742	1739	1741	1747	1747	1744	1743	1745	1745	1745	1745
LV1	1744	1742	1739	1741	1748	1747	1744	1743	1745	1745	1745	1745
LS2	1744	1742	1739	1741	1747	1747	1744	1743	1745	1745	1745	1745
LV2	1744	1742	1739	1741	1748	1747	1744	1743	1745	1745	1745	1745
Benchmark												
LS	1744	1742	1739	1741	1746	1746	1744	1743	1745	1745	1745	1745
LV	1744	1742	1739	1741	1747	1747	1744	1743	1745	1745	1745	1745

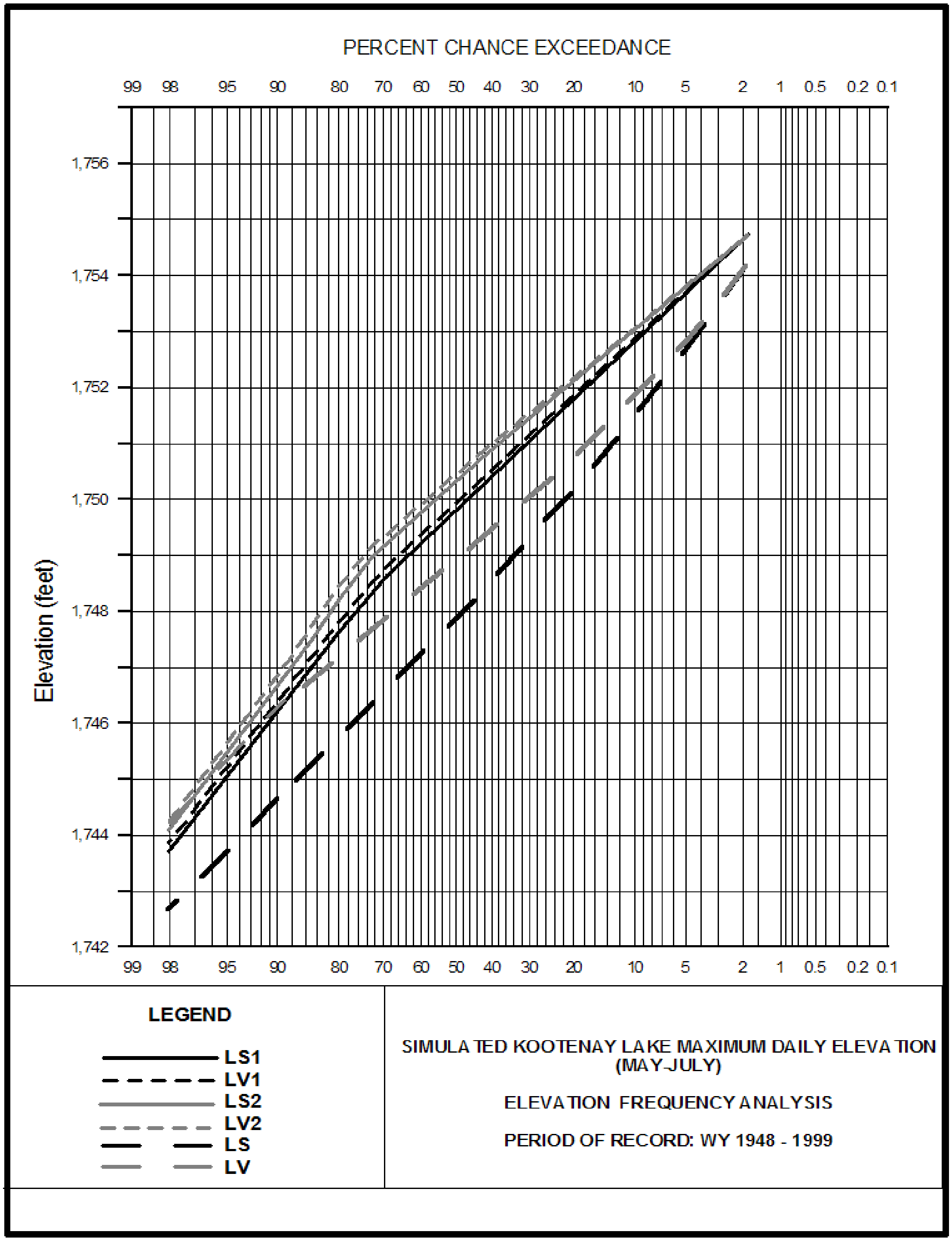

Figure 3-16. Elevation-Frequency Analysis–Kootenay Lake Maximum Daily Elevation (May-July). The values for LVB would fall between LV1 and LV2; the values for LSB would fall between LS1 and LS2.

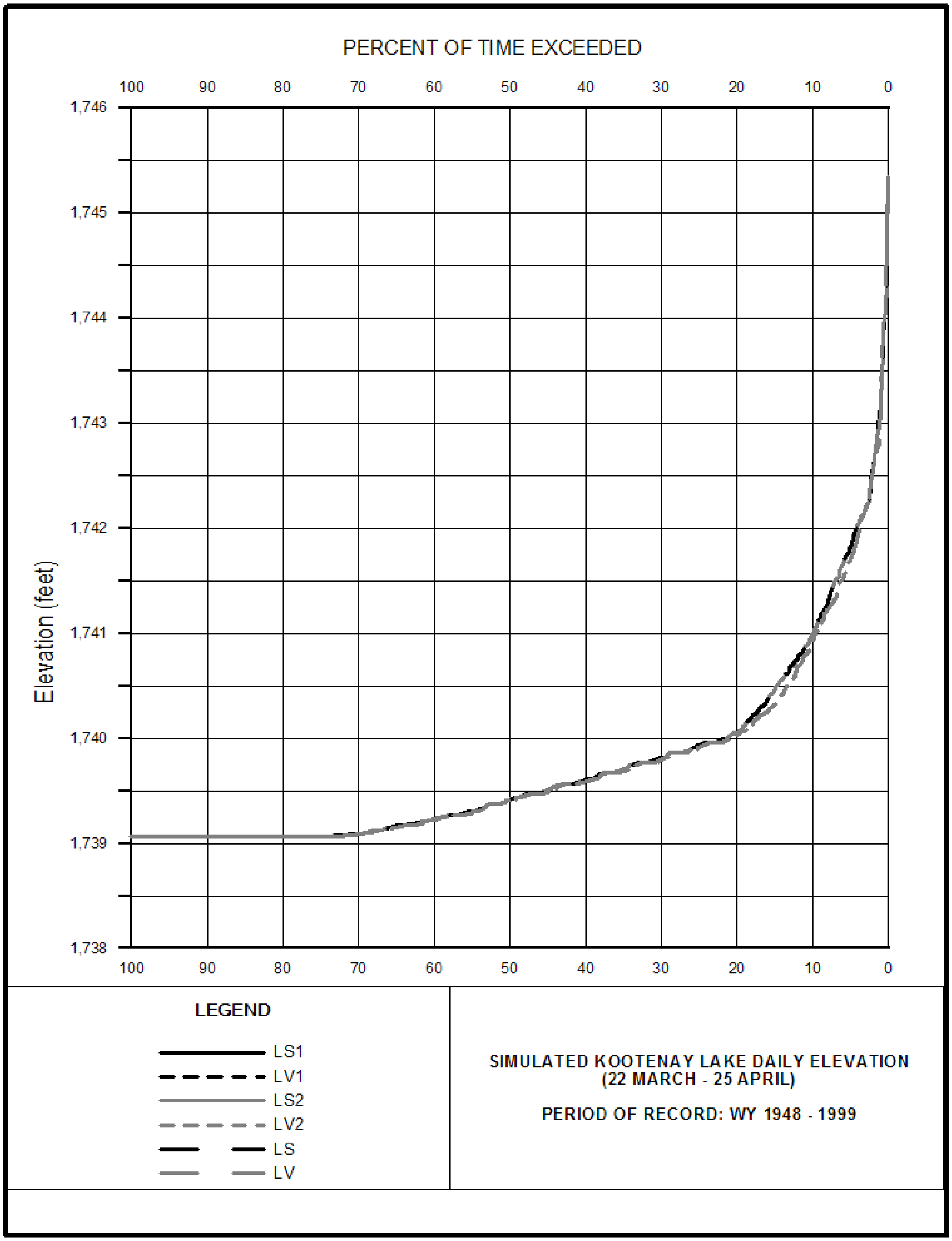

Figure 3-17. Elevation-Duration Analysis–Kootenay Lake Daily Elevation During Early Spring (22 March-25 April). The values for LVB would be similar to those for the other VARQ FC alternatives; the values for LSB would be similar to those for the other Standard FC alternatives.

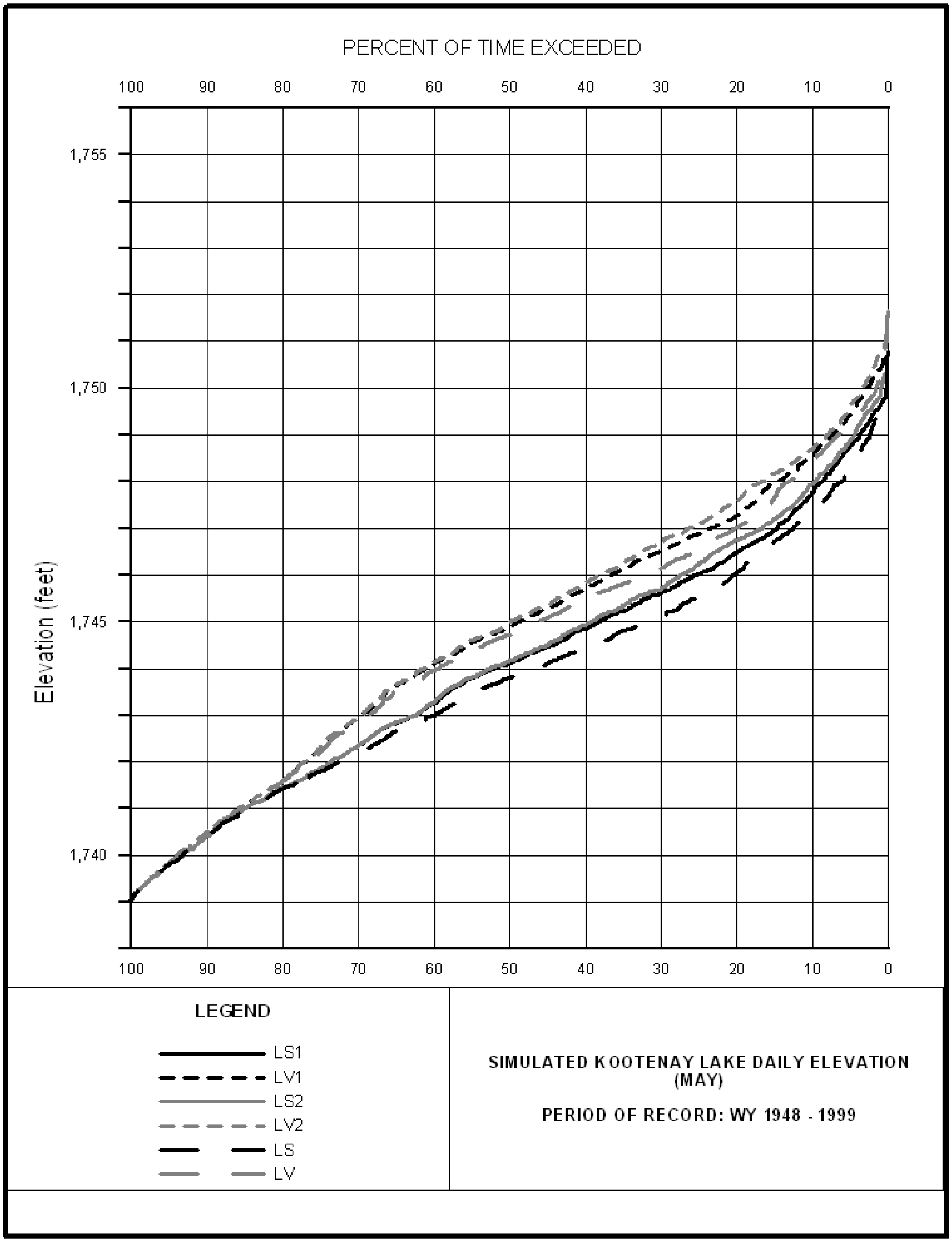

Figure 3-18. Elevation-Duration Analysis–Kootenay Lake Daily Elevation (May). The values for LVB would fall between LV1 and LV2; the values for LSB would fall between LS1 and LS2.

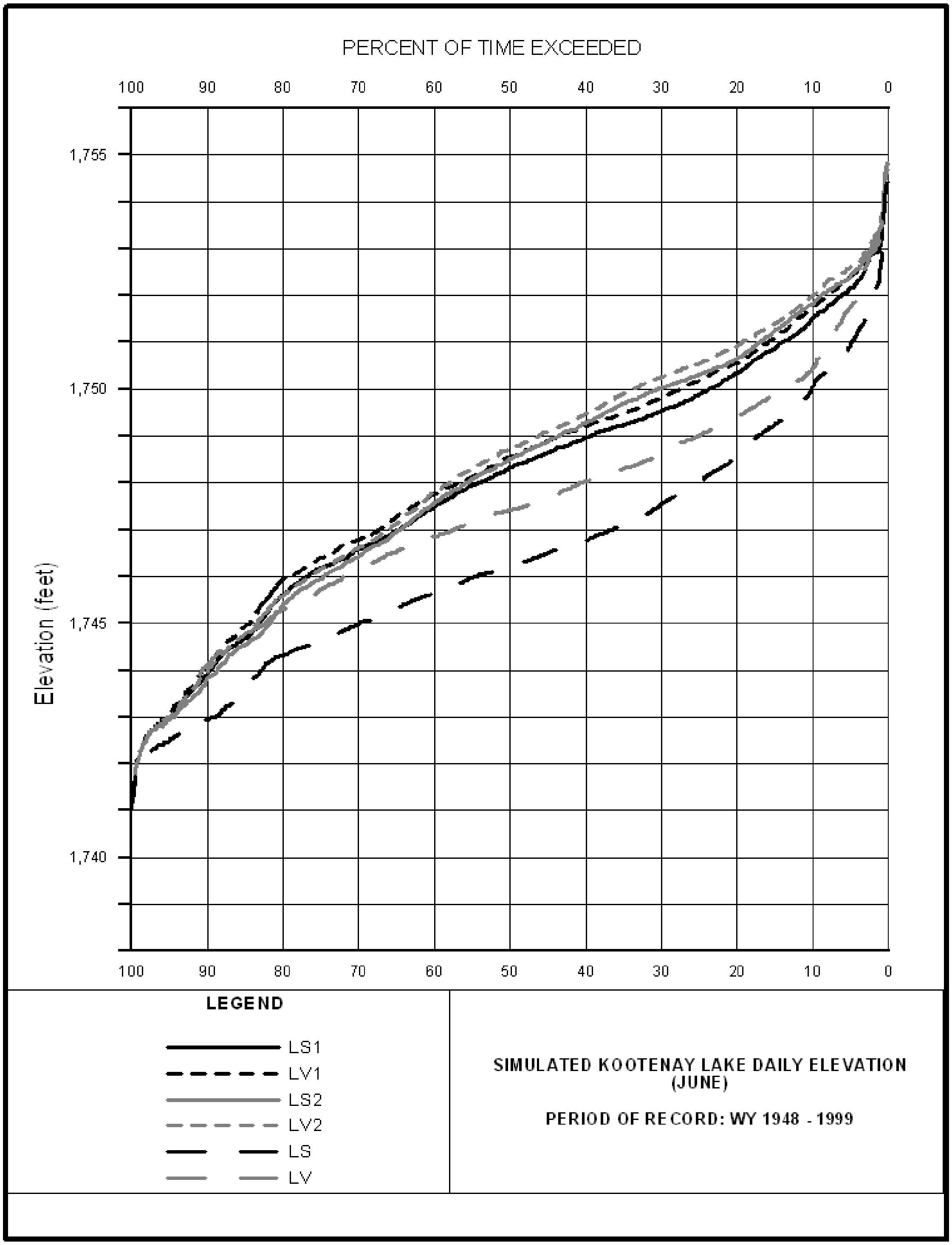

Figure 3-19. Elevation-Duration Analysis–Kootenay Lake Daily Elevation (June). The values for LVB would be fall between LV1 and LV2; the values for LSB would fall between LS1 and LS2.

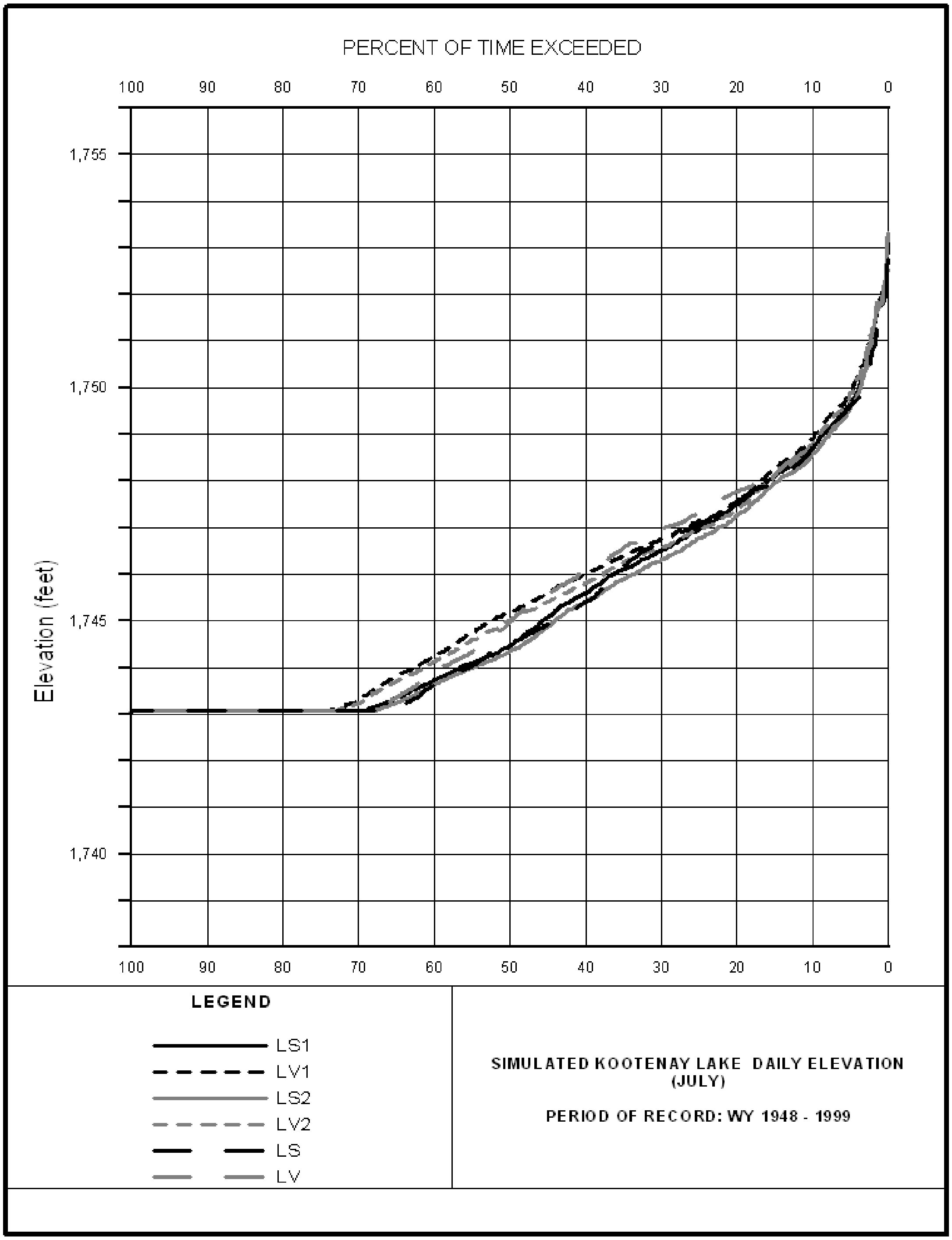

Figure 3-20. Elevation-Duration Analysis–Kootenay Lake Daily Elevation (July). The values for LVB fall between LV1 and LV2; the values for LSB would fall between LS1 and LS2.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Kootenai Lake elevations under LVB would fall between LV1 and LV2, since spill would not be achievable every year and it may not be possible to provide the full 10 kcfs above powerhouse capacity. When spill of 10 kcfs could be achieved (which would likely be more frequently than under LSB), its effect would be similar to LV2, depending on duration.

3.3.2 Water Quality

Generation of elevated levels of total dissolved gas resulting from spill at Libby Dam is the primary water quality impact associated with the different alternatives.

The hydroregulation modeling of the different operations (see Appendix B) provides estimates of spill and a basis for estimating dissolved gas generation at Libby Dam and dams further downstream on the Kootenai River.

The state of Montana maximum water quality standard for total dissolved gas saturation is 110 percent at any point in the river. Monitoring during the spill event that occurred at Libby Dam in 2002 enabled the Corps to determine the relationship between spillway flows and TDG saturation just downstream from the dam. Application of this relationship and the results of the hydroregulation modeling, allowed for tabulation of occurrences of TDG gas levels greater than 100 percent saturation due to spill. Potential effects of spill on water temperatures are discussed qualitatively by comparing relative temperature changes that may occur for different alternatives.

Water temperature can also be affected by using the Libby Dam selective withdrawal system. During the late spring, summer, and fall when the surface layers are warmer than deeper layers (i.e., when the reservoir is stratified), temperatures of the water released can be controlled to a certain extent by using the selective withdrawal system. Temperatures of spillway flows are not affected by use of the selective withdrawal system, so the ability to affect water temperature changes downstream from the dam using spillway flows is limited, as compared to operations using only the powerhouse.

Turbidity in Lake Koocanusa, the Kootenai River, or Kootenay Lake is not likely to be affected by any of the alternatives due to the lack of sediment transport past Libby Dam under any scenario. Lack of nutrient transport downstream past the dam may also be affecting turbidity by restricting the production of single-celled algae in the spring that would be suspended in the water and add to turbidity.

Nutrient levels downstream of Libby Dam will not be affected by any of the alternatives; it is the presence of the Lake Koocanusa itself that has decreased nutrients downstream.

Lake Koocanusa

Total dissolved gas above Libby Dam will not be affected by any alternative; the following alternative evaluations for this reach consider only water temperature.

All alternatives

Upstream from Libby Dam, water quality would likely be similar under all of the alternatives. The primary difference between alternatives is the amount of water stored in Lake Koocanusa during the winter and early spring. At the end of December, reservoir temperatures would be similar under all alternatives since the elevation of Lake Koocanusa and air (ambient) temperature would be the same. During January through April (Figure 3-7), the operations using Standard FC alternatives (LS1, LS2, and LSB) and the LS benchmark operation result in lower reservoir elevations than operations under VARQ FC (LV1, LV2, LVB and the LV benchmark operation). As the winter progresses, LS1, LS2, LSB and the LS benchmark operation could have as much as 40 percent less water in Lake Koocanusa when compared to the VARQ FC operations (LV1, LV2, LVB, and the LV benchmark operation). However, Lake Koocanusa is such a large and deep reservoir that it is difficult to predict how a 40 percent change in volume could impact water temperatures. Winter air temperatures, winter inflow volumes, refill rates, volumes of dam releases, and reservoir ice cover would all factor into wintertime reservoir water temperatures, with the end result that water temperatures in the reservoir during the winter would likely be similar under all alternatives.

In the late spring and summer, warming of surface layers of the lake is likely independent of reservoir volume, which would probably result in similar water temperature regimes under all alternatives. Fish flows would not affect water temperature in Lake Koocanusa.

Libby Dam to Kootenay Lake near Creston, BC

Spill at Libby under Alternatives LS1 and LV1 would occur as a result of flood control operations and are therefore considered involuntary. Alternatives LSB and LVB, developed in response to the 2006 USFWS Biological Opinion, include voluntary spill of up to 10 kcfs when reservoir and inflow conditions allow, and are analyzed concerning possible effects of that voluntary spill. Alternatives LS2 and LV2 involve releases of up to 10 kcfs above powerhouse capacity in all years with sturgeon flow augmentation. However, with these alternatives, the method of discharging the additional 10 kcfs was not identified, so estimates of TDG production for Alternatives LS2 and LV2 were not developed.

(LS1) Standard FC w/fish flows to powerhouse capacity (No Action Alternative)

Water Temperature

Water temperatures of dam outflows under LS1 would be similar to all other since the reservoir water temperatures, and consequently the temperatures available for selective withdrawal, would be similar regardless of the flood control operation. There is little information to suggest that intake water temperatures at the Kootenai Tribal hatchery at Bonners Ferry would change noticeably as a result of any alternative. Recognizing that available water temperatures in the reservoir may limit the ability to achieve optimal release temperatures, the Corps would continue to pursue temperature optimization from Libby Dam for burbot in winter (seeking near-freezing temperatures for spawning) and for sturgeon in spring (seeking warmer temperatures in May to aid migration and spawning). In that context, the Corps would continue to make operational adjustments using the selective withdrawal gates to ensure best access to desired temperatures in water to be withdrawn.

Total Dissolved Gas

Table 3-19 shows the number of years and the total number of days during the 1948-1999 period of record in which TDG levels exceeded saturation levels between 100 percent and 130 percent in the hydroregulation model simulations (Appendix B). Over the period of record, simulations of LS1 would result in spillway flows likely to cause TDG levels higher than the state standard of 110 percent saturation in one year for a total of 2 days. Simulations indicate that elevated TDG levels from spill would not have exceeded 115 percent in any year. Compared to the LS benchmark operation, the addition of fish flows in LS1 would serve to considerably reduce the frequency, duration, and amount of spill. Without fish flows added to operations under Standard FC, simulations indicate that TDG levels above 110 percent would occur in 11 out of the 52-year period of record for a total of 108 days, and TDG levels higher than 125 percent would occur in 6 of those years for a total of 41 days. In contrast to the assumptions inherent in the hydroregulation modeling simulations, real time management of Libby Dam refill provides the ability to reduce the possibility of involuntary spill. The reduction in spill due to fish flows under LS1 is beneficial from a water quality perspective and results primarily from lower elevations for Lake Koocanusa in the late spring and summer due to the fish flow releases.

Table 3-19. Simulated Number of Years and Number of Days of the 1948-1999 Period of Record In Which an Exceedance of Specified TDG Saturations Might Occur at Libby Dam [1]

	Threshold TDG saturation immediately below Libby Dam (%)						
	100%	**105%**	**110%**	**115%**	**120%**	**125%**	**130%**
Alternative	# of years (# of days)						
LS1	1 (3)	1 (3)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)
LV1	3 (31)	3 (31)	3 (31)	2 (25)	2 (25)	2 (24)	1 (12)
Benchmark							
LS	11 (108)	11 (107)	11 (102)	8 (61)	6 (43)	6 (41)	3 (27)
LV	13 (142)	13 (141)	13 (137)	8 (92)	7 (79)	7 (78)	5 (54)

[1] To achieve an additional 10 kcfs above existing powerhouse capacity under Alternatives LS2 and LV2 without exceeding the state of Montana TDG standard of 110 percent saturation, Libby Dam would require some type of modification (spillway modifications, installation of additional units, etc). Predictions of TDG production for Alternatives LS2 and LV2 are not possible at this time since these currently unknown modifications would almost certainly affect the relationship between dam discharge and TDG generation.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Water Temperature

Water temperatures in the river would be similar to those under LS1, though it is possible that if cold winter air temperatures are present as water flows downriver, the VARQ FC operation may be more effective at cooling as compared with Standard FC.

Total Dissolved Gas

Over the 1948-1999 period of record, simulations of LV1 resulted in spill likely to cause TDG levels higher than the state standard of 110 percent saturation in 3 years over a total of 31 days, as a result of flood control operations. In 2 of those years over a total of 24 days, TDG levels from spill would have exceeded 125 percent saturation. In contrast to the assumptions inherent in the hydroregulation modeling simulations, real time management of Libby Dam refill provides the ability to reduce the possibility of involuntary spill. Spill events under LV1 that result in elevated TDG would be rare and of short duration, but more common and longer duration than spill events under LS1. Compared to the LV benchmark operation, the addition of fish flows in LV1 would serve to considerably reduce the frequency, duration, and amount of spill. Without fish flows added to operations under VARQ FC, simulations indicate that TDG levels above 110 percent would occur in 13 years out of the 52-year period of record for a total of 137 days, and TDG levels higher than 125 percent would occur in 7 of those years for a total of 78 days. The reduction in spill due to the fish flows under LV1 would be beneficial from a water quality perspective, and results primarily from depressed elevations for Lake Koocanusa in the late spring and summer.

Changes in periods involuntarily exceeding 120 percent TDG saturation may be significant between LV1 and LS1.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs, and
(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Water Temperature

Except during the spring sturgeon flow augmentation, water temperatures in the river would be similar to those under LS1, though it is possible that if cold winter air temperatures are present as water flows downriver, the VARQ FC operation may be more effective at cooling as compared to Standard FC. During the spring sturgeon flow augmentation, water temperatures in the river downstream of Libby Dam could be slightly cooler than under LS1 or LV1 since water temperatures available in the reservoir would tend to be cooler than ambient river temperatures during the spring and the cooler dam outflows under LS2 or LV2 would be a relatively larger component of total river flow.

Total Dissolved Gas

While this EIS evaluates the effects of the increased sturgeon flow threshold for LV2, the mechanism by which such flows would be achieved at Libby Dam under this alternative was not identified. To achieve an additional 10 kcfs above existing powerhouse capacity without exceeding the State of Montana TDG standard of 110 percent maximum saturation, Libby Dam would require some type of modification (spillway modifications or installation of additional units) (Corps 2005). Such modifications would almost certainly affect the relationship between dam releases and TDG generation or water temperatures during the sturgeon flow augmentation. As such, water quality impacts for Alternatives LS2 and LV2 are not known.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Water Temperature

During sturgeon flows that are at or below powerhouse capacity (in about 75 percent of years), water temperatures in the river would be similar to those under LS1. When sturgeon flows include up to 10 kcfs of spillway releases (in about 25 percent of years), water temperatures may be slightly warmer than the other alternatives due to release of near-surface water from Lake Koocanusa.

Total Dissolved Gas

The probability of involuntary flood control spill under alternative LSB would fall in a range between that under LS1 and LS2. To the extent possible within flood control capabilities, years with potential flood control spills would likely be managed to provide the sturgeon flow augmentation using spillway flows.

Under Standard FC, review of the monthly modeling data shows that the appropriate conditions to allow for releases of sturgeon flows via the Libby Dam spillway would occur for some period of time in approximately 25 percent of years. In the remaining 75 percent of years, TDG levels in the Kootenai River would typically be close to 100 percent saturation near Libby Dam and not affected by Libby Dam operations.

Monitoring of spill events in 2002 (Coastal and Hydraulics Laboratory 2003) provided information for evaluation of likely TDG levels that would result from spillway releases from Libby Dam for sturgeon flows. Release of more than 500 cfs of spill would elevate TDG levels in the Kootenai River between Libby Dam and Kootenai Falls. At releases of the full 10 kcfs, TDG levels immediately below the Libby Dam stilling basin would be approximately 134 percent saturation. Further downstream, dissolved gases in the spilled water would slowly dissipate and the spilled water would gradually mix with powerhouse releases and tributary inflows. At the Thompson Bridge about 0.6 miles downstream of the dam, TDG levels along the left bank of the river would be about 125 percent saturation while TDG levels along the right bank would continue to be about 100 percent saturation.

Spillway and powerhouse releases would be well mixed by approximately 8 miles downstream of the dam (near the haul bridge abutments) with TDG levels about 112 percent saturation throughout the river. TDG levels would continue to slightly decrease as the river flows toward Kootenai Falls (about 29 miles downstream of the dam). Immediately upstream of the falls, TDG levels with 10 kcfs of Libby spill would be about 109 percent saturation. At Kootenai Falls, TDG levels would be re-set by the natural turbulence of the falls, with TDG levels below the falls at 116 to 118 percent saturation under any spill or river flow condition.

In some years under LSB, the full 10 kcfs of spill may not be necessary to achieve the desired river conditions near Bonners Ferry for sturgeon, or water supply (reservoir level and inflow) may not allow providing the full 10 kcfs. All spillway releases greater than about 5 kcfs would result in similar peak TDG levels immediately below the dam. Under these circumstances, the relatively lower proportion of river flow with high TDG levels would result in lower average TDG levels once the river mixes within 8 miles of the dam. For example, at a spill of 5 kcfs, the average TDG level in the river at the haul bridge would be about 109 percent saturation; at 7 kcfs, the average TDG level at the haul bridge would be about 111 percent saturation.

As described above, voluntary spill for sturgeon under LSB would generate TDG levels that exceed Montana water quality standards under current guidelines. The Corps will coordinate with Montana on water quality issues concerning implementation of voluntary spill.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Water Temperature

Water temperatures under LVB would tend to be similar to those under LSB, but years with slightly warmer water possible due to spillway releases would tend to occur about twice as often than under LSB (in about 50 percent of years for LVB versus 25 percent of years for LSB). It is possible that if cold winter air temperatures are present as water flows downriver, the VARQ FC operation may be more effective at cooling as compared to Standard FC.

Total Dissolved Gas

The probability of involuntary flood control spill under alternative LVB would fall within a range between that under LV1 and LV2. To the extent possible within flood control capabilities, years with potential flood control spills would likely be managed to provide sturgeon flow augmentation using spillway flows.

Under VARQ FC, review of the monthly modeling data shows that the appropriate conditions to allow for releases of sturgeon flows from the Libby Dam spillway for some period of time occurs in approximately 50 percent of years (compared to about 25 percent of years for LSB). In these years, TDG levels in the river would be similar to those described for LSB above. Once water from the spillway and powerhouse mixed, average TDG levels in the river may be higher under LVB than LSB since reservoir elevations under VARQ FC would tend to be higher and more likely to support more spill (i.e. the reservoir level is more likely to be higher than the dam's spillway crest under VARQ FC than Standard FC, which increases the ability to provide spillway flows that approach 10 kcfs). In years when sturgeon flows are limited to powerhouse capacity, TDG levels in the Kootenai River would typically be close to 100 percent saturation near Libby Dam and not affected by dam operations.

As described above, voluntary spill for sturgeon under LVB would generate TDG levels that exceed Montana water quality standards under current guidelines. The Corps will coordinate with Montana on water quality issues concerning implementation of voluntary spill.

Kootenay Lake to the Confluence with the Columbia River

All Alternatives

Total Dissolved Gas

The data provided by Canadian stakeholders on the frequency, duration, and magnitude of TDG supersaturation that would result from the different alternatives indicates that the alternatives with fish flows would be expected to increase the duration and magnitude of supersaturated TDG conditions generated by hydropower dams on the Kootenay River downstream of Kootenay Lake. Compared to the Standard FC alternatives, the VARQ FC alternatives would also increase the duration and magnitude of flows that can contribute to supersaturated TDG conditions downstream of Canadian hydroelectric projects. The potential increases in generation of supersaturated TDG resulting from fish flows and VARQ FC may offset the potential benefits of reduced dissolved gas saturation levels realized under the Brilliant Expansion power project that is currently being constructed. Supersaturated conditions would persist into the mainstem Columbia River and occur primarily during the spring runoff period.

3.3.3 Aquatic Life

Biological consequences of alternatives LS1, LV1, LS2 and LV2, as well as benchmarks LS and LV were analyzed using computer models that were calibrated for the reservoir (Marotz *et al.* 1996) and river using field measurements. (LSB and LVB were added as alternatives following the modeling, but except for spill and TDG effects, their impacts are similar to or within the range of LS1 and LS2 for LSB, and LV1 and LV2 in the case of LVB.) Hydrologic data provided by the Corps were used as the basis for assessment of the effects of on fish and aquatic productivity above and below Libby Dam for the alternatives and benchmarks. Nine years ranging from medium dry to medium wet (20th to 80th percentile water years in terms of inflows to Lake Koocanusa) were selected for analysis. The biological models incorporated various assumptions regarding initial reservoir conditions at the start of each water year on October 1; growth parameters for kokanee salmon in Lake Koocanusa; hydrologic physical framework, temperature regime, and food web levels in Lake Koocanusa (Marotz *et al.* 1996); and recovery rates for benthic production following dewatering. Complete details on the assumptions and framework of the biological modeling can be found in Appendix D. The biological analysis for Lake Koocanusa and the Kootenai River is similar to that for Hungry Horse Reservoir and the Flathead River.

Model outputs for Lake Koocanusa provide estimates of primary productivity, zooplankton production, benthic insect production, terrestrial insect deposition, and kokanee growth.

Model outputs for the Kootenai River downstream from Libby Dam provide indices of benthic biomass productivity between the biologically productive months of March and September. Alternatives and benchmark operations were subsequently ranked based on time-series analyses of the growth and decay of benthic biomass.

These models did not evaluate effects of total dissolved gas from spill; however, an evaluation of effects of TDG from spill is included in this section, particularly regarding alternatives LSB and LVB.

See Appendix D for detailed discussions of the methodology and results of the biological modeling.

Lake Koocanusa

Different Libby Dam operations have the potential to affect aquatic life in Lake Koocanusa due to differences in reservoir fluctuations throughout the year. Biological factors evaluated for Lake Koocanusa included primary productivity, zooplankton biomass, benthic insect production, terrestrial insect deposition, and kokanee growth.

Summary

Primary productivity, zooplankton productivity, terrestrial insect deposition, and kokanee growth in the reservoir would tend to be higher under operations that provide higher reservoir levels during the spring, summer, and early fall. In general, the flood control operation tends to influence reservoir elevation more than the fish flows do, with the substantially higher summer reservoir elevations under the VARQ FC alternatives. As a result, primary productivity, benthic production, terrestrial insect deposition, and kokanee growth in Lake Koocanusa would tend to be substantially higher under the VARQ FC alternatives (LV1, LV2, LVB) and the LV benchmark operation when compared to the corresponding Standard FC alternative (LS1, LS2, LSB) or the LS benchmark operation. Fish flows tend to result in lower summer reservoir levels and, as a consequence, substantially lower reservoir productivity (as compared to the LS or LV benchmark operations that would tend to maintain near-full reservoir levels throughout the summer), but the differences in reservoir productivity between the different fish flow operations are relatively small.

Entrainment rates under the VARQ FC alternatives (LV1, LV2, LVB) and the LV benchmark operation would generally be slightly higher than those under the corresponding Standard FC alternative or benchmark. Entrainment rates under LV1 would be slightly higher than the other alternatives, and, due to lower summer outflows, entrainment under LS2, LV2, LSB, and LVB would be slightly lower than LS1 and LV1. The incremental effect of fish flows with the Standard FC alternatives would substantially increase entrainment. For the VARQ FC alternatives, the incremental effect of the fish flows would be very minor in comparison to LV. Under all alternatives, kokanee would be the dominant species entrained (Skaar *et al.* 1996). Given other variables with relatively larger effects on kokanee stocks (predation, fishing pressure, density dependence), the relatively small changes in entrainment rates under the various alternatives would not likely affect the abundance or size of Lake Koocanusa kokanee.

Primary Production

Primary production by reservoir phytoplankton (microscopic drifting plants) refers to the conversion of light and nutrients into organic carbon and resulting phytoplankton growth and biomass. The biological model is sensitive primarily to reservoir surface area, volume, and water temperature at different depths in the reservoir. Primary production was quantified as the number of metric tons of organic carbon for each alternative as shown in Figure 3-21. Washout of phytoplankton through Libby Dam was quantified as the number of metric tons for each alternative, as shown in Figure 3-22.

All Standard FC alternatives (LS1, LS2, LSB)

Because reservoir levels during the summer and fall would tend to be lower under LS1, LS2, and LSB, primary productivity under these alternatives would be the lower than the

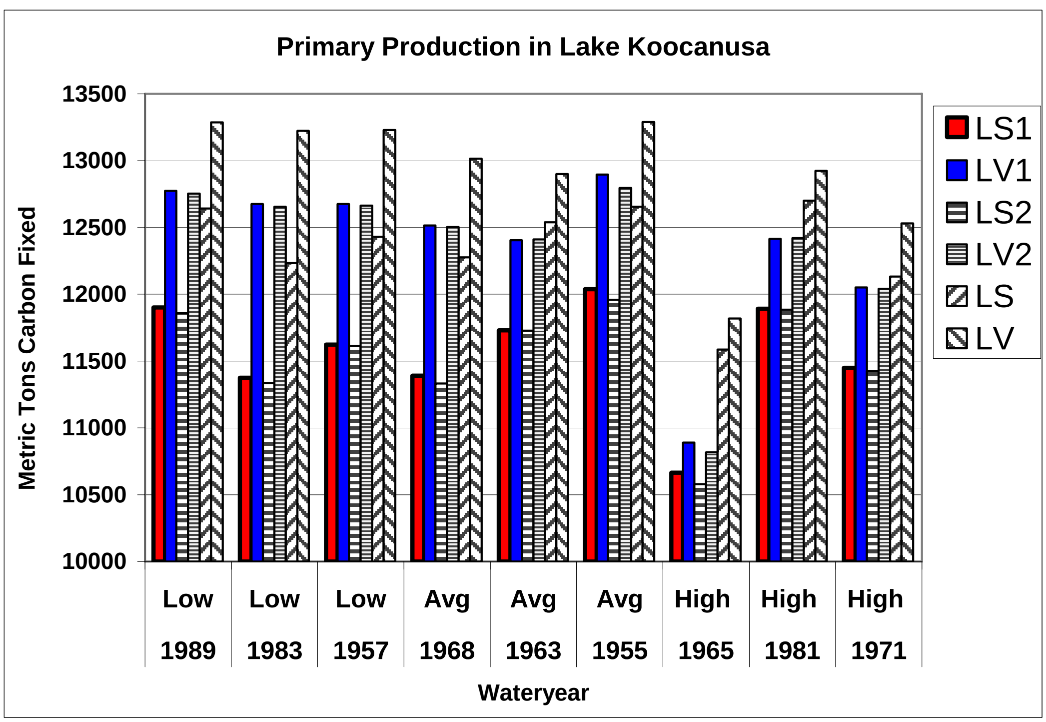

Figure 3-21. Primary Production Calculations (Metric Tons of Carbon Fixed by Phytoplankton) for the Alternative and Benchmark Dam Operations. The values for LVB would fall between LV1 and LV2; the values for LSB would fall between LS1 and LS2.

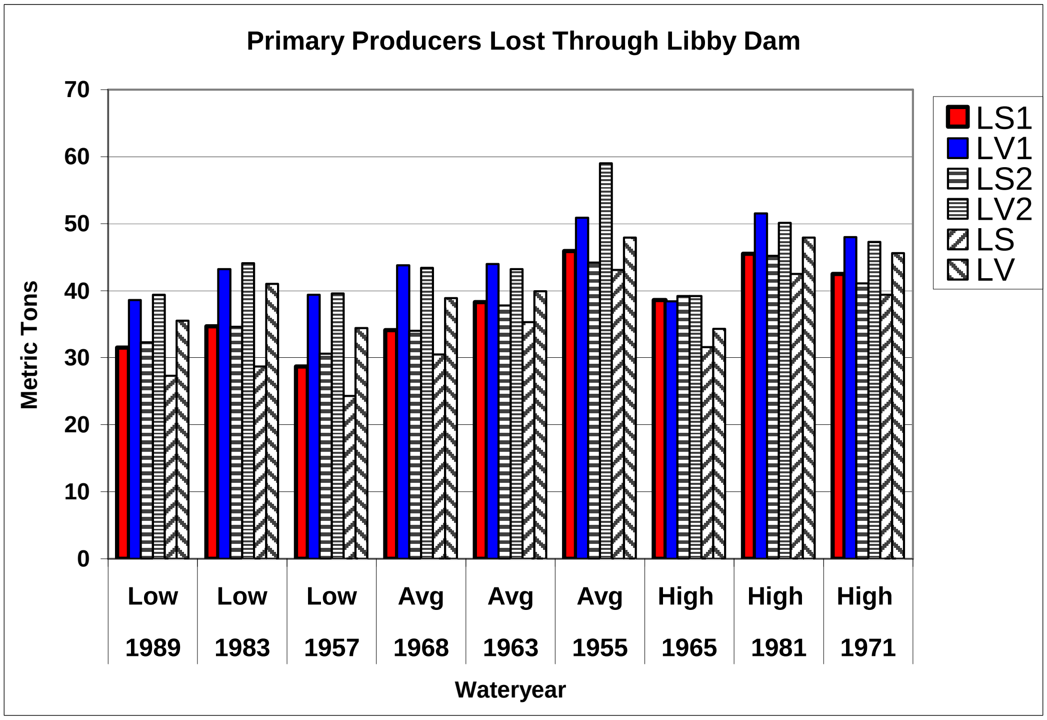

Figure 3-22. Estimated Loss of Primary Producers Through the Dam Resulting for the Alternative and Benchmark Dam Operations. The values for LVB would fall between LV1 and LV2; the values for LSB would fall betweenLS1 and LS2.

corresponding VARQ FC alternative. The addition of fish flows would tend to decrease primary productivity. Since it would tend to maintain near full reservoir levels through the summer, primary productivity under the LS benchmark operation would be higher than that under either LS1, LS2, or LSB.

Loss of primary production due to washout of phytoplankton through Libby Dam would be similarly low under LS1 and LS2. As expected, release of fish flows during the spring and summer increases washout of phytoplankton due to higher dam releases for fish flows when compared to the LS benchmark operation. Under all of the alternatives, washout losses represent a small fraction of the overall production in Lake Koocanusa and provide a trophic gain to the Kootenai River.

Primary production under LSB would be within the range between LS1 and LS2. Though there may be some differences between losses over the spillway and those through the turbines, the washout of phytoplankton as a result of LSB would likely fall within the range between LS1 and LS2.

All VARQ FC alternatives (LV1, LV2, LVB)

Summer and fall reservoir levels under LV1, LV2, and LVB would tend to be higher than the corresponding Standard FC alternatives, and primary productivity would be similarly high. In most average or dry years, primary production under LV1 and LV2 would tend to be higher than even the LS benchmark operation. As with the Standard FC alternatives, the addition of fish flows would result in lower reservoir levels and corresponding lower primary productivity when compared to the LV benchmark operation (which would have higher primary production than all the alternatives since it would provide the highest reservoir levels during the spring and summer).

Phytoplankton washout under LV1 andLV2 would be the highest of all alternatives analyzed, but still represent a small fraction of the overall production in Lake Koocanusa while providing a trophic gain to the Kootenai River. The high dam releases during the spring refill under VARQ FC and more primary production in the reservoir through the summer would be expected to result in higher phytoplankton washout. Compared to the LV benchmark operation, fish flows under LV1 and LV2 tend to increase dam releases and consequently phytoplankton washout.

Primary production under LVB would be within the range between LV1 and LV2. Though there may be some differences between losses over the spillway and those through the turbines, the washout of phytoplankton as a result of LVB would likely fall within the range of that for LV1 and LV2.

Zooplankton Production

Zooplankton are drifting animals that consume primarily phytoplankton and, in turn, are eaten by animals higher in the food web. Once produced, zooplankton survive in the reservoir for an indefinite period until they are eaten by predators (e.g., fish and other invertebrates), die from natural causes and sink, or are lost through the dam, which would benefit their predators downstream. Enough individuals survive through fall and winter that zooplankton provide the primary winter food for fish species that do not prey on fish (including westslope cutthroat trout and juvenile bull trout). Zooplankton are the primary food supply of kokanee throughout their lives. More zooplankton means more kokanee growth. Operations that maximize surface area and volume during summer would produce the most zooplankton; food availability is largely controlled by reservoir surface area and volume during the productive summer months. Zooplankton production was quantified as the number of metric tons of zooplankton produced for LS1, LV1, LS2, LV2, and benchmarks LS and LV, as shown in Figure 3-23.

All Standard FC alternatives (LS1, LS2, LSB)

In general, LS1, LS2, and LSB would have lower reservoir elevations during spring than the corresponding VARQ FC alternatives, which would result in a slower buildup of

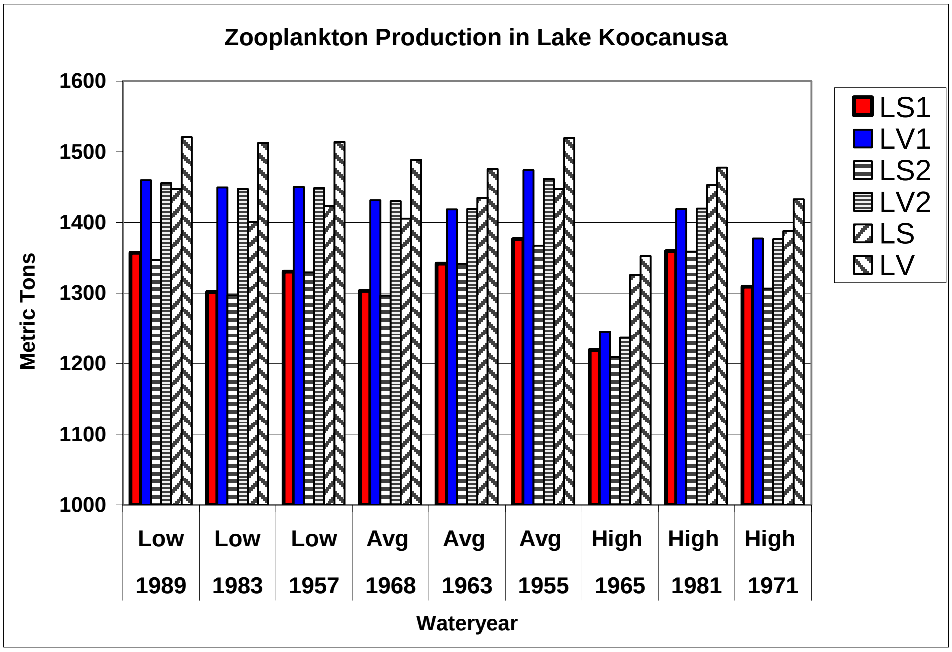

Figure 3-23. Zooplankton Production (Metric Tons) in Lake Koocanusa for the Alternative and Benchmark Dam Operations. LVB values would range between those for LV1 and LV2; LSB values would range between LS1 and LS2 values.

zooplankton biomass and generally lower zooplankton production. As water supply increases (i.e., in wetter years), the differences in reservoir elevation between Standard and VARQ FC become small, with zooplankton production also becoming similar under the corresponding Standard and VARQ FC operations.

Because of relatively low reservoir levels during the summer, zooplankton production under LS1 and LS2 would tend to be lower than the VARQ FC alternatives. Except for wetter years, the addition of fish flows tends to adversely affect zooplankton production (as compared to the LS benchmark operation) by decreasing the elevation and volume of the reservoir in the productive summer months. Similar to the pattern for phytoplankton production, the LS benchmark operation would tend to maintain near full reservoir levels through the summer, which would result in zooplankton productivity that would be higher than that under either LS1 or LS2.

LSB would tend to result in zooplankton production intermediate to LS1 and LS2, because it would not result in spill every year, and the amount and duration of spill would be variable in comparison to LS2 values for outflow. Zooplankton production under LSB would be lower than for benchmark LS because spill for fish under LSB would reduce reservoir refill capability in comparison to LS.

All VARQ FC Alternatives (LV1, LV2, LVB)

Compared to the Standard FC alternatives, higher reservoir levels during spring refill through the summer under LV1, LV2, and LVB would create a larger volume of optimal temperature water as zooplankton production increased toward the summer maximum, which would result in faster buildup of zooplankton biomass and more zooplankton production. As a result, zooplankton production under LV1 and LV2 would be among the highest of any of the alternatives, and higher than any of the Standard FC alternatives in most years. As with the Standard FC alternatives, the addition of fish flows tends to adversely affect zooplankton production (as compared to the LV benchmark operation) by decreasing the elevation and volume of the reservoir in the productive summer months. Again similar to the pattern for phytoplankton production, the LV benchmark operation would tend to maintain higher reservoir levels through the summer than any of the alternatives, which would result in zooplankton productivity that would be higher than any of the alternatives.

LVB would tend to result in zooplankton production intermediate to LV1 and LV2, because it would not result in spill every year, and the amount and duration of spill would be variable in comparison to LV2 values for outflow. Zooplankton production under LVB would be lower than for benchmark LV because spill for fish under LVB would reduce reservoir refill capability in comparison to LV.

Benthic Insect Production

Many insects lay their eggs in water, with early life stages (larvae) residing primarily on or associated with the reservoir bottom after hatching. They are important to aquatic ecosystems and serve as food sources for many fish. Larger, long-lived species dominate the permanently wetted zone, whereas the varial zone contains mainly small, short-lived species. Larvae recolonize previously dewatered substrates as the reservoir fills, and shoreline areas are dominated by dipterans (flies) that produce cohorts throughout the warm summer months (Chisholm *et al.* 1989). In reservoirs, annual production of benthic insects is controlled by the duration and depth of substrate inundation as the reservoir refills and drafts. Benthic insect production was quantified as the number of metric tons of benthic production for LS1, LV1, LS2, LV2, and benchmarks LS and LV, as shown in Figure 3-24.

All Standard FC Alternatives (LS1, LS2, LSB)

In general, LS1, LS2, and LSB would have lower benthic production than their corresponding VARQ FC alternative. The primary reason is that deep reservoir drafts under Standard FC during the winter and early spring would desiccate substrates containing high larval densities from previous summers. As with zooplankton production, the differences between Standard and VARQ FC alternatives would decrease during wetter years since these years would all have similar flood control drafts regardless of alternative. The addition of fish flows under LS1 and LS2 appears to enhance benthic insect production as compared to the LS benchmark operation, but this finding may be an artifact of controlling the reservoir level to full pool at the start of each water year for the LS benchmark operation, which then would tend to cause greater dessication of productive substrate in the subsequent flood control draft and decreased benthic production the next year.

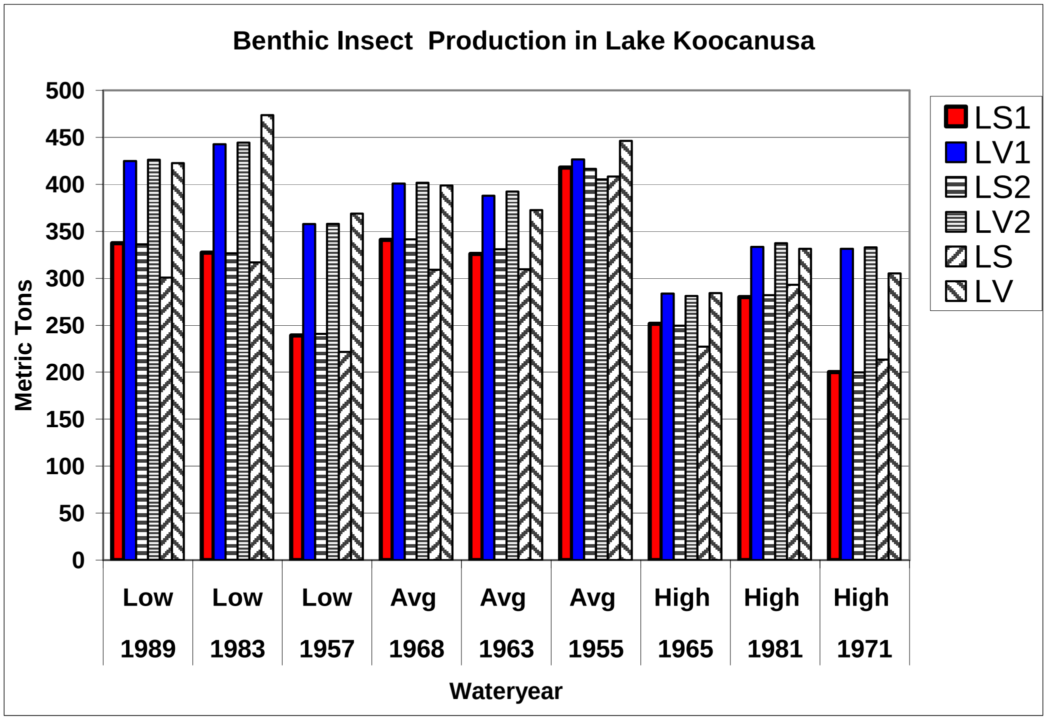

Figure 3-24. Estimates of Benthic Biomass Production in Lake Koocanusa Summarized for the Alternative and Benchmark Dam Operations. LVB values would range between those for LV1 and LV2; LSB values would range between LS1 and LS2 values.

Benthic insect production under LSB would be intermediate to LS1 and LS2, because compared to LS2, reservoir elevations would be more variable under LSB.

All VARQ FC Alternatives (LV1, LV2, LVB)

LV1, LV2, and LVB would tend to produce higher benthic production than the Standard FC alternatives, likely because of less drafting for flood control and higher reservoir levels during the summer and early fall. This finding highlights that relatively shallow reservoir draft for flood control in average runoff years under VARQ FC would benefit benthic production in following months. Fish flows appear to have only minor influence of benthic productivity, with benthic productivity under the LV benchmark operation would tend to be slightly higher in some years to that under LV1 and LV2, but generally similar in most years.

LVB would result in average benthic insect production intermediate to LV1 and LV2, because on average, reservoir levels under LVB would likely be intermediate to the other two VARQ FC alternatives, and possibly lower than with benchmark LV.

Terrestrial Insect Deposition

Insects that fall into the water provide another important source of food for fish. That deposition is greatest when the reservoir is full and therefore closest to shoreline vegetation where the insects are found. Of the four orders of terrestrial insects captured in nearshore (< 100 m) and offshore surface sampling, bees and wasps (Hymenoptera) were the most abundant by weight in surface sampling and by numbers in trout stomach contents (Chisholm *et al.* 1989). During each simulation, the model calculated insect deposition as the percentage of the maximum possible deposition if the reservoir remained at full pool when each insect order is active (see Appendix D for more detailed discussion of terrestrial insect deposition).

All Standard FC Alternatives (LS1, LS2, LSB)

Summer, and early fall, terrestrial insect deposition under LS1, LS2, and LSB would be the lower than the corresponding VARQ FC alternative. Relatively low reservoir levels under LS1 and LS2 would result in less reservoir surface area and the water's edge far away from fringing shoreline vegetation, both of which tend to reduce deposition of terrestrial insects. The addition of fish flows tends to decrease reservoir levels, particularly during the productive summer months, which would result in decreased terrestrial insect deposition (as compared to the LS benchmark operation).

Because of the variable reservoir elevations associated with LSB, terrestrial insect deposition under that alternative would likely be intermediate between LS1 and LS2, and thus lower than for LS.

All VARQ FC Alternatives (LV1, LV2, LVB)

Terrestrial insect deposition under LV1 and LV2 would be the highest of all alternatives. This is primarily due to higher reservoir levels, which lead to greater reservoir surface area and the water's edge closer to fringing shoreline vegetation. The addition of fish flows would tend to result in decreased terrestrial insect deposition (as compared to the LV benchmark operation, which would have higher insect deposition than any of the alternatives). LV1, LV2, LVB, and the LV benchmark operation would result in consistently higher beetle (Coleoptera) deposition than any of the Standard FC alternatives.

Deposition of terrestrial insects under LVB would be within the range of values exhibited for LV1 and LV2, but probably lower than for the LV benchmark.

Growth and Entrainment of Kokanee and Other Fish in Lake Koocanusa

Kokanee growth was modeled for this evaluation; inferences may be made concerning growth of other fish species in Lake Koocanusa. Model calculations of kokanee growth are sensitive to food availability and the volume of water at optimal temperatures for fish growth. Kokanee diet is almost exclusively zooplankton. Growth trajectories for age I and II kokanee were calculated for each water year, then summarized into annual growth in weight (g) (see Appendix D for detailed results).

Skaar *et al.* (1996) found that entrainment rates for kokanee are dependent upon dam outflow and the density of fish in the forebay. Kokanee entrainment for each alternative was estimated using a regression model and average seasonal fish densities from Skaar *et al.* (1996), and the simulated daily Libby Dam releases for each alternative/benchmark over the 1948-1999 period of record. The outflow values are a composite of modeling results from the local flood control (Appendix B) and system hydropower modeling (Appendix J). This composite data set provides the most representative year-round estimate of daily Libby Dam releases.

(LS1) Standard FC w/ fish flows to powerhouse capacity
(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

Kokanee may be entrained at any time of year. Table 3-20 shows the estimated average annual number of kokanee entrained by Libby Dam for alternatives LS1, LV1, LS2 and LV2, and benchmarks LS and LV. Estimated kokanee entrainment for LS1 and LS2 would be similar to the other alternatives, with slightly lower entrainment under LS2 (likely due to lower summer releases). Due to higher releases for sturgeon and salmon in the spring and summer when kokanee entrainment rates are typically high, the addition of the fish flows for Standard FC would substantially increase kokanee entrainment (compared to the LS benchmark operation). Given other variables with relatively larger effects on kokanee stocks (predation, fishing pressure, density dependence), the relatively small changes in entrainment rates under the various alternatives would not likely affect the abundance or size of Lake Koocanusa kokanee. Those that are entrained through the penstocks are likely to suffer injuries; about a quarter of those would be fatal (Skaar *et al.* 1996).

Kokanee are generally in the top 20 meters of Lake Koocanusa during the spring, according to Skaar *et al.* (1996). Under LS1 and LS2, turbine intakes as near to the surface as practicable would be used to optimize release temperatures for sturgeon. Some kokanee may be entrained over the spillway during involuntary spill under LS1 or LS2, or under benchmark LS.

Table 3-20. Estimated Average Annual Kokanee Entrainment at Libby Dam. Entrainment of kokanee for LVB would be within the values for LV1 and LV2, and kokanee entrainment under LSB would be within the range of LS1 and LS2.

Alternative	Estimated Average Annual Number of Entrained Kokanee	% Change (compared to LS1)
LS1	2,494,465	n/a
LV1	2,509,892	+0.62
LS2	2,452,103	-1.70
LV2	2,455,096	-1.58
Benchmark		
LS	1,282,255	-48.60
LV	2,475,616	-0.76

Other fish species may also be entrained in relatively small numbers in addition to kokanee for any alternative or benchmark.

Consistent with other biological parameters for lower trophic levels, kokanee growth under LS1 and LS2 would be less than for the VARQ FC alternatives. This result is logical since kokanee growth depends on overall reservoir productivity, which also would tend to be relatively low under LS1 and LS2. The addition of fish flows to Standard FC tends to decrease overall reservoir level and the resulting reservoir productivity and kokanee growth (compared to the LS benchmark operation).

Growth of other species would be greater or less depending on availability of their food organisms. Because of greater availability of insects under benchmark LS in comparison to alternatives LS1 or LS2, cutthroat trout, for instance, may exhibit better growth and possibly reproduction under the LS benchmark compared to the alternatives. Greater growth or abundance of kokanee under LS may favor growth and possibly reproduction of bull trout, rainbow and other fish consumers in comparison to LS1 or LS2. Standard FC alternatives would be less conducive to growth than would VARQ FC alternatives.

(LV1) VARQ FC w/ fish flows to powerhouse capacity
(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Estimated kokanee entrainment would be highest of all alternatives under LV1, although still only slightly higher than LS1, LS2, or LV2. Entrainment under LV2 would be slightly lower than that under LS1, slightly more than under LS2. Since releases during refill tend to be higher under VARQ FC operations, the addition of fish flows for VARQ FC would only slightly increase kokanee entrainment (compared to the LV benchmark operation. Kokanee may be entrained over the spillway during involuntary spill under alternatives LV1 or LV2, as well as benchmark LV. Injuries, some fatal, may result to kokanee transiting the penstocks, or spillway in the case of involuntary spill.

In addition to kokanee, a few individuals of other fish species may be entrained under any of the VARQ alternatives or the LV benchmark.

Consistent with other biological parameters for lower trophic levels, kokanee growth under LV1 and LV2 would be the highest of all alternatives. The addition of fish flows to VARQ FC tends to decrease overall reservoir level and the resulting reservoir productivity and kokanee growth (compared to the LV benchmark operation which would have higher kokanee growth than any of the alternatives).

Growth under LV2 would be lower than under benchmark LV or LS.

Growth of other species would be greater or less depending on availability of their food organisms. Because of greater availability of insects under benchmark LV in comparison to alternatives LV1 or LV2, cutthroat trout, for instance, may exhibit better growth and possibly reproduction under the LV benchmark compared to the alternatives. Greater growth or abundance of kokanee or other smaller fish under LV may favor growth and possibly reproduction of bull trout, rainbow and other fish consumers in comparison to LV1 or LV2. VARQ FC alternatives would favor fish growth more than would Standard FC alternatives.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

LSB assumes use of the spillway in about 25 percent of years to release up to 10 kcfs of flow for up to 14 days. Under LSB, fish, primarily kokanee, would be subject to springtime spillway entrainment as well as turbine entrainment. Fish which are entrained via the spillway may be less likely to be injured, at least through sudden pressure changes, as they would be going through turbines, but there may be mechanical injuries associated with plunge into the stilling basin. Because release of flows above powerhouse capacity under LSB would be variable in terms of frequency and magnitude compared to LS2, the average entrainment values for kokanee would be intermediate between LS1 and LS2. It would be higher than for benchmarks LS and LV.

Growth of kokanee and other fish species under LSB would be within the range between LS1 and LS2, because of the variable frequency, magnitude and potentially duration of releases above powerhouse for LSB compared with LS2. It would be lower than for the LS or LV benchmark.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Similar to LSB in relation to LS1 and LS2, it is expected that entrainment of kokanee under LVB would be within the range between LV1 and LV2, and higher than for benchmark LV. There may be turbine or spillway-related injuries to entrained kokanee.

Under alternative LVB, growth of kokanee and other fish species would probably be within the range of values between LV1 and LV2, due to the variable frequency and magnitude, as well as duration, of releases above powerhouse capacity for LVB compared with LV2.

Libby Dam to Kootenay Lake near Creston, BC

Modeling calculated the amount of benthic biomass in separate reaches between Libby Dam and Kootenai Falls, and between Kootenai Falls and Bonners Ferry, Idaho. Operations that limit flow fluctuations and dewatering of productive substrate (meaning that the zone of fluctuation, or varial zone, is relatively narrow) generally enhance benthic biomass production. For each water year, model output totaled benthic biomass units for the period March 1 through September 30, as shown in Figure 3-25 and Figure 3-26.

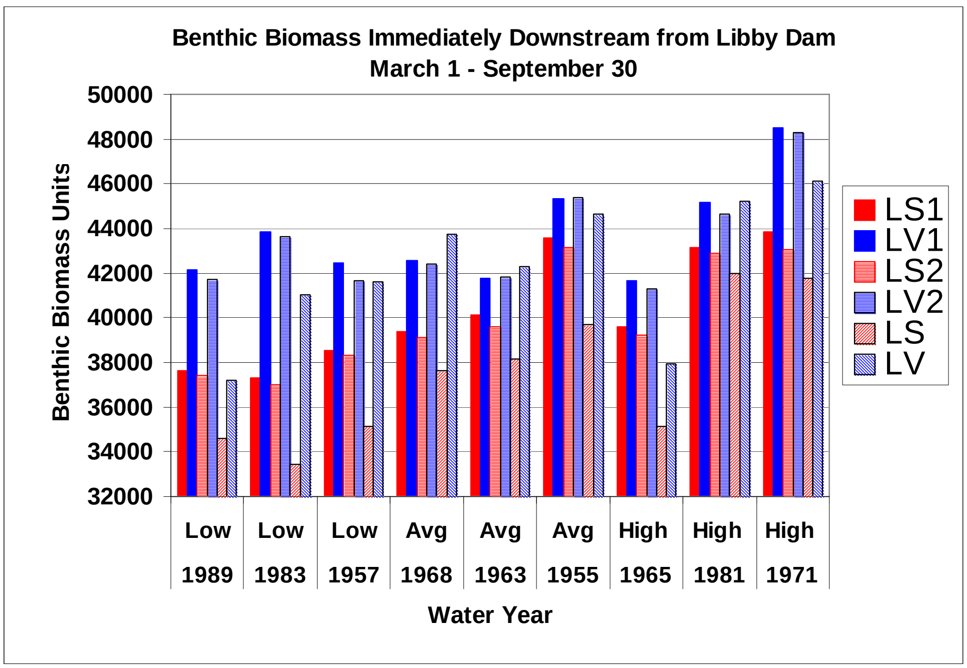

Figure 3-25. Simulated Benthic Biomass Units Accrued During the Period March 1 - September 30 in the Kootenai River Immediately Downstream from Libby Dam. LVB values would range between those for LV1 and LV2; LSB values would range between LS1 and LS2 values.

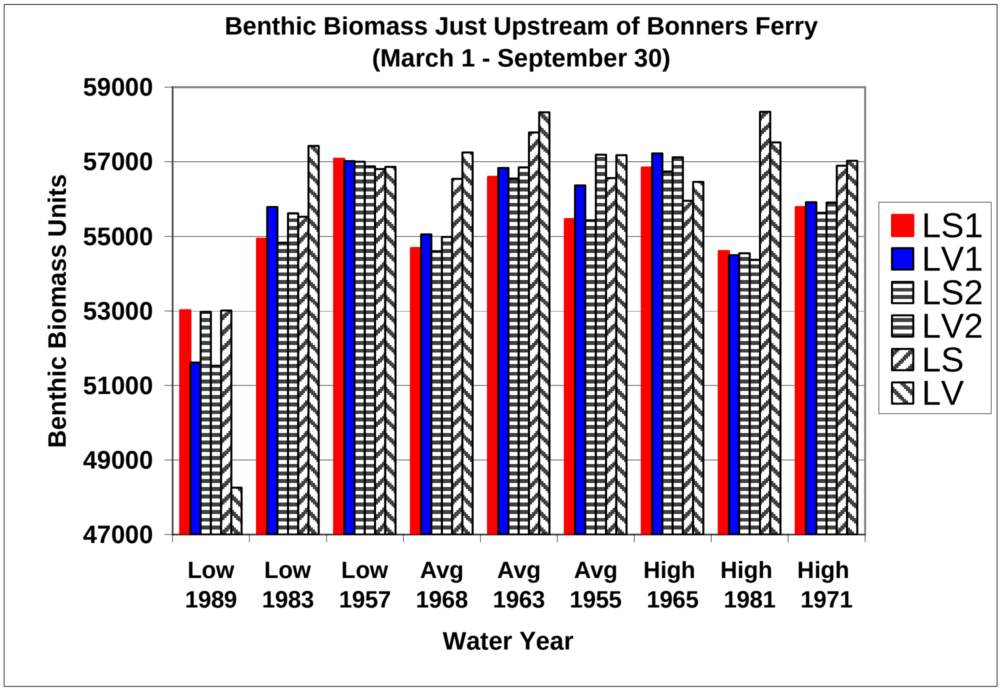

Figure 3-26. Simulated Benthic Biomass Units Accrued During the Period March 1 - September 30 in the Kootenai River Upstream from Bonners Ferry, Idaho. LVB values would range between those for LV1 and LV2; LSB values would range between LS1 and LS2 values.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)
(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

Differences between the alternative operations would be most apparent between Libby Dam and Kootenai Falls. Of the alternatives, LS1 would produce the highest benthic biomass of all the Standard FC alternatives in this upstream reach between the dam and Kootenai Falls. Benthic production under LS2 would be similar to LS1, but slightly lower. With the exception of years like 1965 and 1989 when the LV benchmark operation results in a double-peak hydrograph[29] during the late spring, benthic biomass under LS1 and LS2 is lower than under any of the VARQ FC operations. The addition of fish flows would tend to increase benthic biomass, as compared to the LS benchmark operation. The modeling indicates very slight risk of Libby Dam spill above the maximum sturgeon flow release under LS1, which means that potential harm to aquatic life due to long-duration periods with excessive TDG levels would be extremely unlikely. The addition of fish flows tends to considerably decrease the risk of harm to aquatic life that could result from elevated TDG levels due to involuntary spill. Fish, including white

[29] A double peak hydrograph occurs when high spring discharges drop to low flows in the late spring, only to rise to high levels several weeks later. The dewatering of substrate re-sets the benthos to the low flow period, thus limiting accumulation of benthic biomass that would have occurred if flows remained high continuously through the spring and summer.

sturgeon, would not be affected by elevated TDG levels from Libby Dam since Kootenai Falls essentially re-sets TDG levels in the river regardless of TDG levels upstream of the falls.

Further downstream, inflowing water from unregulated sources progressively moderates the influence of dam operation and trends in benthic biomass are less pronounced than in the reach just downstream of Libby Dam. In the river reach between Kootenai Falls and Bonners Ferry, benthic biomass under LS1 and LS2 would tend to be similar.

Model results for the reach between Kootenai Falls and Bonners Ferry indicate that the addition of fish flows in LS1 and LS2 would tend to decrease benthic biomass (as compared to the LS benchmark operation), primarily because the fish flow in these alternatives would tend to produce very low flows in September as the dam reduces outflows in an attempt to conserve water for fall and early winter power production. This relatively low flow period in the late summer would cut benthic production for the alternatives in the majority of years that were simulated for biological productivity. In contrast, the LS and LV benchmark operations would tend to gradually ramp down flows through the summer and support higher flows and resulting benthic production through September. In the river reach just upstream of Bonners Ferry, flow fluctuations in the late summer are particularly crucial for benthic production since small decreases in flow when total river flows are already low can substantially alter the area of the wetted channel.

(LV1) VARQ FC w/ fish flows to powerhouse capacity
(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

In the reach between Libby Dam and Kootenai Falls, LV1 and LV2 would produce the higher benthic biomass than the Standard FC alternatives. The addition of fish flows tends to increase benthic biomass (as compared to the LV benchmark operation).

The modeling indicates very slight risk of Libby Dam spill above the maximum sturgeon flow release under LV1, but somewhat higher than that under LS1. Accordingly, the risk of harm to aquatic life from elevated TDG levels under LV1 would still be low, but slightly higher than the risk under LS1. Considering that the LV benchmark operation would result in elevated TDG levels and potential harm to aquatic life relatively commonly, the addition of fish flows tends to considerably decrease the risk of harm to aquatic life that could result from elevated TDG levels.

In the reach between Kootenai Falls and Bonners Ferry, LV1 and LV2 would tend to result in slightly higher benthic production than the Standard FC alternatives but lower than the LS benchmark operation. As with the Standard FC alternatives, the addition of fish flows under LV1 and LV2 would tend to decrease benthic production in Idaho.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Flow-related effects on benthic production for LSB would be within the range of effects between LS1 and LS2, and in the spring, more beneficial than for benchmark LS.

Under LSB, spill for sturgeon would occur in about 25 percent of years, and result in negative offsetting effects on aquatic organisms between Libby Dam and Kootenai Falls due to elevated TDG saturations. Near Libby Dam, some benthic insects may be displaced from their habitats as a result of bubbles attaching to them and carrying off the substrate and down the river (Fickeisen and Montgomery undated, Bonde 1987).

Fish in the vicinity of Libby Dam would experience high TDG levels and resulting gas bubble disease. Based on observations during the 2002 spill events (Dunnigan *et al.* 2003), about 80 percent of all fish species along the left bank of the river and about 50 percent of all fish within several miles downstream of the dam would likely exhibit gas bubble disease symptoms. Mountain whitefish would be the most severely affected species. Some of these fish may experience direct or indirect mortality related to gas bubble disease or associated physical injuries. Adverse effects from gas bubble disease would increase in years with spillway releases at rates closer to 10 kcfs or lasting for longer duration. Adverse effects from elevated TDG levels would likely be limited to this 8-mile reach of river between the dam and the haul bridge since the highest expected TDG levels at the haul bridge would be similar to those naturally experienced downstream of Kootenai Falls without apparent harm to aquatic life.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Flow-related effects on benthic production for LVB would be within the range of effects between LV1 and LV2, and in the spring, more beneficial than for benchmark LV.

Under LVB, spill for sturgeon would occur in up to 50 percent of years, and result in negative offsetting effects on aquatic organisms between Libby Dam and Kootenai Falls due to elevated TDG saturations. Adverse effects to aquatic organisms from elevated TDG under LVB would be similar in type to those described under LSB, but would likely occur more frequently.

Kootenay Lake to the Confluence with Columbia River

Little specific information is available concerning the likely effects of the various operations on fish and other aquatic life in Kootenay Lake. Flows at Bonners Ferry, along with operation of Corra Linn Dam under the International Joint Commission (IJC)

Order of 1938, would influence Kootenay Lake dynamics, as well as the operation of Duncan Dam.

Bonners Ferry flows are in part determined by Libby Dam outflows, which are shown in Table 3-16 (above) for each alternative and benchmark.

The IJC Order of 1938 requires drafting of Kootenay Lake to elevations at or below 1745.32 feet from mid-summer through the late spring and these operational protocols would not be affected by any of the alternatives. From the commencement of the spring freshet (typically in April) until the lake level falls below 1743.32 feet in the summer, the alternatives may affect the timing and degree of the peak elevation of the lake.

BC Hydro *et al.* (2005) indicated that the preferred range of elevations for Kootenay Lake from an environmental standpoint is 1744 feet to 1750 feet in spring at Queens Bay, and detrimental levels are below elevation 1740 feet and above elevation 1750 feet. BC Hydro *et al.* (2005) conveyed that fish stranding in the Duncan River delta may be an issue at lower Kootenay Lake levels, although the degree of potential adverse effects from fish stranding is not known.

Table 3-21 shows Kootenay Lake elevation frequencies and median elevations as a product of the alternatives being examined.

Table 3-21. Percent of Time Kootenay Lake is Within and Outside of Optimum Elevation Range, as well as Median Elevation, by Month for Each Alternative and Benchmark. LVB values would range between those for LV1 and LV2; LSB values would range between LS1 and LS2 values.

	May				June				July			
Alternative	Time below 1744 feet (%)	Time within optimum elevation range (%)	Time above 1750 feet (%)	Median elevation (feet)	Time below 1744 feet (%)	Time within optimum elevation range (%)	Time above 1750 feet (%)	Median elevation (feet)	Time below 1744 feet (%)	Time within optimum elevation range (%)	Time above 1750 feet (%)	Median elevatio n (feet)
LS1	48	51	1	1744.2	10	66	24	1748.3	43	42	15	1744.4
LV1	38	59	3	1744.9	9	63	28	1748.6	38	45	17	1745.2
LS2	48	50	2	1744.2	12	57	31	1748.5	45	41	14	1744.3
LV2	38	58	4	1745.0	10	56	34	1748.8	38	46	16	1745.1
Benchmark												
LS	52	47	1	1743.8	17	73	10	1746.2	46	50	4	1744.5
LV	40	58	2	1744.7	9	77	14	1746.4	42	54	4	1745.0

BC Hydro *et al.* (2005) identified elevations between 1744 and 1750 feet as the preferred range from an environmental standpoint. This range was compared to lake elevations simulated by the hydroregulation modeling (Appendix B).

Summary

In general, the Standard FC (LS1, LS2, LSB) alternatives and the LS benchmark operation result in higher winter outflows and lower spring and summer outflows from Libby Dam than do the corresponding VARQ FC alternatives (LV1, LV2, LVB) and the LV benchmark operation. The alternatives raise spring and summer Libby Dam releases compared to the LS and LV benchmark operations. The higher the flows entering Kootenay Lake, the higher the potential washout of nutrients and plankton. Loss of nutrients during the spring may somewhat be counteracted by increased phosphorus loading of Kootenay River inflows to the lake during the spring, provided that the density of the water is sufficient to allow mixing with the epilimnion of the lake. In most cases, loss of nutrients and phytoplankton would generally reduce aquatic productivity, but flushing of mysids (*Mysis relicta)* over a natural sill into the shallow West Arm may benefit kokanee production by providing more readily accessible mysids for consumption by kokanee (KTOI and MFWP 2004). The potential for that is somewhat greater for VARQ FC alternatives in comparison to Standard FC alternatives, and likewise for alternatives with fish flows compared to those without.

Lake levels under the VARQ FC alternatives generally would be within the optimal range more frequently during May and less frequently during June and July than with the corresponding Standard FC alternative. There are some differences in time below elevation 1744 feet, but there are not major differences in time above elevation 1750. For Kootenay Lake elevation-related impacts to fish and aquatic life, the trends are similar among alternatives, but VARQ FC may contribute proportionally more to impacts than fish flows alone.

Kootenay Lake is generally nutrient poor and the subject of a fertilization program carried out in the North Arm by the British Columbia Ministry of Water, Land and Air Protection (Wright *et al.* 2002). The general nutrient paucity is considered a limiting factor in Kootenay Lake productivity, and the fertilization program has shown increases in biological production as evidenced by consistently strengthened kokanee numbers. Because of the variables in tributary inflow below Libby Dam and the way Corra Linn Dam operates, it is difficult to say that washout of nutrients due to water movement through the South Arm of Kootenay Lake would measurably offset productivity relative to the active fertilization program.

Compared to the corresponding Standard FC alternatives, the VARQ FC alternatives would result in relatively greater duration and frequency of adverse impacts to aquatic life from elevated TDG conditions on the Kootenay River due to involuntary spill at projects downstream of Kootenay Lake. Additionally, alternatives with higher thresholds for sturgeon flow releases from Libby Dam would generally result in greater duration and frequency of adverse impacts to aquatic life as a result of elevated TDG conditions in this reach.

All Standard FC Alternatives (LS1, LS2, LSB)

These alternatives, with relatively high Libby Dam flows in winter, and relatively moderate flows in spring, might create moderately high flow-through in Kootenay Lake in spring. This might create some washout of nutrients and plankton over the West Arm sill, affecting biological production. Higher inflows during the freshet under LS2 may also increase flushing of mysids into the West Arm of the lake, which consequently would increase kokanee production. In the spring, the relatively higher flows under LS2 and LSB would likely increase phosphorus inputs to the lake, although the degree that this offsets nutrients lost due to washout is unknown. Compared to the LS benchmark operation, fish flows would increase inflows to Kootenay Lake from May through August, which would tend to increase potential loss of nutrients with resulting decreases in lake productivity. Fish flows under these alternatives are intended, in part, to aid recruitment of Kootenai River white sturgeon, which reside for part of the year in Kootenay Lake. Fish stranding may be an issue in the Duncan River delta in May and July in some years.

Kootenay Lake levels under LS1 and LS2 would be below elevation 1744 feet nearly half the time in May and July, and 10 to 12 percent of the time in June. The lake level would be above 1750 feet a small percentage of time in May and July, and a quarter of the time in June. They would be in optimal range about half the time in May, increasing in June, and decreasing in July. Median lake levels for May through July would be between 1744 feet and 1750 feet. The addition of fish flows would tend to increase the frequency of optimal lake levels in May, and decrease the same in June and July.

Kootenay Lake levels under LSB would be within the range between LS1 and LS2. Effects on biological parameters in the lake would be similar in nature and magnitude, because frequency and magnitude, and possibly duration, of Libby flows above powerhouse capacity would be somewhere intermediate, on average, between those two alternatives.

On the Kootenay River, the Standard FC alternatives would generally result in fewer adverse impacts to aquatic life from elevated TDG levels than the corresponding VARQ FC alternative. As with the VARQ FC alternatives, adverse impacts to aquatic life would increase for alternatives with higher rates of sturgeon flow releases from Libby Dam.

All VARQ FC Alternatives (LV1, LV2, LVB)

Winter inflows to Kootenay Lake would be less under LV1 and LV2 than with the Standard FC alternatives since more water is stored in Lake Koocanusa. Due to greater flows for fish (especially in summer for salmon) during productive warmer months, LV1 or LV2 would likely create somewhat higher flow-through from Kootenay Lake than would LS1 or LS2. Thus, greater washout of nutrients and plankton is possible, which might reduce biological productivity in Kootenay Lake compared to the Standard FC alternatives or the LV benchmark operation. Higher inflows during the freshet under LV1, to a relatively small extent, and LV2, to a larger extent, may also increase flushing of mysids into the West Arm of the lake, with consequent increased kokanee production. In the spring, the relatively higher flows under LV2 and LVB would likely increase phosphorus inputs to the lake although the degree that this offsets nutrients lost due to washout is unknown. Fish flows under these alternatives are intended to aid recruitment of Kootenai River white sturgeon, which reside for part of the year in Kootenay Lake. In May and July, there is a potential for fish stranding in the Duncan River delta.

Under these alternatives, Kootenay Lake levels would be below elevation 1744 feet about 38 percent of the time in May and July, and 9 to 10 percent of the time in June. Lake levels would be above elevation 1750 feet about a quarter (LV1) to one-third (LV2) of the time in June, and a small percentage of time in May and July (but more often than under the Standard FC alternatives). Elevations would be in optimal range more than half the time in May and June, and less than half the time in July. Median lake levels would be between 1744 feet and 1750 feet between May and July. As with Standard FC alternatives, the addition of fish flows would tend to increase the frequency of optimal lake levels in May, and decrease the same in June and July.

Kootenay Lake levels under LVB would be within the range between LV1 and LV2. Effects on biological parameters in the lake would also be within the range between LV1 and LV2 because frequency and magnitude, and possibly duration, of Libby flows above powerhouse capacity would be somewhere intermediate, on average, between those two alternatives.

On the Kootenay River, the VARQ FC alternatives would generally result in greater adverse impacts to aquatic life from elevated TDG levels than the corresponding Standard FC alternative. As with the Standard FC alternatives, adverse impacts to aquatic life would increase for alternatives with higher rates of sturgeon flow releases from Libby Dam.

3.3.4 Sensitive, Threatened and Endangered Species

None of the six Libby Dam alternative operations would affect grizzly bears, gray wolves, woodland caribou, or Canada lynx since these species are terrestrial and are not likely to utilize or depend on the areas that may experience different effects resulting from the various alternatives. White sturgeon, bull trout, and bald eagles may be affected.

State-listed Species of Concern (burbot, South Arm Kootenay Lake kokanee salmon, Columbia River redband Trout, westslope cutthroat trout, and leopard frog) are addressed at the end of this section.

White Sturgeon

Wild spawning white sturgeon have not produced substantial numbers of offspring since 1974, the year Libby Dam became operational. Data on white sturgeon spawning and reproduction in the Kootenai River are available since the mid-1980s. Since then, monitoring has confirmed certain parameters related to sturgeon such as migration timing, spawning locations, preferred range of water temperatures during migration and spawning, population size, and sex composition. However, since spawning events have not produced substantial numbers of young fish over the period of monitoring, the available data do not include empirical observations of conditions which are likely to lead to survival of eggs and larvae and eventual recruitment of juvenile sturgeon to the adult population.

To bridge the gap between the available data and the desired future conditions that produce young sturgeon from wild spawning, the USFWS has used the available data from the Kootenai River and other sturgeon producing systems to identify certain habitat attributes that the team believes would create suitable white sturgeon spawning and rearing habitat (see Table 3-6 in Section 3.2.5).

Turbidity has also been identified as a potentially important factor related to sturgeon migration and spawning. With the exception of substrate and turbidity, and the possible exception of water temperature, each of the parameters varies based on river flows and location along the river corridor. The precise way each of the parameters influences the way sturgeon respond to their environment and select spawning locations is currently unknown, but the USFWS believes that conditions which create high velocity flows, adequate depth and turbulent conditions over gravel or cobble substrates, at the proper temperatures, would likely benefit white sturgeon reproduction (USFWS 2006b). Also, actions which cue sturgeon to migrate to and spawn in areas with such conditions would also likely benefit sturgeon.

To evaluate the effects of the alternative Libby Dam operations on sturgeon, the simulated hydrological conditions produced by the hydroregulation modeling are compared to the conditions believed necessary or desirable for white sturgeon as identified by the USFWS (2006b). This analysis focuses on areas with observed sturgeon migration and spawning in the late spring and early summer, which roughly corresponds to the reach of the river from the Idaho border to Kootenay Lake. The primary factors that were evaluated were:

- The potential effects of water velocities and substrate in the known sturgeon spawning areas from approximately the Route 95 bridge in Bonners Ferry (RM 152.6) downstream to Shorty’s Island (RM 141.4). In this reach, velocity varies with flow, and inversely with Kootenay Lake elevation. Substrate is not changing in response to velocity in this reach, but substrate may still affect sturgeon reproductive success.

- Potential effects of water velocities and depths that may cue sturgeon to migrate and spawn in river reaches with gravel and cobble substrate upstream of the Route 95 bridge. Velocity may affect the sturgeon's choice of spawning location.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

LS1 would potentially benefit sturgeon recovery efforts by providing flow augmentation during key sturgeon life history events. The timing of flow augmentation would approximate the timing of natural peak spring flows. Duration of the sturgeon flow pulse under LS1 would be similar to LV1. Since the volume of the sturgeon pulse is the same but the peak outflow rate is lower, the duration of peak flows under LS1 would likely be longer than the duration of peak flows for LS2 and LV2.

In the absence of other non-operational actions, such flow augmentation is unlikely to result in substantial benefits to sturgeon, as evidenced by the lack of observed wild sturgeon production in the past decade of sturgeon flow augmentation. Sturgeon would continue to spawn in areas of unsuitable sandy substrate between the Route 95 bridge and Shorty's Island. These low water velocities also would allow potential predators to remain in the area during sturgeon spawning (Faler *et al.* 1988). The low water velocities present in the current spawning area likely do not exclude predators, with consequent predation on sturgeon eggs even absent adverse effects from sand burial.

Average annual suspended sand transport under LS1 would be about 113,000 tons per year, which means approximately 26,000 tons more sand would be transported under LS1 than under the LS benchmark operation. With sand transport of this magnitude, channel bed erosion would be substantially less than 1 foot per year (Appendix O). However, even if enough scour occurred over time in the current spawning reach, there is a general lack of buried cobble and gravel substrate that would be exposed.

Higher Kootenay Lake levels may encourage sturgeon to migrate and spawn further upstream. Although selection of spawning locations is likely related to habitat, locations also appear to be influenced by timing of spawning initiation and the elevation of Kootenay Lake (Duke *et al.* 1999). Spawning appears to occur further upstream with increasing lake elevation (Paragamian *et al.* 2002a, Paragamian *et al.* 2002b). Notwithstanding recent modeling that indicates that extreme low flows such as in 2001 may trigger sturgeon spawning near the Route 95 bridge (Barton *et al.* 2005), the 2006 USFWS Biological Opinion on Libby Dam operations indicates that depth may limit the ability or desire of sturgeon to migrate to areas upstream of Bonners Ferry. Accordingly, operations which increase Kootenay Lake level and/or Bonners Ferry stage and therefore also increase river depth near Bonners Ferry may potentially provide better sturgeon access to the rocky substrate in the braided reach upstream of Route 95. Based on past monitoring, sturgeon flows provided by LS1 would not trigger sturgeon migration to areas upstream of the Route 95 bridge and into areas with existing gravel and cobble substrate and higher water velocities that could effectively exclude egg predators.

Flow augmentation provided by LS1 would provide flexibility to continue research, monitoring, and evaluation of the requirements for successful white sturgeon reproduction. These efforts will likely lead to better understanding of the interplay of flow, habitat conditions, and sturgeon behavior, which will better direct sturgeon recovery actions in the future.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Primarily because the peak dam outflow rate and volume of sturgeon flow augmentation are the same, the effects of LV1 on white sturgeon would be similar to those under LS1. However, river stages during the sturgeon flow augmentation under LV1 tend be slightly higher, the result of the higher dam releases under LV1 refill causing Kootenay Lake levels to rise earlier in the season. At 126,000 tons per year, suspended sediment transport under LV1 is slightly higher than that under LS1 and about 24,000 tons more than that under the LV benchmark operation. Sand transport of this magnitude is unlikely to produce substantial bed scour in the sturgeon spawning area.

Kootenay Lake levels in May would tend to be up to one foot higher under LV1, which could help move early sturgeon spawning further upstream. If sturgeon cue on the extent of Kootenay Lake backwater when seeking locations for spawning, they may respond to an increase in lake stage of 1 foot during spring high flows which could move the backwater up close to areas of the river with existing gravel and cobble substrate (C. Berenbrock, USGS, pers. comm. 2004).

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

Under LS2, peak dam releases for sturgeon flow augmentation would be about 40 percent greater than either LS1 or LV1. The higher release rate would allow the dam to support higher peak flows in portions of the river where sturgeon spawn. Since the volume of the sturgeon tiers doesn’t increase, increasing peak dam release rate could lead to shorter duration peaks than might occur under LS1 and LV1. For example, the duration of peak flows in a year with a sturgeon volume of 1.2 MAF (Tier 4) would be 5 to 7 days shorter under LS2 (peak release of about 35 kcfs) than under LS1 or LV2 (peak release of about 25 kcfs).

From May through July, LS2 produces higher peak Bonners Ferry river stages and Kootenay Lake elevations than alternatives with no or lower sturgeon flows. As evidenced by the broad plateau at the 1764 foot flood stage in the frequency curve for peak Bonners Ferry stage, releases of the peak release capacity under LS2 may be limited in many cases due to flood stage constraints at Bonners Ferry. In areas downstream of the Route 95 bridge, these higher peak flows create slightly higher water velocities

(USGS 2005), but still below threshold velocities required to scour substantial quantities of fine grained sediments from the channel bottom in the known sturgeon spawning areas. Calculations indicate that average annual suspended sediment transport under LS2 would be 130,000 tons per year, roughly equivalent to that under LV1. To a currently unknown extent, the flows that could be provided utilizing additional Libby flow capacity may be useful for restoring and maintaining gravel/cobble substrate in areas with more channel gradient that are closer to the Route 95 bridge. Additional flow capacity may also help maintain substrate improvements that may be part of habitat restoration and creation efforts in the Kootenai River.

Compared to LS1 and LV1, flow augmentation provided by LS2 would provide increased flexibility to continue research, monitoring, and evaluation of the requirements for successful white sturgeon reproduction. Increased flow capacity provides a greater range of possible flow conditions. In particular, increased flow capacity would allow dam operations that reliably re-create conditions similar to 1974, the year when the last substantial numbers of sturgeon were produced in the wild.

The flows released under LS2 would produce conditions that are not possible to recreate with non-operational actions, namely increased river stage, Kootenay Lake elevation, river depths, and turbidity. How sturgeon may respond to these conditions is unknown since these conditions have not existed coincident with studies of sturgeon in the Kootenai River. By bringing spring flows closer to historical conditions, increased flow capacity and the resulting higher Kootenay Lake levels may cue sturgeon to migrate further upstream and spawn in areas with existing gravel/cobble substrate. Annual peak lake stage would tend to be up to 0.5 feet higher than that with LS1 or LV1, and typical average lake elevations would be similar to LV1. The timing of flow peaks and Kootenay Lake level increases, which would be determined annually based on real-time operational decisions, would likely determine how sturgeon respond to higher peak flows and lake levels. Monitoring of sturgeon behavior would be a key component of any program utilizing additional flow capacity from Libby Dam.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Similar to LS2, peak dam releases under LV2 would be substantially higher than either LS1 or LV1, thereby supporting the highest peak flows of any alternative in the portions of the river where sturgeon spawn and bringing peak flows closer to unregulated conditions when sturgeon successfully reproduced. The duration of peak dam releases and peak water velocities downstream of the Route 95 bridge would be similar to the those under LS2, with similar effects on substrate composition. At 142,000 tons per year, suspended sediment transport under LV2 would be the highest of any alternative, but likely would result in substantially less than one foot per year of river-bed erosion.

Below about 1759 feet, river stages during the sturgeon flow augmentation under LV2 tend to be similar to those under LV1. The likelihood of river stages above elevation 1759 feet for LV2 is highest of all alternatives, which could facilitate sturgeon migration into the braided reach if such movements are linked with increased river stages, river depths, and consequent changes in water velocity gradients. Annual peak Kootenay Lake stage would tend to be similar to that with LS2, but typical average lake elevations would be similar to LS1 in May and July, and to LV1 in June. As with LS2, monitoring of sturgeon behavior would be a key component of any program utilizing additional flow capacity from Libby Dam.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

This alternative would provide conditions, on average, that are within the range between LS1 and LS2, because frequency and magnitude, as well as possibly duration, of providing flows above powerhouse capacity at Libby Dam will be variable compared to what was assumed for LS2.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

This alternative would provide conditions, on average, that are within the range between LV1 and LV2, because frequency and magnitude, as well as possibly duration, of providing flows above powerhouse capacity at Libby Dam will be variable compared to what was assumed for LV2. This is the preferred alternative because of new recommendations in the 2006 USFWS Biological Opinion (USFWS 2006b) to avoid jeopardy to Kootenai River white sturgeon. Included is flow above Libby powerhouse capacity . Coordination is underway with the State of Montana and other parties to develop a flow implementation plan for this alternative as early as 2006.

It is important to note that the Action Agencies' approach to implementation of additional flows above powerhouse capacity at Libby Dam would be one of adaptive management. Per the 2006 Biological Opinion (USFWS 2006b), the Action Agencies would use monitoring and evaluation to determine effectiveness of actions at achieving the habitat attributes and sturgeon recruitment, and to determine next management steps. If LVB leads to successful recruitment, and it is determined that there are no other means available to provide for the habitat attributes, the Corps will work with BPA and the Service to seeks means to more reliably provide flows up to 10 kcfs above powerhouse capacity.

Bull Trout

Effects on bull trout were assessed using the biological modeling discussed under Aquatic Life (section 3.3.3) as the primary basis. Alternatives which improve biological productivity are considered beneficial to bull trout as well. However, at this time it is not clear that bull trout are limited by food availability in Lake Koocanusa, so increased productivity upstream from Libby Dam may not result in corresponding benefits to bull trout growth, abundance, or distribution.

Downstream from the dam, rapid flow fluctuation in the river could affect bull trout directly by habitat loss and indirectly by decreased food availability. All alternatives would use the same ramping rates at Libby Dam which are consistent with the 2006 USFWS Biological Opinion and, in general, load following using the ramping rates would not likely occur during the spring, summer, or early fall. Alternatives with an increased tendency to produce short-term lower flows between higher flow periods during the spring and summer (*i.e.*, a double-peak operation) would be less beneficial than operations that would be more likely to provide more stable flows. Note that under all of the alternatives, double-peak operations could occur as a result of the sturgeon flow pulse in the late spring, followed by the salmon flow augmentation in the summer, with bull trout minimum flows in between. In real-time, dam operations are managed to avoid the double peak whenever possible.

Downstream from Libby Dam, alternatives that tend to produce higher spring flows are considered beneficial in that higher peak flows may inhibit accretion of deltas at the mouths of important spawning tributaries in Montana and Idaho, most notably Quartz Creek just downstream from Libby (KTOI and MFWP 2004). Also, alternatives with higher flows during the late summer may help bull trout access tributaries with existing deltas.

Water temperatures in the reservoir are not expected to differ between alternatives. Water temperatures of dam releases would continue to be managed within a range agreed upon by the state of Montana for protection of downstream resident fish under all alternatives to the extent possible (See Section 3.2.3). Thus, water temperature effect on bull trout are not expected to differ among the alternatives.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

Under LS1, reservoir and river productivity, including kokanee growth, would tend to be relatively low, which would tend to limit benefits for bull trout, particularly in areas downstream from Libby Dam. Late summer levels of Lake Koocanusa under LS1 tend to be relatively low, but adfluvial bull trout from the lake tend to enter spawning tributaries in June and July, when lake levels would still be relatively high, so access to spawning should not be affected by lake level. Compared to the LS benchmark operation, bull trout entrainment under LS1 would likely be higher, but at a level that would not likely affect Lake Koocanusa population strength (KTOI and MFWP 2004).

Biological modeling indicates that the fish flows incorporated in the alternatives would tend to enhance river productivity compared to the LS or LV benchmark operations, which would be expected to benefit bull trout. Similar to the other alternatives, LS1 would likely lead to double peak operations in some years, which could diminish benefits that fish flows provide for bull trout in the river. Addition of the fish flows would tend to ensure that minimum flows in the river will remain higher through the spring and summer, with corresponding benefits for bull trout from increased food production and habitat access (as compared to the benchmark operations without fish flows).

Releases for sturgeon flows up to powerhouse capacity may inhibit accretion of deltas at the mouths of spawning tributaries such as Quartz Creek, which would likely benefit bull trout access to those streams. Flows under this or any other alternatives would not likely result in erosion of any creek deltas. Additionally, maintenance of relatively high flows through the summer (for salmon flow augmentation or via bull trout minimum flows) could improve access of migrating fluvial bull trout to their spawning tributaries. These benefits would not occur in the absence of fish flows.

The fish flows tend to decrease the incidence of flood control spills, as compared to the LS benchmark operation, which would decrease the risk that TDG levels in the river, particularly in areas just downstream of the dam, exceed thresholds for harm to bull trout.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Lake Koocanusa productivity under LV1 would tend to be higher than the Standard FC alternatives, with resulting benefits to bull trout. River flows under LS1 and LV1 tend to be similar through most of the late spring and summer, and the ecological effects of LV1 on bull trout would also be similar (particularly regarding river productivity) although higher flows during the late summer due to more water available for salmon flow augmentation could help improve bull trout access to tributaries with deltas. Recognizing that the risk of elevated TDG from spill under any of the alternatives is low, the chance of spill events under LV1 is slightly higher than that under the other alternatives, which would slightly increase the chance that TDG in the river exceeds thresholds for harm to bull trout, particularly in areas just downstream from the dam. Compared to the LV benchmark operations, the addition of the fish flows decreases the frequency and duration of spill events that could produce harmful TDG levels. Compared to LS1, bull trout entrainment under LV1 would likely be higher due to higher dam releases during refill and the increased likelihood of spill.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs, and
(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Higher releases during the sturgeon pulse would likely increase the number of bull trout entrained by Libby Dam. The magnitude of the entrainment and the effects on Lake Koocanusa bull trout populations are unknown.

Except for the sturgeon flow pulse, river flows under LS2 and LV2 would produce similar habitat conditions for bull trout as LS1 and LV1. The higher sturgeon releases from Libby Dam could help inhibit delta formation at spawning tributaries such as Quartz Creek.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

The flow effects of this alternative would provide conditions, on average, that are within the range between those provided by LS1 and LS2, because frequency and magnitude, as well as possibly duration, of providing flows above powerhouse capacity at Libby Dam will be variable compared to what was assumed for LS2. Potential adverse effects to bull trout below Libby Dam from elevated TDG would likely occur in about 25 percent of years when spillway releases would be possible under LSB as part of the sturgeon flow augmentation. The 2006 USFWS Biological Opinion estimated that approximately 264 bull trout would be subjected to some level of gas bubble disease during each spill event.

Consistent with the 2006 USFWS BiOp's Incidental Take Statement (ITS) for bull trout, the Corps will operate Libby Dam to avoid exceeding the allowable incidental take for bull trout and will monitor bull trout condition during voluntary spill event(s) to achieve sturgeon flow augmentation.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

The flow effects of this alternative would provide conditions, on average, that are within the range between those provided by LV1 and LV2, because frequency and magnitude, as well as possibly duration, of providing flows above powerhouse capacity at Libby Dam will be variable compared to what was assumed for LV2. Potential adverse effects to bull trout from elevated TDG in each spill event would be similar in magnitude to those under LSB, but would likely occur in more years.

Bald Eagle

For purposes of compliance with the ESA, the effects of FCRPS operations on bald eagles were documented in a biological assessment prepared in 1993 (BPA *et al.* 1993) and supplemented in 1994 (BPA *et al.* 1994). The USFWS (1995) issued a biological opinion concluding that operation of the FCRPS would not jeopardize the continued existence of bald eagles. In a transmittal letter accompanying the 2000 USFWS FCRPS Biological Opinion, the USFWS stated that it was not aware of any changes in FCRPS operations (including the proposed implementation of VARQ FC operations at Libby Dam) that would warrant a change in their determination of effects of dam operations on bald eagles. Possible effects on bald eagles under each alternative are evaluated qualitatively based on changes in reservoir operations and dam releases.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

Under LS1, bald eagles would continue to utilize Lake Koocanusa and the Kootenai River as nesting, wintering, and foraging habitat. Relatively low reservoir and river productivity could have minor negative impacts on bald eagle foraging opportunities. Sturgeon flows at powerhouse capacity would likely result in benefits to riparian vegetation, most notably recruitment of cottonwoods to suitable shoreline areas. Particularly during the sturgeon flow pulse, entrainment of fish, primarily kokanee, through Libby Dam would continue at relatively mid-range levels, thereby providing feeding opportunities to relatively high concentrations of bald eagles that occur in the vicinity of the dam.

In comparison to the LS benchmark operation, the addition of fish flows could slightly increase the potential for adverse impacts to bald eagles around Lake Koocanusa (due to lower reservoir levels), and slightly benefit bald eagles downstream of Libby Dam (due to increased entrainment at the dam, increased river productivity, and enhanced riparian habitat).

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Under LV1, bald eagles would continue to utilize Lake Koocanusa and the Kootenai River as nesting, wintering, and foraging habitat. Relatively high reservoir and river productivity could have minor positive impacts on bald eagle foraging opportunities. Release of higher refill flows per VARQ FC and sturgeon flows at powerhouse capacity would likely benefit riparian vegetation, most notably recruitment of cottonwoods to suitable shoreline areas. Particularly during the sturgeon flow pulse, entrainment of fish, primarily kokanee, through Libby Dam would continue at relatively mid-range levels, thereby providing feeding opportunities to relatively high concentrations of bald eagles that occur in the vicinity of the dam.

The effects of the fish flows under LV1 would be similar to the effects of the addition of fish flows under LS1, but may be less pronounced for VARQ FC operations because, particularly during spring refill, the addition of fish flows to the LV benchmark would not be as great a change as the addition of fish flows to the LS benchmark.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs and (LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Under LS2 and LV2, bald eagles would continue to utilize Lake Koocanusa and the Kootenai River as nesting, wintering, and foraging habitat. Relatively low reservoir and river productivity under LS2 could have minor negative impacts on bald eagle foraging opportunities. In contrast, relatively high reservoir and river productivity under LV2 could have minor positive impacts on bald eagle foraging opportunities sturgeon flows at 10 kcfs above powerhouse capacity would likely result in more substantial benefits to riparian vegetation, most notably recruitment of cottonwoods to suitable shoreline areas. These benefits would be relatively higher under LV2 due to release of higher flows during refill. Particularly during the sturgeon flow pulse, entrainment of fish, primarily kokanee, through Libby Dam would continue at relatively high levels, thereby providing increased feeding opportunities to relatively high concentrations of bald eagles that occur in the vicinity of the dam.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Effects on bald eagle would be within the range between LS1 and LS2 for LSB, and within the range of LV1 and LV2 for LVB.

Lower Kootenai River Burbot

Burbot migrate up the Kootenai River from Kootenay Lake beginning in December and spawn in January and February. Since burbot are very weak swimmers, high flows during the migration and spawning period may inhibit or even prevent spawning. The Corps is considering changes in Libby Dam operational protocols to decrease dam releases during the burbot migration and spawning period. Pursuant to a July 5, 2005, Memorandum of Understanding signed by the Corps, the Idaho Department of Fish and Game and the Kootenai Tribe of Idaho, and others, analysis and evaluation of the real-time opportunities and risks resulting from burbot-specific considerations would be considered for Libby Dam within existing operational flexibility.

To the extent that alternative dam operations affect flood control drafts, winter flows may be slightly different, resulting in different dam releases that could affect burbot spawners. Alternatives that would result in lower dam releases and lower water temperatures in the river may benefit burbot migration and spawning in the Idaho portion of the Kootenai River. In December and January, the various alternatives would not affect water temperatures in Lake Koocanusa or dam releases, but alternatives with lower dam releases in December and January, the primary burbot spawning and migration period, are assumed to benefit burbot.

Results from multiple purpose modeling of Libby Dam operations provide monthly average Libby Dam releases for December and January for each of the alternatives (Table 3-16, Figure 3-27, and Figure 3-28). Monthly average dam releases do not depict the potential to shape dam releases within each month in an attempt to accommodate a low flow burbot operation.

With any alternative, adjustments during December, January, and February would likely be necessary to shape outflows from Libby Dam to maximize potential benefits to burbot migration and spawning. Additionally, operations to benefit burbot would likely reduce the real-time operational flexibility of Libby Dam water management for other project purposes such as power generation during this same time frame. More detailed analysis and evaluation of the potential opportunities and risks resulting from burbot-specific considerations are being developed. Early forecasting technology is also being developed in hopes of having tools to allow reservoir drawdown decisions to be made beginning during fall (see Appendix M) rather than having to wait until January of each year to develop strategies.

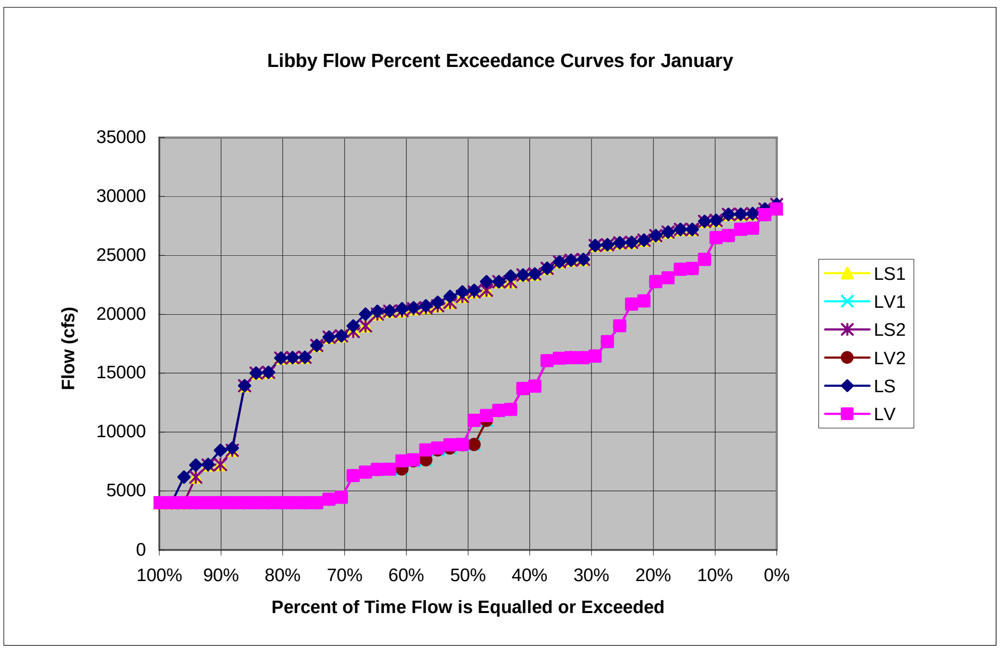

Figure 3-27. Flow Exceedance Curve for Average Libby Dam Flow in December. Values for LVB would be similar to LV1 and LV2; values for LSB would be similar to LS1 and LS2.

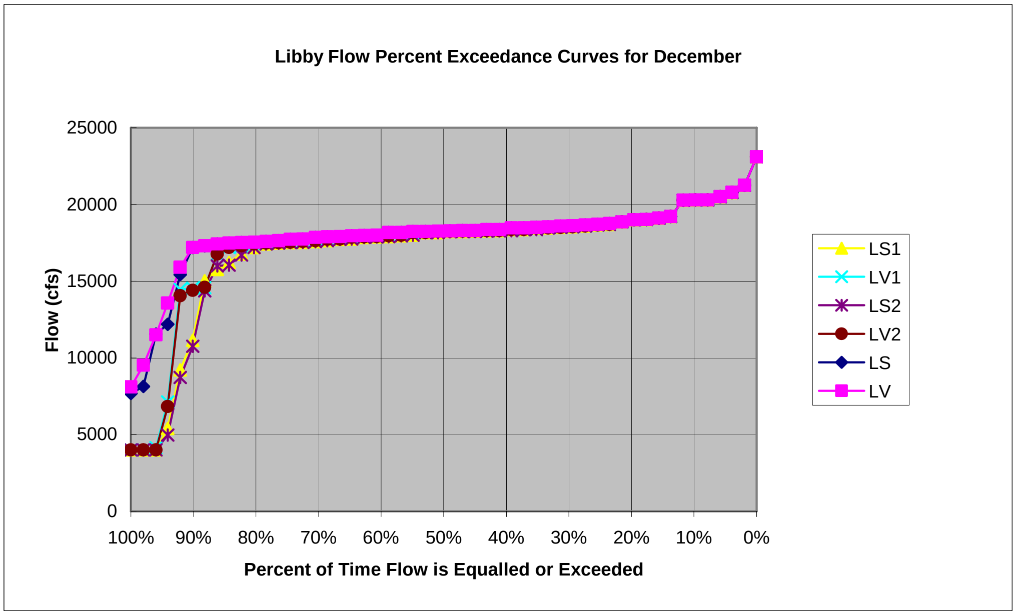

Figure 3-28. Flow Exceedance Curve for Average Libby Dam Flow in January. Values for LVB would be similar to LV1 and LV2; values for LSB would be similar to LS1 and LS2.

All Standard FC Alternatives (LS1, LS2, LSB)

Due to relatively low end-of-summer reservoir levels, December Libby Dam releases under LS1 would be slightly lower than all alternatives except LS2. December Libby Dam releases under LSB would be within the range between LS1 and LS2. In order to achieve the relatively deeper flood control target elevations under Standard FC flood, January Libby Dam releases would be relatively high under LS1, LS2, or LSB, which would allow little flexibility to provide low releases for benefit of burbot migration and spawning. Since end-of-summer reservoir elevations tend to be at or below 2439 feet with fish flows, the addition of fish flows would tend to decrease average December releases by about 5 percent (as compared to the LS benchmark operation). Average January releases would be similar with or without fish flows.

All VARQ FC Alternatives (LV1, LV2, LVB)

In December, average dam releases under LV1, LV2, or LVB would be slightly higher than LS1, LS2, or LSB, but lower than either of the benchmark operations. Since VARQ FC requires relatively less flood control drafting, average January dam releases under LV1, LV2, or LVB would be as low as any of the alternatives and almost 40 percent lower than the Standard FC alternatives. The lower VARQ FC releases would provide greater flexibility to accommodate low flow operations for benefit of burbot. As with Standard FC, the addition of fish flows to VARQ FC tends to decrease December and January dam releases.

South Arm Kootenay Lake Kokanee Salmon, Columbia River Redband Trout, and Westslope Cutthroat Trout

Alternatives producing more natural flow conditions in the main river would likely benefit kokanee, redband rainbow trout, and westslope cutthroat trout. High flows during the summer would tend to adversely affect the effectiveness of nutrient addition activities underway in Kootenay Lake and the Kootenai River (BPA 2005), which may reduce potential benefits to resident fish from the river fertilization. Kokanee, redband rainbow trout, and westslope cutthroat trout do not spawn in the mainstem river so winter dam releases are unlikely to directly affect them.

Monthly average dam releases during the spring and summer are shown in Table 3-16 (on page 122). Average dam releases would be intermediate between LS1 and LS2 for LSB, and between LV1 and LV2 for LVB.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

The flow patterns under LS1 would likely benefit kokanee, redband trout, and westslope cutthroat trout by producing more natural spring flow conditions (although at flow levels much lower than occurred prior to dam construction). Among the different alternatives, the relatively intermediate flows during the summer salmon flow augmentation under LS1 may hinder experimental river and Kootenay Lake fertilization efforts somewhat by diluting and decreasing residence time of the added nutrients in the river and lake. This may reduce the benefits of the lake and river fertilization program for kokanee, redband trout, and westslope cutthroat trout.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Compared to Standard FC alternatives, LV1 and the other VARQ FC alternatives would tend to release relatively higher flows through the spring refill period. The sturgeon flow augmentation further helps to produce more natural spring flow conditions (although at flow levels much lower than occurred prior to dam construction), which could result in increased benefits for kokanee, redband trout, and westslope cutthroat trout. Due to the VARQ FC operation, there is an increased probability of more water available for the summer salmon flow augmentation, which leads to relatively high flows through July and August that could decrease the effectiveness of the lake and river fertilization program and benefits to kokanee, redband trout, and westslope cutthroat trout.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

The higher flows during the sturgeon flow augmentation under LS2 would bring conditions somewhat closer to natural spring flow conditions, with possible benefits to kokanee, redband trout, and westslope cutthroat trout. Effects of summer flows on kokanee, redband trout, and westslope cutthroat trout under LS2 would be essentially the same as those under LS1.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

The higher flows during the sturgeon flow augmentation under LV2 would bring conditions somewhat closer to natural spring flow conditions, with possible benefits to kokanee, redband trout, and westslope cutthroat trout similar to LS2. Effects of summer flows on kokanee, redband trout, and westslope cutthroat trout under LV2 would be essentially the same as those under LV1.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Flow effects of LSB on kokanee, redband trout, and westslope cutthroat trout would be intermediate between those under LS1 and LS2. TDG effects due to voluntary spill for sturgeon in the Kootenai River would occur in about 25 percent of years when spillway releases would be possible under LSB as part of the sturgeon flow augmentation, and could be harmful to these species between Libby Dam and Kootenai Falls, but these effects cannot be quantified with any certainty.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Effects of LVB on kokanee, redband trout, and westslope cutthroat trout would be intermediate between those under LV1 and LV2. TDG effects due to voluntary spill for sturgeon in the Kootenai River would occur in about 50 percent of years when spillway discharges of some duration are possible under LVB, and could be harmful to these species between Libby Dam and Kootenai Falls, but these effects cannot be quantified with any certainty.

Northern Leopard Frog

All Alternatives

The CVWMA is the last area in British Columbia in which the northern leopard frog exists. Sudden 3 to 6 foot increases in water levels could adversely impact egg masses in leopard frog reintroduction areas, and introduce predatory fish. However, based on hydroregulation modeling results (Appendix B), the predicted range of potential increases in peak Kootenay Lake elevation among the alternatives is expected to be much less than 3 feet, and real-time management in operation of Libby Dam may reduce this further. Provided pumping continues, adverse effects to northern leopard frogs are not expected to occur.

3.3.5 Wildlife

Wildlife impacts under the four alternatives and two benchmark operations are governed primarily by the amount and duration of flow, as well as river elevations (stages). Wildlife species themselves are not typically influenced by a gradual change in flow or duration. However, wildlife habitat can be affected, and the majority of this discussion focuses on this habitat and its response to varying levels of flow, elevation and duration.

In general, the maximum range in peak flow rate and river elevation between the four alternatives and two benchmarks is approximately 10 kcfs or 7 feet (*i.e.*, elevation 1757–1764 feet at 50 percent exceedance at Bonners Ferry; LV2 vs. the LS benchmark operation) (Appendix B). One important consideration is that the majority of wildlife habitat adjacent to the Kootenai River downstream of Libby Dam is isolated from the river by a system of levees and dikes at varying elevations, thus minimizing the potential for substantial habitat change landward of the levee alignment. Finally, the habitat surrounding Lake Koocanusa would likely remain unchanged because there is no modification to the overall full pool elevation or the time period when it reaches full pool (about end of June to end of July). It's reasonable to suspect that there would be no change in the riparian interface already established around Lake Koocanusa (Wernham 2005, Marotz 2005, Soults 2005).

The framework used in evaluating wildlife impacts associated with the different dam operations is based on existing literature and on discussions with representatives from the Montana Department of Fish, Wildlife, and Parks, the U.S. Fish & Wildlife Service's Kootenai National Wildlife Refuge, the Kootenai Tribe of Idaho, and the Creston Valley Wildlife Management Area (CVWMA), who are knowledgeable about wildlife in or around Lake Koocanusa, Libby Dam, the Kootenai River, and Kootenay Lake. They represent.

Lake Koocanusa

All Alternatives

Between the early 1990s and 2002, Libby Dam operated under the LS1 alternative, and the general wildlife consequences were addressed in the Columbia River System Operation Review EIS (BPA *et al.* 1995). The wildlife species found in this location have likely adjusted to the Kootenay River and Lake Koocanusa's annual fluctuations and flow rates. Since 2002, the Corps has implemented the LV1 alternative on an interim basis. The habitat surrounding Lake Koocanusa would likely remain unchanged because there is no modification to the overall full pool elevation or the time period when it reaches full pool (between the end of June to end of July). It's reasonable to posit that there would be no change in the riparian interface already established around Lake Koocanusa (Wernham 2005, Marotz 2005, Soults 2005). Because the maximum pool elevation of Lake Koocanusa and the time period when it reaches maximum reservoir elevation are the same under all alternatives, consequences would be the same among the alternatives.

Libby Dam to Kootenay Lake near Creston, BC

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

Between the early 1990s and 2002, Libby Dam operated under this alternative, and the general wildlife consequences were addressed in the Columbia River System Operation Review EIS (BPA *et al.* 1995). However, since 2002 the Corps has been operating under the LV1 alternative and may have slightly changed some environmental attributes that impacted wildlife. Based on discussions with individuals familiar with this matter (Wernham 2005, Marotz 2005, Stushnoff 2005), LV1 has not changed the wildlife condition observed over the previous decade because of the back-to-back low water years. Consecutive low water years may have a negative impact on wildlife, however, this would not be a consequence of implementing a particular alternative. Implementing this alternative would result in slightly lower peak flows and stages over LV1 and would maintain the current wildlife condition.

Under this alternative, the consequences to wildlife would be positive when fish flows are added due to benefits for riparian habitat development. Expanded riparian habitat translates into additional habitat and benefits for wildlife.

In discussions with local, state, Federal, and tribal entities familiar with the basin and its wildlife, the general consensus is that any additional water released during the spring/early summer would benefit wildlife (Marotz 2005, Soults 2005, Ellis 2005, Stushnoff 2002, 2005, Beaucher 2005, Wernham 2005) as the spring flows promote development of riparian habitat. Without fish flows, wildlife that rely on riparian areas would likely continue to suffer adverse impacts due to poor seed dispersal and germination of native riparian plant species and loss of existing riparian habitat along the river corridor.

The consequences to wildlife associated with this alternative would be restricted primarily to the riparian corridor where much of the habitat is confined by levees or dikes and by agricultural lands. However, specific to the CVWMA and generally speaking, no consequences would be anticipated with the exception that during infrequent extreme high water levels resulting from high runoff in conjunction with springtime fish flow augmentation, some waterfowl nesting areas in the Kootenay River delta at the south end of Kootenay Lake may be impacted (Stushnoff 2002 and 2005).

Duck Lake, within the CVWMA, is adjacent to the Kootenay River outlet on Kootenay Lake and isolated from the river and lake by a system of dikes. In all but the lowest runoff years, pumping is required to prevent runoff from Duck Creek and local areas from overfilling Duck Lake and encroaching on the freeboard of the dike that separates the northern area from the southern nesting area. Pumps are available at the northeast corner of Duck Lake to facilitate pumping into Kootenay Lake to limit the Duck Lake water surface elevation in the northern area. Pumping in the 2002 spring runoff period approximates average conditions. During 2002, two 30,000-gal (U.S.)/minute capacity pumps each were run 625 hours to pump approximately 6,900 acre-feet of water. Cost of pumping was approximately $2,400 U.S (Stushnoff 2002).

Bird species directly affected by high water levels include a variety of waterfowl and shorebirds such as Canada geese, mallards, western grebes (red listed in British Columbia), American avocet (red listed), long billed curlew (red listed), and Forster's tern (red listed). Bird species that do not nest on sites vulnerable to flooding but which may experience indirect effects include osprey, great blue heron (blue listed)[30], American white pelican (red listed), and double crested cormorant (red listed). Nests are established in the early spring and the incubation season goes through early summer. The impacts to bird species would depend greatly on the water's level and duration. CVWMA appears to be the only location where flooding of nesting areas can occur during extreme high water events. Other bird species that nest or feed along the river's edge or in riparian vegetation close to the river may be impacted during extreme events, but those impacts are impossible to quantify or predict. Most species would simply relocate during the flooding and reestablish themselves once the flooding subsided. Some nesting may be destroyed. Indirect impacts may include a change in suitable habitat such as food sources, cover, nesting, etc., but those could be positive.

Increased water levels may also adversely affect amphibians and reptiles, most notably western painted turtles (red listed) and northern leopard frogs (red listed) (Stushnoff 2002 and 2005, Beaucher 2005). The CVWMA is the last area in British Columbia in which the northern leopard frog exists. Sudden 3- to 6-foot increases in water levels could adversely impact egg masses in leopard frog reintroduction areas, and introduce predatory fish. However, based on hydroregulation modeling results (Appendix B), the predicted increase in peak Kootenay Lake elevation would be expected to be much less than 3 feet, and management in real-time of Libby Dam would likely reduce this further. Given the pumping capacity and management strategies employed by the CVWMA, adverse effects to wildlife would not be expected to occur.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

In 2002, the Corps implemented this alternative on an interim basis, but because of back-to-back low water years, little or no change has been seen in relation to wildlife as a result. However, as previously discussed in the consequences of implementing LS1, any

[30] Blue-listed species in British Columbia are not immediately threatened, but of concern because of characteristics that make them particularly sensitive to human activities or natural events.

additional water released during the spring/summer would benefit wildlife via an increased riparian zone (Marotz 2005, Soults 2005, Ellis 2005, Stushnoff 2002 and 2005, Beaucher 2005, Wernham 2005). Although LV1 differs from LS1 primarily in the way Lake Koocanusa would be refilled, there would be the possibility that a small increase in flow above that of LS1 would result downstream from Libby Dam above that of LS1. This small increase may provide additional benefits to riparian habitat and wildlife beyond that realized under the no action alternative (LS1).

Compared to the LV benchmark operations, the fish flows in LV1 would maintain and enhance the riparian benefits gained for wildlife over the past decade.

As mentioned in the consequences for LS1, the waterfowl nesting areas in the CVWMA may be additionally impacted by increased flows under VARQ FC and the addition of fish flows during infrequent, extremely high water levels.

As in LS1, flow augmentation for sturgeon generally begins by mid May, but can start as early as April, depending on water temperature and runoff patterns. As a result of sturgeon flows paired with VARQ FC, water levels in the river adjacent to the refuge may rise slightly in most years, but as much as several feet in some extreme years. VARQ FC would not result in greater sturgeon flow augmentation than has been seen since 1992, when such augmentation was initiated.

Peak Kootenay Lake elevation under VARQ FC would likely increase, although when outflow at Libby Dam includes fish flows, increases under VARQ FC would typically be one foot or less in most years. The increased water levels may require more pumping at the CVWMA to maintain water levels in the preferred range within areas protected by dikes and levees; however, water levels in many years may not reach elevations that would require pumping. Although LV1 would slightly increase the peak elevation of Kootenay Lake, most years the lake level would remain well below flooding thresholds for the CVWMA. Operation with VARQ FC may increase the period of pumping required to prevent Duck Lake from overfilling and increase the average head the pumps would be working against. The impact would be to increase average annual pumping costs to the CVWMA by about 40 percent. Provided pumping continues, adverse effects to wildlife would not be expected to occur. Under real-time water management operations, peak lake elevations in more extreme years under either flood control operation may not be as high as the models indicate (Appendix B).

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs, and
(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

As mentioned under LV1, the consequences to wildlife under any alternative with fish flows would likely produce an overall benefit to wildlife. The primary difference between LS2 or LV2, and LV1 is the amount of flow and duration. Using the Bonners

Ferry benchmark identified in the overview of this section, only one alternative, LV2, has a higher average peak flow and Kootenay Lake stage than LV1 (a difference of six inches for the stage-frequency analysis) (Appendix B). This could slightly increase pumping costs to the CVWMA, but pumping would likely prevent any incremental adverse impacts to wildlife over the lake levels where LV2 or LS2 produce different peak lake levels than other alternatives. When modeled for stage-duration, LV2 is roughly six inches lower than LV1 on average, the reason being that, even though LV2 releases more water at the dam for fish flow augmentation, its duration may be shorter than LV1, which causes its overall average flow elevation to be lower than LV1. LV2 would reach more varial zone during its peak flow, but would deposit sediments over a shorter time than LV1. This may result in a slightly lower chance of establishing riparian habitat for wildlife. The difference is considered negligible. However, real-time operation may vary as volumes of water are used to respond to the conditions and objectives in any given year. The objective of LV2 (and LS2) is to allow a higher base flow for sturgeon at Bonners Ferry when dam releases are combined with local inflows, especially earlier in the season, correspondingly less wildlife benefit than LV1, but the differences between them all are still considered negligible.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Effects to wildlife under LSB would fall within the range between LS1 and LS2; effects under LVB would fall within the range between LV1 and LV2.

Kootenay Lake to the Confluence with the Columbia River

All Alternatives

Beginning in the early 1990s, Libby Dam operated under LS1, and the general wildlife consequences were addressed in the Columbia River System Operation Review EIS (BPA *et al.* 1995). However, since 2003 the Corps has been operating on an interim basis under the LV1 alternative and some environmental attributes impacting wildlife may have changed slightly. Based on discussions with individuals familiar with this issue, because of back-to-back low water years, changes in the wildlife condition observed over the previous decade have not changed under LV1. (Stushnoff 2005, Wernham 2005, Marotz 2005). Implementing LS1 would result in slightly lower peak flows compared to LV1 and would maintain the current wildlife condition. The addition of fish flows with LS1 or LV1 would maintain the riparian benefits gained for wildlife over the past decade. Excluding the consequences to the CVWMA identified under LV1, no additional consequences are anticipated for the remaining alternatives below Kootenay

Lake (Stushnoff 2005), but increased peak flows under LV1, LS2, LV2, LSB, or LVB may enhance the riparian benefits of fish flows by more closely mimicking more natural flow conditions.

3.3.6 Vegetation

River and lake level fluctuations vary among the alternatives, and these fluctuations drive wetland and riparian systems adjacent to the reservoir, lake, and river reaches affected by dam operations.

Model simulation of groundwater levels between Bonners Ferry and the international border provides some insight into influences of Kootenai River stage on subsurface hydrology and, in turn, potential wetland impacts. Model simulations of groundwater conditions in the Kootenai River valley in Idaho (Appendix G) indicate that:

- Simulated water levels patterns near the Kootenai River closely resemble the stage hydrographs input for the river.
- Simulated water levels at locations distant from the river are higher compared to levels near the river, with broader seasonal peaks compared to locations near the river.
- Simulated water levels at some locations near the valley margins appear not to be affected by the Kootenai River, and instead appear to respond to precipitation infiltration and tributary stages.
- Drains have a strong influence on water levels at some locations, and create depressions in the groundwater surface.

Qualitative comparisons of magnitude and duration of annual water level patterns provide an indication of potential effects on vegetation (primarily riparian and wetland areas). In general, operations that mimic more natural flow and lake level fluctuations are assumed to enhance development of vegetation along the river corridor.

Lake Koocanusa

All Alternatives

There is little or no shoreline vegetation established around the reservoir below the full pool level. The vegetation surrounding Lake Koocanusa would likely remain unchanged under any of the alternatives because there is no modification to the overall full pool elevation, the typical range of winter flood control draft (up to 172 feet below full pool elevation of 2459 feet under all alternatives), or the time period when the reservoir reaches full pool (which would occur in the period between the end of June and the end of July under all alternatives). Under all alternatives, the riparian interface around Lake Koocanusa would be similar to that already established (Wernham 2005, Marotz 2005, Soults 2005). Similarly, wetland extent and type would remain similar to that already established.

Libby Dam to Kootenay Lake near Creston, BC

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

Between the early 1990s and 2002, Libby Dam operated under this alternative. Since 2002 the Corps has been operating under the LV1 alternative and some environmental attributes that affected vegetation may have slightly changed. Due to back-to-back low water years since 2002, changes in the vegetation conditions observed over the previous decade have not changed with implementation of LV1.. Furthermore, repeated and consecutive low water years may have a negative impact on vegetation, but would not be a result of implementing a particular alternative. Finally, implementing this alternative would result in slightly lower peak flows over LV1 and would maintain the current vegetation condition.

Under this alternative, the consequences to riparian vegetation and wetlands are positive when fish flows are added. Following spring/summer fish flow augmentation beginning in the early 1990s, there was a documented change in riparian habitat spanning a 9-year period (Jamieson and Braatne 2001). Nilsson and Svedmark (2002) say that flow regime determines the successional evolution of riparian plant communities and ecological processes, in addition to serving as pathways for redistribution of organic and inorganic material (*i.e.*, benefits to wildlife). Jamieson and Braatne (2001) concluded that cottonwood stand recruitment did in fact occur solely as a response to increased flows from Libby Dam for white sturgeon spawning from 1991 to 2000. This simply translates into expanded riparian habitat.

Any alternative that increases spring flows, even a small increase over normal, would correspondingly inundate the varial zone of the Kootenai River and promote the recruitment of new riparian habitat as was observed in the study done by Jamieson and Braatne (2001). The premise behind this recruitment is that during higher spring flows, greater seed dispersal and germination is taking place in the newly deposited soils. However, in the case of the Kootenai River and Libby Dam, newly deposited soils and seeds would often be removed by winter flow releases that end up scouring these newly formed areas (Marotz 2005). This condition would likely continue under any of the alternatives.

Groundwater simulations indicate that groundwater levels during the growing season under LS1 would tend to be slightly lower than those under any of the VARQ FC alternatives or LS2. Many wetlands in the valley floodplain are isolated from the river by levees or perched above the river level and primarily supported by tributary flows (Soults 2005). From a valley-wide perspective, lower groundwater levels would tend to impair wetland habitat establishment and conservation by decreasing hydrologic support. Also, LS1 river stages would tend to be lower than the VARQ FC alternatives. While the incremental effect of the fish flows, compared to the LS benchmark operation, would better facilitate wetland establishment, conservation, and restoration in the valley, the relatively low peak and average river stages under LS1 could, in relation to the other alternatives, allow increased drainage of the floodplain through ditch systems or Kootenai River tributaries, and complicate or preclude future wetland restoration projects intended to restore the hydrologic and ecologic connection between floodplain wetlands and the river.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

As with LS1, flow augmentation for sturgeon and salmon under LV1 would tend to benefit development of riparian habitats. LV1 would tend to have slightly higher peak river flows and stages, with corresponding incremental benefits for riparian habitat. The incremental effect of the fish flows would allow maintenance and enhancement of riparian communities, when compared to the LV benchmark operations. Winter flows are reduced in medium-runoff years under LV1 because of increased water storage in Lake Koocanusa, which may reduce scour of newly deposited soils and seeds during the winter and result in additional benefits to riparian vegetation.

Groundwater levels and river stages under LV1 would tend to be similar to LV2 and slightly higher than Standard FC alternatives, which would tend to benefit wetland habitat establishment, conservation, and restoration.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

The objective of LS2 is to allow a higher base flow for sturgeon at Bonners Ferry when dam releases are combined with local inflows, especially earlier in the season. Peak river flows and stages under LS2 during the runoff season would be higher than any other alternative except LV2, but median river elevation would tend to be lower than any alternative. The reason being is that even though LS2 releases higher flows at the dam for sturgeon flow augmentation, the total volume released under all alternatives is the same. Accordingly, the duration of the high flow under LS2 would tend to be shorter than LS1 and result in the lowest median flow and river stage of all the alternatives. As a result, LS2 would reach much of the varial zone during peak flow, but would have a shorter period of time depositing sediments than the other alternatives. This may result in a slightly lower chance of establishing riparian habitat. Real-time operations may vary, however, as volumes of water are used in response to conditions and objectives in any given year. Groundwater conditions and typical river levels under LS2 would tend to be similar to LS1 during higher runoff years, and similar to LV2 and LV1 during more average years. With the tendency for similarity to the VARQ FC alternatives in typical years, LS2 may produce slightly higher benefits for wetland establishment, conservation, and restoration than the other Standard FC alternatives.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

LV2 would result in the highest peak river flows and stages at Bonners Ferry. However, over the course of the spring freshet, the average Bonners Ferry stage under LV2 is roughly six inches lower than that under LV1 (since the total volume released for sturgeon flow augmentation is the same under all alternatives). As a result, LV2 would reach more varial zone than the other alternatives during its peak flow, but would deposit sediments for a shorter period of time than LV1. This may result in a slightly lower chance of establishing riparian habitat. The difference is considered negligible. Real-time operation may vary, however, as volumes of water are used in respond to conditions and objectives in any given year.

Effects on wetlands for LV2 would be similar to those under LV1 since groundwater conditions and typical river levels would be similar under both alternatives.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Effects to vegetation under LSB would fall within the range between LS1 and LS2; effects under LVB would fall within the range between LV1 and LV2.

Kootenay Lake to the Confluence with the Columbia River

All Alternatives

The vegetation in riparian areas and wetlands surrounding Kootenay Lake would likely remain unchanged under any of the alternatives because there is no modification to the typical peak lake elevation, the typical range of lake level fluctuation (which is determined for the most part by the International Joint Commission Order of 1938 under any of the alternatives), or the time period when the lake reaches peak elevation (which would occur between the end of June and the end of July under all alternatives). Under all alternatives, the riparian interface, including fringe wetlands, around Kootenay Lake would be similar to that already established. Similarly, wetland extent and type would remain similar to that already established.

3.3.7 Recreation

Hydroregulation results for Libby Dam form the basis for the analysis of recreational consequences. The templates and assumptions in the hydroregulation analysis are implicit in the recreation analysis.

River-related recreation resources were identified and documented. Threshold water surface elevations or recreation resource characteristics were identified for different recreational activities in each subarea. These thresholds are the data points at which the recreation activity becomes affected by changes in water levels or outflow volumes. To identify impacts, the identified thresholds were compared with derivations of daily or monthly reservoir stages and outflows as simulated over a 52-year period for all alternatives. Impacts were quantified where possible, and in cases where available data were insufficient for quantification, a qualitative evaluation of potential impacts was performed. Quantification of impacts typically involved documenting the number of days in the respective recreation season that the recreational activity would be available with each alternative.

For further details on anticipated environmental consequences, see the portion of Appendix E concerning impacts.

Lake Koocanusa

Upriver of the highest elevation of Lake Koocanusa, there are no anticipated effects from any alternative.

The alternatives affect Lake Koocanusa operation, and thus, reservoir-dependent recreation (including visitation to the Visitors' Center at the dam). During the primary recreation period of May-September, reservoir levels would vary by alternative, as shown in Table 3-14. Specific activities are discussed below. Quantified recreation evaluation criteria for Lake Koocanusa included boat ramp days, swimming days, camping days above the initial impact threshold of 2439 feet, and camping days above the more extensive impact threshold of 2409 feet. In general, Canadian recreationists feel they are impacted at elevations below 2445 feet for various purposes (BC Hydro *et al.* 2004). The total number of days for each criterion and each alternative are summarized in Table 3-22 and Table 3-23.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

This alternative would provide relatively low levels of accessibility for reservoir recreation on Lake Koocanusa, primarily due to relatively low reservoir levels through the primary recreation season. Under LS1, the average reservoir elevation at the end of July would be 2443 feet, 16 feet from full. On average, the reservoir would be more than 20 feet from full pool at the end of May, June, August and September. Under LS1, relatively low lake levels during the prime recreation season would also adversely affect aesthetics around the lake. Under all alternatives, drafting the reservoir to 2439 feet by the end of August for salmon flow augmentation would adversely affect recreation on Lake Koocanusa in late August and September compared to the benchmark, with relatively greater impacts in Canada where such a draft would take much of the reservoir down to the pre-dam river level.

Table 3-22. Summary of Quantified Recreation Impacts at Lake Koocanusa – United States. LVB would fall within the range between LV1 and LV2; LSB would fall within the range of between LS1 and LS2.

	Recreation Evaluation Criteria			
Alternative	Total Boat Ramp Days (May-Sept)	Total Swimming Days (Jun-Aug)	Camping Days above 2439 feet (May-Sep)	Camping Days above 2409 feet (May-Sep)
LS1	1340	107	45	113
LV1	1467	150	65	126
LS2	1351	92	42	112
LV2	1454	142	61	124
Benchmark				
LS	1627	217	102	122
LV	1665	221	104	130

Notes:

a) Alternatives with fewer days for a given activity would have more impacts to that activity.

b) Boat ramp days are the sum of conditions that allow use of 13 boat ramps, so the maximum possible number of boat ramp days from May-September would be 1989 days (153 days x 13 ramps).

c) Swimming days are the sum of usable swimming days at 3 public improved swimming areas, so the maximum possible number of swimming days from June-Aug. would be 276 days (92 days x 3 beaches).

d) Camping days are the number of days over the 153 day May-September period that the lake level exceeds the given thresholds.

Table 3-23. Summary of Quantified Recreation Impacts at Lake Koocanusa – Canada. LVB would fall within the range between LV1 and LV2; LSB would fall within the range between LS1 and LS2.

	Recreation Evaluation Criteria	
Alternative	**Total Boat Ramp Days (May-Sep)**	**Swimming Days (Jun-Aug)**
LS1	352	29
LV1	414	51
LS2	343	24
LV2	404	45
Benchmark		
LS	503	131
LV	522	133

Notes:

a) Alternatives with fewer days for a given activity would have more impacts to that activity.

b) Boat ramp days are the sum of conditions that allow use of 5 boat ramps, so the maximum possible number of boat ramp days from May-September would be 765 days (153 days x 5 ramps).

c) Swimming days are the sum of usable swimming days at two public improved swimming areas, so the maximum possible number of swimming days from June-Aug. would be 181 days (92 days x 2 beaches).

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Primarily because the reservoir would tend to be more full with VARQ FC than Standard FC, the VARQ FC alternatives generally would result in more lake accessibility at boat ramps and camping areas, and improved swimming beaches in comparison to Standard FC. LV1 would result in relatively high levels of recreational accessibility on Lake Koocanusa. Under LV1, the average reservoir elevation at the end of July would be within 11 feet of full on average. At the end of June, July and August, the reservoir would be within 20 feet of full on average. Under LV1, lake levels during the prime recreation season tend to be higher than the Standard FC alternatives with fish flows, resulting in relatively higher aesthetic values around the lake.

Addition of the fish flows tends to substantially decrease reservoir elevation during the recreation season, with corresponding adverse effects on recreation access and aesthetics of Lake Koocanusa (compared to the LV benchmark operation, which would keep the reservoir within 10 feet of full from June through August).

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

Similar to LS1, LS2 would provide relatively low values for recreational accessibility and aesthetics at Lake Koocanusa. Under LS2, the average end of July reservoir elevation would be 2442, or 17 feet from full; the rest of the recreation season, the reservoir would average greater than 20 feet from full. These average reservoir levels tend to be slightly lower than those under LS1 (about 1 foot on average), with likely incremental impacts on recreation accessibility and aesthetics.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Similar to LV1, this alternative would provide intermediate values for recreational accessibility and aesthetics at Lake Koocanusa. This alternative would result in average reservoir elevation within 12 feet of full by the end of July, and within 20 feet of full at the end of June, July and August. These average reservoir levels tend to be slightly lower than those under LV1 (about 1 foot on average), with likely incremental impacts on recreation accessibility and accessibility.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Effects to Lake Koocanusa recreation under LSB would fall within the range between LS1 and LS2; effects under LVB would fall within the range between LV1 and LV2.

Summary

In sum, the differences are minor when comparing differences between LS1, LS2 and LSB, or comparing between LV1, LV2 and LVB. Comparing the Standard FC alternatives to the VARQ FC alternatives, the differences are more pronounced, with the VARQ FC alternatives providing significantly better recreation conditions (particularly for camping and swimming) on Lake Koocanusa. Impacts to recreation in late summer would be similar under all alternatives since reservoir levels in late August and through September would tend to be at or close to 2439 feet, 20 feet below full reservoir levels.

Libby Dam to Kootenay Lake near Creston, BC

Boating and fishing[31] are the primary recreational activities associated with the Kootenai River that are potentially affected by operational changes at Libby Dam. The average monthly release rates for all months from Libby Dam in cubic feet per second (cfs) are presented in Table 3-16 for each alternative and benchmark. Compared to standard flood control operations (LS1 and LS2), VARQ FC operations (LV1 and LV2) result in an increase in outflow from Libby Dam during the summer recreation season (May-September). Fish flows result in higher releases compared to the non-fish-flow LS and LV benchmark operations in May, June and August. Results vary in July, and the alternatives result in lower September and October flows than their corresponding benchmark operation.

Quantified recreation evaluation criteria for the Kootenai River included shore fishing days and boating/boat fishing days. The optimal range for shoreline fishing was identified as 4 to 10 kcfs. The optimal range for boat fishing was identified as 8 to 25 kcfs, which also corresponds to the optimal release rate for use of boat launches along the Kootenai River. From 5 to 7 kcfs, only small drift boats, canoes, and kayaks can be launched. At flows below 5 kcfs, the boat launches are not usable. The total number of days for each criterion and each alternative and benchmark are summarized in Table 3-24.

All Standard FC Alternatives (LS1, LS2, LSB)

LS1 and LS2 would result in relatively high numbers of optimal shore fishing days, and relatively low numbers of days with optimal boat access for the Kootenai River. LSB would fall within the range of LS1 and LS2. The addition of fish flows tends to increase the number of days within the optimal range for shore fishing and boating (as compared to the LS benchmark operation).

[31] No impacts to camping along the river were identified.

Table 3-24. Summary of Quantified Recreation Impacts on the Kootenai River. LVB would fall within the range between LV1 and LV2; LSB would fall within the range between LS1 and LS2.

	Recreation Evaluation Criteria	
Alternative	**Shore Fishing Days (May-Sep)**	**Boating and Boat Fishing Days (May-Sep)**
LS1	77	88
LV1	50	101
LS2	80	88
LV2	54	105
Benchmark		
LS	74	85
LV	48	115

Note: Alternatives with fewer days for a given activity would have more impacts to that activity. The primary recreation season occurs from May through September, 153 days total.

More frequent spill events under LSB would likely adversely affect the quality of river fishing due to potentially decreased numbers of targeted fish species or age classes as a result of displacement or mortality; or, less aesthetically pleasing experience resulting from catching fish with more common fin splits and fungus growth that can result from injuries suffered during periods of high TDG.

Compared to the VARQ FC alternatives, LS1, LS2, and LSB would result in relatively lower flow rates during the summer recreation season, particularly from May through August, and the lower flows with LS1, LS2, or LSB could be generally less aesthetically pleasing than higher flow rates. Fish flows would also result in higher aesthetic values than the LS benchmark operation.

All VARQ FC Alternatives (LV1, LV2, LVB)

LV1 and LV2 would result in relatively low number of days with optimal shore fishing, and an relatively high number of days with optimal boating conditions. LV2 would result in slightly more days within the optimal range for both shore fishing and boating. LVB would fall within the range between LV1 and LV2. The addition of fish flows would tend to increase the number of days within the optimal range for shore fishing, and decrease the number of optimal days for boating (as compared to the LV benchmark operation).

Spill events would be most frequent under LVB and would likely adversely affect the quality of river fishing due to potentially decreased numbers of targeted fish species or age classes as a result of displacement or mortality; or less aesthetically pleasing experience resulting from catching fish with more common fin splits and fungus growth that can result from injuries suffered during periods of high TDG.

LV1, LV2, and LVB would result in relatively higher flow rates during the summer recreation season, particularly from May through August, and the increase in flows would be large enough to be perceptible to recreation users. Higher flow rates could be generally more aesthetically pleasing than lower flow rates. Fish flows would also result in higher aesthetic values than the LV benchmark operation.

Summary

In summary, the VARQ FC alternatives would result in significantly fewer shore fishing days on the Kootenai River. However, compared to Standard FC alternatives, the VARQ FC alternatives would increase the number of boating and boat fishing days so the net impact of VARQ FC on fishing opportunities on the river would be relatively small. LSB and LVB would create episodes of high TDG in up to three out of ten years that would likely adversely affect the quantity or quality of desired game fish species.

Kootenay Lake to the Confluence with the Columbia River

Boating, fishing, swimming and camping were identified as the primary recreational activities at Kootenay Lake that could be affected by changes in lake levels. Table 3-18 presents average end-of-month water surface elevations for Kootenay Lake for twelve months. During the spring break period (typically near Easter, which always falls between March 22 and April 25) when many boaters put their vessels in the lake in preparation for the summer recreation season, lake elevations would be the same under all alternatives (see Figure 3-17).

Average end-of-month stage at Kootenay Lake would be generally similar under all alternatives in all summer recreation season months (May-September). Average end-of-month stages would be one foot higher with VARQ FC alternatives (LV1, and LV2) and the LV benchmark operation during May as compared to Standard FC alternatives (LS1, and LS2) and the LS benchmark operation. The values for LVB would be within the range between LV1 and LV2; the values for LSB would be within the range between LS1 and LS2.

The main recreation evaluation criterion for Kootenay Lake was the number of days with lake elevations between 1740 and 1754 feet, the range of lake elevation identified by Canadian stakeholders as optimal for most recreational resources at the lake. In addition to this general range, several specific threshold impact elevations were identified for specific activities and locations. These additional thresholds included boat moorage days at Pilot Bay Resorts (lake elevation above 1744 feet from January through May), fishing days at Kootenay Kampsites (lake elevation above 1744 feet from May through September), and swimming days (lake elevations below 1749 feet from June through August). The total number of days for each criterion and each alternative are summarized in Table 3-25.

No impacts were identified to Kootenay Lake campgrounds during the primary May-through-September recreation season. The small differences in summer lake elevations between the alternatives should not have any noticeable effect on lake aesthetics.

All Standard FC Alternatives (LS1, LS2, LSB)

LS1 and LS2, as with all the other alternatives, would result in average end of month lake elevation within the optimal range for all months except March, which has an average end of month lake elevation of 1739 feet, one foot below the lower threshold of 1740 feet. All other alternatives also would have an average end-of-March elevation of 1739 as well. Of the alternatives, LS1 would provide the highest and LS2 the second highest number of days within the optimal range from May through September, with 2 to 3 more days than LV1 or LV2. Numbers of fishing days at Kootenay Kampsites would be relatively low under LS1 or LS2. Moorage days at Pilot Bay Resorts under LS1 and LS2 would be similar to that under all the other alternatives, while swimming days would be similar to the other alternatives, but slightly less than the non-fish-flow benchmark operations. As with the Standard FC alternatives, the addition of fish flows would tend to decrease the number of days within the optimal recreational range. The values for LSB would be within the range for LS1 and LS2.

(LV1) VARQ FC w/ fish flows to powerhouse capacity and (LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

LV1 and LV2 would result in slightly fewer numbers of days within the optimal range during the summer compared to their corresponding Standard FC alternative. These alternatives would support relatively high numbers of fishing days at Kootenay Kampsites, and similar numbers of days to those under LS1 or LS2 for other recreational activities on Kootenay Lake. Except for fishing days at Kootenay Kampsites, the addition of fish flows would tend to decrease the number of days within the optimal recreational range. The values for LVB would be within the range for LV1 and LV2.

Table 3-25. Summary of Quantified Recreation Impacts at Kootenay Lake. LVB would fall within the range between LV1 and LV2; LSB would fall within the range between LS1 and LS2.

	Recreation Evaluation Criteria			
Alternative	**Days in the general recreation optimal range (May-Sep)**	**Boat moorage days @Pilot Bay Resorts (Jan-May)**	**Fishing days @Kootenay Kampsites above elevation 1744 feet (May-Sep)**	**Swimming days below lake elevation 1749 feet (Jun-Aug)**
LS1	135	52	83	77
LV1	132	52	90	76
LS2	134	52	82	76
LV2	132	52	89	75
Benchmark				
LS	142	51	79	84
LV	139	52	86	82

Note: a) Alternatives with fewer days for a given activity would have more impacts to that activity.

b) The primary recreation season is May – September, 153 days total.

3.3.8 Environmental Health

Air Quality

Hydroregulation results for Lake Koocanusa formed the basis for the analysis of air quality consequences. The templates and assumptions that went into the hydroregulation analysis were therefore implicit in the air quality analysis.

The primary indicator of air quality problems for the area around Lake Koocanusa is the time during which the lake elevation is below elevation 2404 feet, as well as the amount of dry lakebed exposed below that elevation. The greater the time and area of exposure, the greater the chances of dust becoming airborne during a wind event.

There are no air quality effects anticipated between Libby Dam and the confluence of the Kootenay River with the Columbia River due to the alternatives; therefore, no analysis was performed.

Lake Koocanusa

Table 3-26 shows the percent of time, based on modeled daily average reservoir elevations, that Lake Koocanusa would be below elevation 2404 feet with the alternatives and benchmark operations. This and the amount of dry lakebed exposed would govern susceptibility of dry lakebed sediments to mobilization by wind. In winter, freezing conditions allowing the continued presence of frost, ice, or snow might help prevent some events during otherwise dry periods. Table 3-26 captures the effect on pool elevation of VARQ FC compared to Standard FC. Some additional effect of providing fish flows might also be expected. These effects are discussed in the following summaries.

Table 3-26. Lake Koocanusa elevations below elevation 2404 feet. LVB would fall within the range between LV1 and LV2; LSB would fall within the range between LS1 and LS2.

	Median Reservoir Elevation (feet)				Lake Elevation ≤ 2,404 feet (% of time period)		
Alternative	Jan-Apr	May	Jun	Jul	Jan-Apr	May	Jun
LS1	2370	2371	2415	2440	90	87	32
LV1	2396	2398	2427	2446	63	60	13
LS2	2370	2370	2411	2440	90	88	37
LV2	2396	2398	2425	2445	63	62	18
Benchmark							
LS	2370	2372	2424	2458	90	83	14
LV	2396	2399	2438	2458	63	56	7

Note: Lake Koocanusa would be higher than 2,404 feet by July under all alternatives and benchmark operations

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

With this alternative, Lake Koocanusa would be below elevation 2404 feet most of the time in winter and into spring. In June, on average, it might be below elevation 2404 feet somewhat more than 32 percent of the time. By July it would be above 2404 feet and would remain there through December, at the end of which it would be at elevation 2411 feet or higher. January through April median reservoir elevation would be 2370 feet; it would be 2371 feet in May, 2415 feet in June, and 2440 feet in July. Dust events could occur during dry periods from January through June. Compared to the LS benchmark operation, the addition of fish flows would serve to increase the likelihood of reservoir elevations below 2404 feet during May and June, with resulting increased likelihood of dust events. The incremental effect of the fish flows becomes greatest in June, which corresponds to the beginning of the fish flow season. Frost, ice or snow might mitigate the possibility of events during otherwise dry periods in winter, but in general, air quality may be impacted to some extent by this alternative.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Under this alternative, the lake would be below elevation 2404 feet somewhat more than half the time during January through May, and 13 percent of the time in June. The elevation would be above 2404 feet by July, and would remain above 2404 feet through December, when it would draft to elevation 2411 feet or higher. This would amount to less time with reservoir elevations below elevation 2404 feet than with LS1. Dust events could occur during dry periods from January through June, but conditions conducive to dust events would be less likely than either of the Standard FC alternatives. Frost, ice, or snow might mitigate the possibility of events during otherwise dry periods in winter. In general, air quality would be less impacted through this alternative than it would be under LS1.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs

With this alternative, Lake Koocanusa would be below elevation 2404 feet most of the time in winter and into spring. In June, on average, it might be below elevation 2404 feet 37 percent of the time and slightly more than with LS1 because of flow releases above current powerhouse capacity for sturgeon. By July it would be above 2404 feet and would remain there through December. Air quality impacts might be slightly higher than with LS1 or the LS benchmark operation as a result of the fish flows, and somewhat greater than with LV2.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

Under this alternative, the lake would be below elevation 2404 feet for 63 percent of the time from January through May and 18 percent of the time in June. The elevation would be above 2404 feet by July, and would remain above 2404 feet through December, when it would draft to elevation 2411 feet or higher. Dust events could occur during dry periods during January through June. Frost, ice or snow might mitigate the possibility of events during otherwise dry periods in winter. Air quality impacts under LV2 may be slightly greater than with LV1 or the LV benchmark operation, but less than with any of the Standard FC alternatives.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

The values for LSB would be within the range between LS1 and LS2.

(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

The values for LVB would be within the range between LV1 and LV2.

Summary

The exposure to potential dust events is less with higher reservoir elevations. In general, alternatives including VARQ FC (LV1, LV2, LVB) and the LV benchmark operation would allow the reservoir to be above elevation 2404 feet more of the time than would those incorporating Standard FC (LS1, LS2, LSB) and the LS benchmark operation. Provision of fish flows in spring (alternatives LS1, LV1, LS2, LV2, LSB, LVB) would increase the amount of time the lake might be below elevation 2404 feet compared with alternatives without fish flows. Adding 10 kcfs outflow capacity beyond current powerhouse capacity (alternatives LS2, LV2, and, in some years, LSB and LVB) might increase the length of time before the reservoir would rise above elevation 2404 feet in spring compared with other alternatives having fish flows (LS1, LV1). The longer the reservoir remains below elevation 2404 feet, and the further below elevation 2404 feet it is (as indicated by median elevations in Table 3-26), the greater the chance of a windblown dust event.

Libby Dam to the Confluence with the Columbia River

None of the alternatives would affect environmental health issues in this reach, including potentially contaminated sediments in the river.

3.3.9 Cultural Resources

Lake Koocanusa

Area of Potential Effect (APE)

The APE for VARQ FC at Libby Dam—Lake Koocanusa is defined as the area of direct physical impacts of the reservoir between elevations 2338 and 2459 feet, from the Canadian boundary downstream approximately 48 miles (78 km) to Libby Dam. Reservoir operations have indirect effects to the character of historic properties outside the area of direct physical impacts of reservoir operations. Effects of standard reservoir operations (e.g., bank slumping above elevation 2459 feet) are addressed in the project Historic Properties Management Plan.

This analysis assumes that the known inventory of historic properties at Lake Koocanusa represents a complete number of archaeological sites. The affected shoreline has received 100 percent complete archaeological inventory, but due to the dynamic nature of shoreline sediments there will probably always be additional properties found that are not yet identified. Not included in the analysis are possible effects to Traditional Cultural Properties. Government supported studies confirm that these are present along the inundated reach of Kootenai River in Lake Koocanusa. Affected Indian tribes have the opportunity to comment.

Another assumption is that the vertical distribution reported for cultural sites is accurate. Again, due to fluctuating water and the dynamic nature of the shoreline, some of the known sites may have greater elevational spans than current data show.

For purposes of this analysis, impacts were measured based on median reservoir elevations throughout the water year. A median reservoir elevation can be thought of as the level where it is equally probable to have the water above or below that elevation for the given day.

The primary analysis looks at the specific effects of water fluctuation between 2342 and 2459 feet elevation (where archaeological inventory data exist).

The analysis of impacts to historic properties at Libby Dam-Lake Koocanusa is based upon the latest cultural site inventory in the GIS database at Kootenai National Forest. This information is derived from primary cultural resources management reports from both the Corps and the Forest Service. GIS and other data from Kootenai National Forest were used to determine which sites would be affected by the water fluctuation zone, and the nature of the effects.

Below Libby Dam, temporary flooding of parts of sites is physically evident for a distance of about five miles. In some cases this has resulted in substantial streambank erosion and has potential for gradual attrition of cultural sites. An archaeological inventory survey has been conducted up to 17 miles below Libby Dam (Munsell and Salo 1979). These sites are always exposed and are subject to disturbance by relic collecting and vandalism. Farther downstream about 30 miles (50 km) at Kootenai Falls Archaeological District, inventoried cultural resource sites are above the Kootenai River channel and produce no known effects upon cultural resources.

The impact indicators selected for analysis are considered relative to base conditions, *i.e.*, Standard FC. The indicators are:

- number of historic properties inundated by fluctuating reservoir levels
- National Register status of affected properties
- direct impact by water erosion
- impacts due to relic collecting or vandalism
- timing, frequency, and duration of water operation

Based on the median reservoir elevations determined from flood control simulations, the number of cultural resource sites impacted in Lake Koocanusa by all Standard FC operations, with or without fish flows, is 268 sites. Based on the median reservoir elevations determined from flood control simulations, the number of cultural resource sites impacted by all VARQ FC alternatives, with or without fish flows, equals 247 sites. For this analysis, the impact of each alternative is measured by the timing, duration, and extent of fluctuating water levels in Lake Koocanusa.

The Standard FC alternatives (LS1, LS2, LSB) and the LS benchmark operation would affect 21 more recorded sites than the VARQ FC alternatives (LV1, LV2, LVB) and the LV benchmark operation. From the standpoint of cultural resources impacts, there are no more impacts to cultural resource sites with fish flows than there are without fish flows. There appears to be no major difference in site impact whether or not fish flows are added, but there are other differences in impacts between Standard and VARQ FC operations. The effects of wasting and slumping to upslope sites would not vary among alternatives.

The more meaningful impact comparisons include:

- Median drawdown levels for Standard FC operations typically expose 23,799 acres in the drawdown zone of Lake Koocanusa in an average water year. This compares with 19,325 acres exposure for the VARQ FC operation, 4475 acres less than under Standard FC operations. Less exposure would mean less risk of loss to vandalism and relic collecting. Long periods of inundation from year to year could also limit access to archaeological sites identified for study.
- Based on simulated median reservoir elevations, Standard FC alternatives draw down 41 ft deeper and two to four weeks longer than VARQ FC alternatives. This would produce the most erosion and greatest vulnerability to relic collecting and vandalism to archaeological sites.

The addition of the fish flows would increase vulnerability to vandalism and relic collecting since these operations would not reach full pool of 2459 feet elevation for most of the summer as would the LS and LV benchmark operations. Furthermore, draft of the reservoir in the fall under the alternatives could further increase exposure of resources to adverse impacts. In summary, VARQ FC alternatives have fewer cultural resource impacts at Lake Koocanusa than Standard FC operations. More than 4400 fewer acres and twenty-one fewer sites are exposed during the spring drawdown in an average water year, and the sites are exposed for two to four weeks shorter time period during the peak recreational season. The generally high water levels protect known cultural sites from relic collecting and vandalism, and the sites are less affected by gradual drawdowns during late summer. There is no significant difference in reservoir impacts among the VARQ FC alternatives.

Libby Dam to Kootenay Lake near Creston, BC

Downstream of Libby Dam, the APE is expressed in terms of locations that can be shown to be physically affected by dam releases, in particular, inventoried archaeological sites in the five mile reach of Kootenai River below Libby Dam. The Corps manages indirect effects on a case by case basis.

The impact indicators selected for analysis are considered relative to base conditions, *i.e.*, Standard FC. The indicators are:

- Number of downstream historic properties partially inundated by dam releases,
- National Register status of affected properties,
- Direct impact by water erosion, and
- Impacts due to relic collecting or vandalism.

The various alternatives would affect flows and stages for the river downstream of Libby Dam. Therefore the river is included in the APE for this analysis. The affected reach downstream of the dam extends for about five miles. LS1, LS2, LV1, LV2, LSB, and

LSB all have the potential to affect six archaeological sites below Libby Dam within the Libby-Jennings Archaeological District. Visible impacts, however, appear to be limited to the first five miles below the dam, and these consist primarily of streambank erosion. Farther downstream, the effects are felt in the main Kootenai River channel and produce no known effects upon cultural resources.

Kootenay Lake

As stated in Section 3.2.10, little information is available concerning cultural resources around Kootenay Lake. Based on Table 3-15, there is little difference among lake levels for any of the alternatives or benchmarks, so no difference in effect on cultural resources can be discerned. The effect of the VARQ FC alternatives and benchmark would be very similar, amounting to slightly higher levels in Kootenay Lake, compared to alternatives and the benchmark using Standard FC. It is unlikely that this effect would impact significant archaeological resources.

3.3.10 Indian Sacred Sites

All alternatives

Under Executive Order 13007, “Native American Sacred Sites,” Federal agencies must, consistent with essential mission functions, accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and avoid adversely affecting the physical integrity of such sacred sites. Existing operations, which are an essential Corps mission, may have compromised access to and physical integrity of sacred sites. In informal consultations with the CSKT, they have chosen not to discuss sacred sites at Libby Dam-Lake Koocanusa. Therefore, the possible effects on TCPs are not assessed in this analysis.

3.3.11 Other Affected Tribal Interests

While much of the area retains resources that support hunting, fishing, and gathering activities, some areas may have been already disturbed to the extent that they no longer can support such traditional uses. No additional impacts would affect other Tribal interests under any of the alternatives.

3.3.12 Socioeconomics

Cost and benefit data were based upon October 2004 prices and conditions, with the exception of estimated average annual losses on Kootenay Lake, where 2005 prices and conditions are the basis. Methodologies for evaluating direct socioeconomic impacts and their indirect impacts on regional employment and income are summarized below and described in detail in Appendix F.

Flood Control

When flood waters flow onto developed properties, losses may occur. The extent of these losses is, in part, a function of the depth and duration of the floodwaters. Two flood-prone reaches were evaluated for flooding impacts: the Kootenai River (Bonners Ferry to Canadian border) and the Kootenay Lake shoreline. The Corps estimated average annual losses for flood control impact centers in the United States portion of the Kootenai River basin with each alternative and benchmark operation.[32] Categories of impacts evaluated included residential, commercial/industrial, public, agricultural, emergency aid costs, and miscellaneous, including transportation. In Canada, flood losses were evaluated based on recent qualitative stakeholder surveys conducted by BC Hydro *et al.* (2004) and recent inventories of potential flood impact areas along the West Arm of Kootenay Lake (BC Hydro 2005).

For purposes of this evaluation, the term "damage" refers to economic impacts or losses that might occur as a result of flooding, and does not imply either liability or even certainty that these losses may occur. Thus, the term "estimated average annual losses" refers to potential estimated economic losses that may occur given a certain set of circumstances. The "zero dollar damage point" is based on the approximate elevation of water (stage) in the river or lake at which economic losses may begin. "Stage damage" refers to the relationship between the stage of the river or lake and the economic losses at that level. Details on stage-damage and outflow-frequency functions can be found in Appendix F and Appendix B, respectively.

Libby Dam to Kootenay Lake

The zero dollar damage point for the Libby Dam to U.S.-Canada border reach is considered elevation 1764.0 feet (NGVD datum), which corresponds with the flood stage at Bonners Ferry.

Stage–frequency relationships developed at the Bonners Ferry gage for the four alternatives and two benchmark operations were used to derive estimated average annual losses for this flood impact reach. Table 3-27 presents a summary of estimated average annual losses by category for the alternatives and benchmark operations.

As shown on Table 3-27, all alternatives except the LV benchmark operation would have identical estimated average annual losses of $21,780. The LV benchmark operation would increase estimated average annual losses by $1,170, or 5 percent relative to the other alternatives.

[32] Flood losses were estimated using the Expected Annual Damages program from the Corps' Hydraulic Engineering Center. This program integrates exceedance frequency with associated damages to determine expected annual damages for a given frequency distribution.

Table 3-27. Estimated Average Annual Losses - Libby Dam to Kootenay Lake (x$1,000). Values for LVB and LSB would be the same as for the other alternatives.

Alternative	Residential	Commercial/ Industrial	Public	Agriculture	Emerg. Aid	Misc. (incl. Transportation)	Total Estimated Losses
LS1	0.44	6.10	3.05	6.97	3.7	1.52	21.78
LV1	0.44	6.10	3.05	6.97	3.7	1.52	21.78
LS2	0.44	6.10	3.05	6.97	3.7	1.52	21.78
LV2	0.44	6.10	3.05	6.97	3.7	1.52	21.78
Benchmark							
LS	0.44	6.10	3.05	6.97	3.7	1.52	21.78
LV	0.46	6.43	3.22	7.34	3.9	1.60	22.95

Note: Data presented in October 2004 Prices & Conditions

Kootenay Lake to Confluence with Columbia River

From a flood control perspective, the impacts of VARQ FC operations and fish flows on the level of Kootenay Lake are of greatest importance in May, June, and July.

Daily lake elevations were modeled with each alternative and benchmark operation over a 52-year period and reviewed to identify the average number of days per month that the lake level was at or below elevation 1752 feet, the upper limit of the range of lake elevations identified in BC Hydro *et al.* (2005) as preferred from a flooding perspective. The results are shown in Table 3-28. Results show that the average number of days per month that the lake is at or below 1752 feet is the same during all months except June. LS1 (the No Action alternative) and LV1 both have an average of 28 days below 1752 in June. The two alternatives with additional flow capacity from Libby (LS2 and LV2) have the lowest number of days (27) in June when the elevation is at or below 1752. During June, the LS and LV benchmark operations have the highest average number of days below 1752 (30 and 29, respectively).

Table 3-28. Average Days per Month with Kootenay Lake Elevation at or below 1752 Feet. LVB would fall within the range between LV1 and LV2; LSB would fall within the range betweenLS1 and LS2.

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
LS1	31	28	31	30	31	28	31	31	30	31	30	31	363
LV1	31	28	31	30	31	28	31	31	30	31	30	31	363
LS2	31	28	31	30	31	27	31	31	30	31	30	31	362
LV2	31	28	31	30	31	27	31	31	30	31	30	31	362
Benchmark													
LS	31	28	31	30	31	30	31	31	30	31	30	31	365
LV	31	28	31	30	31	29	31	31	30	31	30	31	364

A recent inventory of properties (BC Hydro 2005) provides stage-damage relationships for the West Arm of Kootenay Lake, the portion of the lake with the most shoreline development. Residential properties account for the primary flood impact category. Table 3-29 presents a summary of estimated average annual losses for the West Arm of Kootenay Lake for each of the alternatives. When fish flows are part of the operation, the estimated average annual losses for the VARQ FC alternatives are 6 to 7 percent higher than the respective Standard FC alternatives. The different fish flow operations appear to have more of an effect on estimated average annual losses than the flood control operation, with about 20 percent more expected annual losses for LS2 and LV2 in comparison with LS1 and LV1, respectively. Values for LVB would fall within the range betweenLV1 and LV2; values for LSB would fall within the range between LS1 and LS2. The addition of fish flows in LS1 and LV1 would result in an increase of 115 percent and 88 percent in estimated average annual losses, respectively, compared to the LS and LV benchmark operations. Baseline information required to estimate potential damages around Kootenay Lake in areas other than the West Arm has not been provided by Canadian stakeholders (and the Corps does not believe that such information currently exists), but relative changes in damages would likely be similar to the estimated changes in damages along the West Arm.

Overwater Structures

Damage to docks, breakwaters, and other over-water structures is most likely and severe during storms that occur when lake levels are relatively high. The likelihood and duration of relatively high lake levels increases under the VARQ FC alternatives, which could therefore increase the extent and annual likelihood of storm-damage.

Navigation

Commercial navigation in the affected area is limited to the Balfour-Kootenay Bay ferry on Kootenay Lake. The operating range of each ferry loading ramp was identified and compared to water surface elevations with each alternative to identify impacts to ferry operations.

Table 3-29. Estimated Average Annual Losses – West Arm of Kootenay Lake. LVB would fall within the range between LV1 and LV2; LSB would fall within the range between LS1 and LS2.

Alternative	Total Estimated Average Annual Losses ($ CDN)
LS1	580,000
LV1	620,000
LS2	700,000
LV2	740,000
Benchmark	
LS	270,000
LV	330,000

Note: Data are presented based on 2005 conditions and prices
Source: BC Hydro, 2005

No alternatives would result in Kootenay Lake water surface elevations outside the Balfour ferry's operational range. Similarly, access for recreational vessels would continue and use the lake under any of the alternatives. Therefore none of the alternatives would be likely to adversely affect navigation.

Agriculture and Irrigation

The primary categories of potential impacts to the Kootenai River basin agriculture from changes in operations at Libby Dam are changes in agricultural pumping power requirements for irrigation and drainage, and changes in estimated losses to agricultural production from high groundwater levels. Any losses resulting from overbank flooding of crops are accounted for in the flood control analysis.

Irrigation Pumping Impacts

Water rights data were collected from state water rights databases and evaluated for each county within the Kootenai River basin to estimate the quantity of water pumped for irrigation. These irrigation volumes were distributed over the growing season of May to September. For the analysis, pumping volumes were divided with 20 percent assumed to occur evenly across May and June prior to July 1 and 80 percent occurring evenly across July-September. The average monthly stages under each alternative were used to estimate the relative number of kilowatt-hours required for pumping with each alternative.

In general, higher river stages tend to reduce power requirements for irrigation pumping.

Annual Kootenai River withdrawals for agricultural irrigation in Montana and Idaho were estimated at 817 acre-feet and 2,334 acre-feet, respectively. Table 3-30 presents the estimates of pumping kilowatt-hours associated with each alternative. Compared to LS1, the greatest change in the agricultural pumping power requirements with any other alternative or benchmark is less than ½ of 1 percent in Montana and less than 1 percent in Idaho.

Table 3-30. Summary of Agricultural Pumping Power Requirements, Kootenai River Basin - Kootenai River in Montana. LVB would fall within the range between LV1 and LV2; LSB would fall within the range between LS1 and LS2.

	Pumping Power Requirements (Thousands of kW-hr)										
	Montana						Idaho				
Alternative	May	June	July	Aug	Sep	Total	May	June	July	Aug	Total
LS1	16.1	15.9	42.7	42.7	43.2	160.6	44.7	43.9	182.2	184.8	455.6
LV1	16.0	15.9	42.5	42.6	43.2	160.2	44.2	43.9	180.9	183.5	452.5
LS2	16.1	15.9	42.7	42.7	43.2	160.6	44.6	43.9	182.5	185.1	456.1
LV2	16.0	15.9	42.5	42.6	43.2	160.2	44.1	43.9	181.2	183.8	453.0
Benchmark											
LS	16.3	16.2	42.6	43.1	42.0	160.2	44.9	44.8	181.1	186.3	457.1
LV	16.1	16.0	42.6	43.1	42.1	159.9	44.1	44.2	180.7	186.3	455.3

Agricultural Impacts from High Groundwater Levels

Potential agricultural losses could result from higher stages in the Kootenai Flats reach between Bonners Ferry and Kootenay Lake. Crop losses in the U.S. portion of this reach were analyzed using a groundwater model developed for the region that simulated groundwater levels in agricultural areas under different dam operations and resulting impacts to crop yield and economic returns.

Agricultural impacts associated high groundwater levels in Kootenai Flats were evaluated in two years that would best represent a ‘typical’ hydrologic year[33] and a ‘more significant’ hydrologic year;[34] 1964 was chosen to represent the ‘typical’ year and 1961 the ‘more significant’ year. Impacts, as measured in dollars of losses due to lost production and lost production costs, were evaluated for hops[35], winter wheat, spring wheat, barley, canola, and alfalfa. Aggregated results of the analysis for these crops are presented in Table 3-31. More detailed discussion of the methodology and results can be found in Appendix G.

In the ‘typical’ year (1964), crop losses associated with high groundwater would be expected to increase by 0.8 percent with LV1, 2.8 percent with LS2, and 3.4 percent with LV2, in relation to the no-action LS1. Since simulated reservoir conditions would not have been suitable to spill for sturgeon in 1964, the estimated impacts for LVB in 1964 would be similar to those under LV1, and the estimated impacts for LSB for 1964 would

[33] A ‘typical’ year, which was defined as a year with a May 1st Libby seasonal water supply forecast between 6.0 and 6.7 million acre-feet (average seasonal runoff at Libby Dam is 6.25 million acre-feet), with a relatively small May 1st forecast error, and hydrograph timing and volume similar to the 50% exceedance summary hydrograph. The May 1 forecast in 1964 was 6.7 million acre-feet.

[34] A ‘more significant’ year was defined as a high-water year that is a cause of concern for the community and would capture the upper bounds of seepage impacts as a result of large differences in river flows and resulting groundwater levels between VARQ FC and Standard FC.

[35] Costs associated with replacement of hop plants killed by seepage, including potential losses while new plants establish over several years, were not evaluated in this analysis.

be similar to those under LS1. The addition of the fish flows in LS1 would result in an increase in crop losses of about 46 percent when compared to the LS benchmark operation. In a similar but to a lesser extent, the addition of fish flows in LV1 would tend to increase crop losses by about 18 percent when compared to the LV benchmark operation. As simulated for 1964, the incremental impacts of the fish flows vary between $^{1}/_{6}$ and ¼ of overall production losses, which could be substantial to the valley-wide production or individual producers. These results indicate that impacts to crops during a typical year would be similar under all alternatives, but the incremental effect of the fish flows would be relatively large.

Table 3-31. Estimated Agricultural Losses due to High Groundwater Levels, Kootenai River Floodplain. Values for LVB would be similar to LV1 in some years and to LV2 in others; values for LSB would be similar to LS1 in some years in to and to LS2 in others.

	Year	
Alternative	**1961 (‘more significant’ year)**	**1964 (‘typical’ year)**
LS1	$5,336,000	$3,811,000
LV1	$5,860,000	$3,843,000
LS2	$5,221,000	$3,916,000
LV2	$5,860,000	$3,940,000
Benchmark		
LS	$4,714,000	$2,609,000
LV	$5,817,000	$3,244,000

For the ‘more significant’ year (1961), crop losses in relation to LS1 would be expected to increase by 10.0 percent with LV1 and LV2, and decrease by 2.2 percent with LS2. For 1961, estimated impacts under LVB would be similar to those under the other VARQ FC alternatives (the river flows were essentially identical for all VARQ FC operations in 1961), and the estimated impacts under LSB would be similar to those under LS2. The addition of the fish flows in LS1 would result in an increase in crop losses of about 13 percent when compared to the LS benchmark operation. The addition of fish flows in LV1 would result in a less than one percent increase in crop losses compared to the LV benchmark operation. This pattern in crop losses indicates that, in larger water years like 1961 when the runoff forecast is lower than actual runoff, the flood control operation tends to contribute as much to impacts as fish flows do. As simulated for 1961, the impacts from VARQ FC would be about $^{1}/_{10}$ of overall production losses, a difference which is not as substantial as the incremental impacts of fish flows in a typical year, but which could be substantial for individual producers.

Potential impacts to agriculture in the Canadian portion of this reach would likely reflect a similar pattern to impacts in the U.S., with the VARQ FC alternatives likely resulting in higher losses than the Standard FC alternatives. Note that impacts to hops represent a substantial proportion of the dollar losses in the U.S. portion of the Kootenai Flats. Crops grown in potentially affected areas in the valley north of the border tend to be relatively low value and annually planted (unlike the perennial nature of hops or fruit trees), which would tend to decrease the magnitude of potential agricultural impacts.

Although their magnitude is not known, pumping costs for drainage of cropland in the Kootenai Valley in Idaho would reflect in a pattern similar to the agricultural losses due to high groundwater levels. In the 'typical year' of 1964, LV2 would result in the highest costs for pumped drainage, followed by LS2, LV1, and LS1 in order of decreasing costs. In the 'more significant' year of 1961, LV2 and LV1 would result in the highest costs, followed by LS1 and LS2 in order of decreasing costs. The incremental effect of fish flows would result in generally higher costs for pumped drainage.

Pumping costs under LSB would fall within the range between LS1 and LS2; pumping costs under LVB would fall within the range betweenLV1 and LV2.

Municipal and Industrial (M&I) Water Supply

The primary category of potential impact to M&I water supplies resulting from changes in operations at Libby Dam is associated with changes in the energy required to pump water. Montana and Idaho water rights data were reviewed to estimate pumped volumes for M&I water supply from the Kootenai River. Pumping power requirements were estimated based upon the average monthly stage for each alternative as measured at Libby, Montana, for Montana use and Bonners Ferry, Idaho, for Idaho use. Based on review of state water rights data, annual Kootenai River withdrawals for M&I water supply in Montana and Idaho were estimated at 5,263 acre-feet and 1,452 acre-feet, respectively. Compared to LS1, the greatest change in M&I pumping power requirements with any other alternative or benchmark operation is about 0.3 percent in Montana and less than 1 percent in Idaho.

Employment and Income

A qualitative evaluation of potential effects to local and regional economies was performed to address potential localized impacts of changes in direct socioeconomic and recreation outputs.

Employment and Income Effects of Flooding and Flood Control, Navigation, Irrigation, and M&I Water Supply

No employment and income effects are expected from flood control impacts of different alternatives in the Kootenai River basin since all alternatives were estimated to provide the same level of flood protection for the Bonners Ferry-Kootenay Lake reach (as measured by estimated average annual losses). While the analysis of days with Kootenay Lake at documented flooding stages and estimated average annual losses along the West Arm of the lake showed no substantial differences across the alternatives, the incremental effect of the fish flows would increase estimated average annual losses to some degree, which could result in employment and income effects from rebuilding efforts. No employment and income effects are expected from the navigation impacts, agricultural irrigation impacts, or M&I water supply impacts of different alternatives in the Kootenai River basin since these parameters would be similarly affected under all alternatives.

Employment and Income Effects of Agriculture Impacts

Employment and income effects are expected as a result of changes in expected crop yields from high groundwater (Table 3-31) because any negative impacts to agriculture would likely result in income losses for the Kootenai River basin farmers. Impacts would be highest under LS2 and LV2.

Employment and Income Effects of Recreation Impacts

Lake Koocanusa

There is potential for positive employment and income benefits at Lake Koocanusa with implementation of LV1, LV2, or LVB. Compared to the no-action LS1, these alternatives would result in an increase in usable boat ramp days, swimming days, and days with optimal lake elevations for lake area campsites. Among the alternatives with fish flows, LV1 results in the greatest increase in usable days at the lake's boat ramps and swimming beaches, and days when lake elevations would be best for camping. It is expected that the increase in recreational opportunities would translate to increased visitation and local spending. The addition of fish flows would tend to decrease recreation days for various uses, and the two benchmark operations without fish flows would have the least impact on recreation-related employment and income.

Libby Dam to Kootenay Lake

Recreation analysis of the Kootenai River between Libby Dam and Kootenay Lake found that shore fishing days would be reduced with implementation of LV1 and LV2 relative to LS1 due to increased days exceeding the upper range of optimal shore fishing flows identified as 10 kcfs. There is a slight improvement in shore fishing days relative to LS1 with LS2. Negative employment effects of the reduced shore fishing days would likely be offset by an increase in days with flows permitting boat fishing on the river. LV1 and LV2 would result in increases in boating days relative to LS1. The average spending associated with boat fishing ($82 per party day) is greater than that for shore fishing ($61 per party day). Adverse impacts to fishery resources from more frequent spill under alternatives LSB and LVB would likely adversely affect employment and income for the local fishing guide industry in the vicinity of Libby, Montana. Based on employment by industry (Table 3-10), the 8.7 percent of Lincoln County jobs in the recreation/ entertainment and accommodation/restaurant industries could be adversely affected by diminished fishing opportunities. Retail trades and real estate may also be impacted. The degree of these adverse effects may be significant in the Libby/Troy area of Montana.

Kootenay Lake to Confluence with Columbia River

Between alternatives, the recreation analysis for Kootenay Lake found a maximum difference of three days in lake levels within the optimal recreational range over the period from May to September. It is not expected that these slight changes in usable recreation days at Kootenay Lake would result in significant effects to regional employment and income.

Summary

The alternatives with fish flows are likely to affect employment and income derived from agriculture in Kootenai Flats and recreation on Lake Koocanusa, relative to the benchmark operations without fish flows. Tax revenues might not change substantially under the various alternatives, but may be somewhat reduced under alternatives with relatively higher agricultural impacts (Table 3-31) or adverse effects on outfitting and fishing guide businesses.

Tribal Socioeconomics

Tribal socioeconomic impacts are identified for each study area in Appendix F. Categories of potential impact that were evaluated include flood control, navigation, irrigation, M&I water supply, and employment and income. Methodologies applied for evaluation of impacts in each of these categories are the same as described in the preceding paragraphs of this section.

Existing agricultural problems associated with agricultural lands on the Kootenai Tribe Reservation, north of Bonners Ferry, Idaho relate to spring flooding and poor drainage. As identified in the flood control analysis above, the Kootenai River basin flood control analysis did not identify any increase in estimated average annual losses with any alternative when compared to LS1 (but estimated average annual losses would be slightly higher with the LV benchmark operation).

The effects of high groundwater levels on tribal agricultural areas would be proportionate to those discussed in the agriculture and irrigation analysis above (see also Appendix G)

In general, substantial recreation-related employment and income effects were not identified along the Kootenai River. Any employment and income effects associated with reductions in optimal days for shore fishing would likely be offset by increased days suitable for boat fishing. Potential adverse impacts to outfitting and fishing guide businesses under LSB and LVB would also adversely affect tribal ventures in these industries. No employment and income effects are expected in the Kootenay Lake study reach in the vicinity of the Lower Kootenay Indian Band reserve and the Tobacco Plains reserve.

3.3.13 Municipal Water and Wastewater Treatment

Lake Koocanusa

The different alternatives are unlikely to affect municipal water sources or wastewater disposal in around Lake Koocanusa. More detailed discussion of the reach between Libby Dam and Kootenay Lake is provided due to community interests in potential impacts in this reach.

Libby Dam to Kootenay Lake Near Creston, BC

(LS1) Standard FC with fish flows to powerhouse capacity (No Action) and (LV1) VARQ FC w/ fish flows to powerhouse capacity

Some water sources close to the Kootenai River are influenced by river level, likely because they are part of a continuous groundwater aquifer. Monitoring has shown that river flows ranging up to dam releases of 40 kcfs do not adversely affect groundwater quality (Easthouse 2004). River flows under LS1 and LV1 would be similar to current operations and thus would not affect municipal water sources. Discharges of treated wastewater occur independent of river conditions and thus would not be affected by any of the alternatives. The addition of fish flows does not alter potential effects on water sources and treatment facilities.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs,
(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs,
(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Although peak flows possible under LS2, LV2, LSB, and LVB would be substantially higher than the other two alternatives, impacts to municipal water sources are not expected based on monitoring during similar high flows in the spring and summer of 2002 (Easthouse 2004). Under LS2, LV2, LSB, and LVB, higher peak flows during the spring would not affect the ability to discharge treated wastewater, but may dilute those discharges to a greater extent than the other alternatives.

3.3.14 Transportation

Kootenay Lake Ferry

Operations under all the alternatives result in Kootenay Lake levels well within the established operating range for the Balfour-Kootenay Bay ferry. Accordingly, none of the alternatives would impede or otherwise affect operations of the Kootenay Lake ferry.

3.3.15 Dam Structural Condition

Under all alternatives, Libby Dam will continue to be fully capable of safe operation, however if the spillway is used more frequently, the areas with chipping and flaking will expand, the spillway flow surface will roughen, and the future repairs will be more expensive. The alternatives differ in the rate at which further deterioration of the spillway surface occurs, as discussed below. Alternatives LS2 and LV2 involve release of up to 10 kcfs above powerhouse capacity in all years with sturgeon flow augmentation. However, the method of discharging the additional 10 kcfs for Alternatives LS2 and LV2 were not identified and analyzed, therefore predictions of effects on the spillway surface for Alternatives LS2 and LV2 are not possible at this time.

(LS1) Standard FC with fish flows to powerhouse capacity (No Action); and
(LV1) VARQ FC w/ fish flows to powerhouse capacity

Use of the spillway would be relatively rare under these alternatives and further deterioration of concrete patches on the spillway would be relatively slow. In years when involuntary spill occurs, some additional chipping and flaking deterioration of the patches would likely occur. During spill events, some concrete would likely be dislodged from previously patched areas on the spillway and these would fall into the stilling basin below. When water is flowing over the spillway, safety plans and procedures would be in place to keep personnel working at the dam away from the access bridge immediately below the spillway. Compared to Alternatives LSB and LVB, repairs to the spillway face under the remaining alternatives would be less pressing due to the infrequency of spillway use.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Under LSB and LVB, the dam would continue to be fully capable of safe operation but the more frequent spill would accelerate deterioration of the concrete patches on the spillway surface. Under these alternatives, use of the spillway to discharge up to 10 kcfs would occur at least 3 times in the next 10 years, and 3 out of the next 4 years if conditions allow. Considering the potential for more routine spillway use, repairs to the spillway surface would become a higher priority maintenance activity for Libby Dam. Similar to the other alternatives during spill, small chunks of concrete would likely be dislodged from previously patched areas on the spillway and these would fall into the stilling basin below. When water is flowing over the spillway, safety plans and procedures would be in place to keep personnel working at the dam away from the access bridge immediately below the spillway.

3.4 Cumulative Impacts

Cumulative impacts are those effects on the environment resulting from the incremental consequences of a proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes these actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. Minor/ nonsignificant effects or significant localized effects may contribute to cumulative effects.

Discussion of the cumulative impacts associated with the benchmark operations (LS or LV) are provided for comparison purposes only.

Table 3-32 summarizes past, present, and reasonably foreseeable future actions in the Kootenai basin, that were considered in the following discussions on potential cumulative impacts for each resource.

3.4.1 Hydrology and Flood Control

All Alternatives

The construction and operation of Libby Dam for the authorized project uses significantly changed hydrologic characteristics (river/lake levels, flow patterns) in the Kootenai River basin and downstream. Flows for fish species have been provided since the early 1990s. The flow patterns that are possible under the alternatives would provide a semblance of natural river conditions, but over the course of any given year, they would still be significantly different from pre-dam conditions in terms of magnitude, duration, and timing.

Table 3-32. Past, Present, and Future Actions Considered For Possible Cumulative Effects for Each Resource

RESOURCE	Past, Present, and Reasonably Foreseeable Future Actions Related to Proposed Action													
	Manipulations of River Flows and Timing					**Physical Modification of Riparian and Floodplain Areas**				**Ecosystem and Species Recovery**				
	Libby Dam operation	IJC Order of 1938	Columbia River Treaty	Kootenay Lake operations	Flood control requirements	Libby Dam construction	Levee construction and maintenance	Agricultural activities	Floodplain development	Federal, tribal, state, and local habitat restoration actions	White sturgeon conservation aquaculture	Kootenai River fertilization	USFWS FCRPS Biological Opinion	Action Agencies' UPA and NOAA Fisheries FCRPS Biological Opinion
Hydrology and Flood Control	X	X	X	X	X	X	X	X	X	X		X	X	X
Water Quality	X	X	X		X	X				X		X	X	X
Aquatic Life	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sensitive, Threatened & Endangered Species	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wildlife	X	X	X	X	X	X	X	X	X	X			X	X
Vegetation	X	X	X	X	X	X	X	X	X	X			X	X
Recreation	X			X	X	X			X				X	X
Environmental Health	X	X	X		X	X		X						
Cultural Resources	X				X	X							X	X
Indian Sacred Sites	X				X	X							X	X
Other Affected Tribal Interests	X				X	X							X	X
Socioeconomics	X	X	X	X	X	X	X	X	X				X	X
Municipal Water and Wastewater Treatment	X				X		X		X					
Transportation	X	X	X	X										

[a] These include Northwest Power and Conservation Council Subbasin Planning efforts and their Mainstem Amendments.

For all the alternatives, the influence of the Columbia River Treaty, the IJC Order of 1938, and requirements for the multiple purposes of Libby operations is incorporated into the hydroregulation modeling simulations. Changing conditions in the floodplain have been considered in the development and operation of Libby Dam. Over time, floodplain development and changing levee conditions have necessitated several adjustments in the flood stage at Bonners Ferry. Currently, the National Weather Service considers elevation 1764 feet to be the flood stage elevation at Bonners Ferry, Idaho. The Corps considers this flood stage elevation in operating Libby Dam for local flood control. Without this operating criteria, peak spring releases in some years could be higher. The exact degree to which a higher flood stage would allow higher and longer peak flows is unknown, as are the potential ecosystem benefits of such flows.

Ongoing ecosystem and species recovery efforts interplay with Libby Dam operations to influence real-time dam operational decisions, particularly during the spring, summer, and mid-winter. Interactions between requirements, recommendations, and proposals provided in the USFWS and NOAA Fisheries FCRPS Biological Opinions will also influence how flow augmentation for fish is provided. Issues such as sturgeon flow augmentation, minimizing a "double-peak" hydrograph, and shaping salmon flow releases would affect Lake Koocanusa fluctuations and river flow patterns. Since the likelihood of reservoir refill is relatively low under LS2 and LV2, decisions on how to allocate stored water for sturgeon flow augmentation and summer salmon flow augmentation, particularly in the late summer, could become more difficult under these alternatives. The Northwest Power and Conservation Council's Mainstem Amendments recommendations for Libby and Hungry Horse summer operations are not currently being implemented; however, through the adaptive management process included in the current USFWS and NOAA Fisheries FCRPS Biological Opinions, with regional support, this operational change could be implemented. If implemented at Libby Dam, this recommended operation would decrease the magnitude and extend the duration of the salmon flow augmentation from Libby Dam. This would provide more natural flow conditions and help maintain Lake Koocanusa levels during the summer.

Snowmelt runoff dominates operation of the Columbia River system operations for multiple uses including hydropower, flood control, irrigation, lake recreation, and instream flows for fish. Recent studies have shown substantial declines in snowpack water volumes over much of the western United States in the last half century, as well as trends towards earlier spring snowmelt and peak spring streamflows (Hamlet *et al.* 2005). Middle-of-the-road climate change scenarios for the mid-21st century indicate that uses most likely to be affected by changes in climate are those uses of the system relying on summer streamflows (i.e. lake recreation, summer fish flow targets; Hamlet 2001).

3.4.2 Water Quality

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative) and
(LV1) VARQ FC w/ fish flows to powerhouse capacity

Consideration of Libby Dam operations, the IJC Order of 1938, the Columbia River Treaty, and flood control requirements is incorporated into the hydroregulation simulations that form the basis for the analysis of the effects of each alternative on water quality. Provisions of the USFWS Biological Opinion include increased Libby Dam releases for sturgeon flow augmentation during the spring. Under LS1 or LV1, these releases are possible entirely through the powerhouse using selective withdrawal gates. Even with the selective withdrawal system, the ability to provide suitable water temperatures from the dam depends on weather conditions and the timing and duration of the sturgeon flow augmentation requested by the USFWS. In some years, available water temperatures in Lake Koocanusa may be different from ambient temperature of other water sources to the Kootenai River, which results in changes in river water temperature during period of sturgeon flow augmentation. The addition of the fish flows would tend to increase the possibility of temperature fluctuations in the river downstream of the dam during the spring. Earlier spring warming of the reservoir resulting from climate change may cause earlier reservoir stratification, which could help attempts to optimize spring release temperatures during the sturgeon pulse. Regardless of the alternative, heat storage by the reservoir would continue to result in higher wintertime water temperatures in the river between Libby Dam and Kootenay Lake, with potential adverse effects on burbot (see Section 3.4.4) though it is possible that if cold air temperatures are present as water flows downriver, they might be more effective at cooling the lower flows released under VARQ as compared with Standard FC.

Adverse cumulative effects due to elevated TDG levels during rare spill events are not anticipated in the United States. Expansion of the powerhouse at Brilliant Dam in British Columbia, which is currently under construction, may serve to decrease the duration or degree of elevated TDG levels in the lower Kootenay River and the mainstem Columbia downstream of the Columbia River. Remaining TDG impacts in Canada and on the mainstem Columbia downstream of the mouth of the Kootenai River would primarily be the result of the incremental effects of the fish flows from Libby Dam.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs and
(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs

In general, cumulative impacts to water quality under LS2 or LV2 in combination with other related actions would be similar to those under LS1. The potential exists for a higher degree of temperature fluctuation in the river due to increased dam releases under LS2 or LV2. However, the degree of potential fluctuations is uncertain since the mechanism for achieving 10 kcfs above powerhouse release capacity is not identified.

Potential temperature effects would be included in analyses that would be necessary to support a decision to move forward with dam modifications that would facilitate the 10 kcfs of additional release capacity. The increased release rate for sturgeon under LS2 or LV2 may increase TDG levels in the Kootenay River downstream of Kootenay Lake. Expansion of the powerhouse at Brilliant Dam may serve to decrease the duration or degree of elevated TDG levels, but not to the same extent as for LS1 or LV1.

(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Cumulative impacts to water quality under LSB and LVB would be similar to those under LS2 and LV2, except these alternatives would provide for some ability to manage temperature impacts through balancing temperatures of spillway and powerhouse releases.

3.4.3 Aquatic Life

All Alternatives

Libby Dam construction created Lake Koocanusa, which acts as a sink for nutrients. As a result, nutrient levels in the river system downstream of the dam are much lower than would be expected under freeflowing conditions [36] and would continue to be low under any of the alternatives. These low nutrient levels could adversely affect ecosystem and species recovery actions by depressing productivity of the river system. Experimental additions of nutrients began in 2005. Even if biological objectives are achieved; however, this would be a long-term, maintenance intensive effort. These experimental nutrient releases by the Kootenai Tribe of Idaho may be diluted by fish flows, perhaps to a greater degree with LS2 or LV2. Long-term conclusions and implementation of fertilization may adapt to fish flows.

The focus of ongoing environmental restoration projects is to restore ecological functions that have been lost. Earlier spring warming of the reservoir resulting from climate change may cause earlier reservoir stratification, which could help attempts to optimize spring release temperatures during the sturgeon pulse and avoid potential adverse effects to sturgeon from abrupt decreases in river temperature as releases from the dam increase.

[36] Industrial nutrient sources from Canada which elevated pre-dam nutrient levels in the river were greatly reduced in the late 1970s (after construction of Libby Dam). This reduction in sources contributed to a substantial reduction in productivity in the river and Lake Koocanusa. Lake Koocanusa aggravated nutrient deficits in the lower river after Canadian source reduction. As empirical evidence of the reduction in nutrients resulting from impoundment by Libby Dam, total phosphorus levels near Wardner, BC (above Lake Koocanusa) are currently nearly threefold higher than levels below Libby Dam (Holderman and Hardy 2004).

Physical modification of riparian and floodplain areas and various operational requirements (Kootenay Lake operations, flood control requirements) can, under certain circumstances, constrain opportunities for ecosystem and species recovery actions that rely solely on operational flexibility that would be provided by the various alternatives. Such constraints could prevent or diminish effectiveness of the suite of actions that are likely necessary to successfully recover and sustain ecosystem functions.

Implementation of the changes in operations at Libby Dam recommended by the Northwest Power and Conservation Council's Mainstem Amendments through the adaptive management processes provide through the USFWS and NOAA Fisheries BiOps, would decrease the magnitude and extend the duration of the salmon flow augmentation from Libby Dam, which would provide more natural flow conditions and help maintain Lake Koocanusa levels during the summer. Benthic production between the dam and Creston may improve under alternatives with fish flows, since benthos would be less likely to be dewatered before the end of the productive warmer months.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

A variety of habitat restoration actions proposed to benefit sturgeon are being planned through regional environmental programs, including the Northwest Power and Conservation Council, BPA's Fish and Wildlife Program, and Federal efforts to comply with the Endangered Species Act. These restoration actions include channel modifications to address substrate needs for sturgeon reproduction, and possibly to address velocity and passage requirements. To a large extent, the planned restoration actions rely on suitable river conditions for success. LS1, primarily due to the fish flows provided during the snowmelt runoff season, would provide flexibility to provide more natural river flows during the spring and summer, but would depart from natural conditions during the winter to a greater extent than any of the VARQ FC alternatives. In general, the more natural river flows possible provided by the fish flows under LS1 may result in some degree of synergistic benefits to the aquatic ecosystem. To the extent that more natural patterns in seasonal flows are important to habitat restoration actions, the relatively larger departure from normative conditions during the winter under LS1 may compromise some of the ecosystem benefits that might be realized with a more natural winter flow pattern. During the summer, flow conditions under LS1 would be relatively more natural since the flows for salmon augmentation under LS1 are typically lower than the VARQ FC alternatives. However, these differences in summer flows would typically be small and in-season management that occurs to minimize adverse biological effects would likely avert any negative cumulative impact to ecosystem restoration.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

Compared to LS1, incremental increases in cumulative benefits to the aquatic ecosystem may be realized under LV1 due to slightly higher flow peaks and durations during the spring freshet. While the VARQ FC operation would provide a portion of these flows, the addition of the fish flows would be the primary driver in realizing more natural river conditions during the spring and early summer and the synergistic benefits to the aquatic ecosystem that could accrue as a result. Winter flows under LV1, as well as the other VARQ FC alternatives, would be relatively more natural than the Standard FC alternatives, which may increase the synergistic benefits to the ecosystem.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs, and
(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

Compared to LS1, incremental increases in cumulative benefits to the aquatic ecosystem may be realized under LS2 or LSB due to higher flow peaks and durations during the spring freshet, and greater flexibility to manage river flows during the spring freshet for synergistic ecosystem benefits.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs, and
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

LV2 or LVB would likely produce the highest incremental increases in cumulative benefits to the aquatic ecosystem due to higher flow peaks and durations during the spring freshet, and the greatest flexibility to manage river flows during the spring freshet for synergistic ecosystem benefits.

3.4.4 Sensitive, Threatened, and Endangered Species

In general, cumulative impacts on sensitive, endangered and threatened species would be similar to those discussed for aquatic life and wildlife, which are not repeated in this section. Details on potential unique or notable cumulative impacts to specific species are discussed below.

White Sturgeon

All Alternatives

In the United States, the operational flood stage level at Bonners Ferry has been modified over time to reflect current floodplain development and levee conditions. The construction and operation of Libby Dam has played a large role in the local development of the floodplain since the dam became operational in the early 1970s by moderating peak spring flows and peak Kootenay Lake elevations. The net result of these cumulative actions is a reduction in the high pre-dam freshet flows in the Kootenai River under which sturgeon successfully reproduced. Restoration of more natural flow conditions is a key element of sturgeon recovery efforts, so actions such as floodplain development that constrain pre-dam natural flow conditions could adversely affect those recovery efforts.

Loss of side channels and construction of levees has likely eliminated important habitat for sturgeon.

Dam operations and river conditions that are achievable under any of the alternatives may contribute to restoration of habitat conditions sufficient to recover and sustain wild sturgeon. When combined with the suite of actions proposed by the Corps and BPA and included in the 2006 USFWS BiOp, including habitat projects, conservation aquaculture, and nutrient supplementation, the flow improvements with any of the fish flow alternatives are expected to produce a cumulative benefit to sturgeon recruitment. If in the short term, hatchery production of sturgeon in the Kootenai River will assist in bridging the gap for sturgeon recovery, and would continue for at least the next several decades and the great majority of sturgeon that persist in the river in coming decades would be hatchery-produced.

Bull Trout

All Alternatives

Cumulatively, habitat restoration in basin tributaries, the more natural hydrograph, bull trout minimum flows, riparian vegetation benefits, and river fertilization will serve to benefit bull trout in the basin. Adverse cumulative impacts from land development or water management would likely be very minor in comparison. Cumulative benefits would accrue largely as a result of the incremental effects of the fish flows.

Bald Eagle

All alternatives

Bald eagle habitat has been altered by human development in many areas of the Kootenai basin. To some extent, bald eagle habitat has been reduced, and it may continue to be impacted with further development; although restrictions on habitat modification currently exist that did not exist historically. Bald eagle food resources have been somewhat altered by the presence and operation of Libby Dam. Although nutrient availability is apparently lower than historically, fish continue to be in ready supply, in Lake Koocanusa, the Kootenai River, and Kootenay Lake.

(LS1) Standard FC w/ fish flows to powerhouse capacity (No Action Alternative)

The existence of Libby Dam provides eagles inhabiting areas just downstream of the dam with a ready food source from entrained fish, primarily kokanee. As a result, eagle concentrations in the vicinity of the dam are likely higher than they would be in the absence of the project for all alternatives. Due to increased entrainment of fish at Libby Dam and benefits to riparian habitat, bald eagles would benefit from Endangered Species Act-related dam operations that require flow augmentation during the spring and summer. Because refill probability is lower with LS1, less water would tend to be available for salmon flow augmentation, which may slightly decrease food available for bald eagles in areas directly downstream of the dam. Bald eagles would indirectly benefit from synergistic cumulative effects of fish flow operations with other ecosystem restoration activities.

(LV1) VARQ FC w/ fish flows to powerhouse capacity

As a cumulative effect of dam existence, flood control operation, sturgeon operations, and salmon flow augmentation, LV1 would have the highest sustained flows through the spring and summer months (considering the sturgeon and salmon flow augmentation), which may slightly increase food availability for bald eagles directly downstream of the dam during these months. Bald eagles would indirectly benefit from synergistic cumulative effects of fish flow operations with other ecosystem restoration activities.

(LS2) Standard FC w/ fish flows to powerhouse capacity plus 10 kcfs, and
(LSB) Standard FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible

In terms of food availability for bald eagles, the cumulative effects of the various factors under LS2 and LSB would tend to result in relatively low average flows through the spring and summer, which would likely correspond to the lowest food availability of any alternative for bald eagle directly downstream of the dam. Bald eagles would indirectly benefit from synergistic cumulative effects of fish flow operations with other ecosystem restoration activities.

(LV2) VARQ FC w/ fish flows to powerhouse capacity plus 10 kcfs.
(LVB) VARQ FC w/ fish flows up to 10 kcfs above powerhouse capacity, using spill when reservoir, inflow and temperature conditions make this possible (Preferred Alternative)

Under LV2 and LVB, cumulative impacts to bald eagles would be similar to those under LV1, but with slightly decreased food availability in the summer.

Lower Kootenai River Burbot

All Alternatives

Libby Dam construction was the most recent event in a timeline of environmental changes in the Kootenai that had deleterious cumulative effects on Lower Kootenai River burbot. Dam operations that provide flexibility to better meet flow conditions beneficial to burbot will assist in the ongoing burbot recovery effort. To the extent dam operations and river conditions that are achievable under any of the alternatives, they may still prove inadequate, despite the best efforts of the Corps and other regional interests, to restore habitat conditions sufficient to recover and sustain burbot. For example, although the VARQ FC alternatives would tend to provide lower river flows during the latter portion (January) of burbot migration and spawning period, the positive effects that lower flows have on burbot migration and spawning could be influenced by the higher-than-desired water temperature in the river as a result of the thermal storage in Lake Koocanusa, which is a consequence of Libby Dam construction.

South Arm Kootenay Lake Kokanee Salmon, Westslope Cutthroat Trout, and Redband Rainbow Trout

Nutrient additions in Kootenay Lake, to the extent they are expanded to the South Arm and successful in the Kootenai River, would benefit aquatic life in Kootenay Lake, including kokanee. They should also benefit westslope cutthroat and redband rainbow trout. This activity, plus flow management to benefit fish, should provide cumulative benefits to sensitive fish species that balance cumulative impacts due to development and recreation. These cumulative benefits would accrue largely as a result of the incremental effects of fish flows.

3.4.5 Wildlife

All Alternatives

The construction and operation of Libby Dam has modified the general make-up of wildlife found in and around Lake Koocanusa, the Kootenai River, and Kootenay Lake. Coupled with flood control requirements, including levee construction and maintenance, these activities and others have allowed for the expansion of agriculture, floodplain development and other types of landscape alterations, which impact wildlife in different ways.

Cumulative impacts associated with all the alternatives, and dependent upon individual species, have resulted in both positive and negative impacts from the initial construction of Libby Dam that dramatically altered the landscape. For example, two negative impacts for at least some wildlife species were 1) the immediate creation of Lake Koocanusa, and 2) the control of seasonal flows in the Kootenai River.

With the creation of Lake Koocanusa, riparian-dependent wildlife species were likely displaced and thousands of acres of established riparian habitat lost. This impact was immediate in nature and likely affected species by forcing them into either secondary habitats or out of the area completely. As for seasonal flow, Libby Dam dramatically reduced river flow variability and impacted those downstream habitats dependent upon that variability for survival. This impact would have been slow to progress, but its overall consequence has been a shift in habitat type, habitat availability, and species composition.

The manipulation of river flow timing and magnitude has allowed establishment of waterfowl breeding grounds in and around Kootenay Lake in areas where none existed before (Stushnoff 2005). This impact provided for not only expanded waterfowl breeding, but for additional stop-over habitat for migratory birds. Another positive impact since the construction of Libby Dam was that when the fish flows were added in the early 1990s, new riparian areas were established along the riparian corridor where none existed for several decades (Jamieson and Braatne 2001). Finally, and certainly dependent up individual species, is that due to the dam's construction, flow regulation, levee construction, increased agriculture and other human development, wildlife species that tend to be more tolerant of human development and utilize agriculture lands for food and cover have likely increased and flourished, whereas those species not adapted to such environments have likely declined.

Implementing any of the alternatives, short of any dramatic increases or decreases in flow, would not significantly add to the cumulative impacts already established, but implementing alternatives LV1, LS2, LV2, LSB, or LVB would aid in lessening the negative impacts to wildlife species by incrementally adding new riparian habitat along the Kootenai River riparian corridor.

3.4.6 Vegetation

All Alternatives

Incremental impacts from any of the alternatives would be unlikely to substantially add or change the vegetation communities or extents around the reservoir since the creation and management of Lake Koocanusa drives vegetation characteristics upstream of Libby Dam. Vegetation communities inundated by Lake Koocanusa were lost, and those above the high pool elevation survive.

Downstream of Libby Dam, development of the floodplain for agriculture and urban use has substantially altered the native vegetation communities. Incremental benefits from operations under any of the alternatives with fish flows would help restore the health and extent of riparian vegetation. Cumulatively, these effects, together with other ecosystem restoration activities, may serve to halt overall degradation of ecosystem health in the basin. Development of healthy riparian areas would likely beget additional riparian vegetation recruitment as new areas provide seed sources and work to capture sediment from high flows during the spring. Conversion of non-native herbaceous riparian areas (e.g., reed canarygrass) to shrub and tree riparian communities may be one result of the synergistic effects of more natural flow patterns provided by fish flow operations, ecosystem restoration activities, and water management activities. To a large extent, cumulative benefits to vegetation would accrue largely as a result of the fish flow operations, with smaller benefits resulting from VARQ FC operations under LV1, LV2, or LVB.

3.4.7 Recreation

All Alternatives

Development of the Kootenai Basin has created the opportunity for water-related recreation. All cumulative impacts for recreation must be predicated on existence of Libby Dam for the foreseeable future, as well as the influence of the Columbia River Treaty, the IJC Order of 1938, and flood control requirements. After completion of the dam and filling of Lake Koocanusa in 1974, reservoir recreation supplanted river recreation in the inundated reach. Fish have been stocked in the reservoir for angling. Tourism will likely be an important source of income over the long term for the Kootenai Basin in Montana and Idaho; more demand would depend on alternatives that provide better resources and associated recreation opportunities. Recreation affected by any of the alternatives is largely based on boating, fishing, camping, and swimming. Reservoir-based camping, swimming, boating, and fishing are directly affected by pool level fluctuations. River-based fishing and boating are directly affected by flows. Fishing is indirectly affected by availability of fish resources, which the proposed actions are intended to benefit. Direct long-term and cumulative impacts are similar to short-term impacts, and they are potentially greater than short-term indirect impacts. So with all alternatives, greater fish resources might indirectly lead to more improved angling opportunities. That might increase the possibility of attracting tourists from other regions, which might lead to development of new facilities on Lake Koocanusa such as reservoir marinas, and recreational services. With fish flows, reservoir refill is not as likely as with the LV benchmark operation, so development along the reservoir would still need to contend with some degree of pool fluctuation during the recreational season. Kootenay Lake recreation may be influenced in the long run by limitations on pool fluctuation due to shoreline development, which has already occurred to some extent. As long as pool elevations stay within the general optimal range, continued development and recreational use may be expected. All alternatives appear to help maintain Kootenay Lake elevations within that range.

All Standard FC Alternatives (LS1, LS2, LSB)

These alternatives would provide fish flows, which, if they help lead to species and ecosystem recovery, may provide long-term recreational opportunities for anglers and eco-tourists.

All VARQ FC Alternatives (LV1, LV2, LVB)

These alternatives would provide fish flows, which, if they help lead to species and ecosystem recovery, may provide long-term recreational opportunities for anglers and eco-tourists. Somewhat better reservoir refill compared to Standard FC could indirectly lead to more recreational development on the reservoir.

3.4.8 Environmental Health

All Alternatives

Air quality issues resulting from windblown dust along Lake Koocanusa shoreline areas are entirely a consequence of Libby Dam construction. Operations of Libby Dam can either increase or decrease air quality problems depending upon how those operations influence the timing and duration of Lake Koocanusa levels lower than 2404 feet. For all the alternatives, the Columbia River Treaty, the IJC Order of 1938, and flood control requirements that influence Libby operations are incorporated into the hydroregulation modeling simulations that form the basis for analysis of impacts to air quality. Changes in the Bonners Ferry flood stage since Libby Dam construction have not influenced Libby Dam flood control operations in any way that contributes to decreased air quality in the basin. Similarly, changes in agricultural practices, including application of pesticides, herbicides, and other agricultural chemicals, also do not contribute to the incremental effect of any of the alternatives on air quality in the basin.

3.4.9 Cultural Resources

All Alternatives

European settlement of the Kootenai Basin has resulted in changes to Tribal use of the area. It has also placed some cultural resources at risk from looting and vandalism over the years since first arrival of Europeans. Creation of Lake Koocanusa has placed some cultural resources out of reach of looters and vandals, but has allowed exposure of others in wave-affected zones. All known sites around Lake Koocanusa have been impacted by reservoir operations since 1972. The better the chance of refill (LV would be the best), the less exposure. The fish flows incorporated into the alternatives would cause ongoing streambank erosion effects in the first five miles downstream of Libby Dam. This would affect six archaeological sites that are contributing members of the Libby-Jennings Archaeological District. Farther downstream, the effects are confined to the existing Kootenai River channel. In total, while the incremental effects of the alternatives are likely small, the cumulative effect of past actions is to increase exposure of cultural resources to possible damage from erosion, looting, and vandalism.

3.4.10 Indian Sacred Sites

Data or information on Indian Sacred Sites could not be obtained, so there is no basis to assess incremental or cumulative impacts to those resources.

3.4.11 Other Affected Tribal Interests

Past actions, most notably construction of Libby Dam, have disturbed areas that support hunting, fishing, and gathering activities to such an extent that additional cumulative impacts from any of the proposed actions would be inconsequential.

3.4.12 Socioeconomics

All Alternatives

Development of the Kootenai Basin has resulted in a largely resource-based economy that depends on agriculture, timber, mining and tourism. Development of the floodplain has affected and been affected by Libby Dam operations, and in fact, was a reason for authorization of Libby Dam. In particular, flood control as a need of the local community helped drive the authorization. Flood control requirements are a factor of the level of development. Fish flows have been added to spring flood control operations and further affected agriculture in Idaho. Declines in fish populations have adversely affected recreation-based economies.

All of the alternatives provide fish flows that are intended to help lead to recovery of threatened and endangered fish populations. If they are successful, then recreation-based employment and income could be supported. However, via groundwater seepage, the alternatives, particularly their fish flow components, also may negatively affect agriculture and their supporting economic system in the Kootenai Valley in Idaho. Damages from groundwater seepage have been made worse by recent development of hops farms, a perennial crop with relatively low tolerance for wet soils, over portions of the valley. Expansion of acreage of hops or other crops that tend to be more sensitive to shallow groundwater would further worsen agricultural impacts from seepage and could influence development of flow regimes intended for ecosystem and species recovery. No alternative is expected to change the ability of Libby Dam to meet flood control requirements, which are a product and a requirement of human development in the basin.

3.4.13 Municipal Water and Wastewater Treatment

All Alternatives

Under any alternative, Libby Dam would continue to be operated for the authorized project uses. Regulation of peak flows by Libby Dam has allowed certain public facilities to be constructed in areas that would have historically been vulnerable to flooding before dam construction. The existence of these facilities is a factor in determining feasible peak flows for flood control and ecosystem restoration purposes.

Future changes to the local flood stage as a result of inadequate levee maintenance or unrestricted floodplain development could affect how fish flows, particularly the sturgeon flow augmentation, would be provided. This could result in peak sturgeon releases in some years that are lower than possible under the different alternatives, and particularly for LS2 and LV2. Impacts to drinking water supply or wastewater treatment systems would likely take precedence over ecosystem restoration, especially in the short term, resulting in the net effect of reduced flexibility for operational actions designed to assist sturgeon recovery. Over the long term, upgrades of municipal water supply or wastewater treatment systems would likely include consideration of Libby Dam operations (including operations intended to benefit ecosystem and species recovery) and existing and forecast regional development (including that in the floodplain) to a greater degree than if fish flows were not provided.

3.4.14 Transportation

Operations of Libby Dam and Kootenay Lake would continue to be governed in part by the Canadian Treaty and the IJC Order of 1938. The Kootenay Lake ferry and all other transportation features would remain operational regardless of differences among alternatives and considering the requirements of these agreements.

3.5 Mitigation Measures

Mitigation for impacts of a proposed action is something that is evaluated as part of documentation under NEPA, such as this EIS. Mitigation takes the following forms (Federal Register 1978):

1. Avoiding the impact altogether by not taking a certain action or parts of an action.
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
5. Compensating for the impact by replacing or providing substitute resources or environments.

All alternatives in this EIS are formulated with the primary intent of avoiding or minimizing impacts. Some impacts cannot be avoided while meeting the purpose and need of the proposed action.

The mitigation measures discussed below cover the range of impacts of the alternatives, including, where it is feasible to do so, impacts that by themselves would not be considered "significant." Potential mitigation measures are identified, even if they are outside the jurisdiction of the Corps or Reclamation. Some of the identified measures may be undertaken by other entities or individuals. No commitments are made in this EIS to any mitigation action beyond avoidance and minimization, particularly those that are not currently authorized, programmed, and funded. The record of decision that supports selection and implementation of operational actions at Libby Dam will document any mitigation actions that will be pursued by the Corps as part of the implementation of the selected alternative.

3.5.1 Hydrology and Flood Control

Libby Dam is operated to provide flood control as one of several authorized project uses. Mitigation for occasional flooding has not been identified, because the alternatives are not considered to increase the risk or severity of flooding. It is not possible to avoid flooding at all times. Levee repairs and upgrades, structural relocation, and individual structural floodproofing are potential measures that local landowners may consider to further decrease flood risk beyond that provided by Libby Dam operations. Sandbags have been used utilized during historical high water periods as temporary means to prevent and minimize impacts from flooding around Kootenay Lake and these temporary flood fighting techniques would likely be effective at preventing damage in the future. To decrease impacts due to high groundwater, capacity of drainage systems such as pumping facilities could be increased. Bank stabilization work of vulnerable shoreline sections (ranging from bioengineering techniques to placement of riprap) would prevent or minimize potential bank erosion that may occur primarily in areas upstream of Bonners Ferry under alternatives with generally higher flows.

3.5.2 Water Quality

Continued provision of fish flows would help avoid forced spill and TDG increases. Water management tools such as water supply forecasting methodology are continually being improved, which may allow water managers to better anticipate and avoid forced spills in real-time. Under any alternative, forced spills leading to elevated TDG increases that adversely impact water quality would be rare. Modification of the dam to provide for spillway deflectors, additional release capacity via the powerhouse, or other options could reduce TDG loadings during spill. Winter heat storage has no known solution at this time. The Corps is currently studying temperature stratification in the Libby Dam forebay and working on a thermal model to improve selective withdrawal system use, including possible water withdrawals closer to the surface, to more accurately provide desired downstream temperatures in the spring and consequently aid sturgeon migration and spawning. To address low nutrient levels in the Kootenai River downstream of Libby Dam, an experimental fertilization program was begun by the Kootenai Tribe of Idaho and BPA in 2005 in the Kootenai River. Nutrients were applied on a continuous basis from tanks placed adjacent to the Kootenai River in Idaho just downstream from the Montana state line. That program will continue at least in the short term if results continue to be positive. Primary production effects have been observed as far downstream as Bonners Ferry.

3.5.3 Aquatic Life

See Water Quality, above, concerning spill, TDG and temperature issues. With respect to flushing of nutrients and plankton from Kootenay Lake, there is an ongoing fertilization program in the north arm of the lake by the BC Ministry of Water, Land and Air Protection, partly funded by the Bonneville Power Administration. That program could be expanded to the South Arm. In addition, there may be benefits from the introduction of nutrients in the Kootenai River by the Kootenai Tribe of Idaho starting in 2005. There is at this time no known solution for possible fish stranding in the Duncan River delta. To address low nutrient levels in the Kootenai River downstream of Libby Dam, an experimental fertilization program was begun by the Kootenai Tribe of Idaho and BPA in 2005 in the Kootenai River. Nutrients were applied on a continuous basis from tanks placed adjacent to the Kootenai River in Idaho just downstream from the Montana state line. That program will continue at least in the short term if results continue to be positive. Primary production effects have been observed as far downstream as Bonners Ferry.

3.5.4 Sensitive, Threatened and Endangered Species

See Water Quality, above, concerning spill, TDG and temperature issues (affects fish species).

3.5.5 Vegetation

Maintenance of fish flows should aid riparian and wetland vegetation recruitment and establishment along the Kootenai River

3.5.6 Wildlife

Options to reduce potential adverse effects from flooding of waterfowl and shorebird nesting areas, as well as reptile and amphibian reproductive sites, could include increased pumping capacity or increasing the height of levees protecting sensitive nesting areas in the Creston Valley Wildlife Management Area. Other possible mitigation may include connection to the river for nesting areas which are currently behind dikes, so that water level rises in nesting areas are more synchronous with onset of lowland runoff.

3.5.7 Recreation

Continued operation under VARQ FC is expected to provide higher Lake Koocanusa elevations during the recreation season. No mitigation is available for any decrease in shore fishing days along the Kootenai River, but if fish flows benefit fish populations in the river, then the quality of the experience may help offset access impacts. No specific mitigation is identified for the relatively minor reductions in the number of swimming days below elevation 1749 feet in Kootenay Lake under some alternatives.

3.5.8 Environmental Health

VARQ FC operations would help minimize the possibility of windblown dust events by assisting with refill of Lake Koocanusa.

3.5.9 Cultural Resources

Although historic properties at Libby Dam are impacted by reservoir operations, they retain analytical and cultural value. These properties are currently managed under an existing BPA agreement known as the Intertie Development and Use Programmatic Agreement (IDUPA). This is a Section 106 compliance program administered by the Corps of Engineers, jointly funded by BPA and the Corps, planned by the Libby Dam—Lake Koocanusa Cultural Resources Cooperating Group (a planning forum that includes the Corps, BPA, and Section 106 interested parties), and carried out by the Corps and by the Kootenai National Forest with the participation of the Confederated Salish and Kootenai Tribes. Appropriate mitigation for adversely affected sites is being formulated in Site Treatment Plans and Site Protection Plans by the Corps, and mitigation planning will continue under the current cultural resources management program at Libby Dam—Lake Koocanusa. Mitigation may include documentation, surface collection of artifacts and features, site stabilization, or more intensive data recovery. Data recovery methods will be broadly interpreted and may include tribal cultural studies that can be shared with the public a visitor centers and for educational programs.

The Corps, BPA, Kootenai National Forest, Confederated Salish and Kootenai Tribes, and the Montana SHPO will continue to coordinate to mitigate impacts as needed under the current program. More detailed information will be included in future compliance documentation for the reservoir under its current Section 106 NHPA compliance program.

3.5.10 Indian Sacred Sites

Data or information on Indian Sacred Sites could not be obtained, so there is no basis to assess incremental or cumulative impacts to those resources.

3.5.11 Other Affected Tribal Interests

No impacts are expected to occur to other Tribal interests, so no mitigation actions are recommended.

3.5.12 Socioeconomics

No mitigation is proposed for damages from occasional flooding, because the alternatives are not considered to increase risk of river or lake elevations above established flooding thresholds.

If local landowners wish to further decrease damages from flooding, then levee repair and upgrades, structural relocation, and individual structural flood proofing are potential methods that local landowners may consider to further decrease damages from occasional flooding. Potential claims for compensation for flooding impacts in Canada could be addressed pursuant the provisions of the Columbia River Treaty.

Local landowners could reduce the socioeconomic effects of agricultural groundwater seepage by providing upgrades to drainage and pumping systems that serve to depress the water table in agricultural areas during high runoff periods. Local drainage districts would be the most appropriate organizations to fund and carry out any upgrades. Other options might include removing seepage-affected areas out of agricultural production. These areas could be managed as wetlands. The cost-effectiveness of mitigation for agricultural seepage may be low.

3.6 Unavoidable Adverse Effects

The alternatives evaluated in this EIS provide, as intended, some environmental benefits, and in addition, they attempt to create some balance with regard to nonenvironmental effects. For example, increased likelihood of Lake Koocanusa refill with VARQ FC would benefit not only fish and aquatic life in the reservoir, but also recreation and air quality.

However, there are some areas that would be adversely affected. They are discussed in individual sections, but are summarized here in the same order as the sections appear.

3.6.1 Hydrology and Flood Control

There are no anticipated unavoidable adverse flooding impacts associated with any alternative. As with the construction and operation of any Corps flood control project, the intent is to reduce the risk of flooding, however, assurances that flooding will not occur are not feasible. All alternatives would provide flood protection to current local flood control requirements whenever possible.

3.6.2 Water Quality

Under VARQ FC (LV1, and the LV benchmark operation), there is a possible increased likelihood of forced spill, in terms of frequency and duration, at Libby Dam compared to Standard FC (LS1, and the LS benchmark operation). Compared to the LS and LV benchmark operations without fish flows, the incremental effects of the fish flows in the different alternatives would serve to decrease forced spill instances and duration, but avoidance of all forced spills is not possible. Spill would increase TDG concentrations in the river downstream, between the dam and Kootenai Falls. This is expected to be an infrequent condition. Increased spill and resulting TDG supersaturation would also likely occur downstream of Kootenay Lake under any of the alternatives.

3.6.3 Aquatic Life

With VARQ FC (LV1, LV2, LVB, the LV benchmark operation), the possible increase in TDG between Libby Dam and Kootenai Falls may infrequently subject fish and aquatic insects to gas bubble disease or displacement from their preferred habitat. This could cause harm, or in extreme cases, mortality, though the latter would be rare for fish. There is also a possibility under all alternatives for stranding fish in the Duncan River delta on Kootenay Lake as a result of low water levels in spring. In addition to that, there may be some flushing of nutrients and plankton over the West Arm sill in Kootenay Lake, for all alternatives. Temperature effects may adversely affect Kootenai River burbot under all alternatives, which require water temperatures close to freezing in winter for spawning.

3.6.4 Sensitive, Threatened and Endangered Species

The possible generation of TDG in the river from Libby Dam to Kootenai Falls could affect sensitive, endangered and threatened species of fish in the Kootenai River. Primary concerns lie with bull trout (listed as threatened), westslope cutthroat trout, and redband trout; no other populations of sensitive, endangered and threatened species are found in the Kootenai River between Libby Dam and Kootenai Falls. Entrainment of fish, primarily kokanee, would occur under any alternative, and to a greater degree for those with higher releases during the spring and summer. Temperature effects may adversely affect Kootenai River burbot under all alternatives, which require water temperatures close to freezing in winter for spawning.

3.6.5 Vegetation

Wetland vegetation may be adversely impacted if the river stages achievable under the different alternatives fail to increase ecological and hydrologic connectivity between the river and riparian areas.

3.6.6 Wildlife

Wildlife species may be impacted by the alternatives. Bird species directly affected by high water levels include a variety of waterfowl and shorebirds such as Canada geese, mallards, western grebes (red listed in British Columbia), American avocet (red listed), long billed curlew (red listed), and Forster's tern (red listed). Bird species that do not nest on sites vulnerable to flooding but who may experience indirect effects include osprey, great blue heron (blue listed), American white pelican (red listed), and double crested cormorant (red listed). Nests are established in the early spring and the incubation season goes through early summer. Increased water levels may also adversely affect amphibians and reptiles, most notably western painted turtles (red listed) and northern leopard frogs (red listed).

3.6.7 Recreation

On Lake Koocanusa, the alternatives would result in less frequent reservoir refill and lower average peak pool elevations in comparison to the LS and LV benchmark operations, adversely affecting usability of boat ramps, marinas, campgrounds, and swimming beaches.

For the Kootenai River below Libby Dam, VARQ FC (LV1, LV2, LVB, the LV benchmark operation) may tend to decrease shore fishing days compared to Standard FC (LS1, LS2, LSB, the LS benchmark operation), on average.

On Kootenay Lake, the alternatives might decrease swimming days below elevation 1749 feet in comparison to the LS and LV benchmark operations.

3.6.8 Environmental Health

For the Kootenai Basin, this relates to air quality. There exists the possibility of a windblown dust event along Lake Koocanusa under any alternative, but alternatives that keep the reservoir below elevation 2404 feet for longer periods of time, or expose more area below that elevation, would be more adverse. Standard FC alternatives (LS1, LS2, LSB) and the LS benchmark operation would fall into that category, as compared with VARQ FC alternatives (LV1, LV2, LVB) and the LV benchmark operation. In comparison with the LS and LV benchmark operations, provision of fish flows might add to time of exposure of sediments to wind events and might be more adverse.

3.6.9 Cultural Resources

With any alternative, impacts to archaeological sites and other historic properties along the reservoir shoreline are unavoidable because of the static and perishable nature of historic properties. Downstream effects of streambank erosion at cultural resource sites are also unavoidable in the first five miles and may become candidates for site stabilization and/or data recovery. This is mainly due to providing fish flows, not because of VARQ FC operation. Sites farther downstream in the Kootenai Falls Archaeological District would remain unaffected.

3.6.10 Indian Sacred Sites

No unavoidable adverse impacts have been identified for Indian sacred sites.

3.6.11 Other Affected Tribal Interests

The proposed actions would not result in unavoidable adverse effects to other Indian interests.

3.6.12 Socioeconomics

As stated above in Section 3.6.1, some flooding is possible under any alternative. Expected annual damages between Libby Dam and Kootenay Lake are similar among all alternatives across damage categories. They are slightly higher under the LV benchmark operation) compared to the alternatives. For Kootenay Lake, the fish flows would contribute to higher losses due to flooding, with slightly higher losses also attributed to the VARQ FC alternatives.

Costs for pumped drainage of agricultural areas in the Kootenai valley in Idaho would be generally higher for the VARQ FC alternatives (LV1, LV2, LVB) than for the Standard FC alternatives (LS1, LS2, LSB); pumped drainage costs would also be higher for any of the alternatives than for the LS and LV benchmark operations. Groundwater seepage in agricultural lands between Bonners Ferry and Kootenay Lake would result from higher flows. This would cause economic losses, including income, in the lower Kootenai Valley in Idaho and British Columbia.

There may be recreation-related income effects stemming from less-reliable Lake Koocanusa refill with the alternatives when compared to the benchmark operations (LS, LV).

3.6.13 Municipal Water and Wastewater Treatment

No unavoidable adverse effect is expected from any alternative.

3.6.14 Transportation

There are no apparent unavoidable adverse effects on transportation, which basically concerns the Kootenay Lake Ferry.

3.7 Irreversible and Irretrievable Commitments of Resources

Irreversible commitments are decisions affecting renewable resources such as soils, wetlands, and riparian areas. Such decisions are considered irreversible because their implementation would affect a resource that cannot be recovered, forgo the uses of resources over a period of time as a result of a decision, deteriorate resources to the point that renewal can occur only over a long period of time or at a great expense, or destroy or remove the resource.

The primary impacts that would be irretrievable are those that involve storage or release of water from Libby Dam once it occurs (storing water means that water is not released downstream, release of water involves lost opportunities to release water at a different time or in a different pattern). Under the LV1, Libby Dam would tend to store more water during the winter, resulting in a loss of power production during the primary heating season in North America. During the spring and summer, Libby Dam would tend to increase dam releases, which increases power production during the spring and summer, but also decreases power generating opportunities at downstream dams that must increase spillway flows to accommodate higher flows during an already high runoff period.

The purpose of the Proposed Action is to provide recommended reservoir and flow conditions for anadromous and resident fish listed as threatened or endangered under the Endangered Species Act, consistent with authorized dam uses, including maintaining the current level of flood control benefits. While hatchery-produced sturgeon would sustain the population for the next several decades, the number of wild-produced sturgeon is rapidly declining. LVB would provide a degree of flexibility in implementing a variety of actions and projects designed to benefit sturgeon. Although based on the best available science, the ability of the recommended reservoir and flow conditions to conserve and recover white sturgeon, an endangered fish species in the Kootenai River, needs to be further investigated. Therefore, decisions and implementation of particular dam operations necessarily preclude other possible operational actions and the potential opportunities that they might afford self-sustaining sturgeon in the Kootenai River.

Agricultural impacts from high groundwater levels result from annual losses of capital and revenue which are irretrievable. These relate primarily to the fish flows associated with various alternatives.

Similarly, any loss of recreation-based income, particularly on Lake Koocanusa as a result of inability to bring the pool level within 20 feet from full during the recreation season (which would tend to occur more often with LS1 and LS2 and less commonly with LV1 and LV2), also would be irretrievable once it occurs.

Taking the current condition of archaeological sites and historic properties at Lake Koocanusa as a baseline, VARQ FC should not result in significant irreversible and irretrievable impacts beyond the baseline. The artifacts and features are already displaced from their original locations, so the main category of irreversible impact would be loss of artifacts and their associations due to looting or vandalism. This would result in the further loss of cultural and scientific values to the American public.

3.8 Relationship between Short-term Uses and Long-term Productivity

This analysis examines the relationship between short-term uses of environmental resources and the maintenance and enhancement of long-term productivity. The Libby Dam alternatives evaluated in this chapter would cause various direct impacts that are described for each resource in preceding sections. Each of the alternatives comprise operational actions that, if implemented, are reversible if additional information becomes available to warrant reconsideration.

To a large extent, the timing and magnitude of short-term impacts and benefits would be weather-dependent since the degree of differences between the various alternatives is dependent on seasonal water supply. For example, the alternative operations, including flows in spring, tend to become relatively similar during drought years or very wet years, so a string of very dry or very wet years in the immediate future would result in minimal differences in short-term impacts or benefits to the environment.

Over the long term, as analyzed by looking at the historical period of record, the alternatives would vary in terms of benefits to fish species, impacts to agricultural production, and recreational use in the Kootenai River basin.

Implementation of alternative flood control and fish flow operations would provide a degree of flexibility for water and natural resource managers to implement and evaluate a wider variety of actions that could benefit the Kootenai River ecosystem. Actions potentially include a mix of real-time dam operations and habitat restoration projects, with research, monitoring and evaluation in an adaptive management framework. In the absence of the operational flexibility provided by alternative flood control and fish flow operations, the population of self-sustaining Kootenai River white sturgeon would likely continue to decline, which, in turn, could lead to extinction of this sturgeon from the Kootenai River.

Implementation of alternative flood control and fish operations would increase the magnitude and likelihood of high groundwater levels that adversely impact agriculture. Continued implementation would result in long-term impacts on agricultural productivity in Boundary County.

Implementation of alternative flood control and fish operations would increase recreational accessibility and use of Lake Koocanusa. Beneficial impacts would occur over the short and long term. Over time, recreational benefits may increase as increased reservoir productivity benefits kokanee salmon growth, which would increase fishing opportunities. Other fish species as well are expected to benefit from VARQ FC and fish flows, which could enhance the recreational economy in the long run. Recovery of species that are now listed as threatened or endangered may create new opportunities for recreation.

3.9 Environmental Justice

Executive Order 12898 on environmental justice directs Federal agencies to identify and address disproportionately high and adverse impacts of their action to low income or minority populations.

In the area affected by the project in the Kootenay/Kootenai valley, minority populations comprise Native American tribes and bands, as well as Hispanics. Tribes and bands include the Tobacco Plains Band near Grasmere and Lake Koocanusa in British Columbia and the Lower Kootenay Band near Creston, British Columbia.

Based on the effects of the alternatives, there is no known disproportionate economic effect on any minority or low-income population. The alternatives, since they include fish flows, are expected to benefit fisheries. There may be seepage due to high groundwater in Tribal agricultural lands related to fish flows, as there is on other agricultural lands in the Kootenai Flats area, but this is not expected to be disproportionately high on Tribal land. There is not expected to be a disproportionate adverse effect to Tribal interests.

Impacts to human health are not anticipated by the preferred alternative. Impacts to the local and regional economy are further discussed elsewhere in Chapter 3. Because of impacts in some years to water quality in the Kootenai River, as a result of spilling up to 10 kcfs, the recreational economy of Lincoln County, Montana, may be affected by the preferred alternative, LVB, as well as LSB.

Chapter 4 Affected Environment and Environmental Consequences: Pend Oreille River Basin

4.1 Introduction

This chapter describes the affected environment and evaluates the environmental consequences of implementing each of the alternatives described in chapter 2. The analysis approach is by basin then by resource then by alternative. The level and depth of environmental analysis corresponds to the context and intensity of the impacts anticipated for each environmental component. Where the alternatives would have the same impacts on an environmental component, the analysis is presented once and summarized or referenced in subsequent analyses to eliminate redundancy.

Two alternatives were analyzed at Hungry Horse Dam: Hungry Horse Standard FC (HS), the no action alternative, and VARQ FC (HV), the preferred alternative.

The resource discussions are split into affected environment (description of the resource) and environmental consequences (effects of the alternatives). Within each section, the discussion of hydrology and flood control, water quality, aquatic life, wildlife, vegetation, and recreation are primarily arranged by river reach (from headwaters to downstream) in the following order: Hungry Horse Reservoir, Hungry Horse Dam to Flathead Lake, Flathead Lake, Flathead Lake Dam to Lake Pend Oreille, Lake Pend Oreille, and Pend Oreille River to confluence with Columbia River.

Resource discussions that do not follow this pattern are sensitive, threatened and endangered species (discussed by species); economics (discussed by county/state divisions); and cultural resources, Indian sacred sites, and other tribal interests which are limited to particular river reaches or a particular reservoir.

4.1.1 Issues Considered but Not Addressed in Detail

None of the alternatives and associated actions would affect regional or local climates, geography, or geology in the Pend Oreille River basin nor would these resources rise to the level of needing analysis. These discussions are summarized as part of the affected environment background information in the basin overview discussion.

Transmission limitation between Hungry Horse and Libby Power Plants

There is currently a 950 megawatt (MW) transmission limitation between Hungry Horse and Libby Power Plants. Full powerhouse capacity is about 1028 MW for the two dams, thus the dams cannot simultaneously operate to full powerhouse capacity due to the transmission limitation. If dam releases cannot be reduced below levels that would result in a combined generation of less than 950 MW of total generation at both dams, then one or both dams could be forced to spill. Although release through dam regulating outlets and spillways (i.e., nonturbine release) contributes to increased TDG, Hungry Horse and Libby Dams can spill a portion of their total releases without exceeding Montana's TDG 110 percent saturation standard.

The hydrologic modeling of Hungry Horse Dam and Libby Dam was completed independently of each other for this EIS. Rarely do both dams need to operate to full powerhouse capacity simultaneously. A sensitivity analysis was completed to determine (1) how often forced spill would occur due to the transmission limitation, and (2) how much, if any, the forced spill would increase TDG above the saturation standard.

Study results indicated that in 23 percent of modeled years forced spill would occur at Hungry Horse Dam during the spring flood control operation due to the transmission limitations; however, only 4 percent of those years would result in TDG exceeding the 110 percent saturation standard. In those years, the maximum TDG saturation level would be about 115.5 percent.

Spill at Libby Dam generally increases TDG more than spill at Hungry Horse Dam. Libby Dam can spill up to 880 cfs without exceeding the 110 percent saturation standard. Therefore, it was assumed that Libby Dam would reduce generation by up to 21 MW (880 cfs) and the majority of the reduction in generation would occur at Hungry Horse Dam. Based on these assumptions, TDG below Libby Dam did not exceed 110 percent due to the transmission limitation. Sensitivity analysis results are in Appendix L.

4.2 Affected Environment

4.2.1 Basin Overview

The Pend Oreille River basin is located in western Montana, northern Idaho, northeastern Washington, and southern British Columbia, Canada. The Pend Oreille River basin is shown in Figure 4-1 and its subbasins are listed in Table 4-1. The Flathead River and Clark Fork are major tributaries of the Pend Oreille River.

The basin is a region of forested mountains and narrow valleys lying on the western slopes of the Rocky Mountains. The Continental Divide borders on the east, southeast,

Table 4-1. Pend Oreille River basin drainage areas in United States and Canada.

Basin		Area (sq. mi.)
Pend Oreille River Basin 170102[1]	Idaho, Montana, Washington	25,100
Subbasin		
North Fork Flathead River 17010206	Montana	967
Middle Fork Flathead River 17010207	Montana	1,160
South Fork Flathead River 17010209	Montana, includes Hungry Horse Reservoir	1,690
Flathead Lake 17010208	Montana	1,160
Lower Flathead River 17010212	Montana	2,010
Lower Clark Fork 17010213	Idaho, Montana	2,330
Lake Pend Oreille 17010214	Idaho, Washington	1,240
Pend Oreille River 17010216	Idaho, Washington	1,080
Flathead River basin in Canada	SE British Columbia	608
Pend Oreille River basin in Canada	SE British Columbia	627
Total Area Pend Oreille River basin	United States & Canada	26,335

[1] USGS HUC: The US Geological Survey (USGS) Hydrological Unit Code (HUC) is a system of classifying varying scale of watersheds. The standard HUC is an eight digit string of numbers (http://www.epa.gov/eimsprod/mapsnew/wgeoloc-hlp.htm, accessed 04-18-2005).

and south; the Bitterroot Range (outside the EIS action area) borders on the south and southwest; and several small ranges border on the north. The highest elevations are along the Bitterroot Divide between Montana and Idaho and along the Continental Divide in Montana. Elevations range from about 10,000 feet along the Continental Divide to about 1300 feet near the confluence of the Pend Oreille River with the Columbia River. Most river systems follow the general mountain orientation except in the central and eastern portions of the basin where mountain and river complexes change orientation rapidly within short distances. The Clark Fork drains into Lake Pend Oreille, a large natural lake in the northwestern part of the basin. (Corps 2000)

Geology

The Pend Oreille River basin is in the northern Rocky Mountain physiographic province. Rocks are mainly ancient argillitic and quartzitic materials, metamorphosed sediments, and granite. These rocks have been folded and faulted during mountain-building movements that formed the Rocky Mountains. The entire region has been heavily glaciated by continental glaciers. Following the melting of the glacial ice sheet about 25,000 years ago, the Pend Oreille River incised deeply into bedrock north of Metaline Falls, making a series of tortuous and picturesque canyons. (Corps 2000)

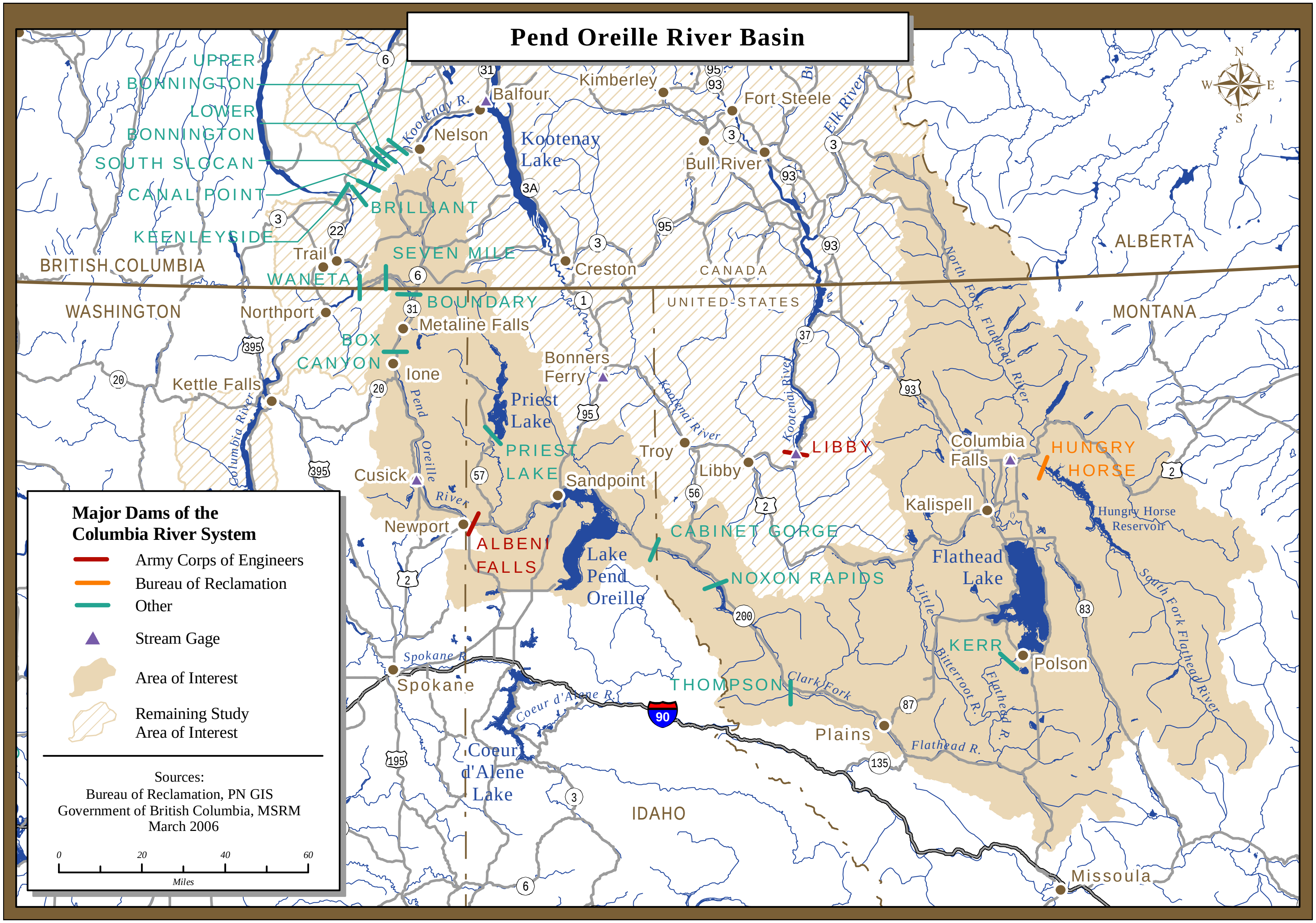

Figure 4-1. Pend Oreille River basin location map.

Climate

The Pend Oreille River basin climate is characterized by warm, moist summers and moderately cold winters during which deep snow generally accumulates at higher elevations. Summer temperatures occasionally range as high as 90° F to 100° F. During the winter, prevailing winds and storms from the Pacific carry moisture-laden air into the basin. Temperatures in the western part of the basin are moderated by Pacific influences while continental air affects temperatures in the eastern part of the basin. (Corps 2000)

Precipitation varies widely with season, elevation, and location. The 52-year adjusted normal annual precipitation for the basin above Albeni Falls Dam is about 28.5 inches, varying from 13 inches in the valleys of the Bitterroot and upper Clark Fork to about 80 inches along some sections of the Continental Divide. Snowfall usually begins in early fall (September-November) and snow depth generally increases through February-March. In higher elevations the accumulated winter snowcap above Hungry Horse melts later than the rest of the basin because it is at a higher elevation. Snow continues to accumulate through April. The spring runoff begins in mid-April/early May and continues through June and into July.

Major Streams

The North Fork Flathead River rises in British Columbia, Canada, and flows generally south joining the Middle Fork and South Fork upstream from Flathead Lake. Hungry Horse Dam is at RM 5 on the South Fork Flathead River. A few miles upstream from Columbia Falls, Montana, the South Fork Flathead River joins the Middle and North Forks to form the mainstem Flathead River[50]. Downstream from Columbia Falls, the river flows through meandering channels in a wide floodplain and enters the north end of Flathead Lake about 20 miles downstream from Kalispell, Montana. Flathead Lake, the largest natural freshwater lake in the western United States, has a surface area of about 200 square miles. The Flathead Indian Reservation borders the southern half of the lake and about 68 miles of the lower Flathead River. The river flows through Flathead Lake to Dixon, Montana, then turns abruptly and flows west to join the Clark Fork (RM 245) about 26 miles downstream from St. Regis, Montana.

The Clark Fork is the principal river entering Lake Pend Oreille. The river begins near Butte, Montana, and with a few deviations flows northwesterly to enter the east side of Lake Pend Oreille in Idaho. The Flathead River is the principal tributary of the Clark Fork within the EIS action area. Main tributaries of the Clark Fork, but outside the EIS study area, are the Blackfoot, Bitterroot, and St. Regis Rivers.

[50] The Middle and North Fork Flathead Rivers meet to form the mainstem Flathead River about 10 river miles upstream from the mouth of the South Fork. The North Fork Flathead River originates in British Columbia and is called Flathead River in Canada.

Table 4-2. Location of landmarks along the Flathead River, Clark Fork, and Pend Oreille River.

Landmark	River Mile
South Fork Flathead River	
Hungry Horse Dam	5
Flathead River	
Confluence of South Fork with mainstem Flathead	149
Columbia Falls, Montana (gage)	143
Kalispell, Montana	~125
Inlet to Flathead Lake	103
Polson, Montana	76
Kerr Dam, outlet to Flathead Lake near Polson, Montana	72
Clark Fork–Pend Oreille River	
Missoula, Montana (gage)	358
Mouth of Flathead River	245
Plains, Montana (gage)	236
Thompson Falls Dam	208
Noxon Rapids Dam	170
Cabinet Gorge Dam	150
Inlet to Lake Pend Oreille	139
Lake Pend Oreille natural outlet	119
Albeni Falls Dam, Idaho[1]	90
Newport, Washington	88
Cusick, Washington	70
Ione, Washington	39
Box Canyon Dam	35
Metaline Falls, Washington	27
Boundary Dam, Washington	17
International Boundary	16
Seven Mile Dam, British Columbia	5
Waneta Dam, British Columbia	0.5

[1] Although Albeni Falls Dam is 29 miles downstream from the Lake Pend Oreille natural outlet; it regulates the level of the lake by 10 feet.
Source: Pacific Northwest River Basins Committee 1976

Lake Pend Oreille is a deep, natural lake with a surface area of 180 square miles. The Pend Oreille River flows westerly out of Lake Pend Oreille at Sandpoint, Idaho, crosses into Washington, then flows north to the international boundary. After entering Canada, the river turns west and flows 16 miles to join the Columbia River just north of the international boundary.

4.2.2 Hydrology and Flood Control

The Pend Oreille River basin is a snowmelt driven basin with peak flows occurring in the late spring/early summer period. The major hydro facilities within the basin include: Hungry Horse Dam on the South Fork Flathead River, Kerr Dam on the Flathead River, Thompson Falls, Noxon Rapids and Cabinet Gorge Dams on the lower Clark Fork, Albeni Falls, Box Canyon and Boundary Dams on the Pend Oreille River in the United States, and Seven Mile and Waneta Dams on the Pend d'Oreille River in British

Columbia, Canada. Thompson Falls, Noxon Rapids, and Cabinet Gorge Dams are non-Federal hydropower projects. These three dams are operated as run-of-river hydropower projects; however, Noxon Rapids Dam also has some flood control. Box Canyon and Boundary Dams, non-Federal run-of-river projects, impound the Pend Oreille River between Albeni Falls Dam and the international boundary. Seven Mile and Waneta Dams impound the Canadian portion of the Pend Oreille River downstream from the international boundary.

Hungry Horse Dam and Reservoir are on the South Fork Flathead River about 5 miles upstream from its confluence with the mainstem Flathead River. The annual peak inflows into the reservoir tend to occur in May, June, or early July, but rain-on-snow events can cause short duration high flows during the winter months. Hungry Horse Dam is operated by Reclamation with flood control and hydropower production as the primary purposes. Full pool elevation for Hungry Horse Reservoir is elevation 3560 feet. Total storage capacity of the reservoir is about 3.5 million acre-feet. Storage capacity in Hungry Horse Reservoir provides local flood control for the communities of Columbia Falls and Kalispell, Montana, as well as system flood control for the Portland/Vancouver area on the mainstem Columbia River.

Figure 4-2 shows how Hungry Horse Reservoir elevations change in a typical year. The reservoir typically reaches its peak elevation around June 30 or the first week of July. Through the summer, the reservoir is gradually drafted to elevation 3540 feet to help meet anadromous fish flow objectives at McNary Dam on the mainstem Columbia River. In the fall, reservoir releases are made to meet flow requirements below Hungry Horse

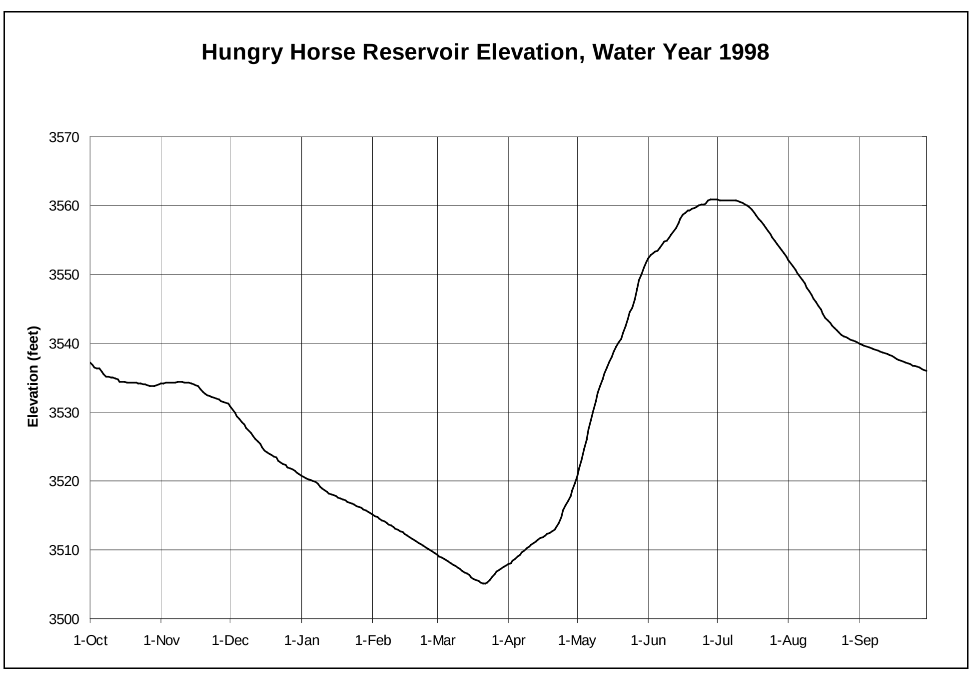

Figure 4-2. Hungry Horse Reservoir elevation, water year 1998.

Dam at Columbia Falls on the mainstem Flathead River. From January through April, the end-of-month target elevation for the reservoir (also known as the flood control rule curve) is determined by the size of the seasonal water supply forecast. The concept is to draft the reservoir to allow it to capture snowmelt runoff while still ensuring a high probability of reservoir refill by the end of the runoff period. In years with larger seasonal water supply forecasts, the reservoir would be drafted more deeply, while in drier years, the reservoir would be kept higher.

The reservoir typically begins to refill by the first of May during the snowmelt runoff period. During refill the dam is operated to manage downstream flows to minimize flooding, while still providing for reservoir elevations at the end of the runoff period as close to full pool as possible. Generally, Hungry Horse Dam and Reservoir are operated to regulate flow in the Flathead River below flood stage at Columbia Falls, Montana. The South Fork downstream from Hungry Horse Dam is the only regulated part of the Flathead River upstream from Columbia Falls. The official flood stage at Columbia Falls is 14 feet which translates to a flow of around 51,500 cfs (note that although flood stage is 14 feet, operators attempt to maintain flow below 13 feet, if possible, which equates to a flow of around 44,500 cfs). Historically, Columbia Falls would exceed flood stage about one year in five with Hungry Horse at minimum flow. Flooding at Columbia Falls would increase without Hungry Horse Reservoir containing flow from the South Fork Flathead River.

Flathead Lake is a natural lake located about 40 miles downstream from Columbia Falls on the Flathead River. The elevation of Flathead Lake was raised 10 feet by the construction of Kerr Dam. Kerr Dam, at the lake outlet, controls lake levels for much of the year except during periods of high flows, such as during the peak runoff season when a natural constriction upstream from the dam near Polson, Montana, regulates flows out of the lake. Kerr Dam regulates the level of Flathead Lake for flood control (thus preventing flooding to lake-front property) and recreation while maintaining minimum flow requirements downstream in the Flathead River.

Kerr Dam is primarily operated to prevent flooding in the Flathead River immediately upstream from the lake which is caused by the combined effects of high lake levels and high Flathead River flows. Specifically, flooding in the Kalispell area begins if the lake level reaches elevation 2893 feet. The Corps and PPL-Montana (operator of Kerr Dam) jointly manage the spring refill of Flathead Lake for flood control. Reclamation coordinates operation of Hungry Horse Dam with PPL-Montana for flood control operations during wet years and during dry years for shaping of flow augmentation water through Flathead Lake. In addition to flood control, Kerr Dam is operated to maintain

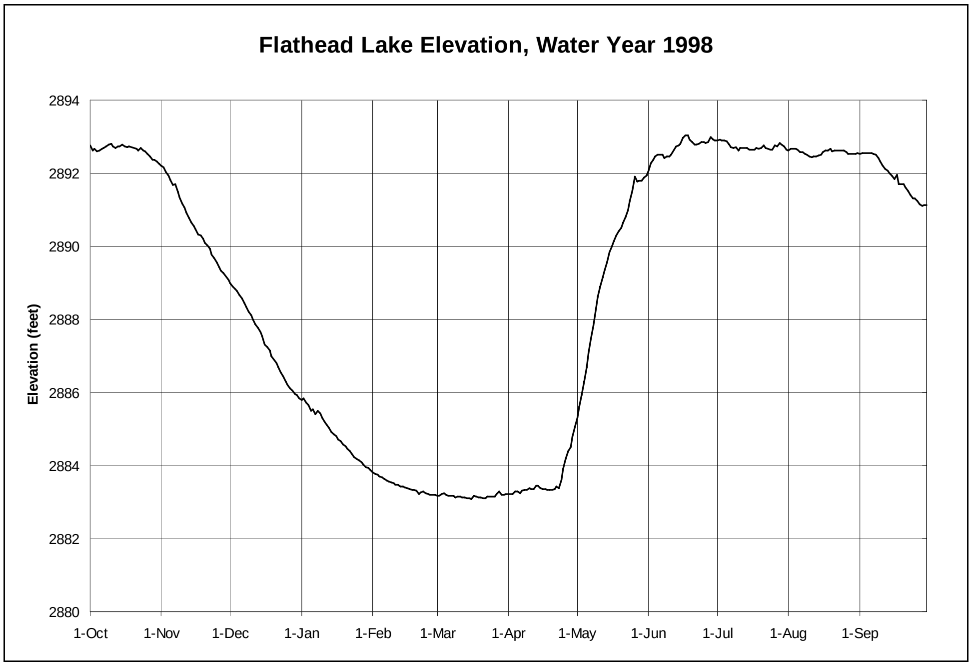

Figure 4-3. Flathead Lake elevation, water year 1998.

minimum flow requirements as prescribed under conditions[51] of section 4e of the project license. Figure 4-3 shows Flathead Lake elevations in a typical year.

The Flathead River flows into the Clark Fork approximately 72 miles downstream from Kerr Dam. Thompson Falls Dam is located on the Clark Fork, 37 miles downstream from the confluence of the Flathead River and Clark Fork. PPL-Montana operates Thompson Falls Dam for power generation. Located 38 miles and 58 miles, respectively, downstream from Thompson Falls Dam are Noxon Rapids and Cabinet Gorge Dams. These two projects are operated for power generation by Avista Corporation. Both Thompson Falls and Cabinet Gorge are run-of-river projects and do not provide flood control protection. Noxon Rapids, a run-of-river project, has a limited storage capacity and it can voluntarily provide some flood protection (CRT Flood Control Operating Plan 2003). The Clark Fork flows into Lake Pend Oreille about 11 miles downstream from Cabinet Gorge Dam and about 106 miles downstream from the confluence of the Flathead River and Clark Fork.

[51] During FERC relicensing of Kerr Dam, the Department of the Interior on behalf of CSKT included 4(e) conditions. FERC provides that in the case of any project located on a reservation of the United States, the License shall contain "Such conditions as the Secretary of the Department of the Interior, under whose supervision such reservation falls shall deem necessary for the adequate protection and utilization of such reservation." The 4(e) conditions established in the 1995 Kerr dam FERC relicensing include minimum flow requirements at different dates throughout the year, ramping rates, and water surface elevation requirements for Flathead Lake. These operations cannot be met during certain drought conditions, so PPL-Montana, is also required to prepare a drought management plan (DMP) to mitigate for those years. The BIA is currently preparing an EIS for the DMP.

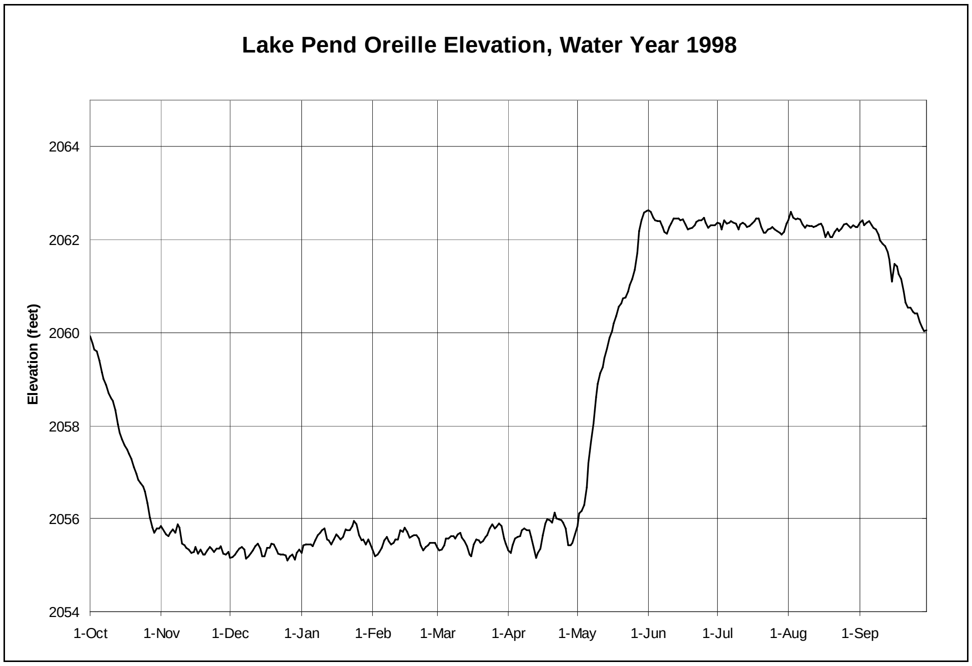

Figure 4-4. Lake Pend Oreille elevation, water year 1998.

Albeni Falls Dam, operated by the Corps, was authorized to regulate Lake Pend Oreille for flood control, navigation, conservation, recreation, and power generation. The dam regulates the outflow for much of the year except during periods of high flows, such as during the peak runoff season, when a natural constriction upstream from the dam controls the flow. Figure 4-4 shows Lake Pend Oreille elevations in a typical year.

Drawdown of Lake Pend Oreille from September through November provides streamflows for downstream hydropower generation and storage for spring flood control. Upstream storage at Hungry Horse Dam and Flathead Lake provides substantial flood control but is not sufficient to fully control Lake Pend Oreille flooding due to limited storage capacity, distance from the lower Pend Oreille River, and large uncontrolled runoff from the basin. Economic losses due to flooding begin to occur around Lake Pend Oreille when the lake exceeds elevation 2062.5 feet.

The area subject to flooding along the Pend Oreille River downstream from Albeni Falls Dam is in the Calispell Flats reach, near Cusick, Washington, approximately 20 miles downstream from Albeni Falls Dam. The zero-dollar damage point[52] for this reach is 85,000 cfs which causes nuisance flooding in areas without levees. Substantial economic losses due to flooding begin to occur at flows of about 120,000 cfs which approximates the design levee height in the areas protected by levees.

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[52] The zero-dollar damage point is based on the approximate flow or water elevation at which economic losses may begin.

Problems can occur at Cusick if flows in excess of 43,000 cfs are passed through Lake Pend Oreille and into the Pend Oreille River during the spring. Spring releases from Albeni Falls Dam can at times coincide with normal spring runoff from Calispell and Trimble Creeks, two lowland streams that border the Cusick Flats agricultural area, and cause flooding in the Cusick area. Box Canyon Dam, located 35 miles downstream from Cusick, raises the water level of the Pend Oreille River approximately 40 feet at the dam site (depending on flow) and 4-6 feet in the Cusick area. Box Canyon Dam is owned by Pend Oreille PUD and operated for power generation. To limit the agricultural impacts of raising the Pend Oreille River, Pend Oreille PUD made agreements with diking districts on Calispell and Trimble Creeks to operate and maintain pumping facilities to drain water from the creeks when the creeks and/or the Pend Oreille River reached specified elevations. Agreements are also in place to lower Box Canyon Reservoir when certain water elevation limits are exceeded.

Boundary Dam is located about 17.5 miles downstream from Box Canyon Dam near the Canadian border. Boundary Dam is operated for power generation by Seattle City Light.

The Pend Oreille River crosses the international boundary 1-mile downstream from Boundary Dam. Approximately 11 miles and 15 miles, respectively, from the border are Seven Mile and Waneta Dams. BC Hydro operates Seven Mile Dam and Columbia Power Corporation and Teck Cominco operates Waneta Dam. Both projects are operated for power generation. The Pend d’Oreille River enters the Columbia River in Canada about 0.5 miles downstream from Waneta Dam.

4.2.3 Water Quality

Throughout the Pend Oreille River basin including the Canadian portion of the Pend Oreille River, water quality data have been continuously collected and monitored through long-term programs by Federal, state, and local agencies. These agencies include USGS; Reclamation; British Columbia Ministry of Water, Land and Air Protection; Tri-State Implementation Council; Montana DEQ; Idaho DEQ; Washington Department of Ecology (Washington DOE); Pend Oreille Watershed Council; Flathead Basin Commission; and multiple other local entities. In Table 4-3, key water quality parameters are listed by median values for some of the major water bodies in the basin.

Montana DEQ lists Flathead Lake, South Fork Flathead River, Clark Fork, and multiple feeder creeks and rivers as water quality limited under Section 303(d) of the CWA. Reasons for the listing of these water bodies include elevated metal and nutrient concentrations, abundant algal growth, increased siltation, and unacceptable dissolved oxygen (DO) levels. Montana DEQ suggests the water quality impairment is due to agriculture, mill tailings, municipal point sources, resource extraction, and hydro modifications.

Table 4-3. Summary of selected water quality median measurements for the Flathead River, Flathead Lake, Clark Fork, and Pend Oreille River.

Sample Location	Dissolved Solids (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Nitrite plus Nitrate (mg/L of N)	Total Phosphorus (mg/L)	Suspended Sediment (mg/L)
Flathead River near Perma, MT	NM	10.15	0.02	0.008	5
Flathead Lake	NM	NM	0.043	0.006	NM
Clark Fork below Cabinet Gorge Dam	101	9.6	0.039	0.012	NM
Pend Oreille River at Newport, WA	NM	11.04	0.005	0.005	NM

NM: No Measurements
Source: USGS 2003, 2005; Tri-State Water Quality Council 2003; Montana DEQ 2001

Idaho DEQ under Section 303(d) of the CWA lists the lower Clark Fork from the Montana/Idaho state line into Lake Pend Oreille (about 12 miles) as water quality limited for elevated mercury levels, total dissolved gas (TDG), and the presence of unknown toxic substances. Lake Pend Oreille is listed due to elevated levels of TDG. Some of the surrounding tributaries are also considered impaired due to increased temperature levels.

Idaho DEQ lists the Pend Oreille River from the outflow of Lake Pend Oreille to the Idaho/Washington state line as impaired due to high levels of TDG, temperature, and sediment. Additional Idaho DEQ and Montana DEQ water quality listings are based on habitat and flow alterations.

Washington DOE lists the section of the Pend Oreille River from the Idaho state line to the international border as impaired under Section 303(d) of the CWA for increased temperatures, high levels of TDG, and unacceptable pH levels along with the presence of exotic aquatic plants. Washington DOE is also beginning to formulate TDG Total Maximum Daily Load (TMDL) criteria for the Pend Oreille River.

Water quality is considered good in the 15 miles of the Pend Oreille River that flows north from Boundary Dam into Canada. According to the Canada-British Columbia Water Quality Monitoring Agreement, the Pend d'Oreille River at Waneta Dam has no environmentally significant trends that could be detected (Wipperman *et al.* 1996). However, TDG saturation levels exceed water quality standards in Canada.

Total Dissolved Gas

Total dissolved gas supersaturation is an important water quality parameter due to the biological effects on fish. Spill[53] events at hydroelectric facilities are the primary cause of elevated TDG levels throughout the basin.

Total dissolved gas supersaturation can also occur due to natural phenomena such as high biological productivity, fluctuations in barometric levels and water temperature, and natural waterfalls and cascades (Pickett 2004). In systems that experience high levels of aquatic plant growth night-time supersaturation of the water column is not uncommon. The Pend Oreille River has TDG issues primarily due to spill events but increased temperature and the presence of excess aquatic plants are secondary contributors.

Since the 1960s, TDG has been a major concern in northwestern river systems with hydroelectric facilities due to the potential adverse effects on resident and migratory fishes and other aquatic organisms. In 1998, the Transboundary Gas Group (TGG) was formed to coordinate the dissolved gas management activities in much of the project area. The TGG is composed of various public and private entities from the United States and Canada (Reclamation 2000).

Hungry Horse Dam TDG monitoring has been conducted by Reclamation since 1997. As shown in Figure 4-5, the TDG levels have been successfully managed at acceptable levels through spill control efforts over the past six years. Selective release occurs at the facility to manage water temperature levels in the Flathead River below the dam. Normal release is too cold for the downstream aquatic environment; therefore, the release happens at a level closer to the reservoir surface which allows the warmer water to be released without increasing the TDG level. River water temperatures generally increase as flows move downstream. The Pend Oreille River in Idaho and Washington is considered temperature impaired.

In a study prepared by Weitkamp (1999), TDG saturation levels in the Thompson Falls forebay during the spring of 1999 were typically less than 105 percent saturation; however, maximum levels occasionally reached between 108 and 110 percent. Total dissolved gas saturation levels in the forebay of Noxon Rapids Dam ranged from 110 to 118 percent saturation, with a median level of 105 percent saturation (Weitkamp 1999). From a system standpoint, the TDG saturation levels were typically about 5 percent higher at the Noxon Rapids Dam forebay than the Thompson Falls Dam forebay.

[53] In this study, spill is defined as any water release made through a hydroelectric facility that is not passed through the power plant, e.g., discharges through the hollow jet valves at Hungry Horse or over the spillway at Kerr Dam.

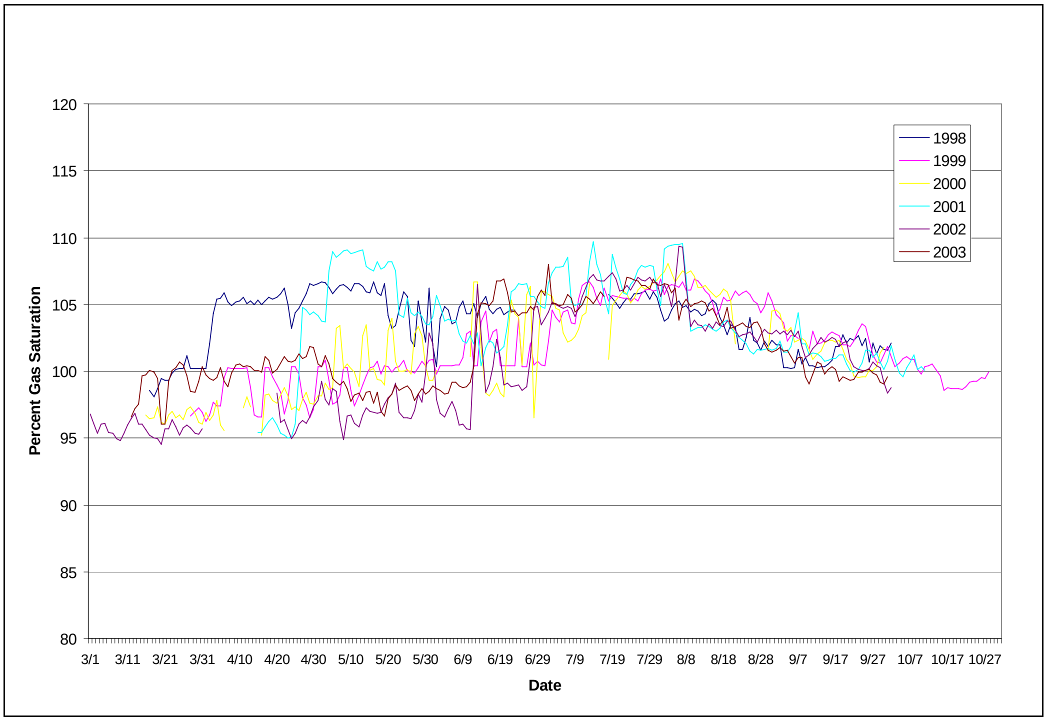

Figure 4-5. Daily average total dissolved gas at Hungry Horse Dam (1998-2003).

In the Clark Fork below Cabinet Gorge, TDG levels generally correspond to spill events at the projects. During the 1997 high flow event the maximum recorded TDG value downstream of Cabinet Gorge Dam was 158 percent saturation. Maximum levels in typical years remain well below 130 percent saturation, with variable spill patterns resulting in daily variations ranging between 105 and 120 percent (Sullivan *et al.* 2002).

Additional data collected from 1997 to 2000 by Weitkamp (2002) showed that TDG levels below Cabinet Gorge frequently exceeded 110 percent saturation. Table 4-4 shows the mean TDG saturation level and the range of values collected during several 15-day study periods from the 1997-2000 study period.

Table 4-4. Mean TDG saturation levels and TDG saturation ranges collected below Cabinet Gorge Dam from 1997-2000.

Year	May 15-31 Mean (range)	June 1-15 Mean (range)	June 16-30 Mean (range)	July 1-15 Mean (range)
1997	150 (142-158)	146 (143-151)	142 (132-145)	133 (127-139)
1998	103 (100-119)	112 (104-121)	117 (103-131)	113 (103-121)
1999	114 (102-128)	125 (119-137)	125 (123-129)	107 (105-117)
2000	108 (NA)	104 (NA)	107 (NA)	No Data

Source: Weitkamp *et al.* 2002
NA= not available

Total dissolved gas saturation levels in Lake Pend Oreille are similar to those found in the Clark Fork below Cabinet Gorge. The highest lake TDG saturation levels typically correspond with spill associated with spring runoff and flow augmentation; most levels exceed 115 percent saturation. In periods before and after spill, the lake TDG saturation levels are similar to those below Cabinet Gorge. (Weitkamp 1999)

Washington DOE has determined that TDG saturation levels in the Pend Oreille River below Lake Pend Oreille exceed the state water quality standards (Pickett 2004). As a result of these exceedances, the state of Washington has initiated a technical study to evaluate TDG saturation levels in the Pend Oreille River.

Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities and natural sources. Excess nutrients can result in accelerated plant growth and can result in a eutrophic or enriched system.

A comprehensive water quality study was conducted in the Pend Oreille River basin, by the Environmental Protection Agency (EPA) under section 525 of the CWA in response to citizens' concerns about nutrient levels, eutrophication problems, and heavy metal pollution due to mining operations, agricultural activities, urbanization, and other resource extraction activities. As a result of finding significant water quality problems, a Tri-State Implementation Council was convened to execute EPA's Management Plan for improving water quality in the basin. The Flathead River basin was included in the area studied. (EPA 1993)

The Tri-State Implementation Council (1998) facilitated the Voluntary Nutrient Reduction Program (VNRP) to improve water quality in the Clark Fork. The program identified acceptable nutrient levels, point sources of nutrient loading, and actions to reduce the nutrient levels. The elevated nutrient levels contributed to high algal growth along the Clark Fork in Montana. This is also an issue in Idaho since the Clark Fork accounts for 90 percent of Lake Pend Oreille's water and 75 percent of its total nutrient loading (Tri-State Implementation Council 1998). The high levels of algal growth impact aquatic life and recreation beneficial uses by reducing dissolved oxygen concentrations and rendering the water aesthetically unpleasing.

According to the *Clark Fork Voluntary Nutrient Reduction Program Three-Year Evaluation Report* (2001), nutrient concentrations have decreased toward target levels in the Clark Fork. The mean total nitrogen concentrations ranged from approximately 0.22 milligrams per liter (mg/L) above Flathead Lake to approximately 0.13 mg/L at Noxon, Montana, for the 1984 through 2003 period of record. The mean total phosphorus concentrations ranged from approximately 0.024 mg/L above Flathead Lake to approximately 0.01 mg/L at Noxon for the 1984 through 2003 period of record. This data is supplemented by data collected by the Tri-State Implementation Council and discussed in the Clark Fork-Pend Oreille Watershed Monitoring 2003 Report Summary. Despite the reduction of nutrients, the algae levels have remained similar to those in previous years in the Clark Fork.

Based on nutrient data reported by Idaho DEQ (2001), total phosphorus and total nitrogen levels in Lake Pend Oreille have not statistically changed over the past 50 years. Total phosphorus concentrations in the euphotic zone ranged from 0.003 mg/L to 0.016 mg/L with a mean concentration of 0.008 mg/L. The range for total nitrogen was not available, but the mean concentration was 0.14 mg/L. Lake Pend Oreille is considered an oligitrophic lake.

Sediment

Both suspended and bedload sediment can have negative effects on water quality. Many fish species can tolerate acutely high levels of sediment for short periods of time, but chronic durations of exposure are often detrimental.

Sediments can also play an integral role in reducing the frequency and duration of phytoplankton blooms in standing waters and large rivers. In some cases there is an immediate response in phytoplankton biomass when external sources are reduced. In other cases, the response time is slower, often taking years.

The mean suspended sediment concentration in the Flathead River at Perma, Montana, is 9.0 mg/L based on a 1984 to 2004 period of record (USGS 2005). While not an ideal measure of water column sediment (due to other suspended material that may exist, such as organic matter), the EPA has indicated that turbidity is a suitable endpoint for determining the effects of sediment-based beneficial use impairment (EPA 1999). Turbidity data were collected on the Clark Fork from below Thompson Falls Dam, at Noxon, Montana, and below Cabinet Gorge Dam in 2003. The mean turbidity concentrations were 3.7 Nephlometric Turbidity Units (NTU), 2.5 NTU, and 2.87 NTU, respectively (MDEQ 2003) which are relatively low levels of turbidity for the Clark Fork.

Temperature

Adequate water temperature is a water quality component integral to the life cycle of fish and other aquatic species. Water temperature dictates whether a warm, cool, or coldwater aquatic community is present. Many factors, both natural and anthropogenic, affect stream temperatures. Natural factors include but are not limited to altitude, aspect, climate, weather, geothermal sources, riparian vegetation (shade), and channel morphology (width and depth). Anthropogenic factors include heated discharges (such as those from point sources), riparian alteration, channel alteration, and flow alteration.

The USGS collected water temperature data from Hungry Horse Reservoir directly above the dam in August and November of 1986 to differentiate the summer/fall thermal regime in the reservoir (USGS 2005). The study showed that in August, water temperatures range from 20.2 °C at the surface to 3.5 °C at the bottom (95 meters deep), with the thermocline developing at about 13 meters. In November, the water temperatures range from 6.4 °C at the surface to 3.4 °C at the bottom. The reservoir is isothermal at this time of year. Selective release from Hungry Horse Dam occurs to manage water temperature levels in the reservoir releases. Bottom water releases are too cold for the downstream aquatic life. Therefore, water releases occur at levels closer to the reservoir surface where warmer water is available.

The USGS also collected water temperature data in the Flathead River near Perma, Montana, from March 1999 to September 2003. Annually, the temperature data were collected on a bimonthly or sometimes monthly basis. The data show that the mean summer/growing season temperature (April-September) in the river is 14.8 °C, while the mean non-growing season (October-March) temperature is 4.8 °C.

Water temperature data were collected on the Clark Fork from below Thompson Falls Dam, at Noxon, Montana, and below Cabinet Gorge Dam in 2003. The mean temperatures were 56.6° F (13.7° C), 57.4° F (14.1° C), and 58.3° F (14.6° C), respectively (MDEQ 2003).

Water temperature data collected by Idaho DEQ as part of the 2001 Lake Pend Oreille TMDL show that in most of the lake temperatures range from 66° F to 73° F (18.8° C to 22.5° C), depending on the depth of the measurement. However, in the shallower northern end of the lake, temperatures were generally 2° C warmer (IDEQ 2001). Water temperatures in the Pend Oreille River below Lake Pend Oreille are similar to the surface temperature of the lake (Easthouse 2005).

4.2.4 Aquatic Life

Hungry Horse Reservoir

Hungry Horse Reservoir contains primarily native fish species, including westslope cutthroat trout, mountain whitefish, and bull trout. Hungry Horse Dam has helped isolate the native fish populations in most of the South Fork Flathead River drainage from nonnative species (such as lake trout) which occur downstream from the dam. Non-game species include northern pikeminnow, largescale and longnose suckers, and sculpins.

The Montana Department of Fish Wildlife and Parks (MFWP) does not artificially stock the reservoir, and fish populations are maintained solely through natural spawning and rearing. Westslope cutthroat and bull trout are the most important game fish species. When sexually mature, these fish migrate to and spawn in the tributary streams that feed the reservoir, including the South Fork Flathead River and its tributaries. Juvenile fish typically rear in these streams for 3 years before they migrate downstream to the reservoir where they grow to maturity. While in the reservoir, westslope cutthroat trout feed primarily on zooplankton, while the larger bull trout forage mostly on other fish. Beginning in 2004, an experimental bull trout season was initiated that allowed limited angler harvest of bull trout from Hungry Horse Reservoir (CSKT and MFWP 2004).

In general, Hungry Horse Reservoir does not support a highly productive resident fishery due to low nutrient level input and the negative effects on fish growth associated with annual pool drawdowns. Annual drawdowns expose vast areas of reservoir bottom to drying, thus killing aquatic insects, which are the primary spring food supply for fish. Reduced reservoir pool volume impacts all aquatic trophic levels due to the diminished size of the aquatic environment (CSKT and MFWP 2004). These changes affect the food base for many wildlife species that feed on aquatic organisms (CSKT and MFWP 2004).

Hungry Horse Dam to Flathead Lake

Most of the fish species that are found in the South Fork Flathead River below Hungry Horse Dam and the mainstem Flathead River spend a large portion of their life in Flathead Lake. Native game fish species in the Flathead River include mountain whitefish, westslope cutthroat trout, and bull trout. Non-native species include lake trout, rainbow trout, lake whitefish, and kokanee. A recent investigation found the mountain whitefish to be the most numerous species in both river sections (CSKT and MFWP 2004). Investigators also observed largescale suckers, rainbow trout, westslope cutthroat trout, bull trout, lake trout, brook trout, and lake whitefish.

Hybridization between rainbow and westslope cutthroat trout is prevalent in the upper Flathead River. Hybridization, competition, and loss of habitat have contributed to declines of westslope cutthroat trout, but they are still widely distributed in tributary streams. Westslope cutthroat trout and bull trout grow to sexual maturity in Flathead Lake and migrate up the Flathead River to spawn and rear in tributaries. Juvenile cutthroat trout and bull trout leave rearing streams in early summer and remain in the affected reach throughout the summer and fall as they move downstream to Flathead Lake. Fluvial populations of cutthroat trout spawn in Flathead River tributaries but mature in the mainstem river without spending time in Flathead Lake.

Historic Hungry Horse Dam operations essentially reversed the natural annual river hydrograph on the South Fork Flathead River. Dam operations stored reservoir inflows during the spring runoff and summer for power production during fall and winter. Dam releases were high during the cold months when pre-dam flows were historically low. Consequently, dam operations produced an unproductive varial zone and increased substrate embeddedness, both of which resulted in poor fish habitat downstream from the dam (CSKT and MFWP 2004). Impoundment by Hungry Horse Dam and the removal of riparian vegetation altered the annual temperature cycle in the river, and coldwater releases in warmer, productive months impaired biological productivity. In August 1995, selective withdrawal structures became operational on Hungry Horse Dam. These structures were designed to allow thermally selective release of reservoir water and restore a more natural temperature regime to the Flathead River downstream. Operation of selective withdrawal returned a more normative thermal regime to the Flathead River upstream from Flathead Lake. The return of more normal river temperatures has likely increased diversity and abundance of certain groups of macroinvertebrates.

Flathead Lake

Flathead Lake is a relatively cold and unproductive lake, and has better water quality than most large lakes in the world (CSKT and MFWP 2004). The lake currently supports native bull trout, westslope cutthroat trout, and mountain whitefish. At least 11 nonnative fish species have been legally or illegally introduced into the system since the late 19th century. The introduction of nonnative fish, coupled with the accidental introduction of the nonnative opossum shrimp (*Mysis relicta*) in Flathead Lake have caused widespread changes in the lake's food web and ecosystem (CSKT and MFWP 2004). Lake trout and northern pikeminnow are now the dominant predator fish species in the lake (CSKT and MFWP 2004). Kokanee, once the dominant fish of Flathead Lake, have nearly disappeared. Westslope cutthroat trout and bull trout populations have declined as well.

Other fish species found in Flathead Lake include lake whitefish, peamouth, longnose and largescale sucker, and yellow perch.

Kerr Dam to Lake Pend Oreille

Downstream from Flathead Lake, in the lower Flathead River, prominent fish species include mountain whitefish, brown trout, rainbow trout, northern pike, largemouth bass, cutthroat trout, and northern pikeminnow. Introduced species have impacted native species, such as bull trout. Historic operations of Kerr Dam resulted in abnormal inundation of normally vegetated areas, and resulted in shoreline areas comprised of an unvegetated zone dominated by mud and rock (CSKT and MFWP 2004). New minimum flows established by the FERC relicensing in 1995 have resulted in more stabilized releases from Kerr Dam which more closely approximate the natural flow regime (CSKT and MFWP 2004). These changes are expected to substantially improve habitat conditions for aquatic species on the lower Flathead River (CSKT and MFWP 2004).

The section of the Clark Fork from the confluence with the Flathead River downstream (RM 245) passes through several run-of-river hydroelectric dams at Thompson Falls, Noxon Rapids, and Cabinet Gorge before flowing into Lake Pend Oreille. All three dams are barriers to upstream fish movement at all times of the year.

Twenty-nine fish species are found in the Clark Fork between Lake Pend Oreille and the Flathead River (Table 4-5). The most common fish are non-game species of sunfish, yellow perch, northern pikeminnow, shiners, suckers, and bass (FERC 2000). Salmonid populations in the reservoirs are small and self-sustaining and consist primarily of westslope cutthroat trout, rainbow trout, brown trout, brook trout, bull trout, lake whitefish, and mountain whitefish.

Factors responsible for the decline in fish populations include the effects of land development on habitat, competition with introduced salmonid and non-salmonid fishes, hybridization with introduced salmonids, angler harvest, and hydro development. Thompson Falls, Noxon Rapids, and Cabinet Gorge Dams prevent upstream fish movements and have isolated fish populations, selecting against migratory life histories for westslope cutthroat trout (FERC 2000).

Attempts at establishing a coldwater fishery on Cabinet Gorge and Noxon Reservoirs were unsuccessful even with stocking efforts (FERC 2000). These reservoirs are long (10-35 miles in length) and experience water temperatures that range up to 75° F during the warmest part of the summer. The inability to establish coldwater fisheries led the MFWP to focus fish management efforts on the enhancement of warm and coolwater species, such as largemouth and smallmouth bass (FERC 2000). It now appears that these projects support productive bass fisheries.

The Clark Fork between Cabinet Gorge Dam and Lake Pend Oreille supports coldwater and coolwater sport fish. Coldwater species including kokanee, rainbow trout, brown trout, and westslope cutthroat trout are common in the riverine reaches, whereas cool and warmwater species such as yellow perch and largemouth bass are more abundant in the delta region of Lake Pend Oreille (FERC 2000).

Lake Pend Oreille

Lake Pend Oreille supports a sport fishery. Currently, target species for management efforts in the lake are kokanee salmon, rainbow trout, bull trout, cutthroat trout, and lake trout. Lake Pend Oreille and its tributaries have historically provided a highly regarded sport fishery for bull trout (GEI 2004a). Other fish species present are listed in Table 4-6. Fish stocking during the past 100 years has influenced fish populations in Lake Pend Oreille.

According to GEI (2004a), westslope cutthroat trout comprised an important part of the sport fishery up until the 1960s, but have since declined. Hybridization with rainbow trout, competition, and loss of habitat have contributed to declines of westslope cutthroat trout, but they are still widely distributed in tributary streams.

Table 4-5. List of fish species present in the lower Clark Fork.

Species	Native/Introduced	Location
Family Salmonidae		
Cutthroat trout *Oncorhynchus clarki*	N	T/R/Rv
Bull trout *Salvelinus confluentus*	N	T/R/Rv
Mountain whitefish *Prosopium williamsoni*	N	T/R/Rv
Rainbow trout *Oncorhynchus mykiss*	I	T/R/Rv
Brown trout Salmo trutta	I	T/R/Rv
Brook trout Salvelinus fontinalis	I	T
Lake trout Salvelinus namaycush	I	R/Rv
Lake whitefish Coregonus clupeaformis	I	R/Rv
Kokanee salmon *Oncorhynchus nerka*	I	Rv
Family Esocidae		
Northern pike *Esox lucius*	I	R
Family Cyprinidae		
Peamouth *Mylocheilus caurinus*	N	T/R/Rv
Northern pikeminnow *Ptychocheilus oregonensis*	N	T/R/Rv
Redside shiner *Richardsonius balteatus*	N	T/R/Rv
Longnose dace *Rhinichtys cataractae*	N	T/R
Speckled dace *Rhinichtys osculus*	N	T
Tench *Tinca tinca*	I	Rv
Family Catastomidae		
Longnose sucker *Catostomus catostomus*	N	T/R/Rv
Largescale sucker *Catostomus macrocheilus*	N	T/R/Rv
Family Ictaluridae		
Bullhead *Ameirus sp*.	I	R/Rv
Family Gadidae		
Burbot *Lota lota*	I	R
Family Centrarchidae		
Smallmouth bass *Micropterus dolomieui*	I	R
Largemouth bass *Micropterus salmoides*	I	R/Rv
Pumpkinseed *Lepomis gibbosus*	I	R/Rv
Black crappie *Pomoxis nigromaculatus*	I	R/Rv
Family Percidae		
Yellow perch *Perca flavescens*	I	R/Rv
Walleye *Stizostedion vitreum*	I	R
Family Cottidae		
Slimy sculpin *Cottus cognatus*	N	T/R/Rv
Mottled sculpin *Cottus bairdi*	N	T

T=Tributary to project reservoir, R=Reservoir, Rv=Clark Fork between Cabinet Gorge Dam and Lake Pend Oreille, N=native, I=introduced
Source: FERC 2000

Kokanee in Lake Pend Oreille were introduced through emigration from Flathead Lake in the 1930s, and have since established themselves as a species that provides forage for predatory bull trout, rainbow, lake trout, bald eagles, and other wildlife species. Historically, kokanee harvest averaged 1-million fish annually with a high of 1.3-million fish in 1953. The kokanee fishery has declined since the 1960s, which IDFG contends is a result of deeper drawdowns of the lake. (GEI 2004a)

According to GEI (2004a), Lake Pend Oreille continues to provide good rearing habitat for coldwater fish species, but Albeni Falls Dam operations have resulted in impaired shoreline spawning habitat for kokanee salmon. Drawdown of the reservoir also results

Table 4-6. Fish species currently present in the Pend Oreille River and Lake Pend Oreille.

Species	Native/ Introduced	Location
Largescale sucker *Catostomus catostomus*	N	L/R/T
Longnose sucker *C. macrocheilus*	N	L/R/T
Slimy sculpin *Cottus cognatus*	N	L/R/T
Torrent sculpin *C. rhotheus*	N	L/R/T
Peamouth *Mylocheilus caurinus*	N	L/R
Westslope cutthroat trout *Oncorhynchus clarki lewisi*	N	L/R/T
Pygmy whitefish *Prosopium coulteri*	N	L
Mountain whitefish *P. williamsoni*	N	L/R/T
Northern pike minnow *Ptychocheilus oregonensis*	N	L/R
Longnose dace *Rhinichthys cataractae*	N	L/R/T
Redside shiner *Richardsonius balteatus*	N	L/R/T
Bull trout *Salvelinus confluentus*	N	L/R/T
Black bullhead *Ameiurus melas*	I	L/R
Brown bullhead *A. nebulosis*	I	L/R
Lake whitefish *Coregonus clupeaformus*	I	L
Northern pike *Esox lucius*	I	L/R
Tiger muskie *E. lucius x E. masquinogy*	I	L/R
Channel catfish *Ictalurus punctatus*	I	L/R
Pumpkinseed *Lepomis gibbosus*	I	L
Bluegill *L. macrochirus*	I	L
Burbot *Lota lota*	I	L/R
Smallmouth bass *Micropterus dolomieui*	I	L/R
Largemouth bass *M. salmoides*	I	L/R
Rainbow trout *Oncorhynchus mykiss*	I	L/R/T
Kokanee salmon *O. nerka*	I	L/R/T
Yellow perch *Perca flavescens*	I	L/R
Crappie *Pomoxis spp*.	I	L/R
Lake trout *Salvelinus namaycush*	I	L
Brook trout *S. fontinalis*	I	T
Brown trout *Salmo trutta*	I	L/R/T
Walleye *Sander vitreus*	I	L/R
Tench *Tinca tinca*	I	L/R

L=Lake Pend Oreille, R=Pend Oreille River, T=Tributary, N=Native, I=Introduced
Source: http://www.nwcouncil.org/fw/subbasinplanning

in a less productive shoreline environment for aquatic invertebrates, potentially reducing a food source for shoreline feeding species such as cutthroat trout.

Nonnative lake trout are well established in Lake Pend Oreille and continue to contribute to the sport fishery. They are considered to be a potentially major threat to native fish and kokanee (GEI 2004a). Idaho Department of Fish and Game’s management emphasis is to reduce lake trout numbers through a year-round, no-bag limit regulation.

Pend Oreille River to Confluence with Columbia River

The portion of the Pend Oreille River from the Lake Pend Oreille outlet to the Columbia River stretches over 100 miles and passes through one Federal dam (Albeni Falls) and four non-Federal hydroelectric run-of-river dams (Box Canyon and Boundary Dams in the United States, Seven Mile and Waneta Dams in Canada). None of these dams were built with fish passage facilities.

Most of this reach of the Pend Oreille River fluctuates between a cold flowing river during the winter months and a warm slackwater reservoir during the summer months. Bennett and Liter (1991) sampled 21 species of fish in Box Canyon Reservoir. Yellow perch, pumpkinseed, and largemouth bass were the game species of greatest abundance, while northern pikeminnow, tench, and largescale sucker were the most abundant non-game species. The fish community in Boundary Reservoir is similar to that of Box Canyon Reservoir.

Seven Mile Reservoir supports mountain whitefish, rainbow trout, and bull trout, but a large majority of the fish biomass consists of non-game species such as northern pikeminnow, peamouth, and longnose sucker. Yellow perch and pumpkinseed are also present.

Waneta Reservoir supports northern pikeminnow and redside shiners, and is believed to have a small number of game species, such as rainbow trout and mountain whitefish. White sturgeon spawning was recorded in June and July 1993 at the outlet of the Pend Oreille River downstream from Waneta Dam.

Throughout the lower Pend Oreille River, lack of suitable overwintering habitat limits the warmwater fishery, and warm water during the summer months limits a coldwater fishery. As a result of factors such as degraded habitat, loss of connectivity, construction of dams, and nonnative fish introductions, the historical coldwater fishery has changed to a cool and warmwater fishery, consisting mainly of bass, mountain whitefish, and perch in the reservoirs.

The largemouth bass fishery is considered important because of its value as a recreational and subsistence fishery from Albeni Falls Dam upstream to Lake Pend Oreille and in Boundary Reservoir (GEI 2004a). The Kalispel Tribe substituted largemouth bass for the

Table 4-7. Endangered and threatened species that may occur in the Pend Oreille River basin.

Species	Listing Status	Section 7 Coverage in FCRPS Biological Opinions
Columbia River bull trout	Threatened	2000 USFWS
Bald eagle	Threatened	1995 USFWS
Grizzly bear	Threatened	2000 USFWS
Gray wolf	Threatened	2000 USFWS
Woodland caribou	Endangered	2000 USFWS
Canada lynx	Threatened	2000 USFWS
Spalding's Silene	Proposed Threatened	2000 USFWS
Water Howellia	Threatened	2000 USFWS

Source: USFWS 2005

loss of anadromous salmon as a result of hydroelectric development on the Columbia River (GEI 2004a).

4.2.5 Sensitive, Threatened, and Endangered Species

The Pend Oreille River basin includes habitat for or may occasionally be used by a number of endangered, threatened or proposed species (Table 4-7). Many of these species are not aquatic or do not occur in or make substantial use of the areas directly affected by operation of Hungry Horse Dam. These species include the grizzly bear, gray wolf, woodland caribou, Canada lynx, water howellia, and Spalding's silene. Effects to these species from the operation of the FCRPS, which includes Hungry Horse Dam, either are not likely to occur or would be very minor (USFWS 2000). Therefore, further discussion of these species is not provided.

Bull Trout

Hungry Horse Reservoir

Hungry Horse Reservoir contains a substantial population of adfluvial bull trout that is stable to increasing in number. These bull trout spawn in the tributaries above Hungry Horse Reservoir and the South Fork Flathead River upstream of the reservoir. Dam operational criteria, in place since the 1995 and 1998 biological opinions for salmon and steelhead, have reduced the frequency of deep reservoir drawdowns and resulted in maintaining higher pool levels from year to year. Mitigation programs of the BPA have funded habitat restoration and fish passage projects in tributaries to Hungry Horse Reservoir, resulting in increased quantity and quality of spawning and rearing habitat for bull trout residing in the reservoir. Because of the location of bull trout and other fish in the reservoir and in the water column in relation to dam intake structures, dam operations are not thought to result in entrainment of significant numbers of fish from Hungry Horse Reservoir (CSKT and MFWP 2004).

Hungry Horse Reservoir flood control, hydropower, and salmon flow augmentation operations can affect reservoir bull trout habitat and food production. Hungry Horse Reservoir can be drawn down 85 feet or more during this annual cycle, which periodically diminishes the amount of aquatic and terrestrial insect production available to bull trout prey species. General aquatic production, and consequently bull trout forage fish production, can also be limited by failure to refill the reservoir. However, forage fish limitations on bull trout are not suspected in Hungry Horse Reservoir.

As a result of a stable and relatively strong population, a limited, experimental harvest fishery for bull trout opened in 2004 in Hungry Horse Reservoir. Individual anglers were limited to harvesting two bull trout per year (one per day) and required to possess and validate a catch card to fish for bull trout.

Hungry Horse Dam to Flathead Lake

Flathead Lake adfluvial bull trout reside in Flathead Lake and migrate to spawn in tributaries of the North Fork and Middle Fork Flathead River. In early summer, adult adfluvial bull trout migrate from Flathead Lake into the river and move toward staging areas. They then move into spawning tributaries generally in August, and following spawning in September, move rapidly back downstream to Flathead Lake (CSKT and MFWP 2004).

Prior to completion of Hungry Horse Dam, bull trout also migrated into the upper reaches of the South Fork. There are also fluvial populations of bull trout which spawn and rear in Flathead River tributaries and move downstream to mature and reside in the Flathead River (CSKT and MFWP 2004).

Historically, bull trout and northern pikeminnow were the dominant piscivorous fishes in Flathead Lake. Following the introductions of other fish species in the early 1900s, and the introduction of opossum shrimp in 1968, fish species composition changed dramatically in Flathead Lake. Since 1996, bull trout comprised roughly 1 percent of fish caught in gill nets in Flathead Lake (CSKT and MFWP 2004).

Since the August 1995 initial operation of selective withdrawal structures on Hungry Horse Dam, Flathead River temperatures have become more normative. This is expected to result in increased diversity and abundance of certain macroinvertebrate groups, improvement in fish growth rates, improvements in the survival of subadult bull trout, and a decline in the presence of predatory lake trout in the mainstem Flathead River (CSKT and MFWP 2004). Reduction in lake trout numbers would aid bull trout recovery in Flathead Lake.

Lower Flathead River

It is assumed that prior to dams being built on the Clark Fork, the lower Flathead River functioned as part of the Lake Pend Oreille-Clark Fork bull trout metapopulation and had a considerable migratory component. It is likely that historically both the Jocko River and Mission Creek (tributaries to the lower Flathead River) drainages supported distinct subpopulations of bull trout that had adfluvial, fluvial, and resident life history forms. (CSKT and MFWP 2004)

Today, bull trout exist as resident and/or disjunct (isolated) populations in the Jocko River and Mission Creek drainages (CSKT and MFWP 2004). Bull trout that are found in the lower Flathead River are likely those that were entrained through Kerr Dam or upstream migrants from the Clark Fork.

The operation of Kerr Dam has negatively affected lower Flathead River water quality, quantity, and water temperature. Impacts included lack of spawning success of lower Flathead River bull trout, behavioral changes, sedimentation, dewatering of juvenile fish habitat, and poor over-winter survival (Corps, Reclamation, and BPA 1999).

In portions of the lower Flathead River downstream from Kerr Dam, agricultural impacts may have been the primary cause of the loss of bull trout (USFWS 2002). Stream dewatering for irrigated agriculture was considered a major fisheries problem. Summer water temperatures approach 75° F as a result of elevated tributary water temperatures and warmwater releases from Flathead Lake.

The 1995 relicensing terms for Kerr Dam include modifications for the protection, mitigation, and enhancement of fisheries in the lower Flathead River.

Clark Fork

Bull trout from Lake Pend Oreille historically had access to the entire Clark Fork basin (Corps, Reclamation, and BPA 1999). Construction of Thompson Falls, Noxon Rapids, and Cabinet Gorge Dams created a series of impoundments over 70 miles of the Clark Fork and was one of the most important factors in reducing the bull trout population of the lower Clark Fork subbasin. These dams permanently interrupted established bull trout migration routes, eliminating access from portions of the tributary system to the productive waters of Lake Pend Oreille and Flathead Lake. Additionally, these dams impacted the habitat that was left behind, impounding river reaches and effecting water temperature and water quality (USFWS 2002). The expansion of nonnative competitive species such as lake trout and brook trout, forestry practices, livestock grazing, agricultural impacts (water withdrawals), transportation systems, mining, and other development activities have had a direct impact on bull trout in the lower Clark Fork.

Since construction of the dams, the catch of bull trout during gill net surveys in the reservoirs (between 1960 and 1985) indicates that bull trout declined in Noxon Reservoir but remained somewhat stable in Cabinet Gorge Reservoir (USFWS 2002). Recently, the Avista Corporation conducted extensive gill net surveys and documented few bull trout in the catch (USFWS 2002).

Currently, the tributary spawning and rearing habitats for bull trout still exist (although degraded), but foraging, migrating, and overwintering habitats for migratory adult and subadult bull trout have changed significantly. Over time, the fish expressing the migratory life history pattern of the lower Clark Fork were largely replaced by bull trout that expressed the resident life form in the tributaries (USFWS 2002).

Lake Pend Oreille

The Lake Pend Oreille subpopulation of bull trout is composed of migratory (adfluvial) fish. It is the largest known bull trout population in Idaho, and they use several different drainages as spawning habitat (Corps, Reclamation, and BPA 1999). Lake Pend Oreille bull trout populations appear to be stable; however, this may change in the future due to the instability of bull trout populations from individual nursery streams (GEI 2004a). GEI (2004a) states "despite the local population decline in some tributary spawning stocks, the Lake Pend Oreille bull trout are considered to be one of the strongest remaining populations in the United States with an estimated total adult population between 8,000 and 16,000 fish." Spawning occurs from August through November, with a peak in October (Corps, Reclamation, and BPA 1999). Once in the lake, bull trout grow more rapidly than in many other locations. Some bull trout in the historic harvest in Lake Pend Oreille reached over 30 pounds (Corps, Reclamation, BPA 1999).

As mentioned previously, the three dams on the lower Clark Fork have substantially reduced the amount of spawning and rearing habitat available to Lake Pend Oreille bull trout. These dams effectively eliminated migration and spawning access from Lake Pend Oreille to 86 percent of the Clark Fork basin (USFWS 2002). Downstream from Cabinet Gorge Dam, bull trout from Lake Pend Oreille are known to take refuge and spawn in coldwater spring areas that are found on the south shore of the Clark Fork. Recent genetic evidence appears to support that these bull trout are genetically similar to upriver stocks above Cabinet Gorge Dam (USFWS 2002).

Albeni Falls Dam on the Pend Oreille River near the Idaho-Washington border interrupts habitat connectivity with the lower portion of the basin and also regulates water levels in Lake Pend Oreille and at the delta of the Clark Fork. According to USFWS (2002), although this dam restricts upstream movement and functionally removes downstream migrants from the Pend Oreille population, these effects are probably less substantial than other effects of this dam, such as impacts to the kokanee population.

Pend Oreille River-Albeni Falls Dam to the Columbia River

Historically, some adult bull trout would migrate out of Lake Pend Oreille, go down the Pend Oreille River and then into tributary streams to spawn, with the progeny eventually returning to the lake (USFWS 2002). This migration pattern, however, was eliminated with the construction and operation of Albeni Falls Dam.

Presently, adult bull trout in this reach of the Pend Oreille River appear to be adfluvial and are likely prevented from returning to spawn in lake tributaries by the lack of fish passage facilities at Albeni Falls Dam. Recent studies have not indicated that entrained adfluvial bull trout will pioneer into Box Canyon tributaries and spawn (Geist *et al.* 2003, Scholz *et al.* 2005) There are several tributaries in the Box Canyon reach supporting bull trout. However, densities appear to be extremely low (USFWS 2002), and little other information is available specific to bull trout use of these streams.

In tributaries below Albeni Falls Dam, embeddedness of spawning substrate has been observed, along with low habitat diversity (USFWS 2002). In addition, nonnative salmonids (mainly brook trout, but also brown and rainbow trout) were more abundant than native species, including bull trout.

The mainstem Pend Oreille River is impounded by Box Canyon Dam, which creates a reservoir nearly 56 miles long to Albeni Falls Dam. Box Canyon Dam, along with Boundary, Seven Mile, and Waneta Dams, have affected bull trout by altering habitats; flow, sediment, and temperature regimes; migration corridors; and interspecific interactions, especially between bull trout and introduced species (USFWS 2002). These impassable dams have contributed to declines of bull trout primarily by preventing access of migratory fish to spawning and rearing areas in headwater areas of tributaries to the Pend Oreille River and Lake Pend Oreille.

Bull Trout Critical Habitat

The USFWS published in the Federal Register on September 26, 2005, a final rule designating critical habitat for the Columbia River populations of bull trout. The final rule did not designate any critical habitat from Hungry Horse Reservoir downstream to Grand Coulee Dam.

Bald Eagles

Bald eagles use riverine, lakeside, and associated habitats from above the three forks of the Flathead River downstream to the mouth of the Pend Oreille River. They occur as resident breeding pairs and as migratory and overwintering birds. Nests and roosts are relatively common along major drainages in western Montana and northern Idaho. Bald eagles prefer large trees for nesting and roosting, and use aquatic and open terrestrial habitats for feeding on fish, small mammals, waterfowl and other birds, and carrion.

Bald eagle numbers along the Flathead River are stable or on the rise (CSKT and MFWP 2004). Migratory and wintering bald eagles occur in the vicinity of Hungry Horse Dam and Reservoir primarily in late fall to early spring (BPA *et al.* 1995). Areas used for feeding and resting by bald eagles include portions of the South Fork Flathead River below Hungry Horse Dam and above the reservoir. Further downstream, migrant bald eagles from Glacier National Park feed along favored stream reaches. Large numbers of bald eagles pass through the Flathead Lake area each year. This area provides important winter foraging habitat for resident and migratory eagles (CSKT and MFWP 2004).

Some twenty bald eagle breeding territories occur within the Flathead Indian Reservation, with most of these along the lower Flathead River, on islands or the shoreline of Flathead Lake, or along tributaries and irrigation diversions (CSKT and MFWP 2004).

Lake Pend Oreille supports up to several hundred bald eagles during the winter when spawned-out kokanee and waterfowl are available as food sources (GEI 2004a). Bald eagles also nest along the Pend Oreille River downstream in Idaho and Washington.

4.2.6 Wildlife

Over 400 species of terrestrial wildlife occur in the principle counties (Flathead, Lake, and Sanders in Montana; Bonner, Boundary, and Kootenai in Idaho; and Pend Oreille in Washington) included within the Pend Oreille River basin (IBIS 2005). These include 13 amphibians, 315 birds, 73 mammals, and 10 reptiles. The following species are representative of those associated with riparian habitats and which breed or feed in those habitats (Table 4-8).

Riparian areas and wetlands and the wildlife species associated with such habitats occur in scattered locations along the length of the Flathead River, Clark Fork, and Pend Oreille River, and adjacent to associated lakes and impoundments. Four areas in particular have relatively high concentrations of riparian areas and wetlands: the lower Flathead River above Flathead Lake, the deltas and shorelines of Flathead Lake and Lake Pend Oreille, the Pend Oreille River below Lake Pend Oreille, and in the vicinity of Cusick, Washington.

4.2.7 Vegetation

The Flathead River originates in forests composed largely of spruce, fir, Douglas-fir, and lodgepole pine. Forested slopes reach down to the high-water mark at Hungry Horse Reservoir; however, due to fluctuating water levels, the reservoir lacks well-established riparian zones and backwater areas.

Table 4-8. Species associated with riparian habitats.

Amphibians	
Long-toed salamander	*Ambystoma macrodactylum*
Idaho giant salamander	*Dicamptodon aterrimus*
Coeur d'Alene salamander	*Plethodon idahoensis*
Rough-skinned newt	*Taricha granulosa*
Tailed frog	*Ascaphus truei*
Western toad	*Bufo boreas*
Pacific chorus (tree) frog	*Pseudacris regilla*
Oregon spotted frog	*Rana pretiosa*
Columbia spotted frog	*Rana luteiventris*
Northern leopard frog	*Rana pipiens*
Wood frog	*Rana sylvatica*
Birds:	
Double-crested cormorant	*Phalacrocorax auritus*
Great blue heron	*Ardea herodias*
American black duck	*Anas rubripes*
Mallard	*Anas platyrhynchos*
Harlequin duck	*Histrionicus histrionicus*
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Ring-necked pheasant	*Phasianus colchicus*
Ruffed grouse	*Bonasa umbellus*
Blue grouse	*Dendragapus obscurus*
Mourning dove	*Zenaida macroura*
Pygmy nuthatch	*Sitta pygmaea*
Red-naped sapsucker	*Sphyrapicus nuchalis*
Willow flycatcher	*Empidonax traillii*
Cordilleran flycatcher	*Empidonax occidentalis*
N. rough-winged swallow	*Stelgidopteryx serripennis*
Red-eyed vireo	*Vireo olivaceus*
Black-billed magpie	*Pica pica*
American dipper	*Cinclus mexicanus*
Veery	*Catharus fuscescens*
Yellow warbler	*Dendroica petechia*
American redstart	*Setophaga ruticella*
Lazuli bunting	*Passerina amoena*
Mammals	
Yuma myotis	*Myotis yumanensis*
Long-legged myotis	*Myotis volans*
Snowshoe hare	*Lepus americanus*
American beaver	*Castor Canadensis*
Muskrat	*Ondrata zibethicus*
Deer mouse	*Peromyscus maniculatus*
Bushy-tailed woodrat	*Neotoma cinerea*
Raccoon	*Procyon lotor*
Fisher	*Martes pennanti*
Mink	*Mustela vison*
Northern river otter	*Lutra Canadensis*
White-tailed deer	*Odocoileus virginianus ochrourus*

Riparian areas and wetlands occur in scattered locations along the length of the Flathead, Clark Fork, and Pend Oreille Rivers and adjacent to associated lakes and impoundments. Four areas, in particular, have relatively large concentrations of riparian areas and wetlands: the lower Flathead River above Flathead Lake, the deltas and shorelines of Flathead Lake and Lake Pend Oreille, the Pend Oreille River below Lake Pend Oreille, and in the vicinity of Cusick, Washington.

Beginning at the upper end of the analysis area, Hungry Horse Reservoir generally lacks well-established riparian areas and wetlands because of highly fluctuating reservoir water levels. The vegetative communities adjacent to the reservoir are dominated by mixed conifer forests.

The Flathead River below Hungry Horse Reservoir gradually passes through a widening valley bottom with diminishing gradient as it flows from the vicinity of Columbia Falls to Flathead Lake. There are substantial and diverse wetlands (e.g., riverine; palustrine aquatic, emergent, scrub-shrub, and forest; lake fringe or lacustrine) associated with the Flathead River as it approaches Flathead Lake, where the river is braided and has a variety of islands, oxbows, sloughs, and river bank areas dominated by emergent vegetation, deciduous trees and shrubs. The Flathead Lake shoreline, particularly along the north and south sides, includes areas of emergent wetland vegetation.

The Flathead River and Clark Fork below Kerr Dam pass through scattered areas of emergent wetlands and deciduous riparian forests and shrublands. Riverine wetlands increasingly give way to palustrine wetlands near the confluence of the Flathead River and Clark Fork. As the Clark Fork enters Lake Pend Oreille it passes through a delta area supporting extensive emergent wetlands and deciduous riparian vegetation; these palustrine wetlands become increasingly forested as the river passes through Lake Pend Oreille and makes its way downstream. Below Lake Pend Oreille, the Pend Oreille River supports scattered wetland and riparian areas until it reaches the vicinity of Cusick, Washington, where extensive areas supporting emergent vegetation occur. Below Cusick, the river again supports a variety of relatively small, scattered wetland and riparian areas until it empties into the Columbia River.

4.2.8 Recreation

Hungry Horse Reservoir

Hungry Horse Reservoir is located 15 miles from Glacier National Park close to Kalispell, Montana. This 34-mile long reservoir has 113 miles of shoreline and is managed for Reclamation by the Flathead National Forest. The area is rich in recreation opportunities, scenic attractions, and affords abundant wildlife viewing opportunities.

Approximately 115 miles of road circle Hungry Horse Reservoir and provide good access for recreation. Primary recreation activities are camping, fishing, and boating. Also popular are sightseeing, hunting, and huckleberry picking. A small visitor center and guided tours of the exterior of the dam are available on site.

Visitation figures have not been collected at Hungry Horse Reservoir for over 10 years; however, according to USFS staff, visitation appears to be steadily increasing (Burren 2004). Visitation at Hungry Horse Reservoir was estimated at 93,500 visitor days in 1993.

Fifteen campgrounds as well as dispersed recreation sites surround the reservoir. Facilities include approximately 174 single camp units, one group campsite (150 person capacity), and 27 picnic units (Corps 1995).

The reservoir receives relatively light angling pressure. The reservoir is open year round to fishing; however, May through November receive the most fishing use. There is currently a limited open season for bull trout.

There are 10 boat ramps along the reservoir (Burren 2004). Reservoir full pool is at elevation 3560 feet. Abbot Bay, on the east side, is the longest boat ramp providing access when the reservoir is down 130 feet. Lost Johnny Point is the longest boat ramp on the west side and provides access to minus 72 feet from full pool through a series of several high water and low water boat ramps (Table 4-9).

The relatively pristine nature of the area is one of the primary recreational attractions, affording high scenic qualities and the opportunity to see an abundance of wildlife (Corps 2002). Views from the shore and pool of the reservoir are confined to the river valley and adjacent steep mountainous terrain ranging up to 8,000 feet in elevation. Coniferous forest surrounds the reservoir and views can extend 10 to 12 miles up and down the reservoir (Corps 1995).

Table 4-9. Hungry Horse Reservoir minimum usable boat ramp elevations.

Boat Ramp	Functional Level from Full Pool Elevation 3560 (feet)	Minimum Useable Boat Ramp Elevation (feet)
Doris	-15	3545
Canyon	-18	3542
Murray Bay CG	-20	3540
Lost Johnny Camp	-24	3536
Lid Creek CG	-31	3529
Emery Bay CG	-33	3527
Devil’s Corkscrew CG	-43	3517
Lost Johnny Point CG	-45 & -72	3515
Riverside	-53	3507
Abbot Bay	-130	3430

Source: Burren 2004

Hungry Horse Dam to Flathead Lake

The Flathead National Forest manages portions of Federal lands below Hungry Horse Dam along the South Fork Flathead River. From Columbia Falls to Flathead Lake, the river flows through the Flathead Valley. Multiple day-use sites provide good river access to this stretch which is popular for floating and boating. Other activities include fishing, sightseeing, dispersed camping, and picnicking.

No recreation use figures are available along the Flathead River; however, the USFS indicates that use is steadily increasing (Burren 2004, Corps 1995). The South Fork and the mainstem Flathead River below Hungry Horse Dam receive low fishing pressure as compared to other Montana rivers.

The South Fork Flathead River is visible to many more people than is Hungry Horse Reservoir and can be seen from U.S. Highway 2. Land uses adjacent to the river include scattered rural residential developments and long stretches of natural appearing undeveloped lands (Corps 1995). Trees and terrain along the river's edge restrict views in many places. Land uses adjacent to the river include scattered rural residential developments, and long stretches of natural appearing undeveloped lands (Corps 1995).

Flathead Lake

Flathead Lake is the largest freshwater lake in the western United States. The lake has nearly 200 square miles of surface area and 185 miles of shoreline. Prominent communities bordering the lake include Polson and Bigfork. The Flathead Indian Reservation surrounds the southern half of the lake. Flathead National Forest lands are close, but not adjacent to the lake on the east and west sides.

Montana Department of Fish, Wildlife, and Parks manages six areas as part of Flathead Lake State Park. The southern half of Flathead Lake is on the Flathead Indian Reservation and managed by the CKST.

Six units of Flathead Lake State Park provide public access. Wildhorse Island, near Big Arm Bay, is the largest island in the lake at 2,100 acres. It is managed by MFWP as a wildlife refuge and open for day-use only. Open space on the shoreline includes the Flathead Lake National Wildlife Refuge on the north shore and state refuge land managed by the Flathead Lake Biological Station on the south shore (Polson Bay). The southern half of Flathead Lake is on the Flathead Indian Reservation.

Visitation numbers are not available.

Popular activities are fishing and boating. Other activities include camping, swimming, hiking, biking, and horseback riding. Sailing, cruising, and waterskiing are also popular

Table 4-10. Flathead Lake minimum usable boat ramp elevations.

Boat Ramp	Functional Level from Full Pool Elevation 2893 (feet)	Minimum Usable Boat Ramp Elevation (feet)
Ducharme	0	2893
Averills Ranch	-1	2892
Arrowhead Park and Marina	-2	2891
Marina Cay Resort and Conference Center	-2	2891
Bigfork	-3	2890
Finley Point	-3	2890
Bayshore Resort	-7	2886
Walstad	-8	2885
Woods Bay	-9	2884
Elmo	-10	2883

summer activities. Winter activities include ice fishing, ice skating, skiing, and snowmobiling.

Flathead Lake is considered one of the premiere fishing lakes in Montana, attracting thousands of anglers annually. Fishing is popular for cutthroat trout, yellow perch, lake trout, kokanee, and whitefish.

Eleven public sites have boating facilities. Additional private boat ramps and docks are also on the lake. Typically, public facilities include access ramps, docks, marinas, fueling stations, mooring, and camping areas. Several commercial companies offer guided fishing trips, boat rental, and scenic cruises. Minimum operable boat ramp elevations are shown in Table 4-10.

There are seven state-run campground facilities, and many more private resorts offering lodging and camping facilities around the lake. Camping facilities offer a variety of campsites, picnic areas, boat access, RV hookups, swim beaches, toilets, and showers.

Visual quality is high, key observation points are numerous, and public sensitivity to change is great. A mixture of forest, rangeland, cropland, orchards, and pasture/meadow areas, as well as residential, commercial, and recreational development surround the lake (Corps 2002). A 90-mile scenic paved loop road around the lake provides panoramic views and access to campgrounds, picnic areas, hiking trails, and orchards. Narrated scenic cruises of the lake are also commercially available during the summer season.

Lower Flathead River

Recreation opportunities on the lower Flathead River are limited. The lower Flathead stretch has a low gradient and primarily warmwater fishery known for a variety of trout, northern pike, and some largemouth bass.

The majority of the lower Flathead River lies within the Flathead Indian Reservation and is managed by the CSKT.

Montana State Highway 200 parallels the lower Flathead River from Dixon, Montana, to the confluence with the Clark Fork in Paradise, Montana.

No visitation data is available.

Recreation activities include boating, fishing, whitewater kayaking and rafting. Downstream from Kerr Dam, kayaking is popular through the Buffalo Rapids reach.

Lower Clark Fork

Three reservoirs on the lower Clark Fork provide recreation opportunities between Kerr Dam and Lake Pend Oreille. Thompson Falls, Noxon Rapids, and Cabinet Gorge are run-of-the-river reservoirs providing fishing, camping, picnicking, boating, water skiing, and other recreation activities.

Recreation facilities are provided by MFWP, Kaniksu and Kootenai National Forest, and Avista Corporation. In 2001, Avista Corporation began a renewed 45-year license to operate Noxon Rapids Dam and Cabinet Gorge Dam known collectively as the Clark Fork Project. The relicensing process led to new recreation resource management plans and improvements to numerous recreation sites along both reservoirs and the lower river.

No visitation data is available.

There are nine boat ramp facilities along the lower Clark Fork. Most of these are unimproved ramps (access only), and a few have marina and docking facilities (MFWP 2004).

This reach is considered a big-water fishery with deep, slow-moving water. The fishery includes mountain whitefish, westslope cutthroat trout, rainbow trout, brook trout, brown trout, as well as northern pike, rainbow trout, smallmouth bass, and yellow perch.

Lake Pend Oreille

Lake Pend Oreille is the largest and deepest lake in Idaho and is a major recreational resource for northern Idaho. Most of Lake Pend Oreille is adjacent to the Coeur d’Alene and Kaniksu National Forest and much of the shoreline is undeveloped.

The estimated number of visitor days to the Corps’ facilities at Lake Pend Oreille averaged 131,953 visitor days per year from 1987-1994. Over the last 10 years, visitation at these facilities decreased to an average of 118,460 visitor days per year (Brengle pers. comm. Dec 2004).

Swimming, boating, fishing, camping, sightseeing, picnicking, hiking, horseback riding, hunting, and snowmobiling are popular activities.

There are more than 28 boating-related facilities on Lake Pend Oreille. These include Federal, state, and city owned parks and campground facilities, as well as private resorts and marinas. There are several charter boat and fishing outfitters and commercial sightseeing cruises are offered on the lake.

Pend Oreille River to Confluence with Columbia River–United States

Downstream from Albeni Falls Dam, the Pend Oreille River is a large flatwater river impounded by a series of run-of-river dams. The dams have created a series of four long reservoirs including two reservoirs in the United States: Box Canyon (55 miles long), and Boundary (17 miles long). Seven Mile and Waneta Dams are just across the border in British Columbia.

The Washington reach of the Pend Oreille River is bordered primarily by the Colville National Forest and on the western side by the Kaniksu National Forest. Scenic views can be enjoyed along the Selkirk Loop, a designated scenic route in Washington, Idaho, and Canada (Selkirk 2005).

Box Canyon Dam is owned and operated by Pend Oreille Public Utility District (PUD). Boundary Dam is owned and operated by Pend Oreille PUD and Seattle City Light with some recreation lands managed by the BLM.

Visitation data is not available.

Recreation activities include fishing, boating, camping, picnicking, and sightseeing. Road access to both sides of the river is generally good providing for numerous dispersed and some developed recreation opportunities. The Corps also operates a visitor center near Albeni Falls Dam.

Downstream from Lake Pend Oreille, boating activities on the Pend Oreille River, Box Canyon Reservoir and Boundary Reservoir are primarily related to fishing. Power boating, cruising, sightseeing as well as kayaking and camping are all popular activities along this reach. There are eleven sites documented as providing boat access, fuel, docks, marina and other boating related services.

4.2.9 Environmental Health

Air Quality

The EPA air quality standard for particulates with a diameter of less than 2.5 micrometers per cubic meter ($< 2.5\ \mu g/m^3$) is $65\ \mu g/m^3$ (24-hour average) and $15\ \mu g/m^3$ (annual mean). The EPA air quality standard for particulates with a diameter of less than 10 $\mu g/m^3$ is 150 $\mu g/m^3$ (24-hour average) and 50 $\mu g/m^3$ (annual mean).

A review of the EPA Air Data Monitor Values report for PM2.5 particulates and PM10 particulates in the year 2003 revealed no exceedances of the air quality standards for any of the sampling locations within the Pend Oreille River basin (discounting locations outside the VARQ affected environment; http://www.epa.gov/air/data/reports.html).

Contaminated Sediments

The Milltown Reservoir is on the Clark Fork, upstream from the confluence with the Flathead River. The Milltown Dam, built at the confluence of the Clark Fork and Blackfoot Rivers in 1907, acts as a repository for sediment and mining wastes. The primary constituents of concern include the heavy metals: arsenic, cadmium, copper, lead, and zinc. The EPA added the site to its National Priorities List (NPL) in September 1983. (http://www.epa.gov/region8/sf/sites/mt/milltowncfr/home.html)

The average annual suspended sediment load leaving Milltown Reservoir for the period 1991 through 1997 was 148,000 tons per year, which likely deposits along the entire downstream reach of the Clark Fork. The scouring effect of seasonally high flows continues the suspended sediment transport to Lake Pend Oreille. A review of available documents has identified no observed adverse effects to Lake Pend Oreille due to these contaminated sediments.

The lower Pend Oreille River basin includes the Metaline mining district, one of the oldest in the state of Washington. Mining in the vicinity of the Pend Oreille River dates back to 1855. Mine tailings in the area typically contain elevated levels of arsenic, cadmium, copper, lead, mercury, and zinc. These tailings and mines continue to provide a source of metals to streams, lakes, and reservoirs as surface water meanders through and erodes tailings deposits and transports these metals downstream or directly to the Pend Oreille River. (EPA 2002)

In June 2001, the Superfund Technical Assessment and Response Team conducted preliminary assessments and site investigations at 21 mines and mills located near the lower reach of the Pend Oreille River in Pend Oreille County, Washington. The *Preliminary Assessments and Site Investigations Report Lower Pend Oreille River Mines and Mills Pend Oreille County, Washington*, was completed in April 2002. The report concluded that 5 of the 21 mines and mill sites warranted further action under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) or other authorities.

Contaminated sediments and dissolved heavy metals released to the Pend Oreille River as a result of mining and milling activities are transported downstream during high flow releases from Albeni Falls Dam and Lake Pend Oreille relative to spring snowmelt and storm events.

4.2.10 Cultural Resources

Hungry Horse Reservoir

Prehistory

There are currently no prehistoric cultural resources overviews for the immediate area surrounding Hungry Horse Reservoir. Prehistoric sites found along the shoreline of the reservoir include 17 lithic scatters indicative of stone tool reduction in short-term camping locations. No dates are currently available for these sites. Occupations are expected to have been larger and more densely distributed in the parkland settings adjacent to the South Fork Flathead River, which were rich in riverine and wetland resources (Confederated Salish and Kootenai Tribal Preservation Department 2001). Many sites may have been inundated by the flooding of Hungry Horse Reservoir before they could be recorded.

Ethnographic Presence

At about 1800, the area north of Flathead Lake was primarily associated with the Kootenai Tribe, who now reside at the Flathead Indian Reservation in Montana, and the Kootenai Reservation in northern Idaho. Other local groups include the Pend d'Oreille, certain bands of the Kalispel Tribe, and the Flathead (Salish) Tribe. Blackfeet war parties occasionally made raiding expeditions into the area. The Confederated Salish and Kootenai Tribes (CSKT) continue to maintain strong ethnic and community identity, and many tribal members reside downstream from the Hungry Horse area in or near the Flathead Reservation.

Native peoples used the area around what is now Hungry Horse Reservoir for short-term seasonal occupations related to resource procurement such as trapping, plant harvesting, fishing, and especially deer and elk hunting (Confederated Salish and Kootenai Tribal Preservation Department 2001). They also used the area extensively as a major travel route between lowland overwintering camps and upland summer camps and fall resource procurement. Several trails are still in excellent condition, and are plainly visible where they cross the reservoir area (Schwab *et al.* 2000). The trails continued to be used into the historic period by trappers and hunters and later by the U.S. Forest Service (Confederated Salish and Kootenai Tribal Preservation Department 2001).

Historic Euro-American Period

Northwestern Montana was one of the last North American regions explored by Euro-Americans (McLeod and Melton 1986). Fur traders may have been operating south of

Hungry Horse as early as 1801 (McLeod and Melton 1986), but the Lewis and Clark expedition marks the first documented presence of Euro-Americans. The British fur trade followed close behind, with the Northwest Company, and later the Hudson's Bay Company, monopolizing all of northwestern Montana (McLeod and Melton 1986). French fur trappers are known to have operated in the Hungry Horse area as late as the 1890s. Marten and beaver were the primary fur species targeted; pelts from the Hungry Horse area were of unusually high quality (Confederated Salish and Kootenai Tribal Preservation Department 2001).

Pioneer settlement did not begin in this area until the Flathead Tribe signed the Hellgate Treaty of 1855; by 1891, immigrants were arriving in a steady stream (Confederated Salish and Kootenai Tribal Preservation Department 2001). The first farmers began irrigating in the Ashley Creek area of the Flathead River valley around 1885 and the Ashley Irrigation District was formed in 1897 (Reclamation 1981).

Critical power shortages in the Pacific Northwest during World War II led Congress to authorize the creation of Hungry Horse Dam on June 5, 1944 (Linenberger 2002). The prime contract for construction of the concrete thick-arch dam was awarded on April 21, 1948 (Reclamation 1981). Construction continued until President Franklin D. Roosevelt "threw the switch" on the new power plant on October 1, 1952.

The area around Hungry Horse Reservoir was designated as part of the Lewis and Clark National Forest in 1907. In 1908, the area was reorganized into the Flathead National Forest, which continues to administer lands surrounding the reservoir today. Historic trails, fire lookouts, ranger cabins, and telephone lines in the vicinity of the reservoir mark the Forest Service's 105-year presence at Hungry Horse Reservoir.

Previous Cultural Resources Surveys

The area around Hungry Horse Reservoir received very limited archaeological investigations prior to the 1990s. A survey carried out by the Smithsonian Institution prior to the 1952 inundation of the reservoir resulted in the discovery of one site, 24FH1. The discovery of only one site along the South Fork Flathead River was attributed by Smithsonian surveyors to very dense vegetative cover. Thereafter, only very limited shoreline reconnaissance was conducted, mostly in the 1980s. In 1991, the FCRPS action agencies, the land management agencies, tribes, and states involved in cultural resources management for the FCRPS signed a Programmatic Agreement that included Hungry Horse Reservoir. In 1992, the Flathead National Forest agreed to take the lead in cultural resources management for the shoreline of Hungry Horse Reservoir. The Forest Service, Reclamation, and the Bonneville Power Administration signed an interagency agreement in 1994 for the Hungry Horse Archaeological Project Investigation (HHAPI), together with input from the CSKT. Section 106 compliance work is funded by BPA and Reclamation.

The first phase of the project (1994-1998) involved a comprehensive reservoir survey and site testing and evaluation (Hamilton 2000). Supplemental survey and evaluation, as well as site monitoring for erosion and looting, continued until the termination of the HHAPI project in 2001. The Flathead National Forest continues to monitor site locations on the Hungry Horse Reservoir shoreline. The Flathead National Forest independently contracted with Kathryn McKay to write a historic overview of the forest, which was completed in 1994, and is planning a prehistoric cultural resources overview that includes the reservoir. Ongoing analysis associated with the HHAPI project includes radiocarbon, lithic raw material, and geo-archaeological analyses.

Studies of traditional cultural properties and other traditional use areas of the Native peoples of the Hungry Horse area have been conducted since 1998 by the Confederated Salish and Kootenai Tribes of the Flathead Nation, under a five-year contract to Reclamation and BPA. These data are gathered using information from interviews and field visits to important areas with Tribal Elders, and historic source documents.

Historic Properties

The historic properties known from the immediate vicinity of the reservoir include 17 undated prehistoric sites (Table 4-11). Figure 4-6 and Table 4-11 do not include 24FH1, which was inundated 50 years ago. All 17 lithic scatters have been impacted by the operations of Hungry Horse Reservoir. Most sites have also been affected by activities associated with logging, road building and maintenance, and recreation under Forest Service administration. To date, one of the sites, 24FH867, has been recommended as eligible to the National Register. As of February 2005, six sites are currently going through the evaluation process. Sites in the Hungry Horse Reservoir area are distributed across elevations ranging from 3495 feet to 3560 feet. Several of the sites span a range of elevations. Figure 4-6 shows that about 45 percent of the sites have components lying between 3530 and 3550 feet. Note that none of the information above reflects portions of the South Fork Flathead River downstream from Hungry Horse Dam. Surveys conducted by the Forest Service in 1997, 1998, and 2004, in the downstream reach resulted in no discoveries of sites.

Traditional Cultural Properties

The prehistoric trails associated with the Hungry Horse reservoir area and associated river fords and sites are in the process of National Register nomination by the CSKT. These trails predated European settlement and continued to be used by modern tribes, settlers, and the Forest Service. The draft CSKT nomination indicates a multi-property or cultural-landscape approach, which includes numerous trails and the 17 sites listed above as contributing elements.

Table 4-11. Hungry Horse Reservoir archaeological sites.

Site State Number	Site Type	Site Elevation (feet)	Site Condition	NR Eligibility
24FH866	Lithic scatter	3490-3505	Eroded	U
24FH488	Lithic scatter	3544	Eroded, deflated	U
24FH876	Lithic scatter	3560	Eroded	U
24FH129	Lithic scatter	3540	Eroded, deflated	U
24FH211	Lithic concentration/ scatter + subsurface hearth	3560	Modern roads, campground nearby	U
24FH863	Lithic scatter	3500-3550	Road construction, deflated	U
24FH912	Lithic scatter with bifacial knife	3500-3550	Heavy erosion, redeposition	U
24FH867	Lithic scatter	3530	Eroded, deflated	E
24FH868	Lithic scatter with fire-affected rock	3542	Deflated, vehicle impacts	U
24FH860	Lithic scatter	3558	Deflated, camping impacts	U
24FH862	Lithic scatter	3529	Recreational impacts	U
24FH130	Lithic scatter	3541	Deflated, logging impacts	U
24FH864	Lithic scatter	3510	Deflated, logging impacts	U
24FH861	Lithic scatter	3500-3550	Deflated, logging impacts	U
24FH865	Lithic scatter	3500-3560	Slight deflation; less than other reservoir sites	U
24FH220	Lithic scatter	3500-3560	Recreational impacts, logging, deflation	U
24FH910	Lithic scatter	3550-3560	Logging, deflation, redeposition	U

U=unevaluated, E= eligible
Source: USFS records

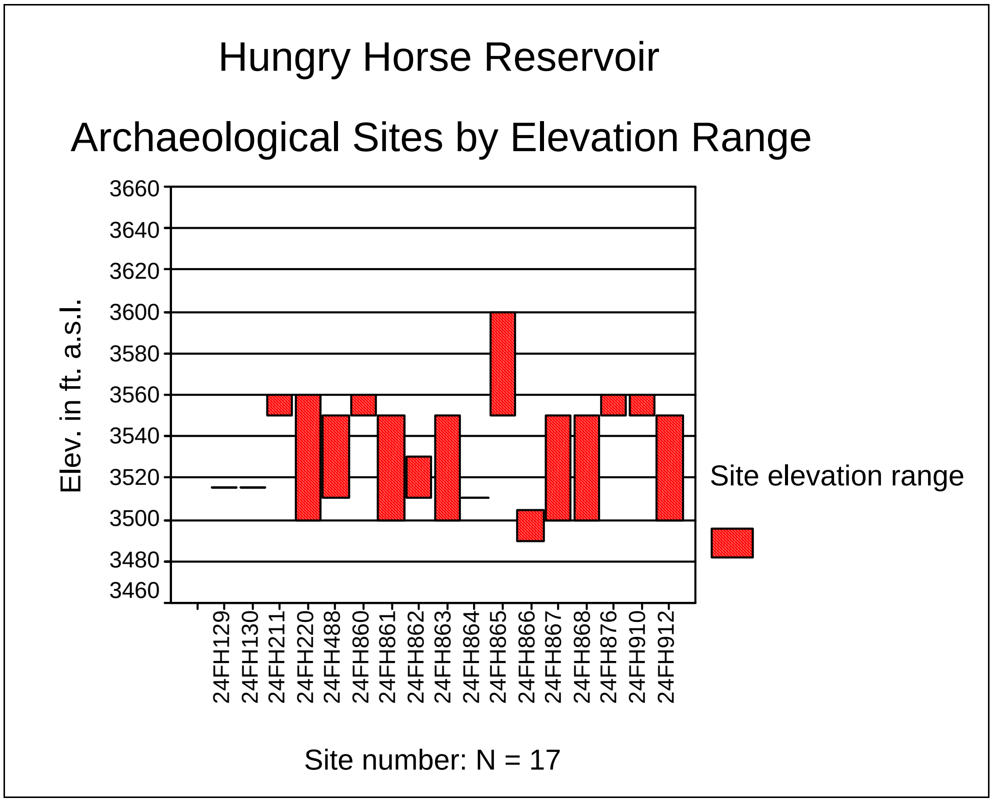

Figure 4-6. Elevation distribution of archaeological sites at Hungry Horse Reservoir.

Lake Pend Oreille

Based on surveys conducted over the last 8 years, 374 prehistoric and historic sites are found within the reservoir of Albeni Falls Dam. Most of these sites are prehistoric and include petroglyphs, open camp sites, and villages. The earliest sites contain materials that are 8,000 to 10,000 years old. As yet, very little is known about the prehistoric occupation at Lake Pend Oreille. Indian tribes that used the area historically include the Upper and Lower Kalispel, Kootenai, Coeur d'Alene, and Spokane. Historic sites include David Thompson's 1809 Kullyspell House, a Hudson's Bay Company village, ferry landings, railroad construction camps, and forestry and mining-related structures. Few of these sites have been evaluated for National Register eligibility. (BPA *et al.* 1995)

Because Lake Pend Oreille is a natural lake where the impoundment by Albeni Falls Dam controls the surface elevation between about 2049 and 2062.5 feet, the Lake Pend Oreille sites are mostly along the shores of the predam lake. (BPA *et al.* 1995)

4.2.11 Indian Sacred Sites

Reclamation currently has been provided no data concerning sacred sites according to the definition set forth by Executive Order 13007 for the Hungry Horse Reservoir shoreline and downstream river reaches.

4.2.12 Other Affected Tribal Interests

In addition to cultural resources and Indian sacred sites, Lake Pend Oreille also retains resources that support hunting, fishing, and gathering activities for the CSKT, the primary tribe historically associated with this area. Some of these areas may have been already disturbed to the extent that they no longer can support such traditional uses.

The United States has a fiduciary responsibility to protect and maintain rights reserved or granted to Indian Tribes or individuals by treaties, statutes, and executive orders. This responsibility is sometimes further interpreted through court decisions and regulations. This trust responsibility requires that Federal agencies ensure that Indian rights are given full effect.

4.2.13 Municipal Water and Wastewater Treatment

Downstream from Hungry Horse Dam, towns draw water from a mix of surface and groundwater sources Table 4-12. Major municipalities discharging secondary treated waste to the Flathead River, Clark Fork, Pend Oreille River, or their tributaries include Columbia Falls, Kalispell, Polson, and Thompson Falls, Montana; Sandpoint and Priest River, Idaho; and Newport, Washington.

4.2.14 Transportation and Navigation

There are no commercially operated non-recreational waterborne transportation systems (such as ferries) operating on the reservoirs or rivers in the Pend Oreille River basin.

There is currently no commercial navigation at Albeni Falls Dam. For a short time, the dam’s unique log chute feature was used to transport logs to the Diamond Match Company during the 1950s. The chute was used for about four years until hauling logs by trucks became more cost effective. The log chute has not been used since and the old pilings are gone.

Table 4-12. Selected statistics for M&I water supply – United States portion of Pend Oreille River basin.

	Flathead County, MT	Lake County, MT	Sanders County, MT	Bonner County, ID	Pend Oreille County, WA
Total population (x1,000)	74.47	26.51	10.23	36.84	11.73
Total population served by public supply (x1,000)	52.74	15.05	5.42	16.94	5.39
Total public supply fresh surface water withdrawals (million gal/day)	2.11	0.89	0.14	3.38	0.13
Total domestic self-supply fresh surface water withdrawals (million gal/day)	0.79	0.09	0.03	0.00	0.00
Total industrial self-supply fresh surface water withdrawals (million gal/day)	0.07	0.00	0.00	0.81	0.92

Source: http://water.usgs.gov/watuse/

4.2.15 Socioeconomics

The Pend Oreille River basin includes a number of large Federal reserves, tribal lands and parks including the Flathead National Forest, Kootenai National Forest, Idaho Panhandle National Forest, Kaniksu National Forest, Colville National Forest, Lolo National Forest and Flathead Indian Reservation. Major industries were historically natural resource based and included timber, mining, and agriculture. In more recent times, other industries such as tourism have become more important.

Socioeconomics information is summarized below and described in detail in Appendix F. Statistics are from the 2003 United States census.

Demographics

The Pend Oreille River basin includes portions of the Central Kootenay Regional District (RD), British Columbia; Flathead, Lake, and Sanders Counties in Montana; Bonner County, Idaho; and Pend Oreille County, Washington. Cities and towns located along the rivers include Hungry Horse, Columbia Falls, Polson, Thompson Falls, Kalispell, and Noxon, Montana; Clark Fork, Sandpoint, and Priest River, Idaho; and Newport, Ione, and Metaline Falls, Washington. The following paragraphs provide an overview of selected demographic data organized by British Columbia, Montana, Idaho, and Washington. Table 4-13 presents a summary of selected demographic and socioeconomic information for this area.

Table 4-13. Selected demographic and socioeconomic information for Pend Oreille River basin.

	Population Estimate[1]	Population Estimate for 2025	Median Per Capita Income[2]	Percent of Province/State Income[2]	Percent Below Poverty Line[2]	Percent Minority Population[2]
Province / States						
British Columbia	4,146,580		$22,095	NA		26.0
Montana	917,621		$17,151	NA	14.6	9.4
Idaho	1,366,332		$17,841	NA	11.8	4.8
Washington	6,131,445		$22,973	NA	10.6	18.2
Regional District / Counties / Cities						
Central Kootenay RD	59,388		$19,008	86.0	no data	5.0
Flathead County, MT	79,485	88,335-121,715	$18,112	105.6	13.0	3.7
Kalispell	16,391		$16,224	94.6	15.9	4.2
Hungry Horse	934		$10,530	61.4	29.7	5.1
Columbia Falls	3,963		$14,355	83.7	17.1	3.7
Evergreen	6,215		$14,277	83.2	14.2	5.2
Lake County, MT	27,197	30,780-31,510	$15,173	88.5	18.7	28.6
Polson	4,497		$13,777	80.3	19.8	21.8
Sanders County, MT	10,455	11,900-12,035	$14,593	85.1	17.2	8.1
Plains	1,169		$13,010	75.9	20.3	4.1
Thompson Falls	1,323		$13,245	77.2	16.1	3.3
Noxon	230		$14,350	83.7	14.7	2.6
Bonner County, ID	39,162	47,695-59,120	$17,263	100.7	12.4	3.4
Clark Fork	566		$13,979	81.5	20.8	6.0
Sandpoint	7,378		$20,643	120.4	18.0	3.8
Priest River	1,863		$14,125	82.4	18.9	5.3
Pend Oreille County, WA	12,254	15,930-16,725	$15,731	68.5	18.1	6.5
Newport	2,105		$13,900	60.5	23.6	5.4
Ione	487		$12,093	52.6	16.4	7.3
Metaline Falls	226		$16,390	71.3	33.2	5.1

[1] U.S. state and county population estimates are for 2003 from U.S. Census Annual Population Estimates, Release Date: April 9, 2004.
U.S. city population estimates are for 2003 from U.S. Census Annual Population Estimates FRO Incorporated Places, Release Date: June 24, 2004.
Canadian Province, RD, and city population data are for 2003 from B.C. Stats Community Facts, release date October 06, 2004.

[2] Canadian income and minority population data are for 2000 from the 2001 Census; U.S. data on income, poverty and minority population are for 1999 from 2000 Census.

British Columbia

A short reach of the Pend d'Oreille River flows through the Central Kootenay RD, but no large towns or cities are located along this river reach in Canada.

Montana

Kalispell is the major population center and county seat of Flathead County. Other larger towns include Whitefish and Columbia Falls. The greater Kalispell area comprises approximately 43 percent of the county's population. The population of Flathead County increased 23 percent from 1990 to 2000, nearly double the average rate for the nation. Average annual population increases since 2000 have been approximately 2 percent. Flathead County is likely to continue to increase in population faster than the state as a whole. Flathead County has a small minority population of 3.7 percent, predominantly individuals of Native American and Hispanic descent.

The largest city in Lake County is Polson, the county seat, which comprises approximately 15 percent of the county's population. Polson is located within the Flathead Indian Reservation. The population of Lake County increased substantially (38 percent) from 1990 to 2000. Since 2000, annual average growth has been approximately 0.7 percent. Lake County has a substantial minority population (28.6 percent), predominantly Native American. Downstream from Flathead Lake, the Flathead River forms the boundary between Lake and Sanders Counties, Montana, before joining the Clark Fork and flowing northwest through sparsely populated Sanders County, Montana.

Thompson Falls, the county seat, is also the largest town in Sanders County. Generally, the population is highly dispersed in several small towns along the Clark Fork and other rural areas, including the Flathead Indian Reservation. The population of Sanders County increased 20 percent from 1990 to 2000, and has averaged approximately 0.6 percent annual growth since 2000. Sanders County has a minority population of 8.1 percent, predominantly Native American and Hispanic.

Idaho

Sandpoint is the largest town in Bonner County, which comprises approximately 18.6 percent of the county's population. Other towns along the river include Clark Fork and Priest River. The population of Bonner County increased by approximately 29 percent from 1990 to 2000, and has continued increasing by an average annual rate of approximately 1.9 percent since 2000. Bonner County has a small minority population of 3.4 percent, predominantly Hispanic and Native American.

Washington

Pend Oreille County is sparsely populated and had a population of 12,254 in 2003. Newport is the largest town along the river, with approximately 16 percent of the county's population. The remainder of the population is dispersed among several other small towns and rural areas along the river and south. The population of Pend Oreille County increased by 24 percent from 1990 to 2000 and has continued increasing by an annual average of 1.4 percent since 2000. Pend Oreille County has a small minority population of 6.5 percent, predominantly Hispanic, Native American, and Asian. The Kalispel Indian Reservation is located north of Newport.

Employment and Income

The Pend Oreille River basin is primarily a forested mountainous region, but there are large open valleys in some areas (Montana) suitable for extensive agriculture. Forestry has historically been and continues to be a major part of the economy; but tourism, government, and health care are now very important industries with higher employment than natural resource extraction industries. Income and employment data are discussed for British Columbia, Montana, Idaho, and Washington; data summaries are shown in Table 4-13 and Table 4-14.

Table 4-14. Percent employment by industry – United States portion of the Pend Oreille River basin.

	Flathead County, MT	Lake County, MT	Sanders County, MT	Bonner County, ID	Pend Oreille County, WA	Average
Agriculture	4.2	17.9	18.1	5.6	15.2	12.2
Forestry and fishing	1.8	1.7	5.2	3.8	D	3.1
Mining	0.6	0.4	1.1	0.6	D	0.7
Construction	9.4	7.5	7.1	10.0	5.2	7.8
Manufacturing	6.5	6.8	7.1	8.8	12.1	8.3
Retail trade	14.0	11.4	9.2	15.6	8.2	11.7
Transportation/ warehousing	2.4	D	3.2	2.0	3.6	2.8
Information	1.4	1.2	0.9	1.2	1.3	1.2
Finance/insurance	3.9	2.8	2.1	3.0	2.4	2.8
Real estate	5.5	3.5	4.8	6.0	2.0	4.4
Professional/technical	6.4	3.6	3.0	5.1	2.3	4.1
Education	0.9	0.5	D	1.2	D	0.9
Healthcare/ social assistance	9.4	10.3	D	6.0	D	8.6
Recreation/entertainment	3.4	1.9	1.4	4.0	D	2.7
Accommodation/restaurant	9.2	6.5	6.3	6.7	D	7.2
Other services	11.6	4.4	16.4	8.8	17.2	11.7
Government	9.3	19.6	14.0	11.8	30.0	16.9

(D) Not shown to avoid disclosure of confidential information, but est. for this item included as "Other Services".
Source: Employment data is for 2002 as presented in Table CA25N – Total full-time and part-time employment by industry, Bureau of Economic Analysis Regional Economic Information System, Table CA25 (NAICS), May 2004.

British Columbia

This sparsely populated reach of the Pend Oreille River is dominated by hilly and mountainous forest lands. The major industries are timber and ranching (British Columbia Ministry of Management Services 2004).

Montana

Flathead County, Montana, primarily consists of Federally owned lands, particularly the Flathead National Forest, which includes the Great Bear and Bob Marshall Wilderness areas, and it is the western gateway to Glacier National Park. These are tourist destinations for camping, hiking, fishing, boating and hunting. Hungry Horse Reservoir and Flathead Lake are also tourist destinations for fishing and boating. Whitefish is well known as a ski destination. Education, health care and social services, retail, construction, manufacturing, and tourism are the major industries in the region (Kalispell Chamber of Commerce web site 2004). High-tech industry is becoming important in the area.

Some of the major employers in Kalispell include American Timber and Plum Creek Timber Companies, Big Mountain Ski Resort, Semitool, Burlington Northern, Wal-Mart, Columbia Falls Aluminum, hospitals and retirement/nursing homes, Flathead Valley Community College and school districts, and Federal, state, and local governments. Agriculture is also a major industry with products such as cattle, wheat, barley, hay, and fruit crops.

Lake County, Montana, comprises the Flathead Indian Reservation and Flathead Lake. There are also numerous wildlife refuges and state parks. These are all tourist destinations for activities such as fishing, camping, boating, and wildlife watching. However, government and agriculture are the dominant industries in Lake County. Major employers in the area include Salish Kootenai College, and various health care and nursing facilities. The tourism industry supports numerous accommodations, restaurants, golf courses, marinas, and outfitters around Flathead Lake and other destinations.

Sanders County, Montana, primarily comprises the Flathead Indian Reservation, Lolo National Forest, and Thompson River State Forest. There is a moderate amount of tourism for camping, hiking, fishing, and boating. The major industries are agriculture, retail, and government.

Idaho

Bonner County, Idaho, has significantly less Federally owned land than other portions of the study area, although the Panhandle National Forest comprises a significant portion of the county. Tourism is a major component of the economy between Schweitzer Mountain Resort ski area and Lake Pend Oreille. Major employers include Coldwater

Creek (catalog), Stimson Lumber, J.D. Lumber, and Riley Creek Lumber, Litehouse (food product manufacturing), Schweitzer Mountain Resort, government, and various health care and nursing facilities. Agriculture is also a major part of the economy.

Washington

Pend Oreille County, Washington, predominantly comprises the Colville and Kaniksu National Forests. Due to its remote location it is not a major tourist destination, although some hunting and fishing takes place. Agriculture, manufacturing, and government are the dominant industries, including agricultural products such as hay, beef, and poultry.

Floods

Economic losses from flooding have historically occurred along the Flathead River, Flathead Lake, Clark Fork, Pend Oreille River, and Lake Pend Oreille. Flood regulation is provided by Hungry Horse Dam on the South Fork Flathead River; Kerr Dam on the Flathead River; and Albeni Falls Dam on the Pend Oreille River. Economic effects associated with flooding are described below for the following areas:

- Columbia Falls to Flathead Lake (Flathead River)
- Flathead Lake (Flathead River)
- Kerr Dam to Thompson Falls (Flathead River and Clark Fork)
- Lake Pend Oreille (Pend Oreille River)
- Albeni Falls, Idaho to Cusick, Washington (Pend Oreille River)

Columbia Falls to Flathead Lake (Flathead River)

The Flathead River drainage upstream from Flathead Lake comprises agricultural property near Columbia Falls and becomes more commercial and residential downstream through Kalispell to Flathead Lake. The floodway is broad, extending one to three miles in width. Flood regulation occurs at Hungry Horse Dam and typically the controlled flood event duration is short, on the order of days. Additional flood control works have been constructed along the river including levees, channel realignments, and bank protection and erosion control measures. Flood stage flow at Columbia Falls is identified as 51,500 cfs. Minor localized flooding can occur at flows above 44,500 cfs (BPA 1995).

Flathead Lake

Historic data indicate that there are no significant flood losses for Flathead Lake and that flooding has not been a problem since the construction of Kerr Dam in 1938. Kerr Dam is primarily operated to prevent flooding in upstream areas caused by the lake backwater effect. The zero-dollar damage point for Flathead Lake has been identified as elevation 2893 feet (coincident with river flow above 51,500 cfs) (BPA 1995).

Lake Pend Oreille (Pend Oreille River)

The normal operating range of Albeni Falls Dam, which controls the level of Lake Pend Oreille, is 2051.0 to 2062.5 feet. Albeni Falls Dam operates to control flooding along the river and lakeshore upstream from the dam. The 2062.5 feet elevation represents the zero-damage stage (BPA 1995f).

Albeni Falls Dam to Cusick, WA (Pend Oreille River)

In the Albeni Falls Dam to Cusick reach, flooding occurs on agricultural and the Kalispel Reservation lands. Historical flood control levees are no longer maintained since the construction of Albeni Falls Dam (BPA 1995f).

This reach can be impacted by two types of flooding: 1) agricultural flooding in March and April as a result of early spring runoff from Calispell and Trimble Creeks and 2) flooding in June due to high flows in the Pend Oreille River from high elevation snowmelt.

Farmers near Cusick may have problems draining their fields in late March and April when Calispell and Trimble Creeks are running high and flows in excess of 43,000 cfs are passed through Lake Pend Oreille. Pend Oreille PUD operates Box Canyon Dam and pumping facilities at the mouth of the creeks to minimize backwater effects on agricultural lands.

Flooding below Albeni Falls Dam in June is due to spring snowmelt, and is a relatively common occurrence happening historically about one year in four. The National Weather Service issues flood warnings when the releases from Albeni Falls Dam are expected to exceed 100,000 cfs.

Agriculture and Irrigation

British Columbia

In British Columbia, there is limited agriculture because fertile flat land is scarce along the Pend Oreille River. There is some cattle ranching on the uplands and hay/pasture production (British Columbia Ministry of Management Services 2004).

Montana

Flathead County, Montana, is a major agricultural area, primarily in the Flathead Valley. The major agricultural products included livestock (primarily cattle, calves, and beef cows), wheat, barley, hay/grass, and approximately 150 acres of vegetables and fruits.

Lake County, Montana, is also a major agricultural area, primarily south of Flathead Lake. Major crops included livestock, primarily cattle and beef cows; wheat, oats, barley, potatoes, hay/pasture, and cherries.

Sanders County, Montana, has significant ranch land along the Flathead River and Clark Fork and uplands. Major crops included livestock, primarily cattle and beef cows; oats and hay/pasture. Approximately 35 acres were in vegetable and fruit production.

Idaho

Bonner County, Idaho, has a moderate agricultural industry. The major agricultural products included livestock, primarily cattle and beef cows; oats and hay/pasture. Approximately 110 acres were in vegetable and fruit production.

Washington

Pend Oreille County, Washington, has a moderate agricultural industry. The major agricultural products included livestock, primarily cattle and beef cows; oats and hay/pasture.

Table 4-15. Agricultural and irrigation summary statistics – United States portion of Pend Oreille River basin.

County, State	Land in Farms	Total Cropland	Harvested Cropland	Irrigated Acres (%)[1]	County's Net Cash Farm Income
Flathead, MT	234,861	107,636	81,462	32,346 (40)	$4,106,000
Lake, MT	601,544	135,199	78,680	88,871 (113)	$6,056,000
Sanders, MT	345,775	52,539	31,942	17,173 (54)	$1,420,000
Bonner, ID	90,585	33,430	18,052	1,844 (10)	-$1,458,000
Pend Oreille, WA	61,239	24,473	15,363	1,427 (9)	$1,038,000

[1] Percent of harvested cropland Source: USDA – NASS 2002

Tribal Socioeconomics

The recognized Native American Tribes located in the Pend Oreille River basin include the Confederated Salish and Kootenai Tribes of the Flathead Reservation, Coeur d'Alene Tribe, and Kalispel Tribe. The Flathead and Kalispel Reservations are located along the river whereas the Coeur D'Alene Reservation is located on Coeur D'Alene Lake.

The CSKT is located on the southern half of Flathead Lake and along the Flathead River from Polson to Paradise. Primary tribal associated business enterprises include many small businesses in the agriculture, construction, home improvement, retail, timber, professional/consulting, and recreation industries. The tribes also operate Salish

Kootenai College. Water related businesses and facilities include the Kwataqnuk Best Western Hotel, S&K Marina, a campground with temporary boat moorage, 3 lake boat ramps, and water intakes, as well the hydroelectric power generation at Kerr Dam. The tribe also has facilities on the Lower Flathead River (below Flathead Lake) including 4 boat ramps and numerous undeveloped access locations for fishing, camping, and subsistence use. (Les Bigcrane, pers. comm. 2004; CSKT 2004) Businesses and facilities that could be affected by changed flows and elevations include Flathead Lake marinas, boat ramps, and water intakes, as well the hydroelectric power generation at Kerr Dam.

The Coeur d'Alene Indian Reservation is located south of Lake Coeur d'Alene; however, the tribe has usual and accustomed hunting, fishing, and gathering rights up to the north bank of the Pend Oreille River. There are also numerous archaeological and cultural resource sites associated with the tribe along the Pend Oreille River and Lake Pend Oreille. The tribe has no economic development adjacent to the Pend Oreille River or Lake, but continues to use many sites for fishing, hunting, or gathering of fruits and other plant materials. (Q. Matheson, Coeur d'Alene Tribe, pers. comm. 11/04)

The Kalispel Indian Reservation is located along both banks of the Pend Oreille River near Cusick, Washington. Tribal business enterprises include the Northern Quest Casino, Kalispel Case Line (manufacturing), Kalispel Agricultural Enterprise, Kalispel Day Care, and the Camas Institute. The tribe operates one boat ramp on the river. Future business development includes a marina, improved or additional boat ramp, and a commerce park. (Kalispel Tribe 2004)

4.3 Environmental Consequences

4.3.1 Hydrology and Flood Control

Implementation of VARQ FC at Hungry Horse was analyzed from Hungry Horse Reservoir to Albeni Falls Dam using a daily timestep, general river basin modeling software tool called Riverware. The Pend Oreille River from Albeni Falls Dam to the confluence with the Columbia River was analyzed by the Corps using a monthly power system model. Two alternatives were simulated at Hungry Horse Dam; Standard FC (HS) and VARQ FC (HV). These two alternatives were compared to each other by analyzing river flows and reservoir elevations.

Hungry Horse Dam and Reservoir

The VARQ FC plan was first developed by the Corps in the late 1980s. The current VARQ FC plan has had some changes and refinements from the original plan but the basic logic is still the same: more water is held in storage at Hungry Horse Reservoir during the winter months in those years when local downstream flooding is not anticipated. This results in higher reservoir elevations and releases during the spring refill period with associated benefits to resident and anadromous fish. The VARQ FC plan was identified in the 2000 USFWS FCRPS Biological Opinion and 2004 NOAA Fisheries FCRPS Biological Opinion, as an action that should be taken for the benefit of bull trout in Hungry Horse Reservoir and anadromous fish downstream in the Columbia River.

The HS and HV model simulations reflect operations that are driven by spring flood control operations, year-round minimum flow targets, summer flow augmentation releases, and winter flood control and power drafts. Hungry Horse pool elevations and releases are frequently different between the two flood control procedures, especially in the winter and spring when flood control drafts have the greatest influence on operations. Figure 4-7 compares average monthly simulated Hungry Horse releases for the HS and HV alternatives.

Hungry Horse Dam releases during the fall are generally controlled by minimum flow targets which are identical for both flood control procedures. An exception is in those rare years of high fall inflows when releases need to be made in December for flood control.

Figure 4-7 shows that average releases are slightly higher for HV in December. Increased releases occurred in years with high fall inflows and Hungry Horse was making releases in December for flood control. Hungry Horse releases in these years were higher under HV because of the larger end-of-December space requirement for HV (250 kaf

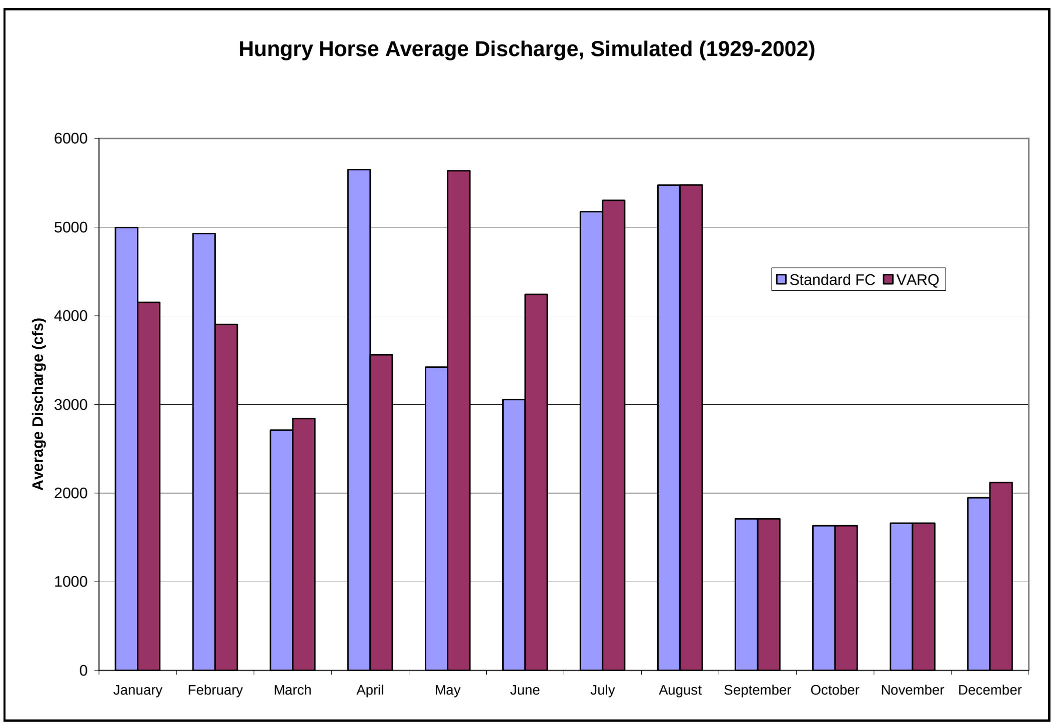

Figure 4-7. Simulated average monthly releases, HS (Standard FC) and HV (VARQ FC).

Table 4-16. Years with increased Hungry Horse releases in December for HV.

Years	Hungry Horse release volume difference between HV and HS, December (acre-feet)
1933	145,000
1959	145,000
1968	81,000
1985	122,000
1989	145,000
1995	145,000

vs.100 kaf). In most years, releases during December reflect the minimum flow requirement for Columbia Falls, which is identical for HV and HS.

Table 4-16 shows the years with increased December releases for HV and the volume difference between HV and HS.

Referring to Figure 4-7, the higher releases in January and February for HS are a result of the larger space requirements under Standard FC rule curves. This is also true in April, when the deeper drafts that are required for HS result in higher releases for that month. In some cases, a change in the volume forecast combined with significant snowmelt runoff required releases to be at power plant capacity or higher for most of April. Flood control releases were limited to maximum turbine release (around 12,000 cfs) plus 2000

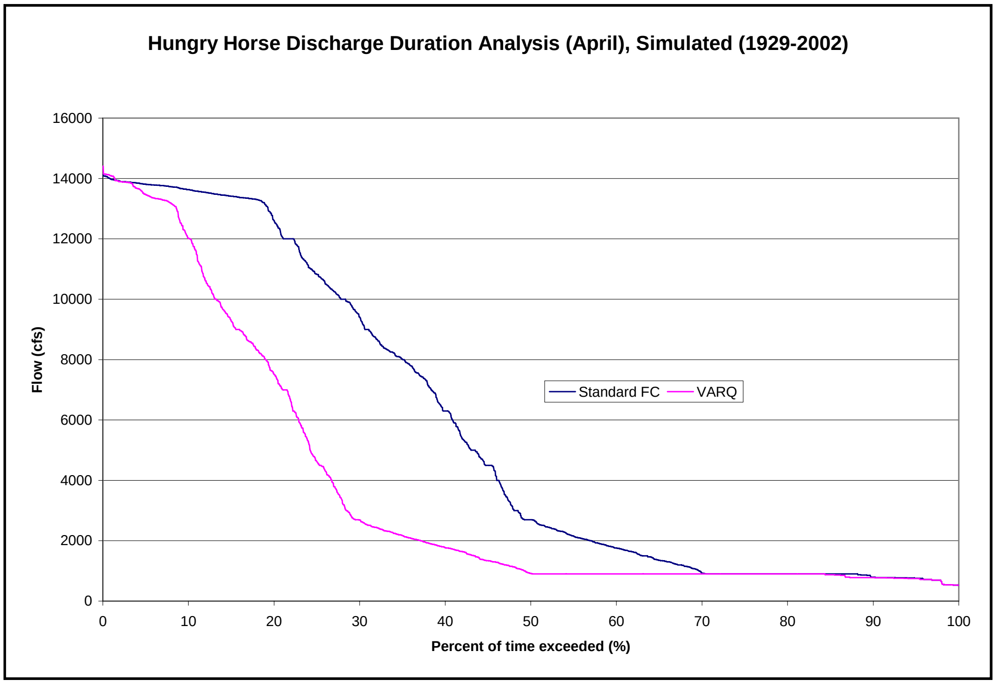

Figure 4-8. Simulated Hungry Horse release duration curves for April, HS (Standard FC) and HV (VARQ FC).

cfs whenever possible. Figure 4-8 shows the duration curves for Hungry Horse Dam releases for April. April releases are much higher under HS.

Simulated Hungry Horse releases in April were guided by the assumption that spill of less than 15 percent of the total release (around 2000 cfs at full power plant capacity) would not exceed the Montana state water quality standard of 110 percent saturation for TDG. Spill above 15 percent of the total release was not allowed in April. Limiting releases to power plant capacity plus 2,000 cfs in April caused May 1 reservoir elevations to exceed May 1 flood control requirements in some years (Table 4-17). Simulated May 1 elevations were above May 1 flood control elevations in 27 of 74 years for HS and 16 of 74 years for HV. Years where simulated May 1 elevations are above flood control requirements are shown as positive values. Drier years, which resulted in reservoir elevations being below the VARQ FC requirement, are shown as negative values.

Table 4-17. Differences between Hungry Horse May 1 flood control elevations and May simulated elevations due to limiting releases to power plant capacity plus 2,000 cfs in April.

	Amount that simulated May 1 reservoir elevation is higher than May 1 flood control requirement (ft)	
Year	**HS**	**HV**
1930	+3	-16
1933	+3	+1
1934	+23	+16
1936	+2	-15
1939	+6	+3
1943	+12	+5
1946	+3	0
1947	+6	+2
1949	+1	-3
1950	+6	+1
1951	+2	+1
1952	+8	+3
1955	+1	-7
1956	+8	+1
1957	+1	-1
1959	+12	+2
1965	+10	+3
1971	+8	+2
1974	+11	+5
1980	+1	-25
1981	+2	+1
1987	+4	-5
1989	+6	+4
1990	+3	0
1991	+1	0
1997	+14	+4
2000	+1	0
Number of years above flood control	27	16

Specific to Hungry Horse Dam, the term "spill" is designated for any release that is not used for power generation. At Hungry Horse Dam, spill can be released via the spillway, outlet works, or the turbines under speed no-load conditions. For example, if the maximum generation capacity was 12,000 cfs and the total release was 15,000 cfs, then 3,000 cfs would be spill. Because it generates very high dissolved gas levels, spillway use is avoided whenever possible. Up to 13,680 cfs can be spilled through the outlet works at elevation 3560 feet before it becomes necessary to use the spillway. Use of the spillway was not necessary under the HS or HV simulations (1929-2002). For comparison purposes, only the days that spill exceeded 15 percent of the total release were considered.

Experience and observations show that spill that is under 15 percent of the total release ensures that the Montana standard of 110 percent TDG saturation is not exceeded and recognizes that minor spills can occur without significant impacts. Spill that exceeded 15 percent of the total release did not occur under HS and occurred for only 20 days in the 74 years examined under HV. The spill that occurred under HV was during the month May (1 day on May 31) in 1948 and during June in 1933, 1948, and 1961. These spill calculations were based on the assumption that all four generating units were available and that there were no power generation restrictions.

Figure 4-9 compares the May 1 reservoir elevation for HS and HV as related to the seasonal volume forecast. In most years of the simulations and particularly in years with an inflow forecast (May-September) of less than 2.4 million acre-feet, reservoir elevations were higher on May 1 under HV than HS. This is in large part due to the deeper flood control draft requirements of HS for these years. For years with an inflow forecast (May-September) greater than 2.4 million acre-feet, flood control requirements for May 1 are similar for HS and HV.

The generally higher May 1 elevations for HV resulted in higher releases from Hungry Horse in May and June than with HS. The higher releases of HV are evident in the flow duration curves for May and June as shown in Figure 4-10 and Figure 4-11.

The higher May 1 reservoir elevations also resulted in slightly better refill probabilities for HV. Figure 4-12 shows the percentage of years that Hungry Horse refilled to within a specified distance from full for both HS and HV. The reservoir refilled to within 1 foot from full in 64.9 percent of all years for HV and 62.2 percent of all years for HS.

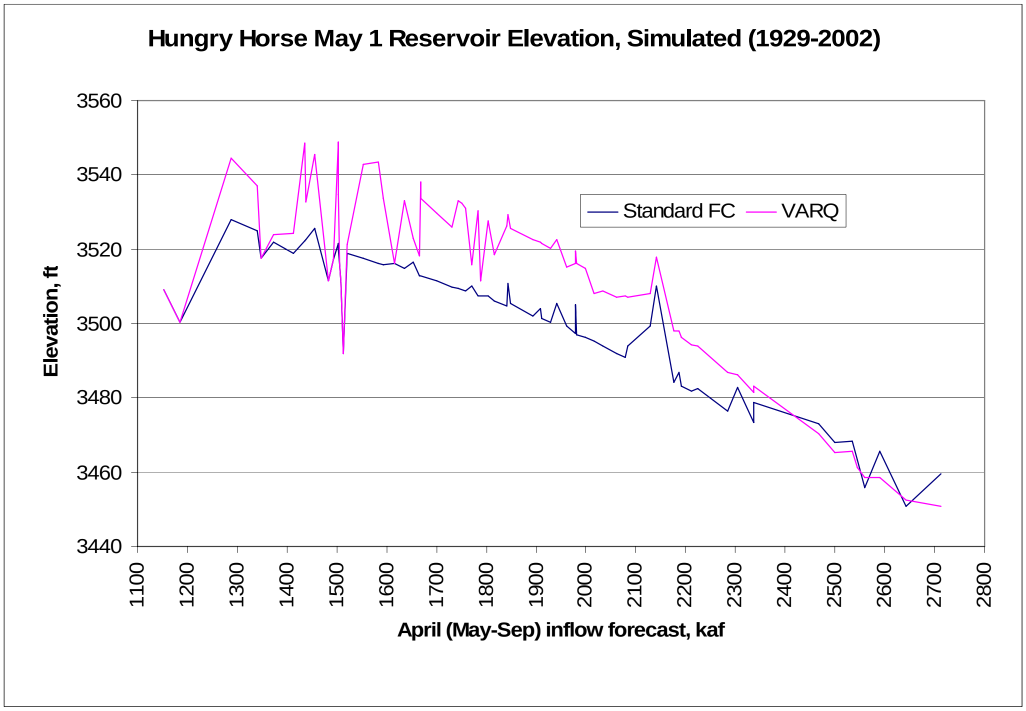

Figure 4-9. Simulated May 1 Hungry Horse Reservoir elevations, HS (Standard FC) and HV (VARQ FC).

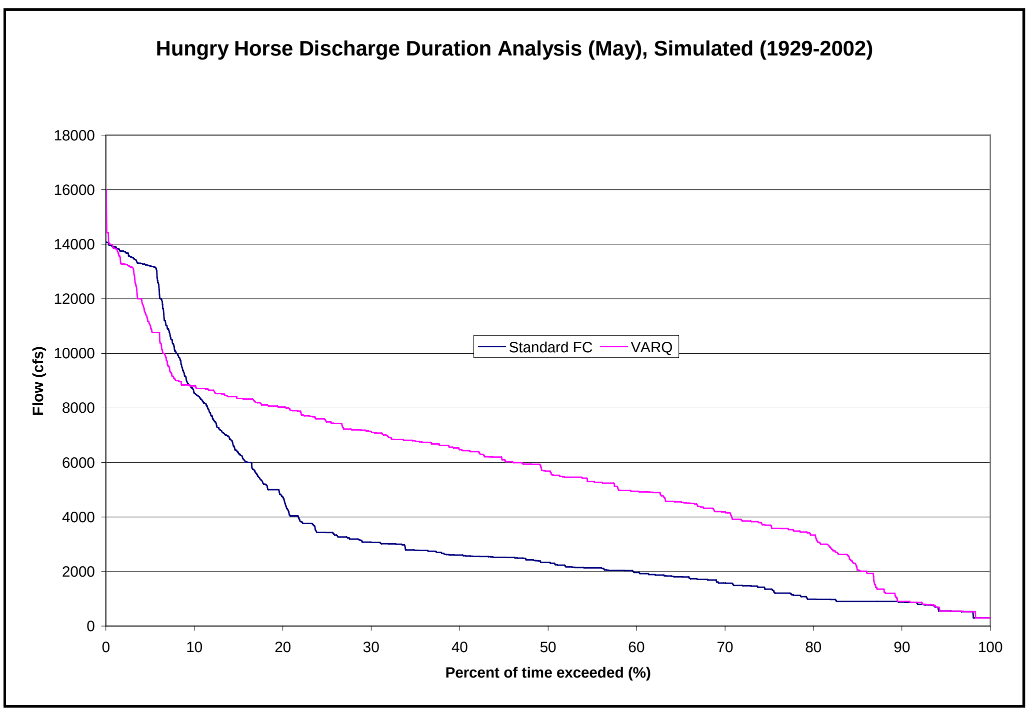

Figure 4-10. Simulated Hungry Horse release duration curves for May, HS (Standard FC) and HV (VARQ FC).

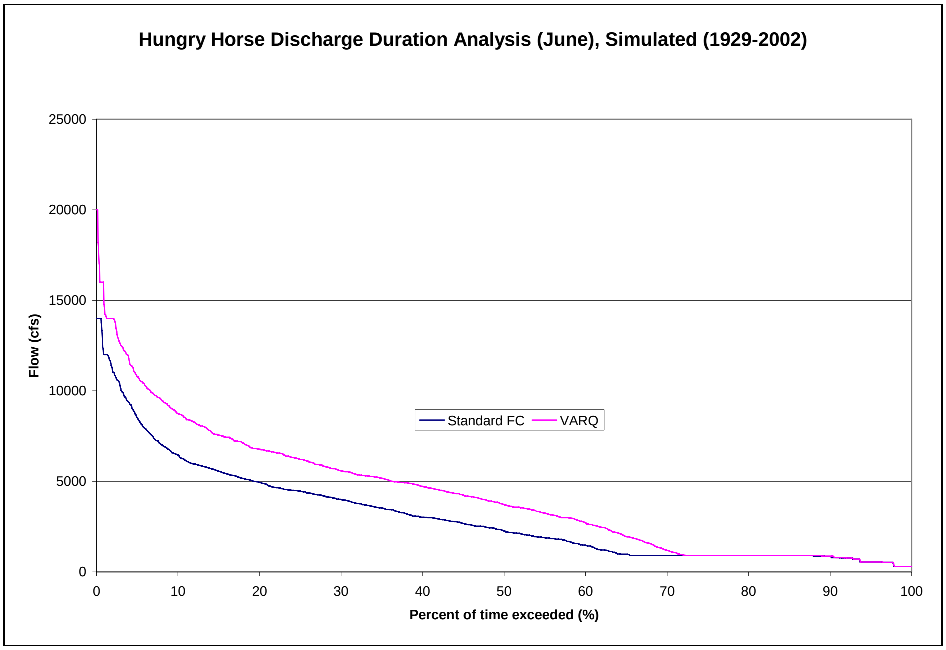

Figure 4-11. Simulated Hungry Horse release duration curves for June, HS (Standard FC) and HV (VARQ FC).

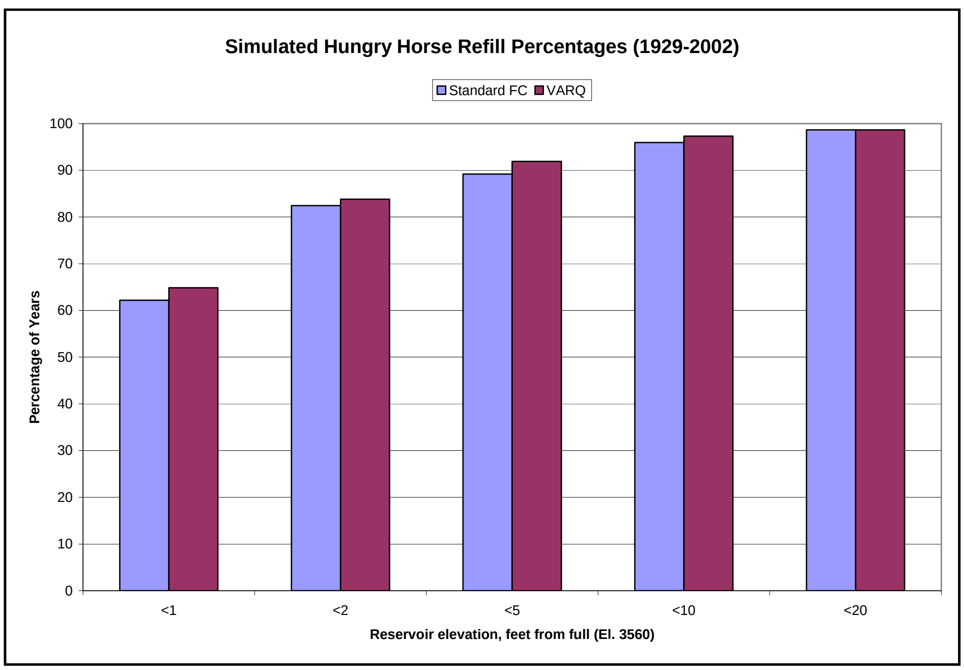

Figure 4-12. Simulated Hungry Horse Reservoir refill percentages, HS (Standard FC) and HV (VARQ FC).

Figure 4-13 compares the peak daily elevation reached during the summer refill period (June/July) for both HS and HV. Figure 4-13 reaffirms the slightly higher probability of refill for HV.

Hungry Horse releases during the summer (July and August) are determined primarily by flow augmentation needs for ESA listed mainstem Columbia River salmon. Inflows and the maximum volume of water available in the reservoir above elevation 3540 feet is

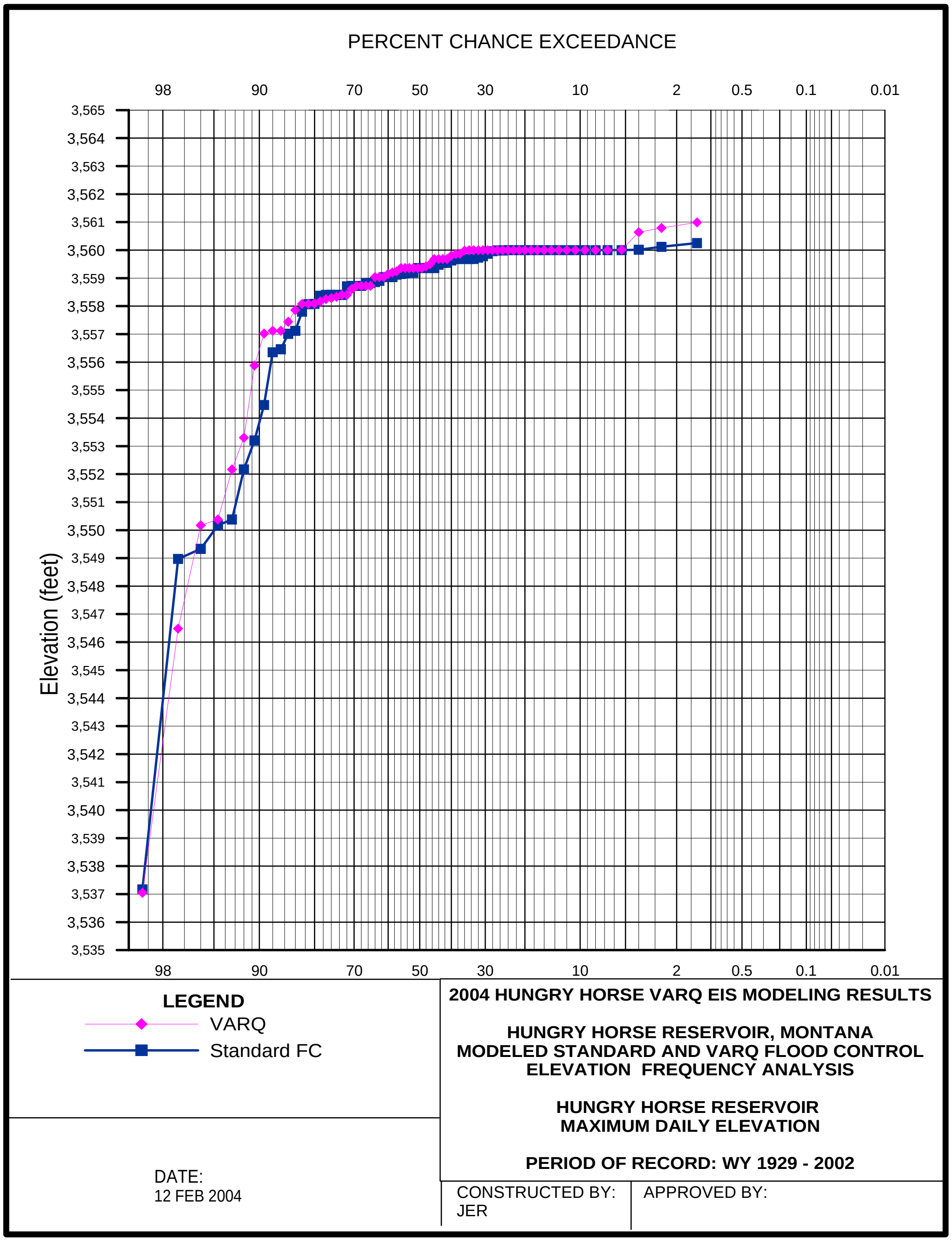

Figure 4-13. Frequency curves for Hungry Horse Reservoir, 1-day maximum elevation, HS (Standard FC) and HV (VARQ FC).

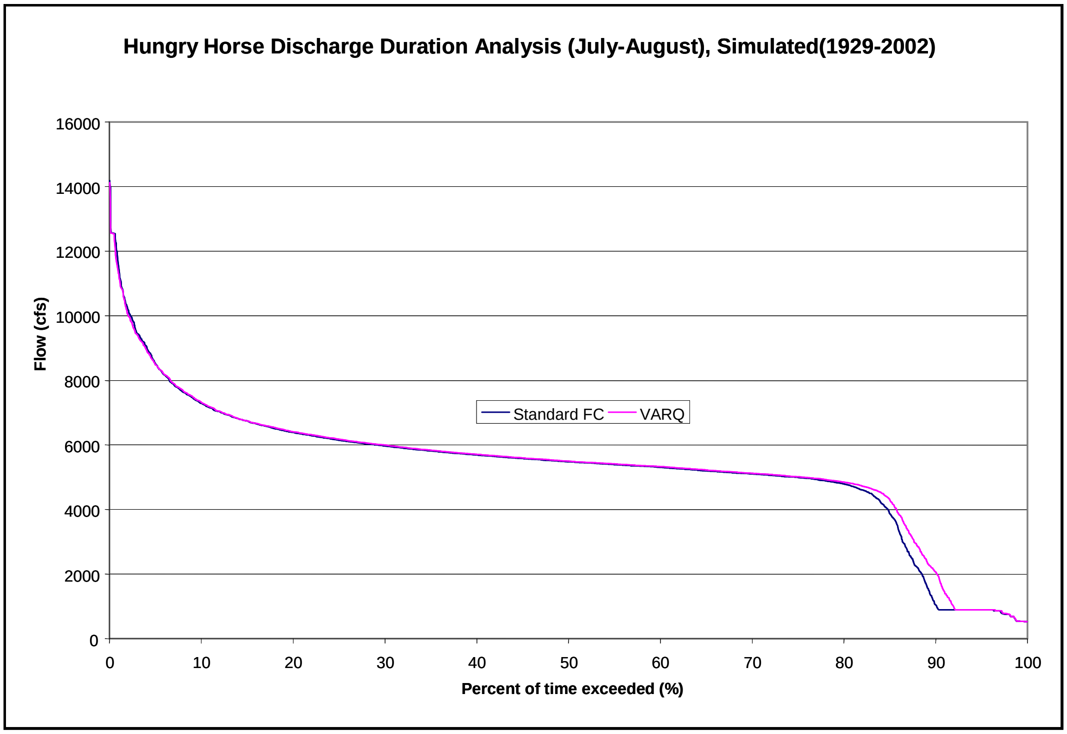

Figure 4-14. Simulated Hungry Horse release duration curves for July-August, HS (Standard FC) and HV (VARQ FC).

used to compute July and August releases. Figure 4-14 is a duration analysis for Hungry Horse releases (July-August). Note the similarities between HS and HV; this is due to the comparable refill elevations between the simulations.

Local Flood Effects at Columbia Falls, Montana

Hungry Horse Dam is operated under section 7 of the Flood Control Act of 1944 by Reclamation for flood control, in coordination with the Corps. The reservoir provides flood regulation which locally benefits the flood plain from Columbia Falls to Flathead Lake and downstream to Lake Pend Oreille and Albeni Falls Dam. In addition to local flood control, Hungry Horse Reservoir provides approximately 5 percent of the total flood storage in the Columbia River basin for system flood control.

Columbia Falls, Montana, is downstream of the confluence of the North, South, and Middle Forks of the Flathead River. Only Hungry Horse Dam on the South Fork provides flood protection. Flood stage at Columbia Falls is at 14 feet (~51,500 cfs), but there is some minor localized flooding above 13 feet (~44,500 cfs). For HS and HV simulations, Hungry Horse releases were decreased to 300 cfs whenever the stage at Columbia Falls exceeded 13 feet. Historically, Columbia Falls exceeds flood stage about one year in five with Hungry Horse at minimum flow. The peak 1-day flow frequency analysis for the Flathead River at Columbia Falls for HS and HV simulations is shown in Figure 4-15.

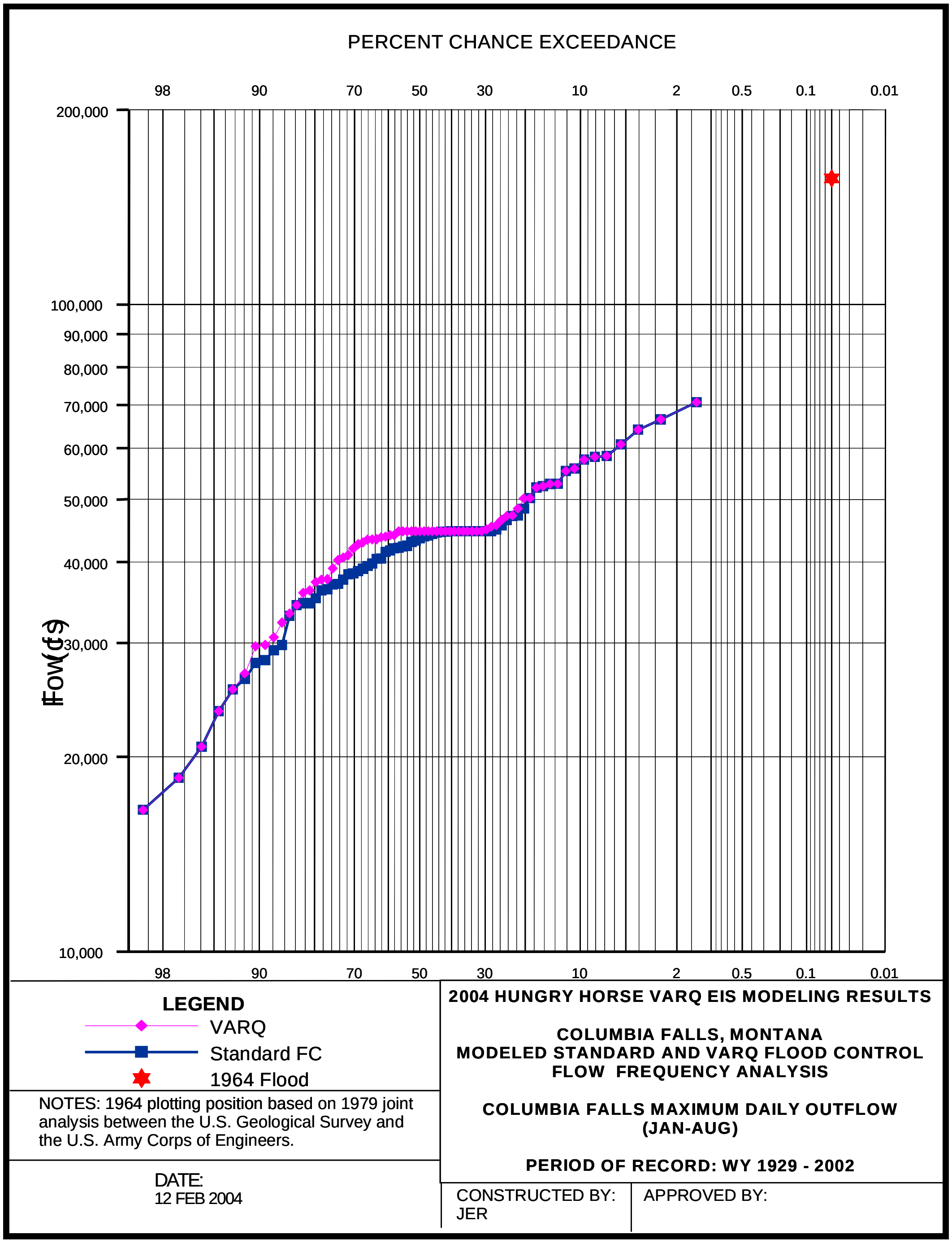

Figure 4-15. Peak 1-day flow frequency curves for the Flathead River at Columbia Falls, Montana.

A summary of the frequency analysis[54] is shown in Table 4-18. There is no difference in the probability of exceeding flood stage between the simulations. The stage at Columbia Falls exceeded 14 feet for a total of 35 days in 14 years for HV and HS. Below flood stage, flows are slightly higher for HV. The flow frequency analysis covers the simulation period of record (1929-2002) excluding 1964. This year, 1964, is considered an extreme outlier event and was assigned an exceedance probability of 0.05 percent based on an analysis discussed in a Memorandum for Record [55] written by the Corps in 1979. The plotting position for the 1964 flood (0.05 percent) is included as a separate point in the plot. There is no difference between the simulations for this event since Hungry Horse Reservoir contained the South Fork's flows and was releasing only 300 cfs for both HV and HS at the time of the flood.

Kerr Dam and Flathead Lake

The differences in Hungry Horse releases between HS and HV have subsequent effects in the operation of Kerr Dam on Flathead Lake. For the purpose of modeling these effects at Kerr Dam, the following guidelines and assumptions were followed in the simulations:

Table 4-18. Peak 1-day flow frequency analysis for the Flathead River at Columbia Falls, Montana.

Exceedance Frequency (%)[2]	Flow (cfs)		Stage (ft)		Flow Difference (cfs)	Stage Difference (feet)
	HS	HV	HS	HV		
1	71,800	71,800	16.5	16.5	0	0.0
2	68,600	68,600	16.1	16.1	0	0.0
5	61,800	61,800	15.3	15.3	0	0.0
10	56,900	56,900	14.7	14.7	0	0.0
18	51,500	51,500	14.0	14.0	0	0.0
20	48,800	50,200	13.6	13.8	1,400	0.2
30	44,600	44,800	13.0	13.0	200	0.0
40	44,600	44,600	13.0	13.0	0	0.0
50	43,600	44,600	12.8	13.0	1,000	0.1
70	38,500	42,100	12.1	12.6	3,600	0.6
90	28,000	29,700	10.2	10.6	1,700	0.3
99	16,600	16,600	7.8	7.8	0	0.0

[1] Flows based on USGS rating table as of August 2002
[2] Probability of exceeding a given flow or stage in any given year

[54] Flows based on U.S. Geological Survey rating table as of August 2002.
[55] Memorandum for Record, U.S. Army Corps of Engineers, Chief, Hydrology & Hydraulics Branch, Seattle District, Seattle, Washington, *Flood-Frequency Determination for the Flathead River at Columbia Falls, Montana – Joint Memo for Agreement Between U.S. Geological Survey and U.S. Army Corps of Engineers*, September 1979.

1. Flood control requirements were followed in accordance with a 1962 Memorandum of Understanding (MOU) between the Kerr Dam licensee and the Corps. The required April 15 flood control elevation of 2883 feet was modified, if applicable, during drought years to allow for a higher April 15 flood control elevation. This would help Flathead Lake fill in dry years and still maintain minimum flow requirements below Kerr Dam without jeopardizing flood control. Kerr Dam is currently operating under an "Interim Drought Management Plan" during drought years which includes this type of operation.

2. Minimum flows below Kerr Dam are in accordance with Article 56 of its Federal Energy Regulatory Commission (FERC) license. Table 4-19 shows the minimum flow requirements below Kerr Dam.

3. Maximum releases are limited by the natural lake and channel configurations.

4. Release ramping rates were adhered to.

Differences in HS and HV affect the timing and magnitude of Hungry Horse releases which in turn affect operations at Kerr Dam and Flathead Lake. As mentioned in the Hungry Horse effects section, Hungry Horse releases are generally lower in April and higher in May and June for HV. Since Flathead Lake is usually drafting during the first half of April to its flood control elevation of 2883 feet, flows from Hungry Horse are being passed through Flathead Lake. Conversely, the higher Hungry Horse releases in May and June under HV can be stored in Flathead Lake during the refill period. The end result is Flathead Lake has a slightly better probability of filling to elevation 2893 feet while still meeting minimum flow requirements below Kerr Dam. Figure 4-16 shows the probability that Flathead Lake would fill to a certain elevation for both HS and HV.

Table 4-19. Minimum flow requirements below Kerr Dam.

Dates	Minimum Flow (cfs)	Ramped to: (cfs)	Daily Ramp Increment (cfs/day)
August 1 to April 15	3,200		
April 16 to April 30	3,200	5,000	120
May 1 to May 15	5,000	12,700	513
May 16 to June 30	12,700		
July 1 to July 15	12,700	6,400	-420
July 16 to July 31	6,400	3,200	-200

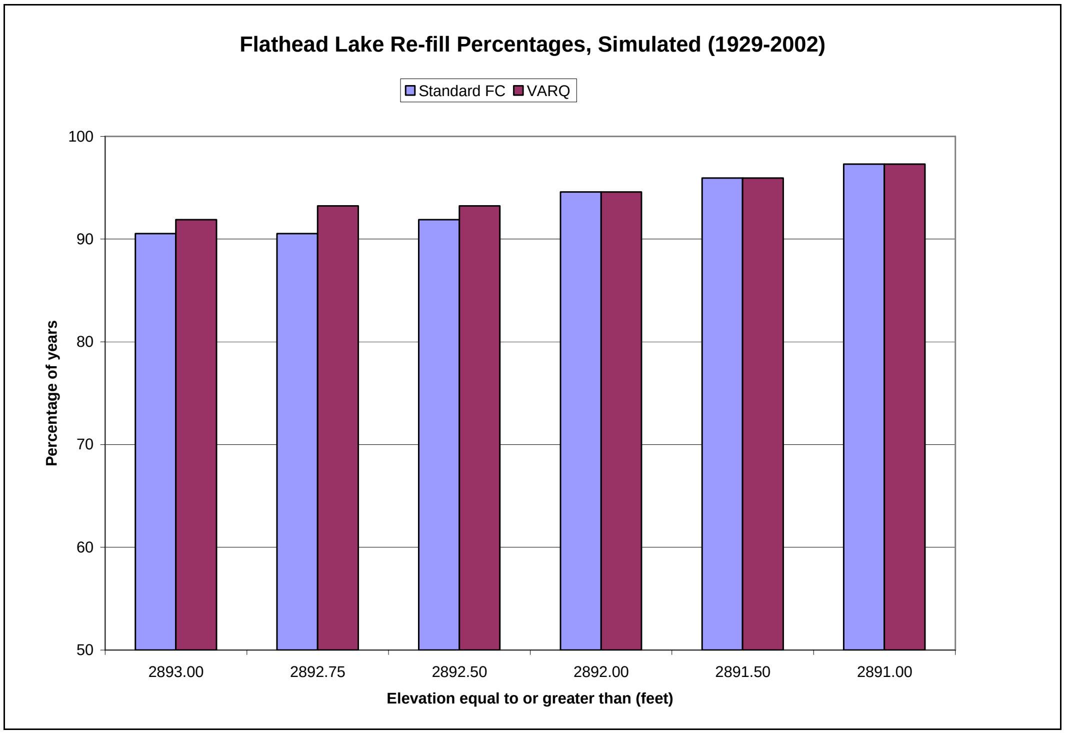

Figure 4-16. Flathead lake refill percentages, HS (Standard FC) and HV (VARQ FC).

It is desirable to maintain Flathead Lake full (2893 feet) throughout the summer for recreational purposes without jeopardizing the minimum flow requirement. Figure 4-17 shows the duration curves for Flathead Lake elevation from June 15–August 31 for HS and HV. Flathead Lake has a slightly better probability of being near full under HV.

There are minor release differences between HV and HS at Kerr Dam. The higher Hungry Horse releases in May and June and the lower releases in April for HV create a similar effect on the releases at Kerr Dam. Figure 4-18 shows average monthly releases from Kerr Dam. Flows are slightly higher in May and June and lower in January, February, and April under HV.

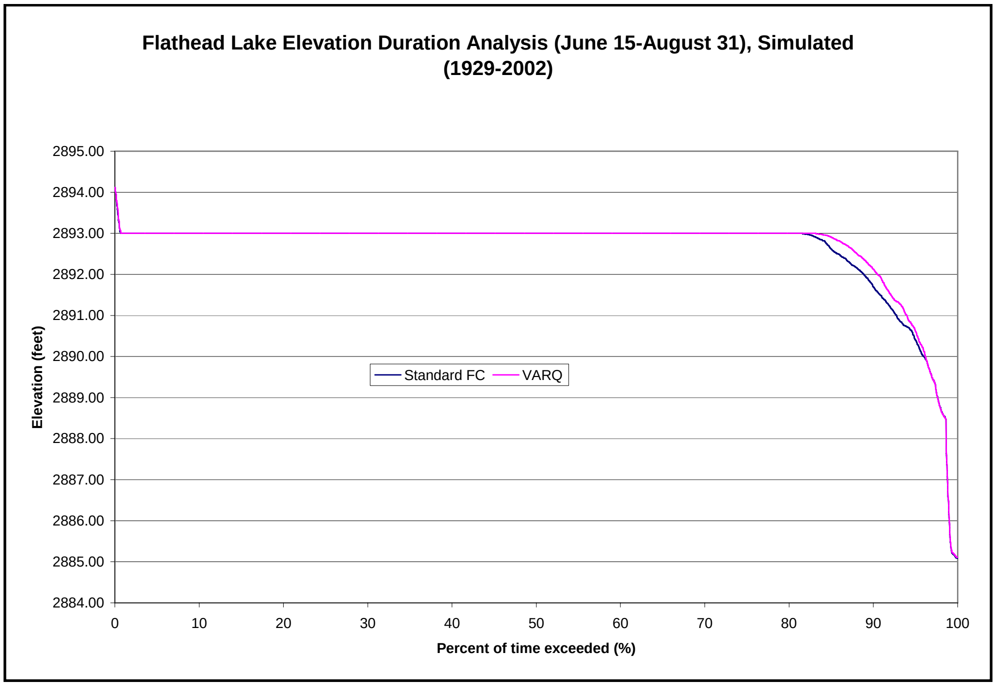

Figure 4-17. Elevation duration analysis at Flathead Lake (June 15-August 31), HS (Standard FC) and HV (VARQ FC).

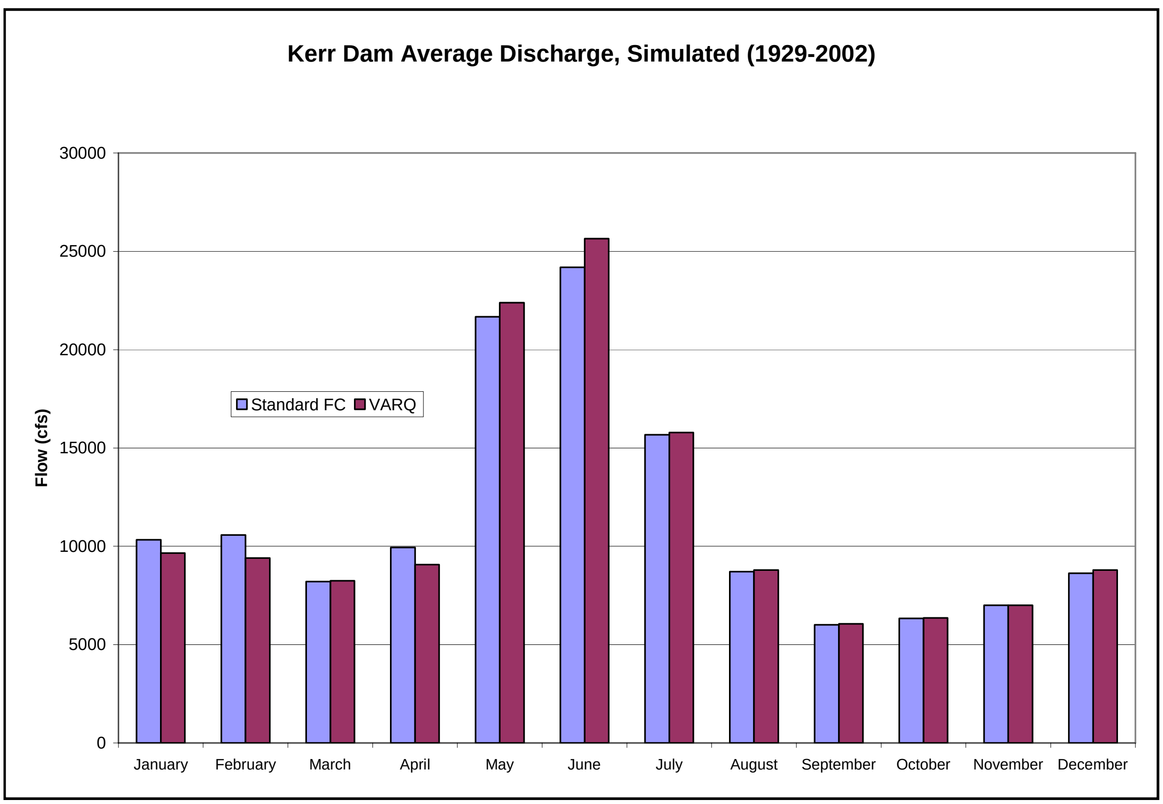

Figure 4-18. Kerr Dam average monthly releases, HS (Standard FC) and HV (VARQ FC).

Peak releases below Kerr Dam were also analyzed for the HV and HS simulations. The peak 1-day flow frequency analysis for the Flathead River below Kerr Dam is shown in Figure 4-19. There are only minor differences between HS and HV.

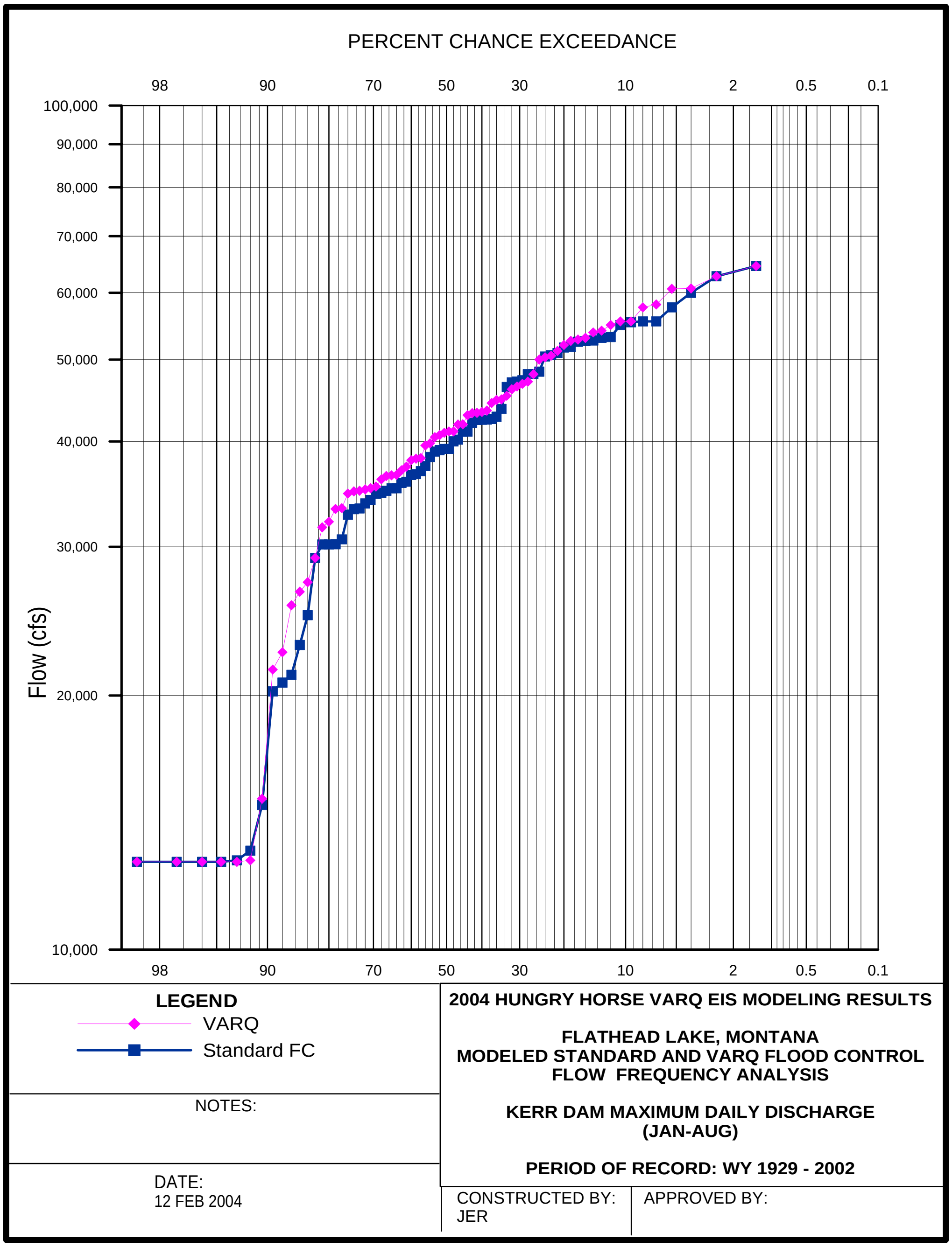

Figure 4-19. Peak 1-day flow frequency curves for Flathead River below Kerr Dam, HS (Standard FC) and HV (VARQ FC).

There is evidence that shows flooding can occur above Flathead Lake along the southern portion of the Flathead floodplain during times when Flathead Lake elevation in combination with flow at Columbia Falls reaches a certain level.[56] Flooding can occur when Flathead Lake is at or above elevation 2893 feet and flows at Columbia Falls exceed 48,000 cfs. In the simulations, Flathead Lake was above elevation 2893 feet and Columbia Falls flow exceeded 48,000 cfs 16 times in 4 years for Standard FC and 31 times in 7 years for VARQ FC. All instances occurred in June and amounted to 0.7 percent of the total days in June for Standard FC and 1.4 percent of the total days in June for VARQ FC.

Lake Pend Oreille

The effects of HV and HS on lake elevations and releases were analyzed at Albeni Falls Dam. For the purpose of modeling these effects at Albeni Falls Dam, the following guidelines and assumptions were followed in the simulations:

1. Target elevations for Lake Pend Oreille include flood control elevations, winter target elevations, and summer normal operating elevations. For this analysis, two different winter target elevations were used for Lake Pend Oreille. One analysis looked at a winter target elevation of 2055 feet for the period of record (1929-2002). Another analysis looked at elevation 2051 feet for a winter target elevation. These two winter elevations are being used in different years in an attempt to determine effects on kokanee salmon spawning along the shoreline of Lake Pend Oreille.
2. Minimum release below Albeni Falls Dam is 4,000 cfs.
3. Maximum releases are limited by the natural lake and channel configurations.
4. Release ramping rates limited to 10,000 cfs/day.

Winter Target Elevation (2055 feet)

HV operations at Hungry Horse had a negligible effect on the summer operating elevation of 2062.5 feet or the winter target elevation of 2055 feet at Pend Oreille Lake. This is evidenced by the elevation duration curves shown in Figure 4-20 and Figure 4-21.

Winter Target Elevation (2051 feet)

At elevation 2051 feet Lake Pend Oreille has 353,000 acre-feet more space than at elevation 2055 feet. HV operations at Hungry Horse had a negligible effect on the summer operating elevation of 2062.5 feet or the winter target elevation of 2051 feet at Lake Pend Oreille. This is evidenced by the elevation duration curves shown in Figure 4-22 and Figure 4-23.

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[56] Based on Corps nomograph chart no. 4515, dated 2-4-1947, *Nondamaging Flow Flathead River at Columbia Falls, Montana*

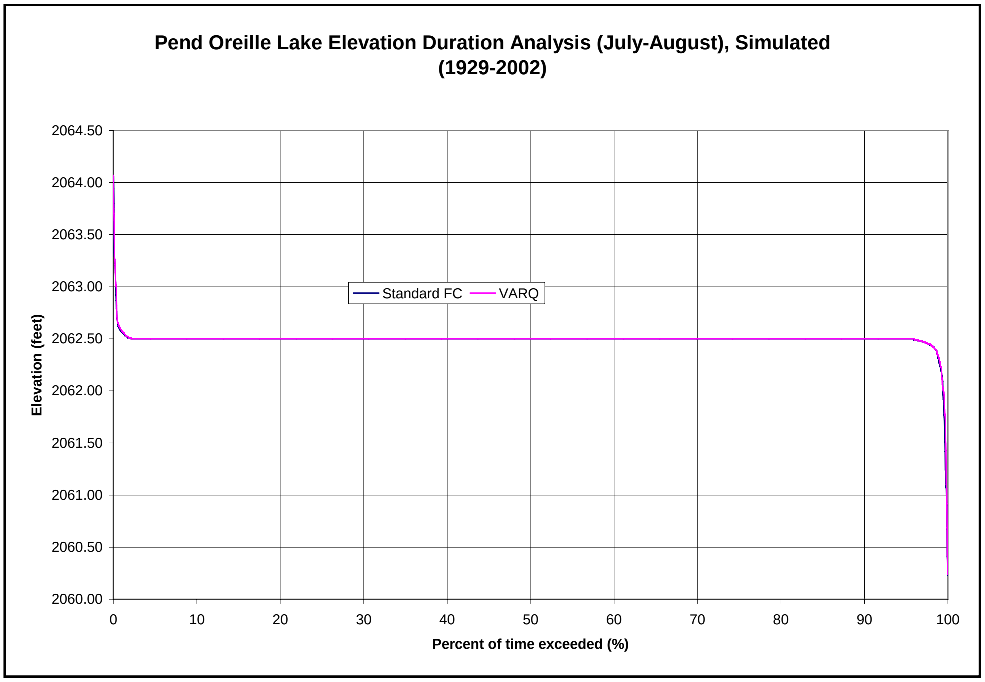

Figure 4-20. Elevation duration analysis at Pend Oreille Lake for July-August (winter target elevation 2055 feet), HS (Standard FC) and HV (VARQ FC).

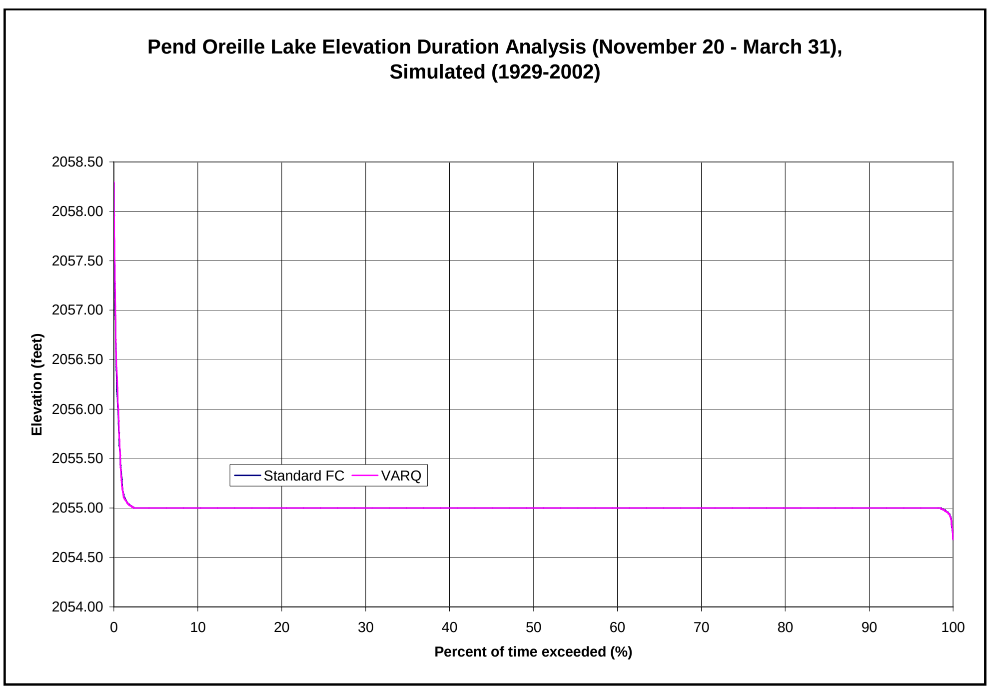

Figure 4-21. Elevation duration analysis at Lake Pend Oreille for November 20-March 31 (winter target elevation 2055 feet), HS (Standard FC) and HV (VARQ FC).

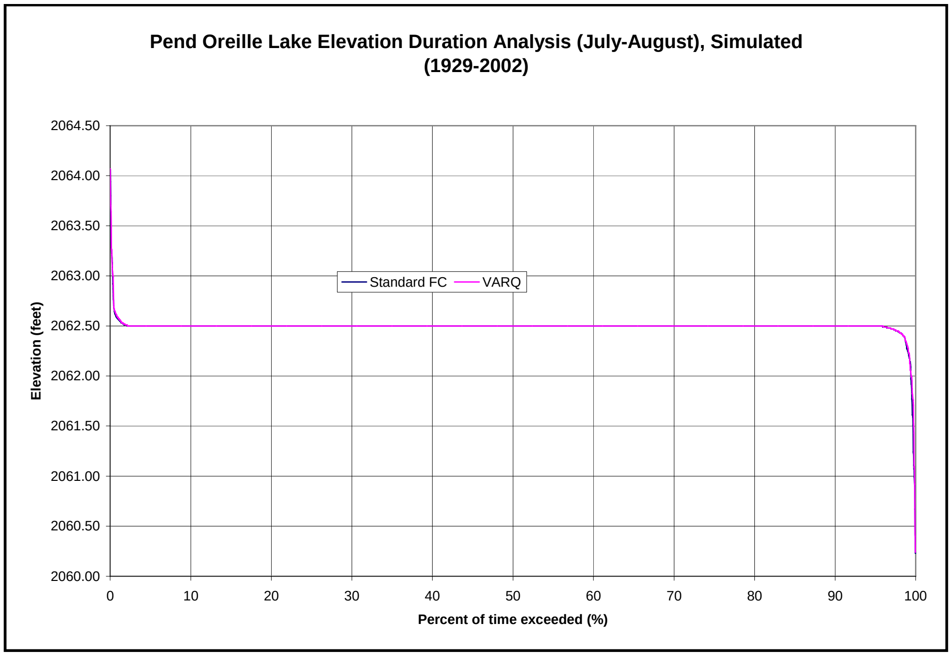

Figure 4-22. Elevation duration analysis at Pend Oreille Lake for July-August (winter target elevation 2051 feet), HS (Standard FC) and HV (VARQ FC).

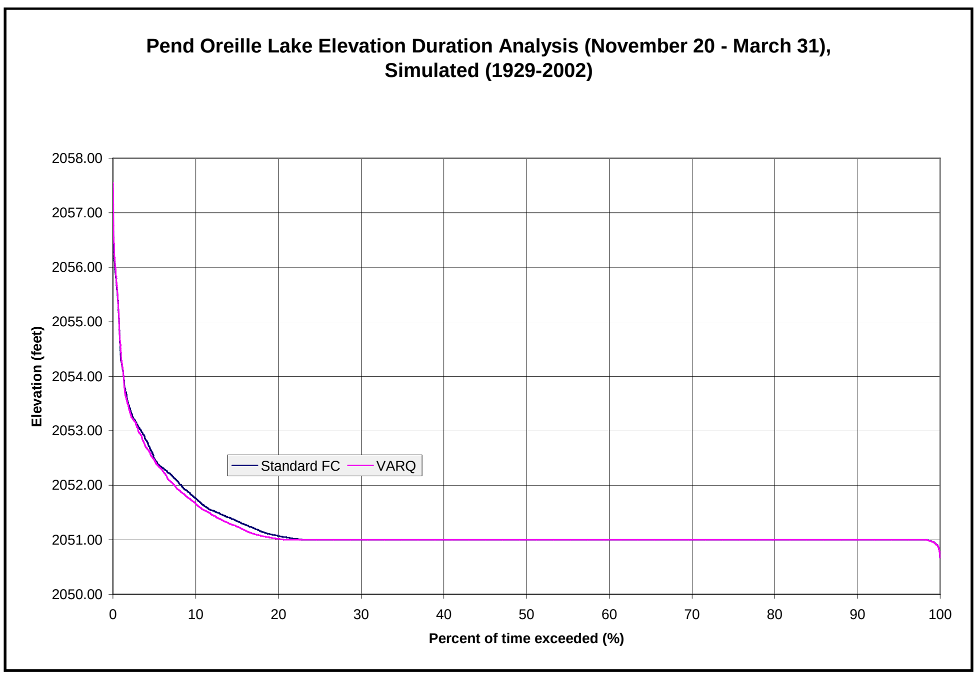

Figure 4-23. Elevation duration analysis at Lake Pend Oreille for November 20-March 31 (winter target elevation 2051 feet).

Albeni Falls Dam to the Columbia River

Winter Target Elevation (2055 feet)

For a winter target elevation of 2055 feet at Lake Pend Oreille, average Albeni Falls releases are slightly higher in June and lower in January, February, and April for HV. Figure 4-24 shows average monthly releases for Albeni Falls Dam.

The area below Albeni Falls Dam can be impacted by two types of flooding: 1) agricultural flooding in March and April as a result of early spring runoff from Calispell and Trimble Creeks and 2) flooding in June due to high flows in the Pend Oreille River from high elevation snowmelt.

The agricultural flooding in the Cusick, Washington area is due to a combination of early spring runoff from Calispell and Trimble Creeks and high river levels due to the operation of Box Canyon and Albeni Falls Dams. Farmers near Cusick may have problems draining their fields in late March and April when Calispell and Trimble Creeks are running high. Pend Oreille PUD operates Box Canyon Dam and pumping facilities at the mouth of the creeks to minimize backwater effects on agricultural lands. Problems

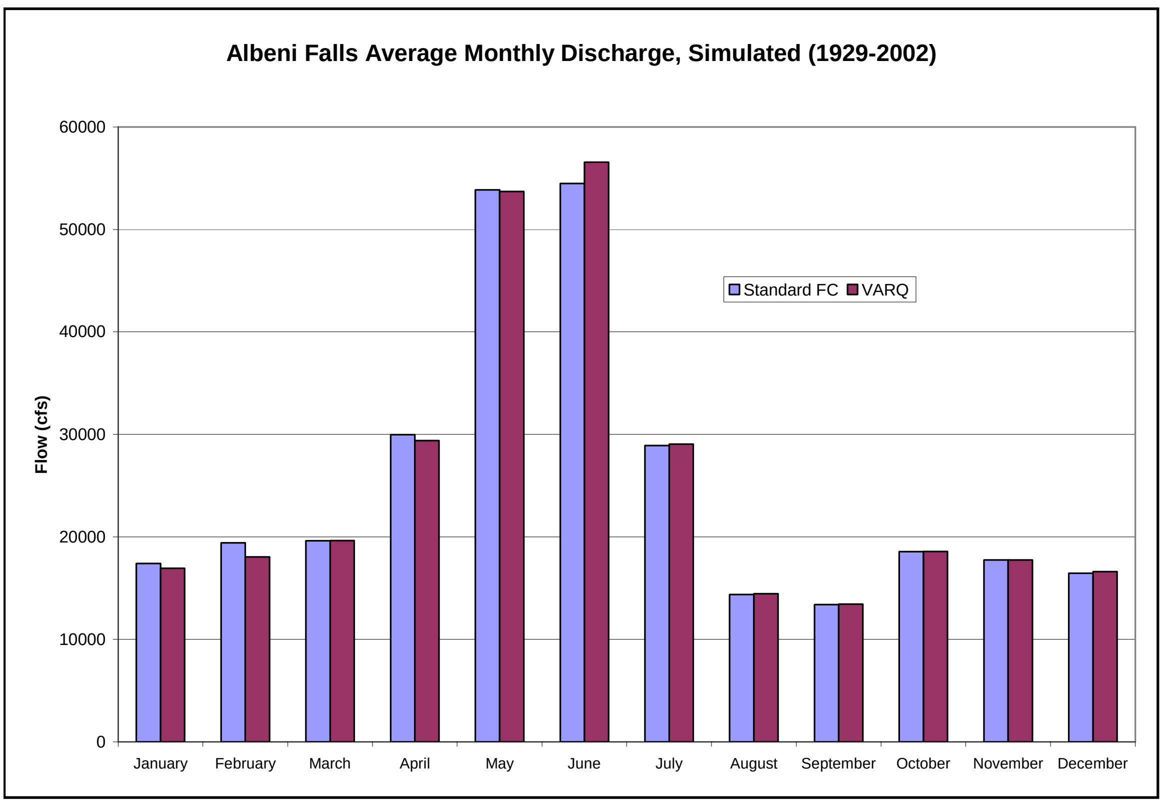

Figure 4-24. Albeni Falls Dam average monthly releases (winter target elevation 2055 feet), HS (Standard FC) and HV (VARQ FC).

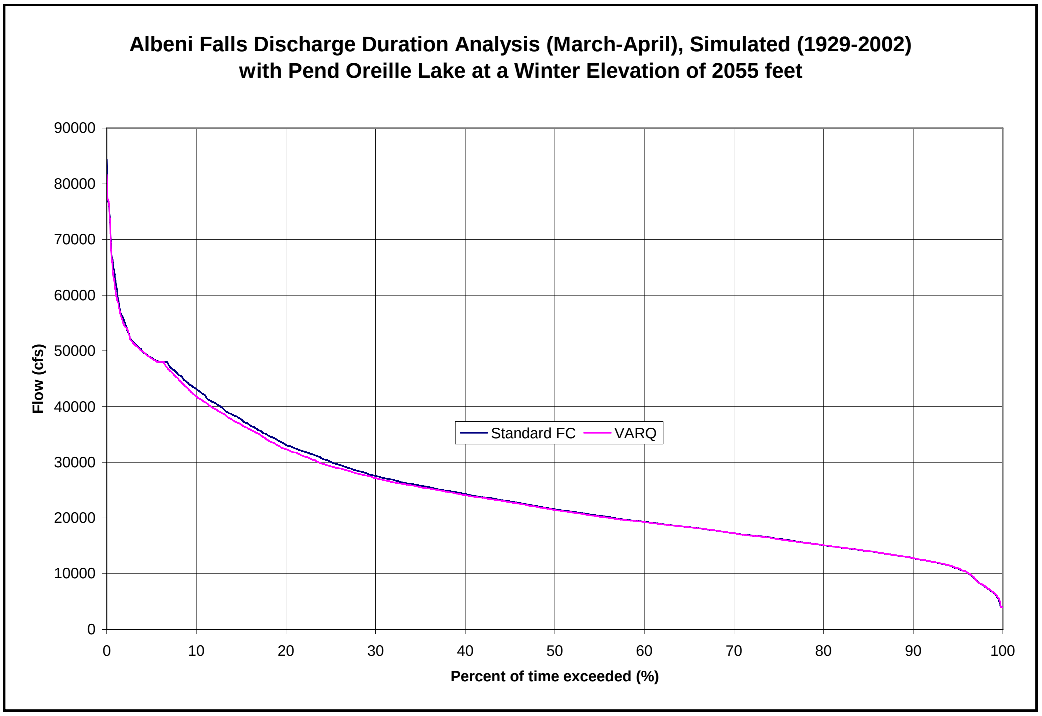

Figure 4-25. Simulated Albeni Falls Dam release duration curves for March-April (winter target elevation 2055 feet), HS (Standard FC), HV

with flooding can occur at Cusick, Washington if flows in excess of 43,000 cfs are passed through Lake Pend Oreille. Figure 4-25 is a duration analysis for Albeni Falls releases (March-April). Flows below Albeni Falls Dam are slightly lower with HV.

Flows exceed 43,000 cfs about 9 percent of the time for HV and about 10 percent of the time for HS during the period March 1-April 30. In relation to the field drainage issue, this is the period of most concern to farmers near Cusick.

Figure 4-26 is a duration analysis for Albeni Falls releases (May-June). Flows are slightly higher for HV when compared to HS.

Flooding below Albeni Falls Dam in June is due to spring snowmelt, and is a relatively common occurrence happening historically about one year in four. The National Weather Service issues flood warnings when the releases from Albeni Falls Dam are expected to exceed 100,000 cfs. The peak 1-day flow frequency analysis for the Pend Oreille River below Albeni Falls Dam is shown in Figure 4-27 for HS and HV simulations. No significant differences exist between the two flood control simulations when comparing years with peak flows above flood stage. The annual peak flow exceeded 100,000 cfs about 27 percent of the time for HS and HV[57].

[57] Figure 4-27 indicates there would be increased flooding below Albeni Falls Dam in an extreme high water year. Hungry Horse Dam is not typically operated to reduce flooding at Albeni Falls Dam; however, in extreme water years operations would be coordinated through inseason management to minimize downstream impacts.

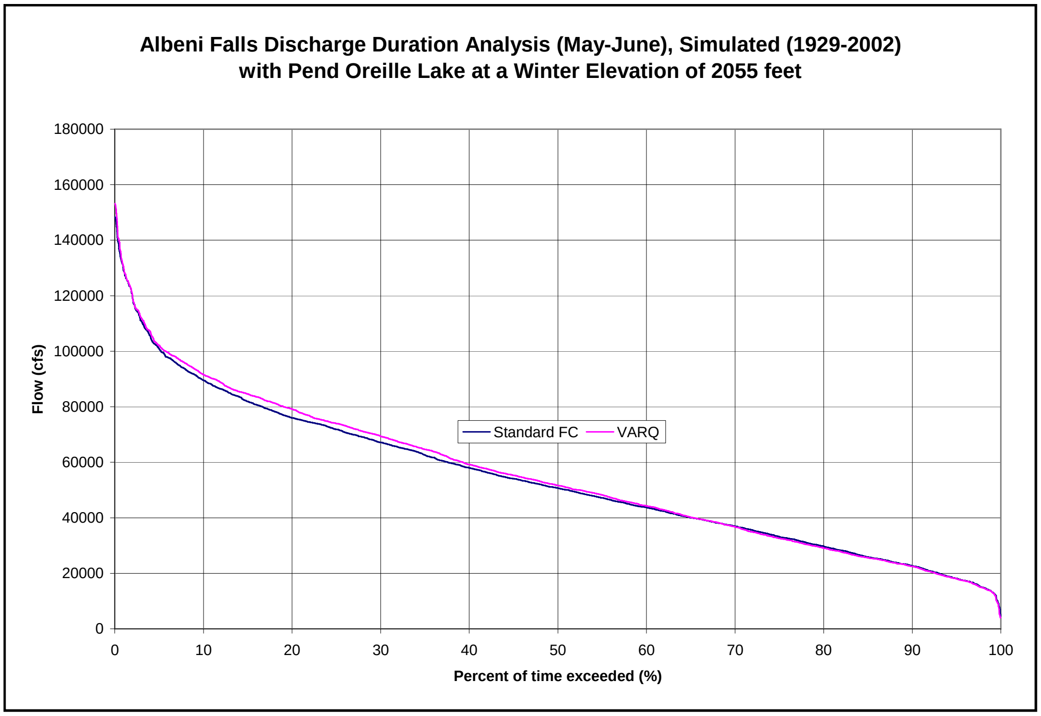

Figure 4-26. Simulated Albeni Falls release duration analysis for May-June (winter target elevation 2055 feet), HS (Standard FC) and HV (VARQ FC).

Winter Target Elevation (2051 feet)

For a winter target elevation of 2051 feet at Pend Oreille Lake, average monthly releases at Albeni Falls Dam are shown in Figure 4-28. Releases are slightly higher in June and lower in January, February, and April for HV.

Figure 4-29 is a duration analysis for Albeni Falls releases (March-April). Flows below Albeni Falls Dam under HV are slightly lower than under HS. Flows exceed 43,000 cfs about 6 percent of the time for both HV and HS during the period March 1-April 30. The duration analysis for Albeni Falls releases (March-April) is also shown for a winter target elevation of 2055 feet (for Lake Pend Oreille) on the same graph. This comparison shows that there is a noticeable effect on Albeni Falls Dam March-April releases between the two different winter target elevations. The extra four feet of space, in the winter target of 2051 feet analysis, translated into decreased flows during March and April. The difference between HV and HS is insignificant in either winter target scenario.

Figure 4-30 is a duration analysis for Albeni Falls releases (May-June) for the winter target elevation of 2051 feet. Flows are slightly higher for HV when compared to HS.

Results using a winter target elevation of 2055 feet were essentially the same.

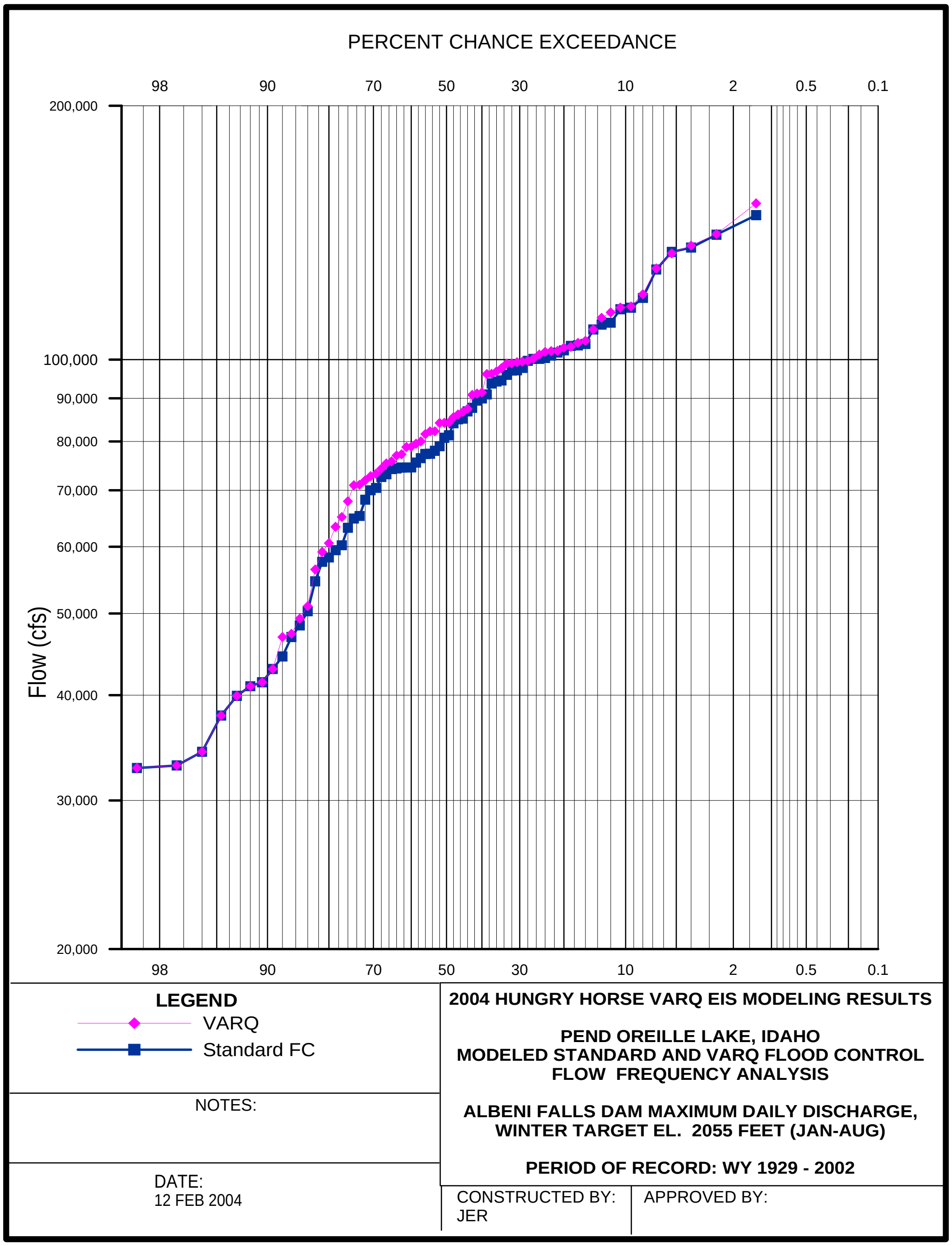

Figure 4-27. Peak 1-day flow frequency curves for Pend Oreille River below Albeni Falls Dam winter target elevation 2055 feet, HS (Standard FC) and HV (VARQ FC).

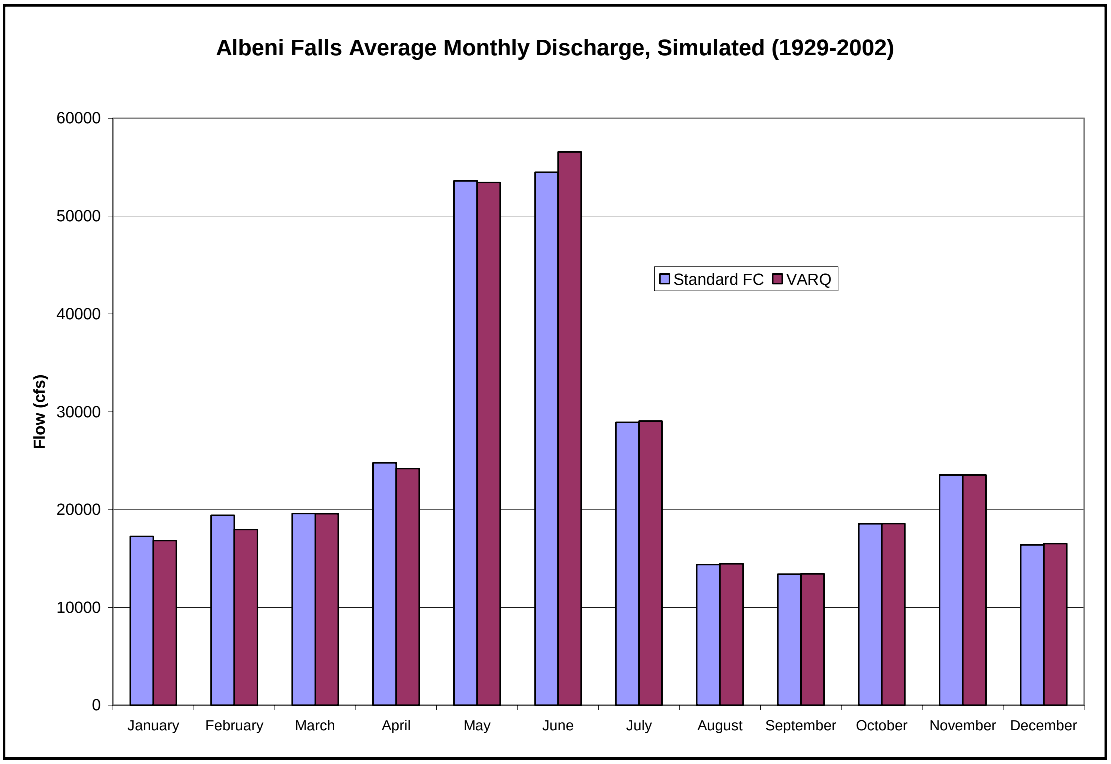

Figure 4-28. Simulated Albeni Falls Dam average monthly releases (winter target elevation 2051 feet), HS (Standard FC) and HV (VARQ FC).

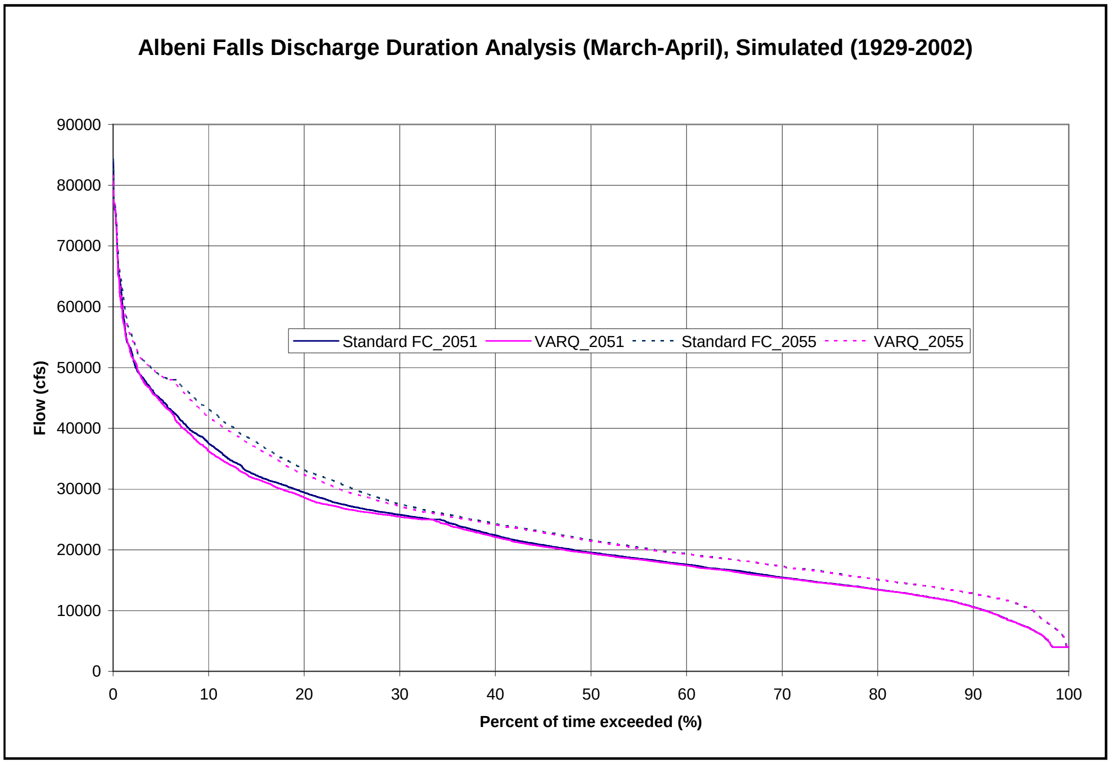

Figure 4-29. Simulated Albeni Falls Dam duration curves for March-April, both winter target elevations of 2051 feet and 2055 feet, HS (Standard FC) and HV (VARQ FC).

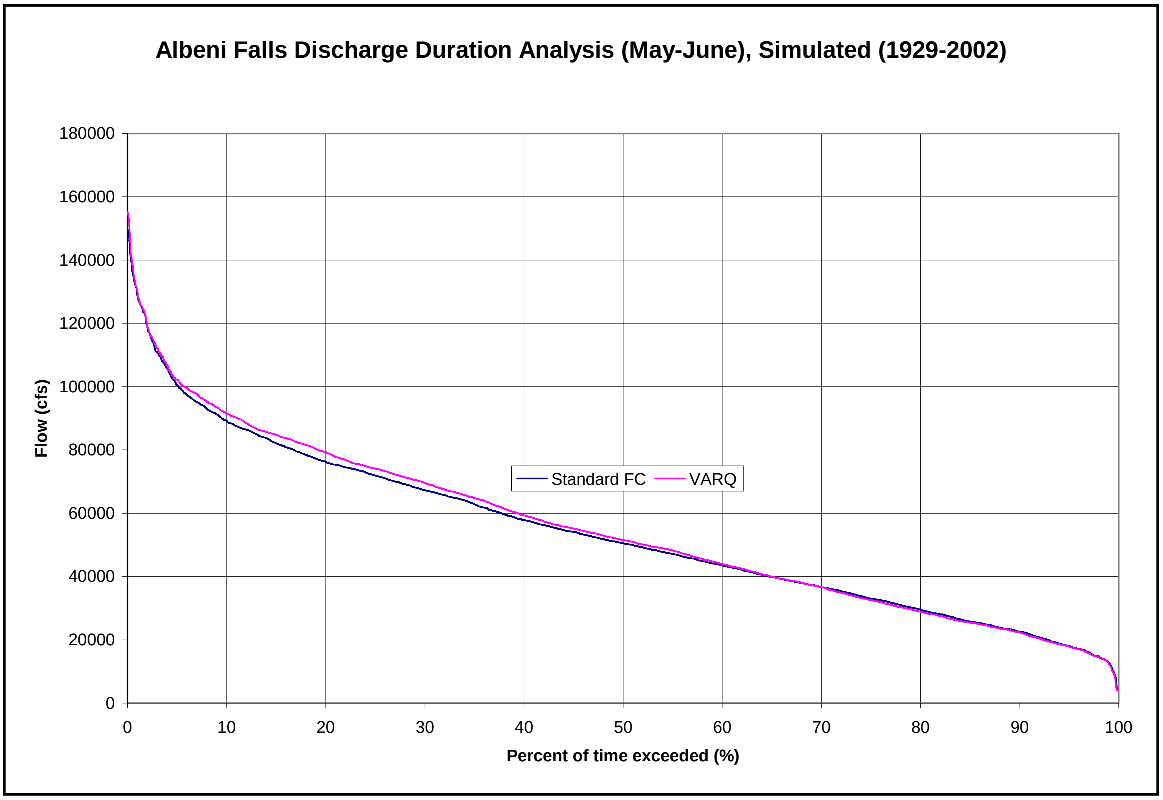

Figure 4-30. Simulated Albeni Falls Dam release duration curves for May-June (winter target elevation 2051 feet), HS (Standard FC) and HV (VARQ FC).

Figure 4-31 shows the peak 1-day flow frequency analysis for the Pend Oreille River below Albeni Falls Dam for HS and HV simulations. No significant differences exist between the two flood control simulations when comparing years with peak flows above flood stage. The annual peak flow exceeded 100,000 cfs about 27 percent of the time for HS and HV, essentially the same result as in target elevation of 2055 feet.

The Pend Oreille River from Albeni Falls Dam to the confluence with the Columbia River passes through several run-of-river projects. These projects include the Box Canyon and Boundary projects which are located in the United States and the Seven mile and Waneta projects which are located in British Columbia, Canada. Differences in flows through these projects due to HV at Hungry Horse are minor. The Canadian section of the Columbia River Treaty Operating Committee (BC Hydro) has reviewed the impacts of implementing the VARQ flood control plan at Hungry Horse and has concluded that these impacts appear to be insignificant to power production in Canada. The Corps conducted a power study which analyzed the impacts due to the implementation of VARQ FC at Libby and Hungry Horse Dams. In this analysis, simulated flows through Box Canyon and Boundary Dams were calculated for HS and HV.

Figure 4-32 and Figure 4-33 show average monthly releases for Box Canyon and Boundary Dams for alternatives HS and HV at Hungry Horse. Note that there are only minor differences between HS and HV.

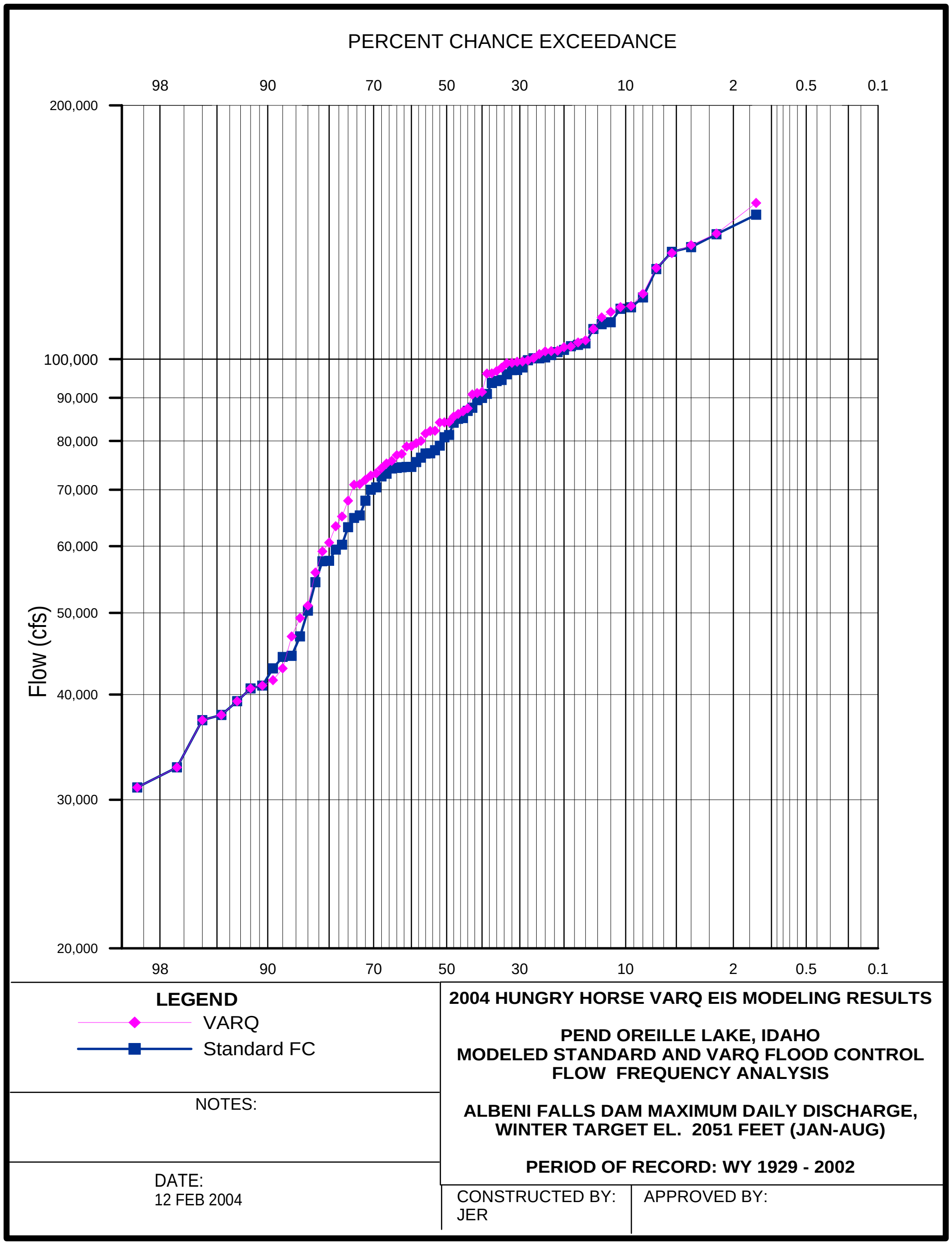

Figure 4-31. Peak 1-day flow frequency curves–Pend Oreille River below Albeni Falls Dam (winter target elevation 2051 feet), HS (Standard FC) and HV (VARQ FC).

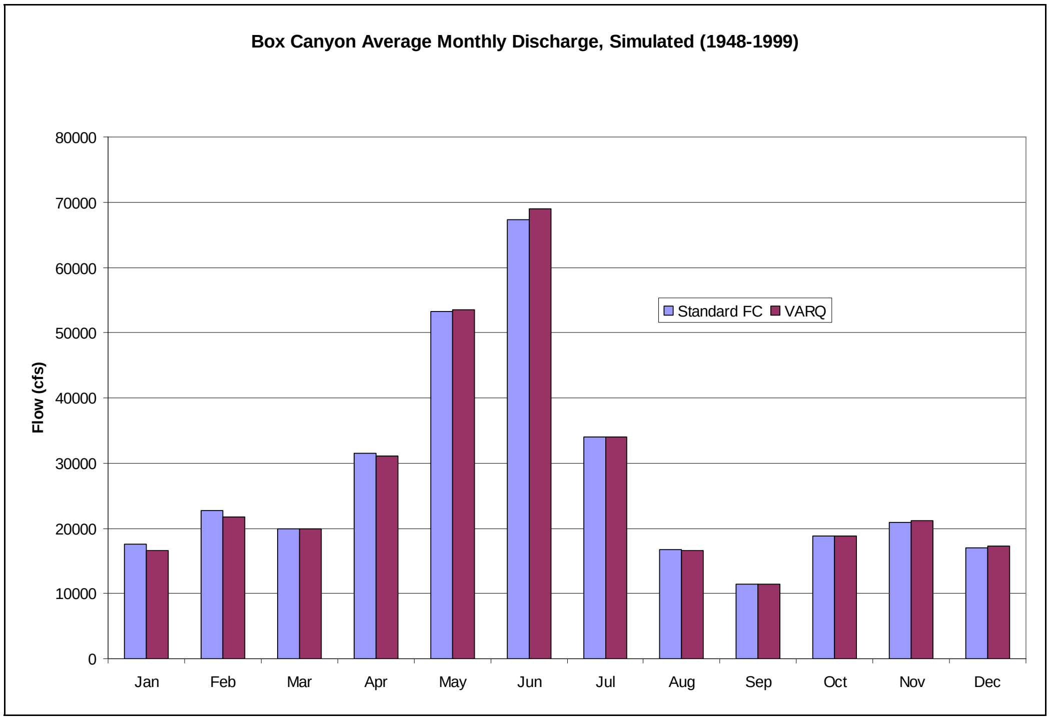

Figure 4-32. Box Canyon Dam average monthly releases, simulated (1948-1999), HS (Standard HS), HV (VARQ FC).

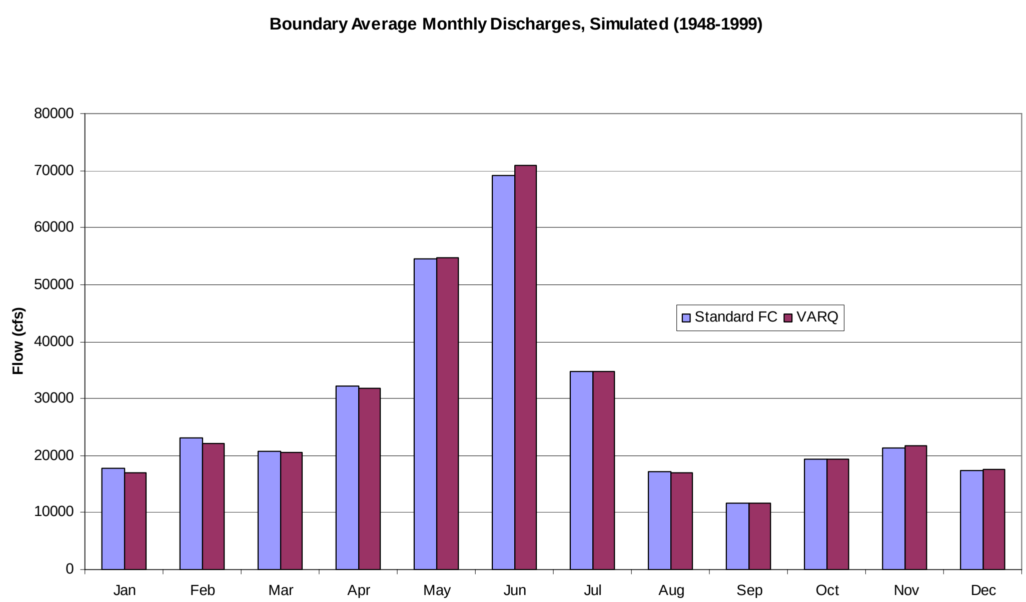

Figure 4-33. Simulated Boundary Dam average monthly releases, HS (Standard FC) and HV (VARQ FC).

Summary

The hydrologic analysis of HV at Hungry Horse Dam has shown that there are only small impacts to reservoir elevations and river flows when compared to HS. This is true not only at Hungry Horse Reservoir but also at all points from Hungry Horse Dam downstream to the confluence of the Pend Oreille and Columbia Rivers.

Refill probabilities are slightly higher at Hungry Horse Reservoir and at Flathead Lake under HV. Flathead Lake also can stay full a little longer in the summer under HV. The releases from Hungry Horse under the HV rule curves are generally higher in May and June and lower in April when compared to HS. These releases are reflected in the release patterns at Kerr and Albeni Falls Dams where flows are slightly higher in June and slightly lower in April under HV.

There is no increase in the occurrence of flooding on the Flathead River at Columbia Falls, Montana, under HV. The river stage at Columbia Falls exceeded 14 feet a total of 35 days in 14 different years for both HV and HS. HV resulted in slightly lower flows in the Pend Oreille River below Albeni Falls Dam during the March-April time period when flooding at Cusick, Washington, can be a problem. Flows in the Pend Oreille River below Albeni Falls Dam are slightly higher in June under HV when high flows from snowmelt can cause flooding problems, but the frequency of exceeding the flood warning threshold of 100,000 cfs is essentially the same for HV or HS. Differences in flows in the Pend Oreille River from Albeni Falls Dam to the confluence with the Columbia River are fairly insignificant when comparing HV to HS.

4.3.2 Water Quality

Introduction

The primary water quality concern associated with alternative HV is TDG supersaturation. This is due to the occurrence of spill at the dams during certain times of the year. Other basin water quality issues are nutrients and sediment. A brief discussion of potential affects to TDG, nutrients, and sediment water quality parameters follows.

Total Dissolved Gas

When the total release of water is greater than the hydraulic capacity of hydropower facilities, spill results as the excess. Spill is typically the primary contributor of TDG supersaturation in a hydro-modified system. Spill causes an increase in the TDG levels because the spilled water forces gas from the surrounding environment into solution. This creates more dissolved gas in the water which, at high levels, may significantly affect aquatic organisms. The biologic effect on fish when TDG levels are excessive includes gas bubble disease, which is a condition similar to the “bends” in human divers.

Due to the potential adverse affect on fish as a result of increased TDG levels, Montana, Idaho, and Washington have set the water quality criterion for TDG at 110 percent saturation. It has been determined that at levels much above the 110 percent criterion for extended periods of time, fish are susceptible to gas bubble disease. TDG saturation can persist from one location to the next in large rivers with multiple spill sources such as the Clark Fork and Pend Oreille Rivers.

To determine the water quality effects of HV in the Pend Oreille River basin from Hungry Horse to Albeni Falls, data obtained from the Corps (2004) and Reclamation (2004) were utilized. The Corps provided monthly flow, elevation, generation, and spill data over a 52-year period and Reclamation provided spill data from Hungry Horse Reservoir to Albeni Falls Dam utilizing similar modeling techniques over a 74-year period.

To determine the water quality effects of HV on Box Canyon, Boundary, Waneta, and Seven Mile Dams, 1985 to 2002 flow and spill data were acquired from the Corps and Pend Oreille PUD.

Hungry Horse Reservoir

Figure 4-34 shows a TDG/spill correlation developed by Reclamation using 1996 and 1997 winter/spring data and 2002 summer data. The figure suggests that if spill as a percent of total flow remains less than 21 percent, the TDG level would remain within the 110 percent criterion (Roache 2004). As shown in Table 4-20, the percent of days when spill is expected to result in greater than 110 percent TDG at Hungry Horse Dam is rare except for the month of June. Spill would result in greater than 110 percent TDG 1-percent of the time in June under HV and not at all under HS. These percentages take into account the 380 MW transmission restriction at Hungry Horse Dam.

At Hungry Horse Dam, TDG has been monitored by Reclamation through instrumentation since 1998. During this time period, the TDG has remained within Montana's TDG criteria of 110 percent as shown in Figure 4-34. This is likely to continue under HV since the spill as a percent of total flow is negligible and generally lower than HS.

Table 4-20. Percent and (number) of days when spill is expected to result in greater than 110 percent TDG for the period modeled (1929-2002).

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Hungry Horse Dam												
HS	0	0	0	0	0	0	0	0	0	0	0	0
HV	0	0	0	0	0	0	0	0	0	<1(1)	1(21)	0

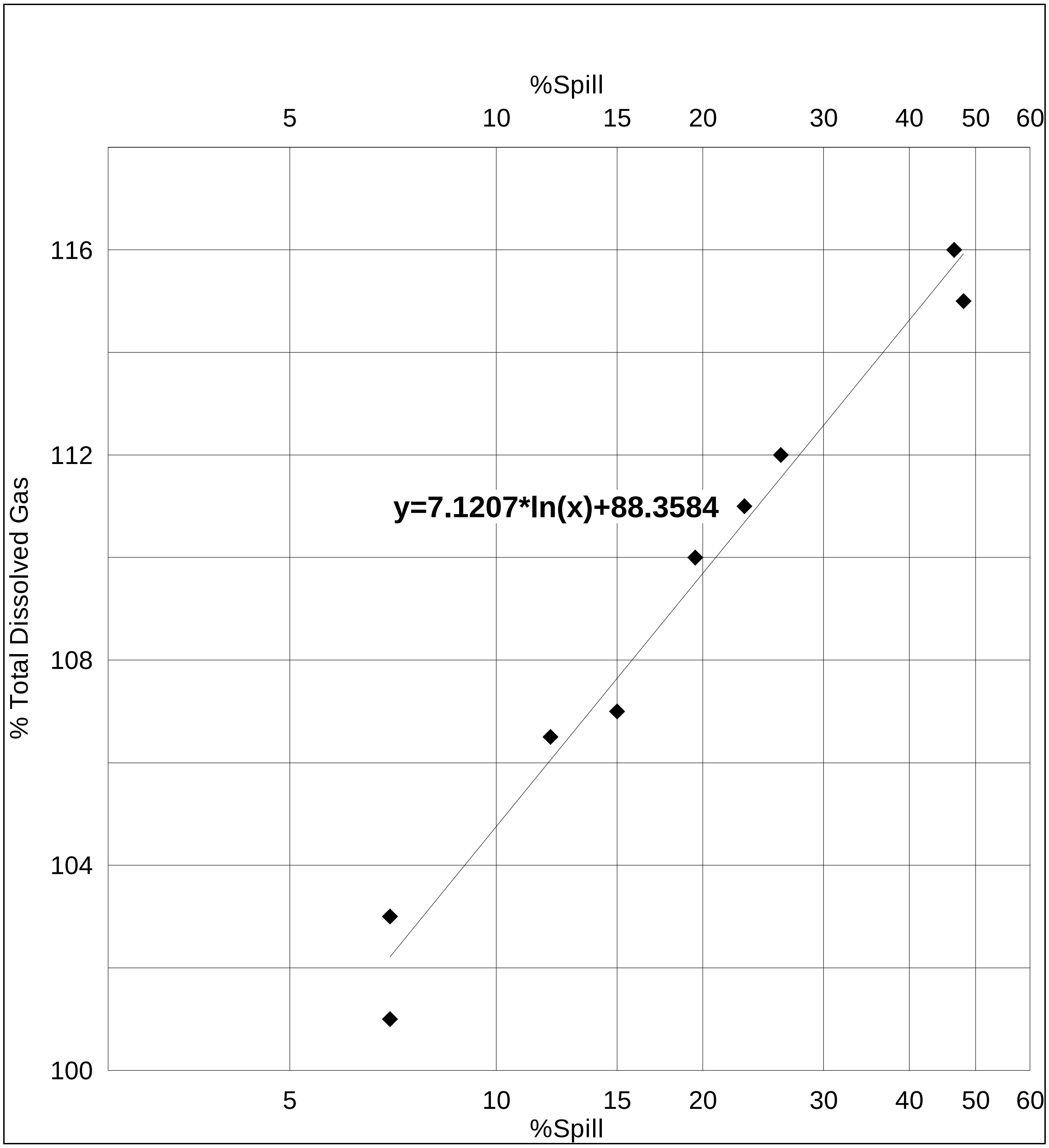

Figure 4-34. Evaluation of spill levels as it relates to TDG levels at Hungry Horse Reservoir.

TDG saturation modeling based on the effects of HV flows was not possible below Hungry Horse Dam because sufficient data were not available. To analyze the effects of HV below Hungry Horse Dam, spill volume was used as a surrogate for TDG saturation, which is based on the premise that TDG saturation below dams is generally higher during spill events than nonspill events. The power plant hydraulic capacities listed in Table 4-21 were used to estimate the percent spill. These hydraulic capacities are estimates based on historical information, but there may be some variability among these values due to different levels of power plant activity.

Table 4-21. Estimated powerhouse hydraulic capacities used for TDG analysis.

Facility	Hydraulic Capacity (cfs)
Kerr	14,000
Thompson Falls	23,000
Noxon Rapids	51,000
Cabinet Gorge	38,000
Albeni Falls	33,000
Box Canyon	29,000
Boundary	55,000
Seven Mile	38,000
Waneta	25,000

Source: Reclamation 2004

Kerr Dam

As shown in Table 4-21, Kerr Dam has a small hydraulic capacity. The total percent of days that spill occurs decreases slightly under HV (Table 4-22). However, most of the spill occurs during the peak months of May through July and the number of days with spill under alternative HV actually increases slightly during this period. The spill is close to 50 percent of the total flow in June under HS and HV. Thus, any additional spill beyond these flows could increase TDG levels below Kerr Dam, although this is not likely to occur solely as a result of HV.

Table 4-22. Percent of days with spill for the period modeled (1929-2002).

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Annual
Kerr Dam													
HS	5	0	1	2	2	23	28	2	20	64	66	50	22
HV	5	0	1	2	4	18	16	3	13	65	70	51	21
Thompson Falls Dam													
HS	12	0	1	2	3	14	16	6	37	89	85	42	25
HV	12	0	0	2	4	11	10	6	33	86	85	43	23
Noxon Rapids Dam													
HS	0	0	0	0	0	0	0	0	3	37	35	3	6
HV	0	0	0	0	0	0	0	0	2	39	40	3	7
Cabinet Gorge Dam													
HS	0	0	0	0	0	1	1	0	11	59	61	14	12
HV	0	0	0	0	1	1	0	0	9	60	63	13	12
Albeni Falls Dam													
HS	0	0	1	3	3	5	6	4	34	79	70	32	20
HV	0	0	1	3	3	4	5	4	32	77	71	33	19

Source: Reclamation 2004

Thompson Falls Dam

The hydraulic capacity of Thompson Falls is relatively small compared to other Clark Fork Projects (Table 4-21). The spill as a percent of total flow is slightly higher for Thompson Falls Dam than for Kerr Dam during the May-July time period. There are slightly higher proportions of spill through the year under HV, although, the percent of days with spill under HV is slightly less than that of HS (Table 4-22). This suggests there would be a small increase in TDG saturation levels with the implementation of HV.

Noxon Rapids and Cabinet Gorge Dams

Spill as a percent of total flow for Noxon Rapids and Cabinet Gorge Dams increases slightly in June under HV, but only slightly more than HS. The percent increase is 1.06 percent and 1.79 percent, respectively. Noxon Rapids has the largest hydraulic capacity of the Clark Fork projects.

It has been suggested that if the spill rate is greater than 8,000 cfs at Noxon Rapids and Cabinet Gorge Dams, there is potential to exceed the 110 percent Montana maximum TDG criterion (Sullivan *et al.* 2002). The percent of days with any spill and the percent of days with spill greater than 8,000 cfs increases slightly under alternative HV in May and June at both sites (Table 4-22 and Table 4-23). Therefore, implementation of HV flood control could result in slightly more frequent exceedances of Montana's TDG standard at Noxon Rapids and Cabinet Gorge Dams.

Table 4-23. Percent of days with spill greater than 8,000 cfs for the period modeled (1929-2002).

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Noxon Rapids Dam												
HS	0	0	0	0	0	0	0	0	2	25	27	2
HV	0	0	0	0	0	0	0	0	1	27	29	2
Cabinet Gorge Dam												
HS	0	0	0	0	1	0	0	0	5	46	44	6
HV	0	0	0	0	1	0	0	0	4	47	49	6

Source: Reclamation 2004

Albeni Falls Dam

The difference in spill as a percent of total flow between HS and HV at Albeni Falls is minimal. The percent of days when spill occurs increases slightly with HV during the peak months from June to July, but decreases on an annual basis. Overall, the effects of HV on spill are negligible, suggesting that current TDG levels would not be appreciably affected (Table 4-22).

Box Canyon and Boundary Dams

As shown in Table 4-24, the implementation of HV at Box Canyon would result in a minimal change in the percent of days with spill for the months of June through December. For the months of January through May, the percent of days with spill would decrease slightly under HV. However, while there is very little change in the percent of days with spill from an annual standpoint, the actual volume of spill during the month of

June is notably higher under HV. Box Canyon would spill an average 2,820 cfs more during the month of June. While not quantifiable, this increase in spill may result in additional TDG generation below the dam.

Similar to Box Canyon, there is very little change in the percent of days with spill at Boundary under HV (Table 4-24). The only detectable changes occur during the months of April and June, with the changes being a slight decrease in April and a slight increase in June. However, as with Box Canyon, the actual volume of spill at Boundary would notable increase in June. Boundary would spill an average 1,345 cfs more during the month of June. While not quantifiable, this increase in spill may result in additional TDG generation below the dam.

Table 4-24. Percent of days with spill at Box Canyon and Boundary Dams for the period modeled.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Annual
Box Canyon Dam													
HS	1	0	2	14	6	10	12	18	48	84	63	35	24
HV	1	0	2	14	7	9	9	16	46	82	63	35	24
Boundary Dam													
HS	0	0	0	0	1	0	2	0	6	33	33	5	7
HV	0	0	0	0	1	0	2	0	4	33	35	5	7

Waneta and Seven Mile Dams

The change in the percent of days with spill at Seven Mile and Waneta Dams as a result of implementing HV is minimal (Table 4-25), with the greatest change occurring in April for Seven Mile (3 percent) and February for Waneta (6 percent). In most months there is no net change in the percentage or the change is only 1 percent. However, similar to Box Canyon and Boundary, while there is very little change in the percent of day with spill from an annual standpoint, the actual volume of spill during the month of June is notably high under HV at both dams. Seven Mile Dam would spill an average 1,704 cfs more during the month of June while Waneta Dam would spill an average 1,750 cfs more. While not quantifiable, these increases in spill may result in a change in TDG levels below each dam.

Table 4-25. Percent of days with spill at Seven Mile and Waneta Dams for the period modeled.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Annual
Seven Mile Dam													
HS	0	3	1	4	4	3	5	7	34	76	58	25	18
HV	0	3	1	4	5	2	5	6	31	74	59	25	18
Waneta Dam													
HS	4	1	10	31	10	19	27	31	67	94	77	48	35
HV	4	1	10	31	11	19	21	30	66	93	76	48	34

Summary

Spill analysis indicates that implementation of HV could result in increases in TDG saturation levels from May through July in the Pend Oreille River basin. Changes in the saturation levels are not quantifiable with the available data, but appear to be minor in most instances

Sediment and Nutrients

The change in release timing from Hungry Horse Reservoir under HV would affect the transport and delivery dynamics of sediment and nutrients in the riverine segment of the Flathead River between Hungry Horse Dam and Flathead Lake. Below Flathead Lake (beginning at Kerr Dam) the monthly hydrograph is very similar under HV and HS (Roache 2004) and; therefore, the sediment and nutrient transport dynamics in these segments would not likely be affected and further discussion is not necessary.

The primary transport mechanism for water column sediment is surface water flow. Higher flows transport larger amounts of sediment with a wider range of particle sizes and weights. The size distribution is based on the volume of flow and the flow power. Alternatively, lower flows transport lighter, smaller particle fractions. Sediment particles are deposited in areas where flows and velocity decrease. Sediments fall out of suspension proportionately with size and weight distributions. This is why the substrate material in pool and glide habitats are typified by smaller materials than in riffle and run habitats, which often contain enough power to keep sediments in suspension.

The primary mechanism for nutrient transport is surface water flow. Nutrients can be partitioned into multiple fractions, including dissolved fractions in the water column or adsorbed fractions onto the surface of sediment particles or organic matter. Typically, fine sediments have the highest capacity for adsorbing nutrients. Fine sediments also have the capacity to be transported long distances before they leave suspension. Once deposited, fine sediment particles can act as a source of phosphorus enrichment.

On average, flows in the South Fork Flathead River are expected to be lower under HV than HS in January, February, and April by 17 percent, 21 percent and 37 percent, respectively. As described above, lower flows generally result in seasonally reduced sediment and nutrient transport. Similarly, as flows under HV are expected to increase by 65 percent in May and 39 percent in June, there would likely be a related seasonal increase in sediment and nutrient transport during this period.

The changes in transport dynamics described above would alter the current sediment and nutrient loading rate at any given time and point in the river and would also change the seasonal loading rates to Flathead Lake. Additionally, the change in transport dynamics under HV may alter some of the ecological factors in the river, depending on how the factors interact with the addition or loss of sediment and nutrients. Examples of the ecological factors that may be affected include, but are not limited to algal and other aquatic plant growth dynamics, the feeding behavior of aquatic life, and the distribution of aquatic life within habitat units. While these and possibly other ecological factors are expected to change somewhat under HV, sediment and nutrient transport remains less of an issue than TDG saturation. Modeling efforts (Appendix D) found that HV operations generally increased the benthic biomass production in the Flathead River because the natural temperature regime and physical properties of the river are more closely mimicked.

4.3.3 Aquatic Life

Please see Appendix D for detailed discussion of the methodology and results of biological modeling including graphs and tables. Appendix D terminology uses BASE and VARQ in the text and on the figures. In all cases BASE refers to the no action alternative (HS) and VARQ refers to the action alternative (HV). Study results and their interpretations are summarized here. Nine representative years were analyzed; three each in above average (wet) (1932, 1943, 1952), average (1979, 1981, 1993), and below average (dry) (1937, 1969, 1980).

Physical characteristics of the environment, such as reservoir contents and streamflow, determine the limits of fish survival, growth, and reproduction. The basic assumption is that reservoir contents and streamflows are linked to fish habitat, and fish habitat is linked to fish populations. This analysis emphasizes basinwide impacts.

The indicators used to evaluate impacts to fish were biological productivity in the reservoir biota and impacts to Hungry Horse Reservoir fish and biological productivity in the Flathead River. Model outputs for Hungry Horse Reservoir provide estimates of primary productivity, zooplankton production, benthic insect production, terrestrial insect deposition, and cutthroat trout growth. Model outputs for the Flathead River downstream from Hungry Horse Dam provide indices of benthic biomass productivity between the biologically productive months of March through September.

Hungry Horse Reservoir

Primary Production

Primary production by reservoir phytoplankton (microscopic drifting plants) refers to the conversion of light and nutrients into organic carbon and resulting phytoplankton growth and biomass. The biological model is sensitive primarily to reservoir surface area, volume, and water temperature at different depths in the reservoir. Primary production was quantified as the number of metric tons of organic carbon for each alternative as shown in Appendix D, figure 25. Washout of phytoplankton through Hungry Horse Dam was quantified as the number of metric tons for each alternative, as shown in Appendix D, figure 26.

When compared to the no action alternative (HS), the action alternative (HV) resulted in greater phytoplankton production during 7 of 9 water years modeled.

Model results for loss of phytoplankton through the dam turbines, however, differed very little between the alternatives because the selective withdrawal was automated (depth of withdrawal constant) the same way in all alternatives.

Zooplankton Production

Zooplankton are drifting animals that consume primarily phytoplankton and, in turn, are eaten by animals higher in the food web. Once produced, zooplankton survive in the reservoir for an indefinite period until they are eaten by predators (e.g., fish or other invertebrates), die from natural causes and sink, or are lost through the dam. Enough individuals survive through fall and winter that zooplankton provide the primary winter food for fish species that do not prey on fish (including westslope cutthroat trout and juvenile bull trout). The alternative operation which would maximize surface area and volume during summer would produce the most zooplankton; food availability is largely controlled by reservoir surface area and volume during the productive summer months. Zooplankton production was quantified as the number of metric tons of zooplankton produced for each alternative as shown in Appendix D, figure 28.

Model results indicated that alternative HV produced slightly more zooplankton (*Daphnia*) during 7 of 9 water years at Hungry Horse Reservoir. Zooplankton densities in Hungry Horse Reservoir were low compared to Lake Koocanusa. These low densities are likely a result of zooplankton lost through the selective withdrawal device. Zooplankton washout losses can be managed to a limited extent using the selective withdrawal system at the dam. Such control would be beneficial because zooplankton production is very low in Hungry Horse Reservoir due to oligotrophic nutrient conditions.

Zooplankton loss through Hungry Horse Dam was slightly higher under HV during 6 of 9 simulated water years. As a result of selective withdrawal, zooplankton washout was most sensitive to release volume, especially during summer.

Benthic Insect Production

Many insects lay their eggs in water, with early life stages (larvae) residing primarily on or close to the reservoir bottom after hatching. They are important to aquatic ecosystems and serve as food sources for many fish. Larger, long-lived species dominate the permanently wetted zone, whereas the varial zone contains mainly small, short-lived species. Larvae recolonize previously dewatered substrates as the reservoir fills, and shoreline areas are dominated by dipterans (flies) that produce several populations throughout the warm summer months. In reservoirs, annual production of benthic insects is controlled by the duration and depth of substrate inundation as the reservoir refills and drafts. Benthic insect production was quantified as the number of metric tons of benthic production for each alternative as shown in Appendix D, figure 31.

The HV alternative produced more benthos than the HS alternative during 7 of 9 simulated water years, likely a result of less drafting for flood control and higher reservoir levels during the summer and early fall. Benthic insects are the primary food item for westslope cutthroat trout during spring.

Terrestrial Insect Deposition

There are four orders of terrestrial insects: Hymenoptera (bees and wasps), Hemiptera (true bugs such as water boatmen, backswimmers, water striders, leaf bugs, assassin bugs), Homoptera (includes cicadas, leafhoppers, aphids, scales), and Coleoptera (beetles). Terrestrial insects that fall into the water are another important source of food for fish.

Terrestrial insect deposition is greatest when the reservoir is full and, therefore, closest to shoreline vegetation where the insects are found. Of the four orders of terrestrial insects captured in nearshore (less than 100 meters) and offshore surface tow samples, bees and wasps were the most abundant by weight in surface tow samples and by numbers in fish stomach contents in Hungry Horse Reservoir. During each simulation, the model calculated insect deposition as the percentage of the maximum possible deposition if the reservoir remained at full pool when each insect order is active. Terrestrial insects deposited and trapped on the surface of Hungry Horse Reservoir are the primary food source for insectivorous fish between late-June and mid-November, or when freezing weather ends most terrestrial insect activity.

Results were calculated for Hymenoptera, Hemiptera, Homoptera, and Coleoptera. Of the four insect orders, only the deposition of Coleoptera would differ between the two alternatives (see Appendix D, figure 33). The Action alternative (HV) would trap as many or more beetles than the No Action alternative (HS) during 7 of 9 simulated water years. This is primarily due to higher reservoir levels, which lead to greater reservoir surface area and the water's edge being closer to fringing shoreline vegetation. The HS alternative would result in greater reservoir drawdown during all years except 1937 when the alternatives did not differ. Deep drawdown slows the reservoir refill process, so the surface area remains smaller and further from shoreline vegetation and fewer beetles are trapped on the surface.

Westslope Cutthroat Trout Growth

Trout growth is controlled primarily by water temperature and food availability. Little growth occurs when water temperature is less than 6˚ C or greater than 18˚ C. Annual growth calculations at age III, IV and V were calculated for each water year, and then summarized in length (millimeters). Results are shown in Appendix D, figure 35.

Model results revealed slightly higher growth for all three age classes of westslope cutthroat trout under HV conditions in 5 of 9 simulated water years. During the three average years (1979, 1981, 1993) and the lower-two high-water years (1932, 1952), results indicated that HV would produce greater food production in the lower trophic levels due to the large volume of reservoir at optimal water temperatures.

South Fork Flathead River

Flood control operations limit high spring flows and result in physical changes to river morphology. Control of periodic flood events removes the hydraulic energy required for channel maintenance and sorting of river sediments. This generally occurs during spring runoff on average or greater water years. Under regulated conditions, frequent flow fluctuations cause extensive bank instability and erosion as water repeatedly flows into and out of the banks. Excess sediments increase substrate embeddedness and reduce interstitial habitat required by aquatic insects.

Since 2000, ramping rate practices consistent with the 2000 USFWS FCRPS Biological Opinion have helped reduce rapid flow fluctuations from Hungry Horse Dam.

Modeling calculated the amount of benthic biomass in separate reaches for the South Fork Flathead River immediately downstream from Hungry Horse Dam and the mainstem Flathead River at Columbia Falls, Montana. Operations that limit flow fluctuations and dewatering of productive substrate generally enhance benthic biomass production. For each water year, model output totaled benthic biomass units for the year, as shown in Appendix D, figure 46 and figure 48.

The effect of hydropower operations is most apparent in the South Fork Flathead River immediately downstream from Hungry Horse Dam. Inflowing water from the unregulated North Fork and Middle Fork of the Flathead River and the Stillwater River progressively moderates the influence of dam operation with distance downstream. There would be an increasing trend in benthic biomass with increasing water availability (Appendix D, figure 46).

Benthic biomass production under the HV alternative was equal to or greater than HS during 7 of 9 simulated water years. Results indicated the HS alternative would provide more favorable conditions for benthic production during 1980 and 1993. Alternatives that provided stable flows during the productive warm months produced more benthic biomass units during the water year.

Flathead River at Columbia Falls

Unregulated inflows from the Middle Fork and North Fork Flathead River dilute and mask the effects of short-duration operational changes. The effects of Hungry Horse Dam operations on river biota (Appendix D, figure 48) would be moderated by minimum flows established for the South Fork and the annual minimum flow limit at Columbia Falls (3,500 cfs). Since HS and HV alternatives adhere to these limits, the depth zones protected by minimum flows remained productive under both alternatives. The HV alternative produced slightly more benthic biomass than the HS alternative in 5 of 9 simulated water years.

Flathead Lake

Modeling results for the effects of HS and HV alternatives on Flathead Lake were very similar, particularly during water years with medium-low to medium-high water availability. Implementation of HV may result in minor benefits to aquatic resources associated with riparian areas and wetlands owing to the slightly higher probability of refill at Flathead Lake. Otherwise, no discernible effects to aquatic resources are expected. Marotz and Althen (2004) found that the influence of VARQ FC on the Flathead Lake fishery was minimal over the range of modeled flows.

Kerr Dam to the Columbia River

No discernible effects to aquatic resources are expected to occur downstream from Kerr Dam to the Columbia River.

Summary

Implementation of alternative HV would likely benefit resident fish, especially those in Hungry Horse Reservoir and immediately downstream from Hungry Horse Dam in the Flathead River. Releases would follow a more normative hydrograph and be higher in March, May, and June.

4.3.4 Sensitive, Threatened and Endangered Species

With the exception of bull trout, effects to threatened and endangered species in the Pend Oreille River basin from the operation of the FCRPS, which includes Hungry Horse Dam, either are not likely to occur or would be very minor (USFWS 2000). Based on consideration of direct and indirect effects from continued operation of the FCRPS (including implementation of alternative HV at Hungry Horse Dam), the USFWS (2000) determined endangered and threatened species are not likely to be adversely affected. Specifics on the possible effects, even if minor, are discussed below.

Bull Trout

Hungry Horse Reservoir

Effects on bull trout were assessed using the biological modeling discussed in Aquatic Life, section 4.3.3 as the primary basis. Operations which improve biological productivity for resident fish are considered beneficial to bull trout as well.

Based on model analyses of biological responses to HS and HV flood control strategies, HV operations would generally result in improved biological conditions in the Flathead River downstream from Hungry Horse Dam that would subsequently benefit bull trout. HV also would improve biological conditions in Hungry Horse Reservoir compared to the HS alternative during most years. Reservoir biota benefit when the annual reservoir drawdown is reduced, thus increasing feeding opportunities for overwintering bull trout, and those that remain in the reservoir year round.

Hungry Horse Dam to Flathead Lake

Under the HS alternative, consequences on bull trout would be no different from those identified for general aquatic species.

Under the HV alternative, in addition to benefits identified for general aquatic species (which would benefit bull trout), higher flows during May and June would help adult bull trout access smaller streams for foraging and spawning.

Flathead Lake to Columbia River

Bull trout would experience similar conditions as identified under general aquatic species for the HS and HV alternatives.

Bald Eagle

The bald eagle nesting, roosting, and feeding habitats along the rivers and other water bodies influenced by ongoing flood control operations at Hungry Horse Dam generally have been in place since flood control and other water management operations were implemented at Hungry Horse (1953), Kerr Dam (1938), and Albeni Falls Dam (1955). Some minor, localized changes may occur from time to time to stream banks, islands, and associated bald eagle nesting and roosting habitat as a result of localized high flow events and associated changes in stream morphology. If HS were continued, the existing habitat areas generally would remain unchanged unless affected by other, presently unforeseen factors such as extreme weather events, fire, or changes in local land uses.

Implementing HV at Hungry Horse would result in small changes to reservoir elevations and river flows when compared to HS. This is true not only at Hungry Horse Reservoir but also at all points from Hungry Horse Dam downstream to the Pend Oreille River below Albeni Falls Dam. Given the hydrologic similarities of HS and HV, the effects to bald eagle habitats would also be similar.[58]

Alternative HV may result in minor benefits to riparian vegetation and riparian-dependent wildlife species at Flathead Lake. There may also be minor benefits to aquatic resources including the fish prey base for bald eagles at Hungry Horse Reservoir and Flathead Lake.

Below Kerr Dam to the mouth of the Pend Oreille River, the effects to bald eagle nesting, roosting, and feeding habitats would be essentially identical for HS and HV. If either alternative were implemented, the existing habitat areas generally would remain unchanged unless affected by other, presently unforeseen factors such as extreme weather events, fire, or changes in local land uses.

4.3.5 Wildlife

Under HS, the riparian and wetland habitats along the rivers and other water bodies influenced by ongoing flood control operations at Hungry Horse Dam have generally been in place since flood control and other water management operations were implemented at Hungry Horse (1953), Kerr Dam (1938), and Albeni Falls Dam (1955). Some minor, localized changes may occur from time to time to stream banks and islands as a result of localized high flow events and associated changes in stream morphology. If HS were continued, existing riparian and wetland habitats and associated wildlife communities generally would remain in place unless affected by other factors such as local wetland restoration or drainage projects or other changes in local land uses.

Implementation of HV at Hungry Horse would result in small changes in reservoir elevations and river flows when compared to HS. This is true not only at Hungry Horse Reservoir but also at all points from Hungry Horse Dam downstream to the Pend Oreille River below Albeni Falls Dam. Given the hydrologic similarities of HS and HV, the effects to riparian and wetland habitats, and associated wildlife communities would also be similar.

The HV alternative would result in a slightly increased probability of higher water levels in wetland and riparian habitats adjacent to the lake. This may generally benefit riparian vegetation and riparian-dependent wildlife species.

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[58]For purposes of compliance with ESA, the effects of FCRPS operations on bald eagles were documented in a biological assessment prepared in 1993 (BPA *et al.* 1993) and supplemented in 1994 (BPA *et al.* 1994). The USFWS issued a biological opinion in 1995 (USFWS 1995) concluding that operation of the FCRPS would not jeopardize the continued existence of bald eagles. In a transmittal letter accompanying the 2000 USFWS FCRPS Biological Opinion, the USFWS stated it was not aware of any changes in FCRPS operations (including the proposed implementation of VARQ FC operations at Hungry Horse Dam) that would warrant reinitiation of consultation.

Below Kerr Dam to the mouth of the Pend Oreille River, the effects to riparian and wetland habitats would be essentially identical for HS and HV.

4.3.6 Vegetation

Riparian Areas and Wetlands

The riparian areas and wetlands along the rivers and other water bodies influenced by ongoing flood control operations at Hungry Horse Dam have generally been in place since flood control and other water management operations were implemented at Hungry Horse (1953), Kerr Dam (1938), and Albeni Falls Dam (1955). Some minor, localized changes may occur from time to time to stream banks and islands as a result of localized high flow events and associated changes in stream morphology. If HS were to continue, existing riparian areas and wetlands generally would remain in place unless affected by other factors such as local wetland restoration or drainage projects, or other changes in local land uses.

Implementation of HV at Hungry Horse would result in minor changes to reservoir elevations and river flows when compared to HS. This is true not only at Hungry Horse Reservoir but also at all points from Hungry Horse Dam downstream to the Pend Oreille River below Albeni Falls Dam. Given the hydrologic similarities of HS and HV, the effects to riparian areas and wetlands would be similar. This is particularly true given that the frequencies of relatively high, channel-shaping flows and relatively low flows are essentially identical for HS and HV.

Alternative HV would result in a slightly increased probability of refill (and near-refill) for Flathead Lake and, therefore, would also result in a slightly increased probability of high water levels in wetlands and riparian areas adjacent to the lake. This may generally benefit riparian vegetation and riparian-dependent wildlife species. In addition, hydrologic modeling indicates there is a slightly increased potential for localized flooding above Flathead Lake along the southern portion of the Flathead River plain. This would occur when Flathead Lake is at or above elevation 2893 feet and flows at Columbia Falls exceed 48,000 cfs. In modeled simulations, this occurs 16 days in 4 years (out of a 74-year period of record) for HS, and 31 days in 7 years for HV. All instances occur in June and involve 0.7 percent of the total days in June for HS and 1.4 percent of the total days in June for HV. This means that the extensive wetland and riparian areas along the lower Flathead River above Flathead Lake would experience a minor increase in the probability of high water tables and flooding in June. This may provide minor benefits to riparian vegetation and riparian-dependent wildlife species.

Below Kerr Dam to the mouth of the Pend Oreille River, the effects to riparian areas and wetlands would be essentially identical for HS and HV.

4.3.7 Recreation

Hungry Horse Reservoir

Table 4-26 shows the sum of the average number of days per month that each of 10 boat ramps would be usable (boat ramp days) over the summer recreation season (May to September) under alternatives HS and HV. The analysis shows fewer usable boat ramp days in May under HS than under HV. In other summer months there would be little to no change in boat ramp days between the alternatives.

Table 4-26. Hungry Horse Reservoir average usable boat ramp days per month.

Month	HS	HV
May	103	145
June	257	262
July	309	309
August	293	293
September	213	209
Total[1]	1,175	1,218

[1] 10 boat ramps were evaluated on Hungry Horse Reservoir

The hydrologic model indicates that the probability of refill is slightly higher under HV than under HS. Hungry Horse Reservoir would refill to within 1 foot from full in 62 percent of all years under HS versus 65 percent under HV. This slight difference would be imperceptible to most recreation users.

Exposed lakebed would be clearly visible under both alternatives in May, August, and September. The HV alternative would most likely improve aesthetics during the month of May.

The effects of HV on recreation and aesthetics would be slightly positive at Hungry Horse Reservoir. Reservoir water elevations would be higher in May and June in those years when local downstream flooding is not anticipated. Alternative HV would result in no perceptible changes to elevations from HS during the rest of the summer. Refill probabilities would be slightly higher at Hungry Horse Reservoir under HV.

Hungry Horse Dam to Flathead Lake

Table 4-27 shows the average monthly release from Hungry Horse Dam for alternatives HS and HV. During the main recreation season flows are less with HS than with HV from May through July. Flows are basically the same with either alternative from July through September. A slightly negative effect on the catchability of fish and a slightly positive effect on aesthetics could be expected with high flows in early summer.

Table 4-27. Hungry Horse Dam monthly average release (cfs).

Month	HS	HV
May	3,423	5,637
June	3,054	4,243
July	5,174	5,302
August	5,474	5,476
September	1,708	1,708

Flow is also measured at Columbia Falls, downstream from the confluence of the North Fork, Middle Fork, and South Fork Flathead River (Table 4-28).

Table 4-28. Flathead River at Columbia Falls monthly average release (cfs).

Month	HS	HV
May	23,874	26,088
June	23,650	24,839
July	13,323	13,451
August	8,571	8,573
September	3,871	3,871

During the first half of the recreation season downstream flows as measured at Columbia Falls would be slightly lower under HS than under HV. There would be little to no difference in flows for the remaining summer months. Effects on recreation and aesthetics on the Flathead River below Columbia Falls would be imperceptible.

There are several unimproved boat ramps along the Flathead River. These ramps are operable down to flows of 4,000 cfs. There would be no change in days between HS and HV with flows at or above 4,000 cfs during the summer recreation season.

Table 4-29 shows the average days per month with optimal fishing flows as modeled at Columbia Falls under alternatives HS and HV. The optimal release range for recreational fishing was identified as 4,000 to 17,000 cfs. During the summer months, HS results in slightly more fishing days in May, June, and July than HV. August and September had the same number of fishing days under HS and HV.

HV would result in higher releases from Hungry Horse Dam to the South Fork Flathead River in May (65 percent increase) and June (39 percent increase), with little change the remainder of the summer. This could have a slightly negative effect on fishing during May and June in this upper reach, and a positive effect on aesthetics. By the time the Flathead River reaches Columbia Falls, releases are only slightly higher in May (9 percent) and June (5 percent). This small increase would be imperceptible to most recreation users.

Table 4-29. Flathead River at Columbia Falls average number of days between 4,000 and 17,000 cfs.

Month	HS	HV
May	8	6
June	9	8
July	23	22
August	30	30
September	6	6
Total	76	72

Flathead Lake

Recreation users and residents of Flathead Lake are particularly sensitive to low water levels for both recreation access and aesthetic reasons. Table 4-30 shows the number of usable boat ramp days at Flathead Lake during the recreation season under alternatives HS and HV. Differences between the alternatives are minimal. Alternative HS would result in a slightly lower probability of maintaining full pool at Flathead Lake during the summer season than would alternative HV.

Table 4-30. Flathead Lake average usable boat ramp days per month.

Month	HS	HV
May	130	132
June	267	269
July	295	298
August	302	303
September	271	271
Total	1,265	1,273

*10 boat ramps evaluated

Alternative HV would have a slightly positive effect for recreation and visual resources on Flathead Lake. Alternative HV would be expected to help Flathead Lake fill in some years. The higher Hungry Horse releases in May and June under HV could be stored in Flathead Lake during the refill period. This would result in Flathead Lake having a slightly better probability of filling to elevation 2893 feet (full pool). Flathead Lake could also stay full a little longer in the summer under HV. This extends the quantity and quality of recreation opportunities and is desirable for boat ramp function, shoreline activities, and aesthetic values.

Kerr Dam to Lake Pend Oreille

Table 4-31 illustrates that there are only minor differences between HS and HV on the Flathead River below Kerr Dam. Under HV, flows are slightly higher in May and June and approximately the same for the remainder of the summer. Alternative HV would have minor to no discernible recreation or aesthetic effects from Kerr Dam to Lake Pend Oreille.

Table 4-31. Kerr Dam monthly average release (cfs).

Month	HS	HV
May	21,592	22,312
June	24,222	25,675
July	15,652	15,793
August	8,741	8,821
September	6,062	6,075

Lake Pend Oreille

The summer operating elevation of 2062.5 feet and the winter target elevation of 2055 feet at Lake Pend Oreille would be expected to remain the same under HS and HV. No effects would be expected for recreation or visual resources.

Pend Oreille River, United States

Under alternative HV, differences in flows below Albeni Falls Dam would be imperceptible to recreationists and viewers of the river. During the main recreation season from May-September, only June shows a slight increase in average monthly release over HS (Table 4-32).

Table 4-32. Albeni Falls Dam monthly average release (cfs).

Month	HS	HV
May	53,678	53,536
June	54,518	56,578
July	28,905	29,047
August	14,396	14,484
September	13,461	13,473

Pend d'Oreille River, Canada

The primary location for recreational activities on the Pend d'Oreille River in Canada is BC Hydro's Pend d'Oreille Recreation Area. Based upon the minimal changes to release from Albeni Falls Dam with HV, no impacts to recreation or aesthetics are expected at Pend d'Oreille Recreation Area.

4.3.8 Environmental Health

Air Quality

There is no indication that riverine environmental conditions including available contaminated sediments would have any adverse impact on the local air quality under either HS or HV.

Contaminated Sediments

A review of available literature has shown no elevated concentrations of contaminated sediments in the Flathead River section of the Pend Oreille basin.

The Milltown Reservoir, located on the Clark Fork upstream from the confluence with the Flathead River, is a repository for sediment and mining wastes. The reservoir maintains a long-term dynamic equilibrium, passing the incoming sediment load downstream. The suspended sediment load leaving the Milltown Reservoir is most likely deposited along the entire downstream reach of the Clark Fork. The scouring effect of seasonally high flows continues the suspended sediment transport to Lake Pend Oreille. A review of available documents has identified no observed adverse effects to Lake Pend Oreille due to these contaminated sediments.

The minor increases in May and June releases from Kerr Dam under HV would have minimal affect on the transport of sediments in the Clark Fork. Area drinking water systems predominantly use groundwater as a drinking water source. Relative to the effects of HV versus HS, there are no apparent routes of migration which measurably impact human health or the environment.

The lower Pend Oreille River basin includes the Metaline mining district. Mine tailings in the area continue to provide a source of metals to streams, lakes, and reservoirs as surface water meanders through and erodes tailings deposits and transports these metals downstream or directly into the Pend Oreille River (EPA 2002). The Albeni Falls Dam average monthly releases in June would be slightly higher under HV. Any contribution to the downstream migration of these deposits and contaminated sediments would be minimal. There are some drinking water systems which use surface water from tributaries; however, these systems are not likely impacted by flows of the Pend Oreille River. Again, relative to the effects of HV versus HS, there are no apparent routes of migration which measurably impact human health or the environment.

4.3.9 Cultural Resources

Hungry Horse Reservoir

The analysis for impacts to historic properties at Hungry Horse reservoir is based upon the latest data derived from cultural resources management reports from the Flathead National Forest and the CSKT, and upon Reclamation’s hydrologic projections of timing and extent of reservoir elevation changes under HS and HV implementation. Reclamation consulted in person with Section 106 interested parties to ensure that no historic properties or impacts were omitted from consideration. GIS and other data from Reclamation’s Pacific Northwest Regional Office database were used to determine which sites would be affected by elevation zone, and the nature of the effects.

Area of Potential Effect

The Area of Potential Effect (APE) for operations at Hungry Horse Reservoir is defined as the portion of the reservoir shoreline that is impacted by such operations. The area of direct physical impacts of the reservoir is defined as shoreline elevations between 3336 and 3560 feet, from the dam upstream to the wild and scenic river designation boundary for the South Fork Flathead River and other locations that can be shown to be physically affected by reservoir operations. Reservoir operations may also have indirect effects to the character of historic properties outside the area of direct physical impacts of reservoir operations, such as visual effects. However, given the similarity between HS and HV operations, such indirect effects are not expected to differ appreciably between the two alternatives.

Impacts Analysis

Alternative HS would result in a continuation of ongoing effects to historic properties. All known sites at Hungry Horse have been impacted by reservoir operations for more than 50 years. Current effects to historic properties from reservoir operations include erosion and some slumping at 17 archaeological sites and along sections of prehistoric/historic trail treads where they cross the reservoir. Erosion and slumping has resulted in vertical and horizontal movement of sediments and artifacts, and thus loss of spatial integrity and sometimes of artifacts themselves. Recreational use of the reservoir indirectly impacts historic properties through visitor use of the shoreline and illegal collecting. Reclamation has an ongoing program to mitigate impacts to cultural resource sites within the reservoir fluctuation zone.

Alternative HV generally would have effects on cultural resources similar to alternative HS with the following exceptions. Average winter and early spring (January-May) pool elevations would be about 7 feet higher under HV (3528[59] *vs.* 3535 feet). This means that the average elevation zone for winter erosion and ice impacts to cultural resources would also be correspondingly higher, affecting sites located at higher levels and generally affecting slightly more winter shoreline. Eight of the 17 known sites at Hungry Horse Reservoir are located between elevations 3520 to 3540. Based on average winter reservoir elevations, there likely would be a minor increase in the potential for winter erosion and ice impacts to cultural resources located within the affected elevation zone.

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[59] The modeled average draft 3528 feet is higher than the historic 3500 foot average since the historic draft does not include the 1995 NMFS FCRPS Biological Opinion requirements which restrict power drafts. The 1995 NMFS FCRPS Biological Opinion requirements were carried forward in subsequent NMFS biological opinions. Hungry Horse operations no longer include power drafts below the upper rule curve, hence, the reservoir is drafted less. Hungry Horse can still draft some for power in the winter, just not as much as in the past (loss peaking).

Alternative HV may provide minor benefits to cultural resources during the summer recreation season owing to the increased probability of reservoir refill. Once full, the reservoir helps to protect cultural sites below the high water line which otherwise would be exposed to impacts from summer erosion and visitor use, including camping, ATV and boat use, and illegal collecting.

Traditional Cultural Properties

The prehistoric trails district has not been officially determined a traditional cultural property. However, the trails district is included in this section for the purposes of this analysis because it is under evaluation for eligibility to the National Register. Implementation of HV would likely raise the elevation zone of ice impact to the trail treads where they intersect with the Hungry Horse shoreline, from about 3528 to 3535 feet. It is not expected that the trails would be adversely affected by this change.

Downstream Effects

The South Fork Flathead River and other rivers downstream from the dam generally would continue to flow within their current ranges of stage variability under HS and HV. No effects to cultural resources are anticipated within these reaches.

4.3.10 Indian Sacred Sites

Sacred Sites at Hungry Horse

Under Executive Order 13007 of 1996, Federal agencies must, consistent with essential mission functions, accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and avoid adversely affecting the physical integrity of such sacred sites. Existing operations essential to Reclamation’s mission may have compromised and may continue to compromise access to and physical integrity of sacred sites. No sacred sites have been identified through consultation with the CSKT.

4.3.11 Other Affected Tribal Interests

Much of the area retains resources that support hunting, fishing, and gathering activities. No additional impacts would occur to other affected interests under either the HV or HS alternative.

4.3.12 Transportation

There would be no effect from either alternative on either land-based or commercial non-recreation waterborne transportation systems.

4.3.13 Municipal Water and Wastewater Treatment

Neither the HS nor HV alternative would likely affect municipal water sources or wastewater treatment or disposal facilities in the Pend Oreille River basin.

4.3.14 Socioeconomics

Cost and benefit data were based upon October 2004 prices and conditions. Methodologies for evaluating direct socioeconomic impacts and their indirect impacts on regional employment and income are summarized below and described in detail in Appendix F.

Flood Impacts

Columbia Falls to Flathead Lake: There would be no difference in losses between HS and HV since the release-frequency curves of the alternatives merge at a point just below the zero-dollar damage point release of 52,000 cfs (Table 4-33).

Table 4-33. Estimated average annual losses-Columbia Falls to Flathead Lake.

Alternative	Residential	Commercial	Agricultural	Other	Total Damages
HS	233.41	78.02	140.89	55.13	507.45
HV	233.41	78.02	140.89	55.13	507.45

Source: October 2004 Prices & Conditions - $1,000

Flathead Lake: Implementing HV as shown in Table 4-34 would increase estimated annual losses about $15,000 or 4 percent over HS. Erosion of waterfront land and damage to docks represent the majority of losses and include any impacts resulting from high lake level backwater effects. The lake front floodplain has changed significantly over the years from a primarily rural agricultural area to a developing residential area composed of primary and recreational second homes. The zero-dollar damage point for this reach is 2893 feet.

Table 4-34. Estimated average annual losses-Flathead Lake.

Alternative	Residential	Commercial	Agricultural	Public	Total Damages
HS	250.92	15.92	7.96	70.96	345.76
HV	262.44	16.38	8.19	73.95	360.96

Source: October 2004 Prices & Conditions - $1,000

Lake Pend Oreille: Estimated average annual losses are essentially the same for the two alternatives. The zero-dollar damage point for this reach is 2062.5 feet (Table 4-35).

Table 4-35. Estimated average annual losses–Lake Pend Oreille.

Alternative	Residential	Commercial	Agricultural	Public	Total Damages
HS	5.18	3.27	1.16	3.07	12.68
HV	5.17	3.26	1.16	3.06	12.65

Source: 2004 Prices & Conditions - $1,000

Albeni Falls to Box Canyon Dam: Implementing HV as shown in Table 4-36 would increase estimated average annual losses by about $83,860, or 12 percent over HS.[60] However, this represents an increase that is disproportionately high due to one year (1948) in the period of record. This was the worst year on record for the Pend Oreille basin but not the worst year for Hungry Horse Reservoir which had space available to shape spring releases without increasing local flooding downstream. In a year such as 1948, the Corps and Reclamation would be in constant communication, and Reclamation as well as PPL-Montana (Kerr Dam) would do what they could to help reduce flooding in this reach. This would be handled during real time operations.

Damageable property in the flood plain is believed to have undergone minor changes (except for cropping patterns) since the 1992 survey was conducted. The minor amount of residential development which has occurred in the flood plain likely has been flood proofed to above the 100-year flood level due to strict local and Washington State floodplain ordinances and enforcement.

Table 4-36. Average annual damages - Albeni Falls to Box Canyon Dam.

Alternative	Residential	Commercial/ Industrial	Agricultural	Public	Total Damages
HS	140.05	39.50	423.81	76.18	679.54
HV	157.25	44.32	477.66	84.17	763.40

Source: 2004 Prices & Conditions - $1,000

Agriculture and Irrigation

The primary categories of potential impacts to agriculture from changes in operations at Hungry Horse Dam are changes in the energy required to pump water and resultant changes in agricultural pumping costs. The change in the average annual pumping power requirements is less than two tenths of one percent between alternatives, with HV having the lesser impact when applicable for all reaches.

Municipal and Industrial Water Supply

Change in the energy required to pump water and the resultant change in pumping cost is the primary category of potential impact to M&I water supply in the study area. The change in the average annual M&I power requirements ranged from no change to less

[60] Hungry Horse Reservoir is typically not operated for flood control below Albeni Falls Dam; however, in an extreme water year Reclamation would likely be called upon to help reduce flooding.

than one half of one percent between alternatives with alternative HV having the higher impact when applicable for all reaches.

Employment and Income

No employment or income effects would be expected from flood control impacts of the alternatives in the Columbia Falls to Flathead Lake reach or the Lake Pend Oreille area. Commercial/industrial and agricultural sectors could experience a slight negative employment and income effect from HV in the Flathead Lake area and the Pend Oreille River reach due to increased estimated annual losses from flooding; increases of 4.2 percent and 12 percent, respectively, over HS.

Employment and Income Effects of Agriculture and Irrigation

No employment and income effects would be expected in the Pend Oreille River basin from changes in agricultural irrigation pumping costs associated with the alternatives. Under HS and HV the estimated pumping costs were similar. Changes in cost from HS and HV would be less than 1 percent in all reaches evaluated except for the lower Flathead River as evaluated at the Polson, Montana, gage where the change would be 1.6 percent.

Employment and Income Effects of M&I Water Supply

No employment and income effects would be expected in the Pend Oreille River basin from changes in M&I water supply pumping costs. The estimated pumping costs for both alternatives were similar. Changes in cost from HS and HV would be less than 1 percent in the evaluated reaches.

Employment and Income Effects of Recreation

Operational changes that affect recreation opportunities and visitation can have employment and income effects on regional communities. Effects of identified recreation impacts on regional employment and income are described below.

Hungry Horse Reservoir: The recreation analysis of Hungry Horse Reservoir showed a slight increase in usable boat ramp days at the lake (increase of 4 percent, or 43 additional usable ramp days) under HV. The increased recreational opportunities could result in some increased boating visitation and associated regional spending.

Flathead River: The optimal range of Flathead River flows for fishing was identified as between 4,000 and 17,000 cfs. Alternative HV would result in an average of 4 fewer days in this range per summer (May to September), a 5 percent decrease, which would have a negligible effect on regional income and employment.

Flathead Lake: The recreation analysis of Flathead Lake identified a minor (less than 1 percent) increase in usable boat ramp days at Flathead Lake. This change would have a negligible effect on regional income and employment.

Lower Flathead River: The recreation analysis for the lower Flathead River and lower Clark Fork identified a decrease in average kayaking days per month at Buffalo Rapids under HV. The decrease would be 4 days over the summer months (May to September). The analysis also showed a minor decrease (2 percent) in days within the identified optimal flow range (4,000-17,000 cfs) for fishing. These changes would have a negligible effect on regional income and employment.

Tribal Socioeconomics

The CSKT businesses and facilities that could be affected by changed flows and water surface elevations include marinas, boat ramps, water intakes, and hydroelectric power generation at Kerr Dam. A slight decrease in expected in power requirements for agricultural and M&I water pumping from the Lake with HV as compared to HS. No employment and income effects are expected associated with these slight changes. Flood control studies that show an approximate 4 percent increase in estimated average annual flood losses[61] along the Flathead Lake shoreline.

The Kalispel Indian Tribe operates a boat ramp on the river and is interested in future development including a marina and additional boat ramp. No impacts to use of boat ramps were identified in the reach. Neither alternative would be expected to preclude the identified future development of a marina or additional boat ramp. Alternative HV would increase total estimated average annual losses by about $83,860 (12 percent) over HS in the vicinity of the Kalispel Indian Reservation (Table 4-36). Slight negative employment and income effects could be expected from the flood control impacts with HV in the Pend Oreille River reach. Employment and income effects could include lost income due to increased agricultural flooding.

4.4 Cumulative Impacts

Cumulative impacts are those effects on the environment resulting from the incremental consequences of a proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes these actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. Minor and nonsignificant effects or significant localized effects may contribute to cumulative impacts.

[61] This is the estimated average annual losses for Flathead Lake. It does not separate out Tribal from non-Tribal ownership.

4.4.1 Hydrology and Flood Control

Flathead Drought Management Plan

The Bureau of Indian Affairs has been working with FERC and PPL Montana and the CSKT (co-owners of Kerr Dam on Flathead Lake in Montana) to develop a Drought Management Plan (DMP) for Flathead Lake. In March 2002, PPL Montana filed a DMP with the Secretary of the Department of the Interior for approval (see footnote 51, page 249). The Bureau of Indian Affairs is currently preparing an EIS to evaluate PPL Montana's proposed DMP and other alternatives. This DMP is intended to improve operations during drought years, by allowing dam managers to meet minimum fisheries flows below the dam and improve refill and the ability to maintain higher pool elevations through August. Implementation of VARQ FC at Hungry Horse could improve the probability of refill at Flathead Lake by moving winter Hungry Horse Reservoir releases to the spring refill period. Reclamation does not anticipate the drought management plan to have any effects on implementation of VARQ FC at Hungry Horse.

Ramping rates were implemented at Hungry Horse Dam to reduce the large daily flow fluctuations that were a result of power peaking operations. The new ramping rates set limits on daily flow changes except for emergency operations such as flood control or transmission outages. Ramping rates are not impacted by implementation of VARQ FC.

4.4.2 Water Quality

The analysis concluded the implementation of the preferred alternative would not result in substantial changes in TDG levels in the Pend Oreille basin. The other components affecting water quality include state programs intended to benefit water quality and increases in electricity, water, recreation, and other needs associated with population growth. It is difficult to determine the cumulative result of these programs and population demands considering the broad geographic area and uncertainties associated with implementation.

The projects associated with water quality are described below:

The state of Washington passed The Watershed Planning Act in 1998, which encourages voluntary planning by local governments, citizens, and tribes for water supply and use, water quality, and habitat. Washington is under a court order to develop TMDL management plans on each of its 303(d) water quality listed streams.

The Montana DEQ, under their State Water Quality Act is required to ensure that water quality restoration plans and permits are developed by prescribed due dates for all waters on the 303(d) list and within 10 years for any new water body added to the list. Montana is implementing a new TMDL program to assess the quality of its water bodies and systematically implement water quality plans to restore and protect them. The plan calls for developing TMDLs for each of the 800 impaired water bodies on the 303(d) list.

The Idaho DEQ is establishing TMDLs in the Snake River basin; this program is regarded as having positive water quality effects.

4.4.3 Sensitive, Threatened and Endangered Species

Cumulatively, ongoing stream and riparian restoration measures, TMDL processes, state agency programs, and other conservation activities in conjunction with Federal recovery efforts, could help preserve and possibly improve habitat conditions for bull trout populations.

USFWS Bull Trout Recovery Plan

The USFWS issued a final rule listing the Columbia River and Klamath River populations of bull trout as threatened species on June 10, 1998 (63 FR 31647). Recovery Plans describe overall recovery strategy of the species for individual recovery units, define recovery, and identify recovery actions applicable for all listed bull trout in the coterminous United States.

The Northeast Washington Recovery Unit encompasses the mainstem Columbia River and all tributaries upstream from Chief Joseph Dam to the Canadian border, Spokane River and its tributaries upstream to Post Falls Dam, and the Pend Oreille River and its tributaries from the Canadian border upstream to Albeni Falls Dam. The Clark Fork Recovery Unit encompasses four recovery subunits (Upper Clark Fork, Lower Clark Fork, Flathead, and Priest), including Lake Pend Oreille and Flathead Lake.

The USFWS has temporarily suspended work on draft Recovery Plans for the Columbia River population of bull trout pending completion of the 5-year status review of bull trout. When the Recovery Plan is completed, Reclamation does not anticipate that it will have any effects on implementation of VARQ FC at Hungry Horse Reservoir.

Status Review of Bull Trout

The 5-year review will assess the best available information on how bull trout have fared since they were listed for protection across their range in the lower 48 states in 1998. The purpose of the 5-year review is to ensure that the classification of bull trout as threatened is accurate.

Reclamation does not anticipate that the status review will have any effects on implementation of VARQ FC at Hungry Horse Reservoir.

Subbasin Planning

Subbasin plans have been adopted as part of the NPCC's Columbia River Basin Fish and Wildlife Program, and will help direct BPA funding of projects that protect, mitigate and enhance fish and wildlife that have been adversely impacted by the development and operation of the Columbia River hydropower system. The NPCC, Bonneville, NOAA Fisheries, and USFWS intend to use adopted subbasin plans to help meet requirements of the 2000 FCRPS Biological Opinion. The NOAA Fisheries and the USFWS intend to use subbasin plans as building blocks for recovery planning for threatened and endangered species.

Reclamation does not anticipate the subbasin plans to have any effect on implementation of VARQ FC at Hungry Horse Reservoir.

4.5 Mitigation Measures

No mitigation needs, beyond the minimization and avoidance measures already being implemented, were identified based on the impact analysis.

4.6 Unavoidable Adverse Effects

Unavoidable adverse impacts are environmental consequences that cannot be avoided either by changing the nature of the action or through mitigation, if the action is taken.

Hydrology and Flood Control: The existing potential for adverse flooding effects would remain under the implementation of either alternative.

Water Quality: The existing potential for elevated TDG saturation during high water events would continue under the implementation of either alternative.

Cultural Resources: Impacts arising from implementation of either alternative to archaeological sites or other historic properties along the reservoir shoreline are unavoidable because of the static nature of historic properties.

4.7 Irreversible and Irretrievable Commitments of Resources

The purpose of this requirement is to examine the irreversible and irretrievable commitments of resources associated with implementation of the proposed action. Water management involves water storage, water release, and timing of these operations and would be necessary under either alternative. Once a decision is made for an operational approach, it would affect the ability to release water at a different time or in a different manner. Operations can be tailored within specified ranges through adaptive management. From this perspective, the proposed action would not involve irreversible and irretrievable commitments of resources.

4.8 Relationship Between Short-term Uses and Long-term Productivity

This analysis examines the relationship between short-term uses of environmental resources and the maintenance and enhancement of long-term productivity. To a large extent, the timing and magnitude of short-term impacts are weather dependent since the size of the difference between the alternatives is dependent on seasonal water supply. For example, a series of very dry or very wet years in the immediate future would result in minimal differences between alternatives in the short-term.

A review of the historical period of record shows long-term productivity would vary slightly between alternatives. For example, the potential for increased reservoir productivity may benefit fish species.

4.9 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, dated February 11, 1994, requires agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities as well as the equity of the distribution of the benefits and risks of their decisions. Environmental justice addresses the fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that no group of people should bear a disproportionate share of negative impacts from an environmental action. To comply with the environmental justice policy established by the Secretary, all Interior agencies are to identify and evaluate any anticipated effects, direct or indirect, from the proposed action, or decision on minority and low-income populations and communities, including the equity of the distribution of the benefits and risks.

Although such populations are found in the area and may uses its resources, VARQ FC operations would not disproportionately adversely affect them.

Chapter 5 Affected Environment and Environmental Consequences: Mainstem Columbia River and Columbia Basin Power System

5.1 Introduction

This chapter describes operational effects of the Libby Dam and Hungry Horse Dam alternative and benchmark combinations on resources and uses associated with the mainstem Columbia River and system operational effects including system flood control, and hydropower generation and revenues. Figure 5-1, Figure 5-2 and Figure 5-3 show the study area.

5.1.1 Resources Not Affected by Operations

None of the alternative or benchmark combinations and associated actions would affect regional or local climates, geography, geology, or water temperature in the area and would not rise to the level of needing analysis.

Water temperature is not expected to be affected in the mainstem Columbia River by any of the alternative or benchmark combinations. The Independent Scientific Advisory Board for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and NOAA Fisheries (ISAB 2004) determined operational changes at Hungry Horse and Libby Dams would probably not affect lower Columbia River temperatures because of the large intervening distance involved.

Under any of the alternative or benchmark combinations, water temperature would likely continue to exceed the Washington DOE and Oregon DEQ maximum standards in some warmer months of the year in various parts of the Columbia River, but there is no basis to indicate that mainstem Columbia River temperatures would differ or be influenced by any of the alternative or benchmark combinations.

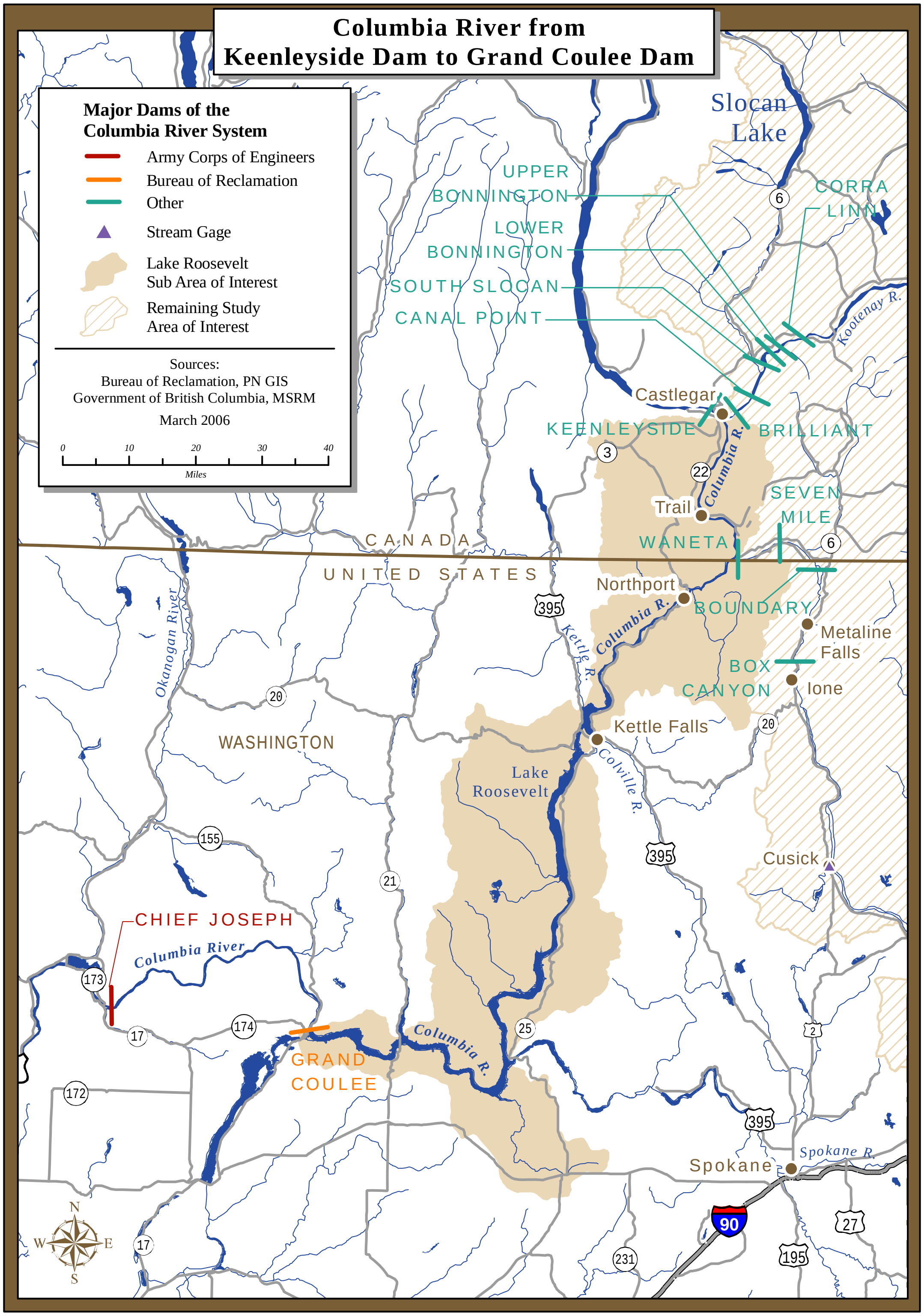

Figure 5-1. Mainstem Columbia River upstream from Grand Coulee Dam.

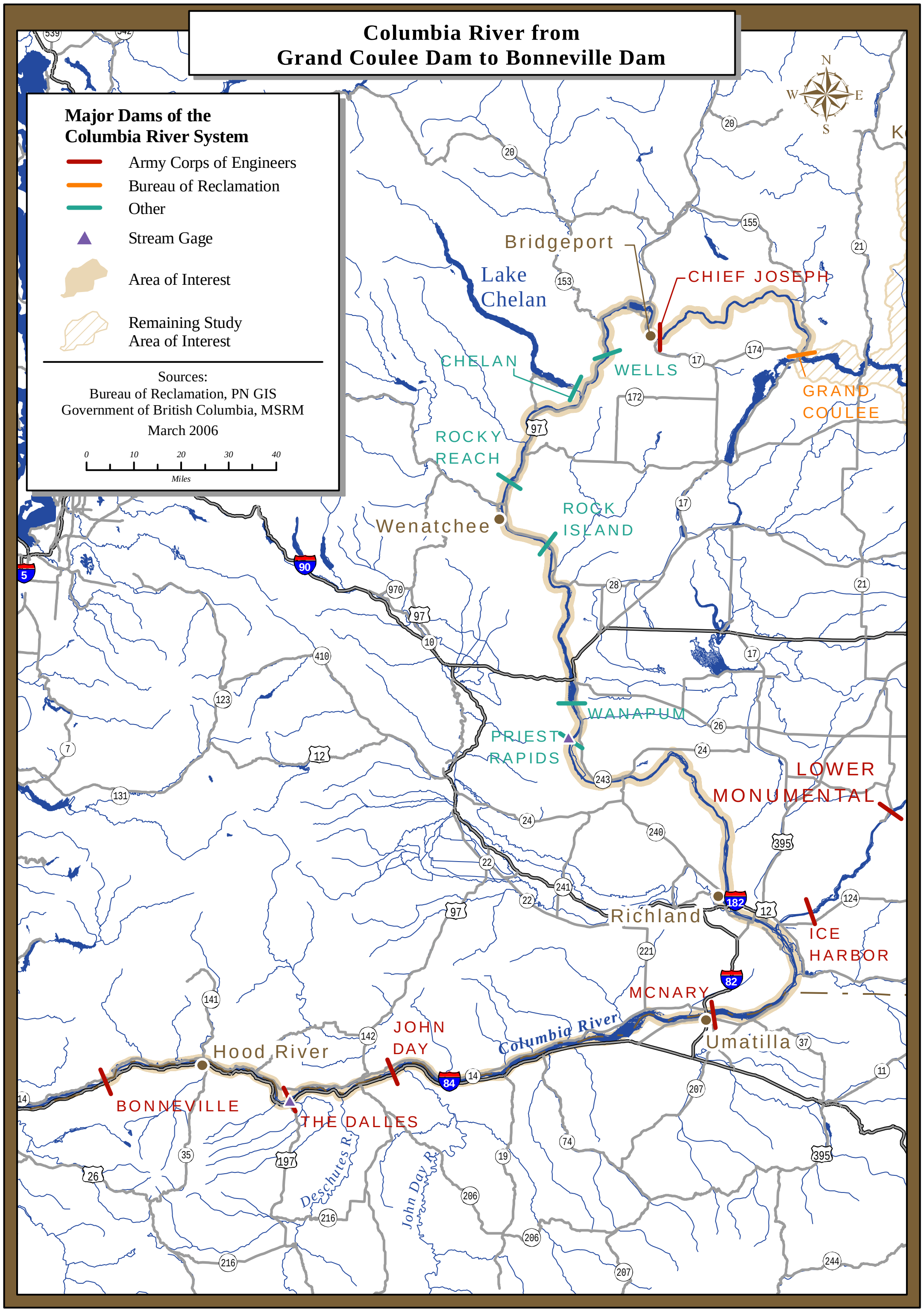

Figure 5-2. Mainstem Columbia River from Grand Coulee Dam to Bonneville Dam.

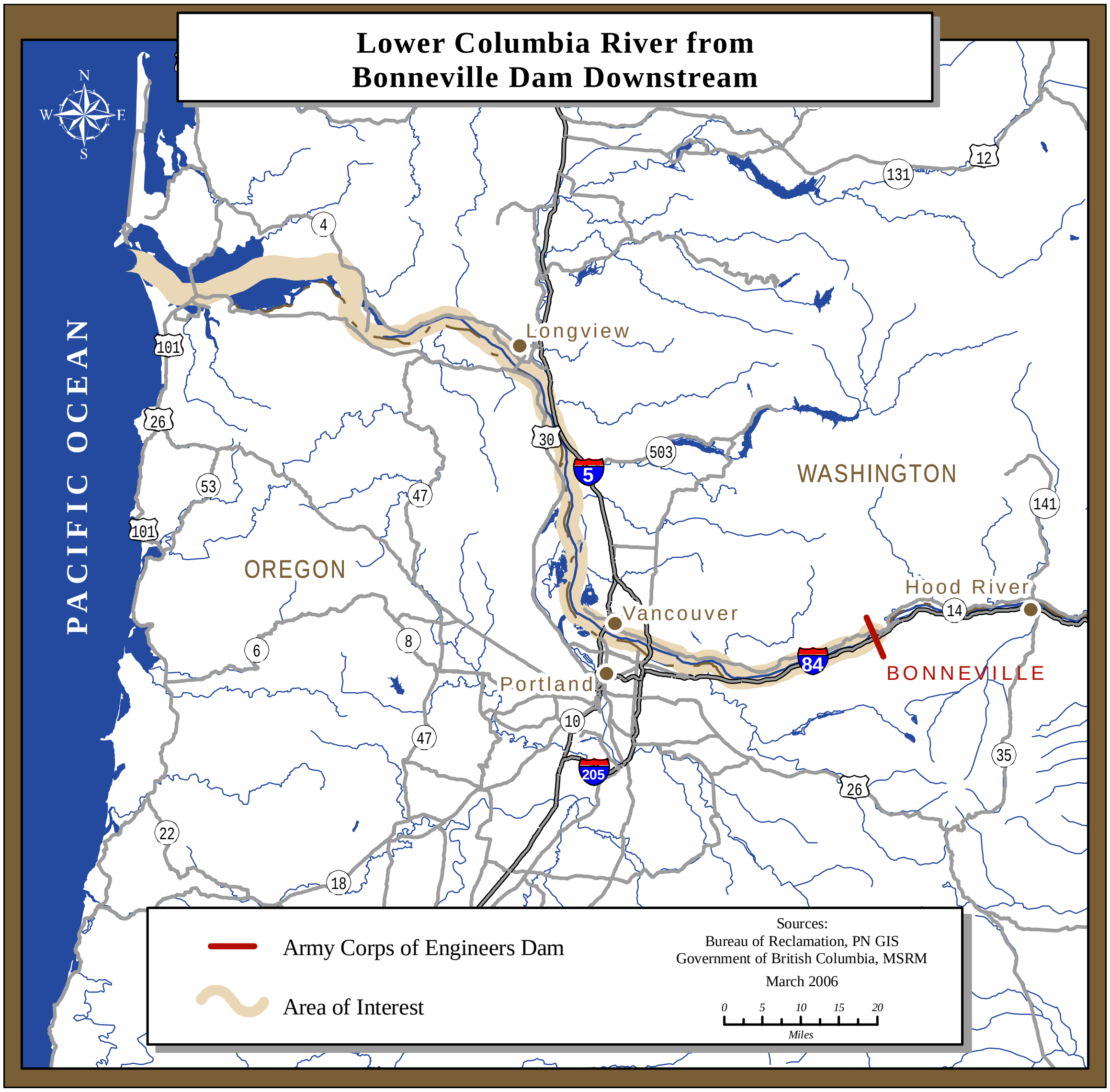

Figure 5-3. Mainstem Columbia River downstream from Bonneville Dam.

5.2 Affected Environment

The Columbia River is the predominant river in the Pacific Northwest. It is the 15th longest river in North America and carries the 6th largest volume of runoff. The river and its tributaries are the region's dominant water system. The system drains 219,000 square miles in Washington, Oregon, Idaho, Montana, Wyoming, Nevada, and Utah. The Columbia River Basin drainage covers 39,500 square miles in British Columbia, Canada (BPA *et al.* 2001).

The Columbia River originates at Columbia Lake, British Columbia, on the west slope of the Rocky Mountains. It flows from Canada into the United States and eventually becomes the state line boundary between Oregon and Washington. The river is 1,214-miles-long, emptying into the Pacific Ocean near Astoria, Oregon.

The Rocky Mountains to the east and north, the Cascade Range on the west, and the Great Basin to the south are the principal boundaries of the Columbia River Basin. The major tributaries in the United States are the Kootenai, Pend Oreille, Snake, and Willamette Rivers.

5.2.1 Hydrology and Flood Control

The climate in the Columbia River Basin ranges from moist, mild, maritime conditions near the mouth of the river to near desert conditions in some of the inland valleys. The Cascade Mountain Range separates the coast from the interior of the basin and has a strong influence on the climate of both areas (BPA *et al.* 2001).

There are two important runoff patterns in the Columbia River Basin: the snowmelt runoff in the interior east of the Cascade Mountain Range, and the rainfall runoff of the coastal drainages west of the Cascades. In both areas, most of the precipitation occurs during the winter months.

East of the Cascades, most of the precipitation falls as snow in the mountains. Snow accumulates and water is held in the snowpack until temperatures rise in the spring. Streamflows begin to increase in volume in mid-April, reaching peak flows in May or early June. Spring and summer rainfall may add to the runoff.

West of the Cascades, winter storms tend to bring rain rather than snow. River levels can rise within hours during major storms. Most of the runoff occurs in the fall and winter months, November through March, but moderate streamflows continue through the spring and early summer, fed by precipitation, snowmelt, and groundwater discharge.

At the mouth of the Columbia River, average annual runoff is 198 million acre-feet (BPA *et al.* 2001). For system operations, runoff is usually measured at The Dalles, Oregon, where annual average runoff is 134 million acre-feet. The system of major dams on the river and its tributaries regulates river flows to balance benefits for multiple purposes which include flood control, hydropower, irrigation, navigation, fish and wildlife, and recreation. On average, about 25 percent of the Columbia River flow comes from Canada. Before any mainstem dams were built, natural instantaneous streamflow at the border ranged from as low as 14,000 cfs to as high as 550,000 cfs.

The Columbia River Treaty Flood Control Operating Plan (FCOP), finalized in 1972, provides the basis for the current Columbia River system flood control operation. The most current version of the FCOP, issued in 2003 (Corps 2003), clarifies general operating procedures, contains updated statistics, and details a formal process to exchange flood control space between Arrow and Mica storage projects. Table 5-1 denotes major features of the flood control system.

Table 5-1. Major features of the Columbia River flood control system.

Storage Dam	Primary Flood Control Space (acre-feet)	Additional On-Call Flood Control Space (acre-feet)
Mica	2,080,000*	9,920,000
Arrow	5,100,000*	2,000,000
Duncan	1,270,000	77,000
Libby	4,960,000	
Hungry Horse	2,980,000	
Grand Coulee	5,185,000	
Dworshak	2,016,000	
Brownlee	975,300	
John Day	535,000	
Total	25,101,300	11,997,000

The 2003 FCOP provides for a maximum allowable exchange of flood control space of 3.5 million acre-feet from Arrow to Mica (Corps 2003). The development of the new storage reservation diagrams for this exchange is documented in the Corps Summary Report, Proposed Reallocation of Flood Control Space, Mica and Arrow Reservoirs (1995).

The 2003 FCOP describes the general flood characteristics for the Columbia River Basin as follows:

> Flood flows are typically experienced in the Columbia River Basin during May and June as a result of the melting of the accumulated winter snowpack. Maximum flood peaks result from heavy snow accumulation and a prolonged period of intense snowmelt, occasionally augmented by heavy rain. Natural streamflow recedes during July and August and remains at relatively low levels throughout the winter. Occasionally, heavy rains augmented by unseasonable low-elevation snowmelt can cause flood flows in the lower Columbia River and its tributaries during the fall and winter months.

The objective of the Columbia River system flood control operations for potential flood events is to regulate the total reservoir system to the lowest possible stage at potential flood-prone areas in Canada and the United States. Elements of annual flood control strategies include: development of seasonal runoff or water supply forecasts, use of storage reservation diagrams, determination of the initial controlled flow (ICF) which determines when system refill begins, regulation of dams to avoid jeopardizing refill, if possible, and local flood control operating criteria and project operating limits (Corps 2003).

In the context of system flood control operations, storage reservoirs throughout the Columbia River Basin operate from January through April using guidance provided by a storage reservation diagram (SRD). A SRD shows how much water storage space is required for the current seasonal runoff forecast. Beginning in January, water supply forecasts are developed for each separate subbasin and for the entire Columbia River system to The Dalles. Based on the water supply forecast, and using the SRD as guidance, the Corps calculates the end of January through April upper storage limit at each reservoir that provides for meeting flood control objectives at The Dalles. In February, the new water supply forecast is used to develop updated end of February through April upper storage limits. The process repeats for each month through April.

In May, June, and July the refill of reservoirs is guided by upper flood control elevation limits which vary each year. The May, June, and July upper limits are dependent upon the natural flow at The Dalles, the amount of runoff that may remain in the system, the amount of storage available in the system, and the weather forecast.

The flood stage at Vancouver, Washington, is 16 feet (National Geodetic Vertical Datum, or NGVD). Most floods can be regulated to 450,000 cfs or less. In the case of major floods that cannot be limited to 450,000 cfs, the goal is to control the flow to as low as possible at The Dalles. When flows reach 400,000 cfs, as measured at Priest Rapids Dam, the zero-dollar damage point discharge is reached in the mid-Columbia River area near Hanford, Washington. The regulation required for system flood control at The Dalles normally would achieve the desired protection in the mid-Columbia area, because the storage reservoirs used to regulate flow at The Dalles are mostly upstream from Priest Rapids Dam.

River flows at The Dalles fluctuate seasonally in response to runoff patterns and operations of the FCRPS. Peak flows occur during the spring freshet in May and June, with monthly average flows of about 300,000 cfs for May and June (Corps 2004). A secondary peak flow, on the order of 220,000 cfs average monthly flow, occurs in January for power production and flood control draft (Corps 2004). The highest monthly average flow observed at The Dalles was 1,002,000 cfs in June 1894 (Columbia River Water Management Group 2003). The lowest monthly average flow observed at The Dalles was 42,340 cfs in January 1937 (Columbia River Water Management Group 2003). This year is still considered a critical year for power operation.

5.2.2 System Power

System Coordination

Hydroelectric dams on the Columbia and Snake Rivers are the foundation of the Northwest's power supply; flowing water turns the power generating turbines at the dams. Hydropower accounts for approximately 75 percent of the Northwest's electricity supply. When there is a surplus, it is an important regional export product. BPA markets and distributes the power generated by the Corps and Reclamation at the Federal dams in the Columbia River Basin, and sells power from the dams and other generating plants to public and private utilities in the region, utilities outside the region, and some of the region's largest industries. BPA operates the transmission system, which consists of approximately 15,000 circuit miles. The Northwest grid is interconnected with Canada to the north, California to the south, and other states to the east.

Coordinated system planning is done with guidance from the CRT and the Pacific Northwest Coordination Agreement (PNCA).

Columbia River Treaty

The CRT requires an Assured Operating Plan (AOP) for Canadian CRT storage to be developed for the sixth succeeding operating year from hydro-regulation studies designed to achieve optimum power and flood control revenue in Canada and the United States. The AOP defines the operating criteria that are used for Mica, Duncan, and Arrow Dams in actual operations unless otherwise agreed. A Detailed Operating Plan (DOP) is prepared for the upcoming operating year and includes operating criteria from the AOP with any agreed upon changes. Information from the DOP is included in plans developed under the PNCA, as releases from Canadian storage reservoirs are important for coordinated system planning in the United States. Coordination of the operation of Libby Dam between the United States and Canada is through the Libby Coordination Agreement.

Pacific Northwest Coordination Agreement

The basis for planning power coordination among the hydropower facilities in the Columbia River Basin in the United States is the PNCA. Coordinating system operations through annual planning is useful as it enables power generators to plan optimal use of the resource and to operate hydro and thermal resources more efficiently. These generators can produce more power and operate for nonpower requirements with greater reliability through coordination than they could by operating independently.

Libby Dam

The Libby Dam powerhouse contains eight generator bays; units 1 through 5 are currently operating and units 6 through 8 are partially completed units not in operation. The discharge capacity of the powerhouse is generally considered to be about 25,000 cfs and up to slightly more than 28,000 cfs under certain reservoir conditions. The routine electrical generating capacity at Libby Dam is 525 megawatts (MW) with a 600 MW peak generating capacity under optimal conditions.

Hungry Horse Dam

The Hungry Horse Dam powerhouse contains four generating units. The maximum discharge capacity is around 12,000 cfs. The routine electrical generating capacity at Hungry Horse Dam is 408 MW with a 428 MW peak generating capacity under optimal conditions.

Columbia River

The Columbia-Snake River system has been heavily developed for hydroelectric power. More than 250 hydroelectric projects have been constructed in the Columbia River Basin. The integrated system of hydroelectric projects in the Columbia River Basin has a total installed generating capacity of more than 36,000 MW. The 14 Federal dams[74] included in the FCRPS ESA consultation and biological opinion account for 18,900 MW. Nine Federal and a variety of private, public, and provincial dams are located within areas potentially affected by the proposed action. Table 5-2 lists some characteristics of selected hydroelectric facilities in the Columbia River Basin.

Table 5-2. Characteristics of United States and Canadian hydroelectric dams in the study area.

Dam	Operator	Location	Year Completed	Nameplate Electrical Capacity (MW)
Libby	Corps	Kootenai River near Libby, MT	1973	525
Corra Linn	FortisBC	Kootenay River near Nelson, BC	1932	40
Kootenay Plants[1]	FortisBC	Kootenay River near Nelson, BC	various	157
Kootenay Canal	BC Hydro	Off the Kootenay River near Nelson, BC	1975	528
Brilliant	FortisBC	Kootenay River near Castlegar, BC	1944	145
Brilliant Expansion	FortisBC	Kootenay River near Castlegar, BC	*scheduled completion in* 2006	125
Hungry Horse	Reclamation	S. Fork of the Flathead River, near Hungry Horse, MT	1953	428
Kerr	PPL Montana	Flathead River, near Polson, MT	1938	168
Thompson Falls	PPL Montana	Clark Fork near Thompson Falls, MT	1917	30
Noxon Rapids	Avista	Clark Fork, near Noxon, MT	1959	397

[74] A more comprehensive definition of the FCRPS that may be used in other documents might include up to 31 federally-owned hydropower projects together with the associated electrical transmission system (BPA 1993).

Dam	Operator	Location	Year Completed	Nameplate Electrical Capacity (MW)
Cabinet Gorge	Avista	Clark Fork, near Clark Fork, ID	1953	200
Albeni Falls	Corps	Pend Oreille River, near Newport, WA	1955	42
Box Canyon	Pend Oreille PUD	Pend Oreille River, near Ione, WA	1955	60
Boundary	Seattle City Light	Pend Oreille River, near Metaline Falls, WA	1967	1055
Seven Mile	BC Hydro	Pend d'Oreille River, near Waneta, BC	1979	607
Waneta[2]	FortisBC	Pend Oreille River, near Waneta, BC	1944	288
Grand Coulee	Reclamation	Columbia River, at Grand Coulee, WA	1942	6494
Chief Joseph	Corps	Columbia River, near Bridgeport, WA	1961	2069
Wells	Douglas County PUD	Columbia River near Pateros, WA	1967	840
Rocky Reach	Chelan County PUD	Columbia River near Wenatchee, WA	1961	1280
Rock Island	Chelan County PUD	Columbia River near Wenatchee, WA	1933	660
Wanapum	Grant County PUD	Columbia River near Vantage, WA	1963	1038
Priest Rapids	Grant County PUD	Columbia River near Mattawa, WA	1961	955
McNary	Corps	Columbia River, near Umatilla, OR	1957	980
John Day	Corps	Columbia River, near Rufus, OR	1971	2160
The Dalles	Corps	Columbia River, at The Dalles, OR	1960	1696
Bonneville	Corps	Columbia River, at Bonneville, OR	1938	1050

[1] Includes Upper Bonnington, Bonnington, Lower Bonnington, and South Slocan dams.
[2] The 435 MW Waneta Expansion project is currently under development and expected to be completed in 2010.
Source: Corps 1989

Confederated Colville Tribe Power Benefits

In 1994, following litigation under the Act of August 13, 1946 (commonly known as the Indian Claims Commission Act, (0 Stat. 1049, chapter 959; former 25 U.S.C. 70 et seq.), Congress ratified the Colville Settlement Agreement, which required for continued use of the Colville Tribes' land, annual payments of $15,250,000, adjusted annually based on revenues from the sale of electric power from the Grand Coulee Dam project and transmission of that power by the Bonneville Power Administration. No later than March 1 of the succeeding year, BPA is obligated to pay the Confederated Tribes of the Colville

Reservation an amount determined by multiplying the annual generation at Grand Coulee by a price calculated by a simple formula. A full discussion of the development of the rate and contract details are beyond the scope of this document, however details are available from BPA and in the Colville Settlement Agreement.

5.2.3 Water Quality

Water quality in the Columbia River Basin has been impaired by many land and water uses. The EPA reports that of 266,258 miles of cataloged streams within the Interior Columbia Basin Ecosystem Management Project, 26,266 miles are classified as impaired (USFS 1996).

The Washington DOE has listed the Columbia River mainstem from the international border through Lake Roosevelt as water quality limited for elevated levels of TDG and temperature under section 303(d) of the CWA. Total dissolved gas is likely to be affected by the alternative and benchmark combinations; temperature is not. Therefore, the discussion focuses on TDG.

Total Dissolved Gas

Supersaturated conditions can occur as a result of high-energy plunge of water from spillways on dams. Supersaturated TDG conditions are a cumulative problem (Frizell 1996) since high levels of TDG may persist for many miles downriver, even passing through downstream dams, if no mechanism exists to allow the dissolved gas to escape more quickly into the atmosphere. Harmful effects on fish occur due to blockage of blood vessels by bubbles or by bubble formation in tissues as gases come out of solution.

Harmful effects to aquatic biota from TDG are considered minimal at 110 percent saturation. Higher levels (especially over 120 percent saturation) may have more serious consequences to aquatic species, depending on a number of conditions including duration of exposure, water temperature, fish species, fish life stage, depth of fish below the surface (fish become less susceptible to harm if they are 3.2 to 6.5 feet below the water surface), and other stressors. Symptoms may not appear immediately and fish may recover from relatively short-term exposures. See Corps (2000) for more details on the effects of high TDG on fish and other aquatic organisms.

The EPA issued a TMDL for TDG in all waters including tribal waters upstream from Grand Coulee Dam. Washington DOE submitted the same TMDL for waters downstream from Grand Coulee Dam to EPA for approval (Pickett *et al.* 2004). The TMDL development is a result of TDG levels exceeding Washington DOE water quality standards. The primary contributors of dissolved gases that enter Lake Roosevelt come from Canada (Frizell 1996), but dams in the United States are also sources that contribute to system TDG issues.

Under the Washington State 1997 version of the water quality standards for surface water, the Columbia River is classified as a Class A (excellent) surface water from the mouth to Grand Coulee Dam. Upstream from the dam, Washington classifies the Columbia River as a Class AA (extraordinary) water body (WAC 173-201A-130). The CCT classified the Columbia River as a Class I (extraordinary) water body above Chief Joseph Dam and a Class II (excellent) water body below the dam under tribal law.

Washington and the CCT have a similar TDG maximum standard of 110 percent saturation. However, Washington allows exceedance of the 110 percent TDG saturation criterion to facilitate fish passage spills (Table 5-3). For example, in its rulemaking the Washington DOE provided for TDG up to 120 percent saturation at Chief Joseph Dam for the purpose of managing system spill. In addition, the TDG criterion established by Washington and the CCT does not apply to flows above the 222 kcfs, 7-day 10-year frequency (7Q10) flood flow.

Table 5-3. Washington DOE and CCT water quality standards for TDG that apply to the mainstem Columbia River under 1997 and 2003 rules.

Regulator	Standard
Washington DOE	Shall not exceed 110 % saturation at any point of sample collection, except during spill season for fish passage in which total dissolved gas shall be measured as follows:
	(1) Must not exceed an average of 115 % as measured in the forebay of the next downstream dam.
	(2) Must not exceed an average of 120 % as measured in the tailrace of each dam; TDG is measured as an average of the 12 highest consecutive hourly readings in any one day, relative to atmospheric pressure.
	(3) A maximum TDG one-hour average of 125 % as measured in the tailrace must not be exceeded during spillage for fish passage.
CCT	Shall not exceed 110 % saturation at any point of sample collection.

Oregon DEQ has listed the mainstem Columbia River from the Oregon-Washington state line to the mouth of the Columbia River as water quality limited under section 303(d) of the CWA for elevated levels of TDG and temperature. Oregon and Washington jointly issued a TDG-TMDL for the lower Columbia River.

Figure 5-4 shows TDG saturation levels for years 1998 through 2003 were often in excess of 110 percent saturation at Grand Coulee Dam, especially during the summer months.

NOAA Fisheries recommended passing salmon smolts downstream over spillways as an alternative to turbine passage under the 2004 UPA and 2004 NOAA Fisheries Biological Opinion. This fish passage spill operation is called "voluntary spill," and is used each spring and summer at dams in the mid and lower Columbia River.

Spill at Chief Joseph Dam and dams upstream occurs when river flow exceeds powerhouse capacity, and in the case of storage reservoirs the ability of the reservoir to impound excess flows. This involuntary or "forced" spill may also occur if flow becomes excessive at dams where fish passage spill occurs.

Involuntary spill from high runoff does not occur every year. For example, at Grand Coulee Dam involuntary spills occur approximately one out of six years (M. McClendon Reclamation, pers. comm. 2000). For storage dams like Grand Coulee Dam, spill may be avoided by storing water if reservoir space is available. For run-of-river dams with little or no storage capacity, such as Chief Joseph Dam, any situation where inflow exceeds turbine capacity or generating requirements, can lead to spill. Involuntary spill occurred at many of the mainstem Columbia River dams in 1996 and 1997 due to high runoff from heavy snowmelt.

The current preferred gas abatement strategy for Grand Coulee Dam is a joint operation with Chief Joseph Dam, which is about 60 miles downstream. Under this strategy, when involuntary spill is required at Chief Joseph and Grand Coulee Dams, generation load would be shifted from Chief Joseph Dam to Grand Coulee Dam, which would virtually eliminate spill at Grand Coulee Dam at flows less than the 7Q10 high flow event. To manage the effects of those increased spills at Chief Joseph Dam to a level no greater than 120 percent TDG saturation, flow deflectors are being constructed. The deflectors are scheduled for completion in 2008. Turbines are being added to Brilliant Dam in British Columbia, which would allow higher flows for electrical generation, reducing the

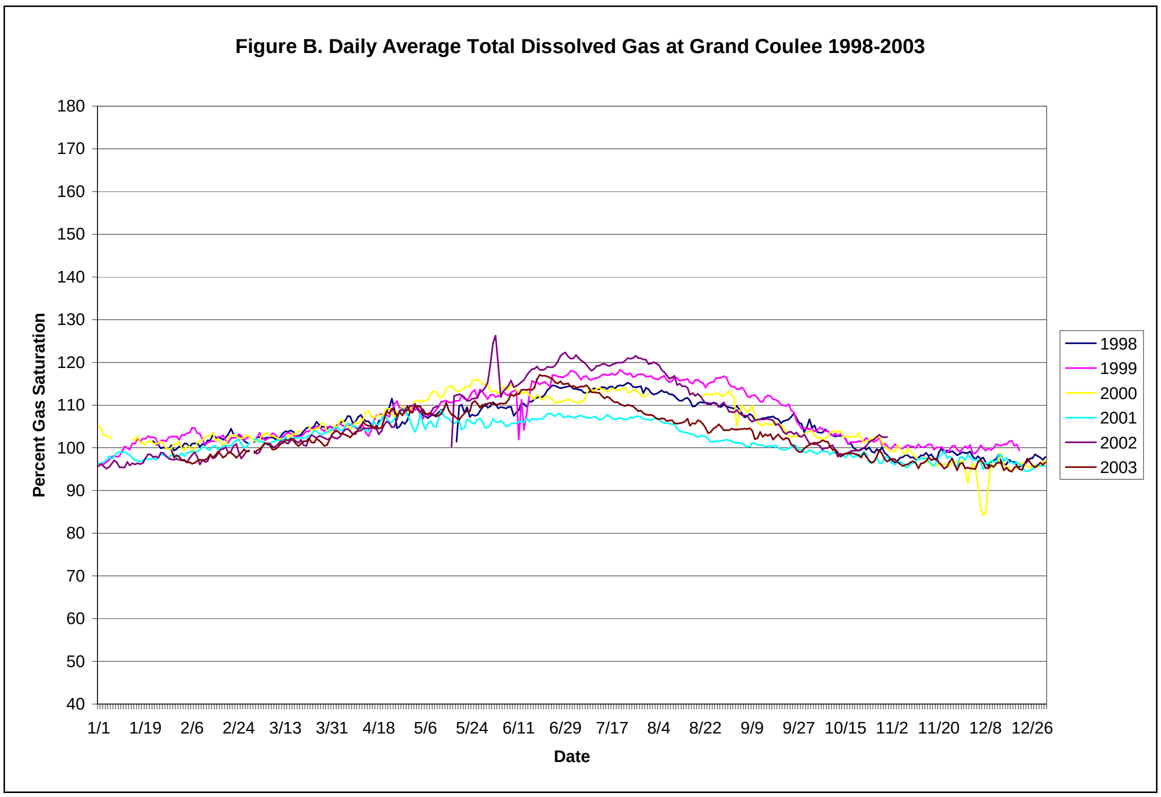

Figure 5-4. Daily average total dissolved gas at Grand Coulee 1998-2003.

incidence of involuntary spill (Columbia Power 2000). This should result in reduced TDG levels in Canada and Washington.

The Corps develops a TDG management plan each year to establish spill caps for each of the Federal and non-Federal Columbia River dams, as well as for those on the Snake River system. Table 5-4 shows 110 percent and 120 percent spill caps for most of the Federal and non-Federal dams. Spill cap information is not available for all dams.

Table 5-4. Spill caps for Federal and non-Federal dams.

Dam	Spill Cap 110 % Saturation (cfs)	Spill Cap 120 % Saturation (cfs)
Federal		
Libby	1,000	2,000
Hungry Horse	3,000	No information
Albeni Falls	No information	No information
Grand Coulee (outlet works)	0	10,000
Grand Coulee (spillway)	20,000	30,000
Chief Joe	5,000	30,000
McNary	20,000	170,000
John Day	40,000	160,000
The Dalles	50,000	200,000
Bonneville	70,000	170,000
Non-Federal		
Kerr	No information	No information
Thompson Falls	No information	No information
Noxon Rapids	25,000	75,000
Cabinet Gorge	14,900	21,000
Box Canyon	No information	No information
Boundary	No information	No information
Priest Rapids	25,000	40,000
Wanapum	10,000	20,000
Rock Island	5,000	20,000
Rocky Reach	5,000	20,000
Wells	10,000	25,000

5.2.4 Aquatic Life

Mainstem Columbia River Upstream From Grand Coulee Dam

Construction of Grand Coulee Dam inundated 151 miles of river habitat in the mainstem Columbia River. Native fish populations consisting of westslope cutthroat trout, redband trout, bull trout, and mountain whitefish, accustomed to a riverine environment, have diminished as a result of habitat inundation, entrainment, and other factors. Resident fish populations have also been impacted by habitat degradation throughout the basin.

The construction of Grand Coulee Dam blocked the migration of anadromous and resident fish from lower reaches of the Columbia River to the Upper Columbia River basin. The loss of connectivity and free flowing sections of the Columbia River also affected native white sturgeon, bull trout, and burbot (GEI 2004b).

White sturgeon are found in Lake Roosevelt and the Columbia River upstream from the reservoir. White sturgeon population estimates are about 1,400 adults in the transboundary region of the Upper Columbia River basin (GEI 2004b). Specific numbers for Lake Roosevelt are not known.

Current fish assemblages in the upper Columbia River are dominated by nonnative sport fishes such as brown trout, rainbow trout, kokanee salmon, brook trout, and warmwater species such as smallmouth bass, walleye, and yellow perch. Native bull trout, westslope cutthroat trout, white sturgeon, and redband trout are all still present in the basin. These native fishes are currently below their historic capacity and potentially nonexistent in the mainstem Columbia River. Nongame native species including suckers and northern pikeminnow are quite abundant, as are the nonnative lake whitefish.

More than 25 fish species are known to occur throughout Lake Roosevelt. In 1999, rainbow trout and walleye comprised more than 99 percent of the harvested fish in the reservoir.

Rainbow trout are stocked in Lake Roosevelt in large numbers annually through a resident fish hatchery program established as partial mitigation for losses of anadromous salmon and steelhead in the blocked area above Grand Coulee Dam. They comprise an important part of the recreational fishery in Lake Roosevelt and the current Lake Roosevelt population of rainbow trout is generally strong.

Kokanee salmon have been used as partial mitigation for the loss of anadromous salmonids in the Upper Columbia River basin. They are an economically and culturally important species in the Lake Roosevelt area subsistence and recreational harvest. The Upper Columbia River basin currently supports abundant adfluvial stocks of kokanee as well as hatchery supported stocks originating in Lake Roosevelt. Kokanee entrainment through Grand Coulee Dam has been documented to negatively affect the population within Lake Roosevelt.

Existing habitat conditions in Lake Roosevelt are highly variable as a result of large (more than 80 feet) fluctuations in reservoir levels. These drawdowns reduce the productivity of the reservoir; result in increased fish entrainment, and severely impact resident fish populations and limit fisheries managers in their ability to achieve objectives and goals. Furthermore, short-duration water flow-through rates may be limiting production of zooplankton, which kokanee depend on for food.

Mainstem Columbia River Downstream From Grand Coulee Dam

Lake Rufus Woods is a 51-mile-long impoundment on the mainstem Columbia River. It is bounded by Grand Coulee Dam (RM 596) and Chief Joseph Dam (RM 545). The Colville Indian Reservation borders the entire north shoreline of the lake (LeCaire 2000).

In Lake Rufus Woods, a total of 28 fish species were captured and the relative abundance of 23 species determined from electrofishing and beach seining sampling in 1999. Caught species were dominated by longnose sucker (1,456), redside shiner (1,102), rainbow trout (1,046), sculpin (593), unidentified sucker (522), bridgelip sucker (494), walleye (479), largescale sucker (462), and northern pikeminnow (438) (LeCaire 2000).

Below Chief Joseph Dam, a variety of native and nonnative resident fish are found, including bull trout, northern pikeminnow, kokanee, mountain whitefish, peamouth, redside shiner, suckers, bluegill, smallmouth and largemouth bass, and yellow perch.

Several anadromous species are also found below Chief Joseph Dam. These species include salmon and steelhead populations (see Section 5.2.5 for further information), as well as Pacific lamprey (*Lampetra tridentata*) and nonnative American shad (*Alosa sapidissima*).

5.2.5 Sensitive, Threatened and Endangered Species

The mainstem Columbia River (including Lake Roosevelt and impoundments downstream) provides or passes through habitat which may be used by a number of endangered or threatened species. Table 5-5 and

Table 5-6 list threatened and endangered species occurring in the Columbia River Basin.

In December 2000, the USFWS determined that effects from the operation of the FCRPS, which includes Hungry Horse and Libby Dams, either are not likely to occur or would be very minor for the following species: grizzly bear, gray wolf, woodland caribou, Canada lynx, northern Idaho ground squirrel, Macfarlane’s four-o’clock, water howellia, Ute ladies’-tresses, and Spalding’s catchfly. Based on consideration of direct and indirect effects from continued operation of the FCRPS (including implementation of VARQ FC procedures at Hungry Horse and Libby Dams), the USFWS determined that these species are not likely to be adversely affected (USFWS 2000). Accordingly, these species would not be affected by any of the alternative and benchmark combinations.

Mainstem Columbia River Upstream From Grand Coulee Dam

Bull Trout (Columbia Basin Distinct Population Segment, Threatened Under ESA)

Little is known regarding historic bull trout abundance prior to the creation of Lake Roosevelt. The STI conducted surveys in Lake Roosevelt near major tributaries and found four bull trout between 1989 and 1995. Bull trout also are not extensively found in tributaries to Lake Roosevelt; degraded habitat conditions in those streams may be more of a limiting factor than reservoir operations (USFWS 2002). Primary impacts from present operation of Lake Roosevelt to this species may involve possible reduction of juvenile-growth potential, since benthic or other food items may be exposed and killed by drawdowns.

The mainstem Columbia River upstream from Grand Coulee Dam is not designated as critical habitat for bull trout.

Table 5-5. Threatened and endangered species occurring in the Columbia River Basin (excluding the Snake River basin).

Species	ESA Status	Critical Habitat	Section 7 Coverage/Comments
Birds			
Marbled murrelet	Threatened	Yes	Occurs in coastal waters and mature forests within 60 miles of Pacific coast
Northern spotted owl	Threatened	Yes	Occurs in mature forests throughout the Pacific Northwest
Mammals			
Grizzly bear	Threatened	No	2000 USFWS Biological Opinion
Gray wolf	Threatened	No	2000 USFWS Biological Opinion
Woodland caribou	Endangered	No	2000 USFWS Biological Opinion
Northern Idaho ground squirrel	Threatened	No	2000 USFWS Biological Opinion
Canada lynx	Threatened	No	2000 USFWS Biological Opinion
Columbian white-tailed deer	Endangered	No	Occurs along Columbia River downstream of Multnomah Co., OR and Skamania Co., WA Federally listed since 1968 info from April 2004 Crims Island BA
Plants			
Macfarlane's four o'clock	Threatened	No	2000 USFWS Biological Opinion
Spalding's catchfly	Threatened	No	2000 USFWS Biological Opinion; USFWS Final Rule 10 Oct 2001
Water howellia	Threatened	No	2000 USFWS Biological Opinion FR:July 14, 1994
Ute ladies'-tresses	Threatened	No	2000 USFWS Biological Opinion
Kincaid's lupine	Threatened	No	Willamette Valley distribution
Nelson's checkermallow	Threatened	No	Occurs in the Willamette Valley; Coast Range of Oregon and Cowlitz County, WA
Wenatchee Mountains checkermallow	Endangered	Yes	Occurs in the vicinity of Leavenworth, WA
Showy stickseed	Endangered	No	Occurs in dry habitats from 1500-2500 feet elevation in Wenatchee Mountains

Table 5-6. Threatened and endangered evolutionarily significant units of salmon and steelhead in the Columbia River Basin.

Species	ESU	Designated Status	Critical Habitat
Chinook salmon (*Oncorhynchus tshawytscha*)	Snake River Fall	Threatened	designated
	Snake River Spring/Summer	Threatened	designated
	Upper Columbia River Spring	Endangered	designated
	Lower Columbia River	Threatened	designated
	Upper Willamette River	Threatened	designated
Chum salmon (*O. keta*)	Columbia River	Threatened	designated
Sockeye salmon (*O. nerka*)	Snake River	Endangered	designated
Coho (*O. kisutch*)	Lower Columbia	Threatened	n/a
Steelhead (*O. mykiss*)	Snake River	Threatened	designated
	Upper Columbia River	Endangered	designated
	Middle Columbia River	Threatened	designated
	Lower Columbia River	Threatened	designated
	Upper Willamette River	Threatened	designated

White Sturgeon (in Canada)

The white sturgeon (*Acipenser transmontanus*) was designated Special Concern in 1990. Its status was re-examined and uplisted to endangered in November 2003 (COSEWIC 2003). The British Columbia Conservation Data Centre reviewed the status of white sturgeon in British Columbia and provincially listed it as imperiled (the second highest at-risk rating) and placed it on British Columbia's red list. Three populations (Nechako, upper Columbia, and Kootenay) were given the highest possible ranking of critically imperiled. (BCFisheries 2005)

Columbia white sturgeon in British Columbia, upstream from Lake Roosevelt, are listed as a Canadian national Species of Special Concern, and they are "red-listed" (critically imperiled) at the provincial level (BCMWLAP 2005).

In 2002, a recovery plan for the upper Columbia white sturgeon was published. Harvest of all white sturgeon is now closed. Juvenile white sturgeon are being stocked to supplement existing populations in the Columbia River near the United States-Canadian border (GEI 2004b).

Bald Eagle (Threatened under ESA)

Bald eagles breed and winter at Lake Roosevelt. The first surveyed bald eagle nesting territory on the reservoir was recorded in 1987. The number of occupied nesting territories increased to 21 in 2000 with 35 young produced (Murphy 2000). Productivity has been relatively good with an average of 1.36 young produced per occupied nesting territory from 1987-2000. These numbers easily exceed the minimum goals in the Pacific Bald Eagle Recovery Plan (USFWS 1996) of two breeding pairs at Lake Roosevelt and 1.0 young produced per occupied territory in the Pacific recovery area.

The reasons for this increasing trend in bald eagle nesting are thought to be an expansion of the local breeding population with relatively good nesting success, an excess in available nest habitat in certain reaches of Lake Roosevelt, an abundant food base, and low levels of human disturbance in some locales (Murphy 2000).

Breeding bald eagles feed primarily on dead and live fish, with waterfowl, other birds, and small mammals making up the remainder of their diet (SAIC 1996). Suckers were the most common prey item identified and are the most abundant fish in the lake but may have been over-represented in prey remains because of their robust size. Other fish species such as carp, kokanee, rainbow trout, whitefish, walleye, and yellow perch were also observed in prey remains.

Winter bald eagle surveys have shown an increase in use of Lake Roosevelt, particularly through the 1980s. Complete surveys conducted by the NPS in the mid 1990s found as many as 245 eagles using the lake during the winter (SAIC 1996). This compares with the Pacific Bald Eagle Recovery Plan wintering population of 40 eagles (USFWS 1996). Wintering bald eagles also rely predominantly on fish and waterfowl either taken alive or as carrion for food.

Mainstem Columbia River Downstream From Grand Coulee Dam

Anadromous Fish

Use of water stored in headwater reservoirs like Lake Koocanusa and Hungry Horse Reservoir forms an important component of the plans designed to conserve and recover populations of Columbia River anadromous fish. Spring and summer releases from these dams are intended to aid outmigration of juvenile salmonids in portions of the Columbia River still accessible to anadromous fish. Additionally, autumn and winter flow releases benefit chum salmon spawning and incubation in areas below Bonneville Dam, though those releases are not part of the alternative or benchmark combinations evaluated in this EIS.

In total, 13 threatened or endangered (under ESA) evolutionarily significant units (ESUs) of salmon and steelhead utilize the mainstem Columbia River downstream from Chief Joseph Dam (Table 5-6). The 2004 NOAA Fisheries FCRPS Biological Opinion and the

Northwest Region web page at http://www.nwr.noaa.gov/1salmon/salmesa/index.htm provide more detail on the status of Columbia River anadromous fish ESUs.

Of these ESUs, upper Columbia spring Chinook and upper Columbia steelhead are found in the vicinity of Chief Joseph Dam. They are most likely to be affected by water quality effects of the alternative combinations, as might middle Columbia steelhead. In addition, most listed ESUs in the Columbia River should benefit from increased flows at Priest Rapids and McNary Dams, which VARQ FC at Libby and Hungry Horse Dams is intended to help achieve.

Bull Trout (Columbia Basin Distinct Population Segment, Threatened Under ESA)

The following excerpts from the Draft Bull Trout Recovery Plan (USFWS 2002) describe bull trout occurrence and use of the mainstem Columbia River downstream from Grand Coulee Dam:

> Historically, the mainstem Snake and Columbia Rivers were likely used as migration corridors, foraging areas, and overwintering habitat by fluvial bull trout that originated in tributary streams throughout the basins. Presently, mainstem habitat may or may not be used by bull trout depending on the strength of their populations in tributary streams and the availability of migration corridors that connect to the Columbia and Snake Rivers.
>
> In the mid-Columbia River, bull trout have been observed passing the fish ladders at Wells, Rocky Reach, and Rock Island Dams. Bull trout have also been observed in the fish ladder counting stations at Bonneville Dam in the lower Columbia River (Sprague 2002).
>
> …[F]oraging and migratory habitat are important to bull trout. Although currently fragmented by the presence of dams, the mainstem Columbia and Snake Rivers provide habitat that potentially helps to maintain interactions between populations of bull trout in the tributaries, and provides for foraging and overwintering opportunities. Migratory corridors such as these allow individuals access to unoccupied but suitable habitats, foraging areas, and refuges from disturbances (Saunders *et al.* 1991).

The mainstem Columbia River is not designated as critical habitat for bull trout.

5.2.6 Vegetation

Mainstem Columbia River

Vegetation along the mainstem Columbia River falls into eight major types, four of which may be affected by the proposed action as outlined in Johnson and O'Neil (2001) and IBIS (2005):

1. Herbaceous wetlands are generally a mix of emergent herbaceous plants with grass-like life forms (graminoids). Cattails, bulrush, burreed, rushes and sedges all occur in this type. This vegetation type is found throughout the length of the Columbia River.

2. Eastside riparian-wetlands contain shrublands, woodlands, and forest communities alongside a stream course. Cottonwood, aspen, alder and willow are dominant trees in this type. Dogwood, gooseberry, snowberry are common shrubs. This vegetation type is found throughout eastern Washington.

3. Westside riparian-wetlands are most often either a tall deciduous shrubland, forest, or some mosaic of these. Red alder is the most widespread tree species. Others include black cottonwood, bigleaf maple and Oregon ash. Shrubs that commonly dominate underneath a tree layer include salmonberry, salal, vine maple and devils club. This vegetation type is patchily distributed in the lowlands west of the Cascade Crest.

4. Bays and estuaries exhibit diverse habitats that result from mixing of salt and freshwater, as well as sedimentation. Eelgrass meadows are codominant with surfgrass on submerged tideflats. Pickleweed, arrowgrass, and three-square rush are often codominant in tideflats bordering salt marshes.

Lake Roosevelt lacks extensive riparian and wetland communities. The southern portion of Lake Roosevelt is within the shrub-steppe region of eastern Washington and is subject to periodic drought. Most riparian habitat at the lake is associated with small tributary streams and springs. Riparian vegetation has established in some areas of silt accumulation that are subject to infrequent flooding. Most of the wetlands associated with the lake are located at the northern end and are dominated by reed canary grass.

5.2.7 Wildlife

Mainstem Columbia River

Wide assemblages of wildlife species live along the mainstem Columbia River in a number of different habitats. The variety of wildlife communities and habitats are in part a consequence of the rainfall amounts, elevation, and land use. Table 5-7 summarizes the number of wildlife species associated with each of the four vegetation types most likely to be affected by the alternative and benchmark combinations.

Table 5-7. Number of species known or expected to occur in a particular wildlife habitat.

Vegetation Type	Amphibians	Reptiles	Birds	Mammals
Herbaceous Wetlands	14	7	150	55
Eastside Riparian-Wetlands	14	10	163	79
Westside Riparian- Wetlands	24	16	145	69
Bays & Estuaries	0	1	157	11

Source: Johnson *et al.* 2001

5.2.8 Recreation

Mainstem Columbia River Upstream From Grand Coulee Dam

The scenic and recreational resources of the upper Columbia River reach are unique in the Columbia River Basin. Although visitation from other areas is low, the upper Columbia River is used extensively for recreation by local residents. Visitation in this river reach has been estimated at approximately 155,000 visitor days per year (BPA *et al.* 1995).

Developed recreation sites provide boating, fishing, camping, and swimming facilities. The most popular activities are sightseeing, picnicking, and fishing. Other popular activities include swimming, canoeing, kayaking, waterskiing, and rafting.

Lake Roosevelt

Lake Roosevelt offers a wide variety of recreation opportunities. Lake Roosevelt is one of the few large lakes in the region that has an extensive amount of shoreline and adjacent lands available for public recreation.

The shorelands of the Lake Roosevelt National Recreation Area, managed by the NPS, consist primarily of a narrow band of land above the maximum high water elevation (1290 feet). In most cases, the minimum amount is determined by the 1310-foot contour, while the maximum ranges up to almost one-half-mile from the high water line in a few locations. The norm is a narrow strip of land that is just a few hundred feet wide (NPS 2002).

Visitation at Lake Roosevelt National Recreation Area has been between 1.3 and 1.5 million people for the last several years (NPS 2002). The peak period of use is from May to September.

The most popular activities in the park are camping, swimming, motor boating, and fishing, followed by family gatherings, picnicking, sightseeing, and water skiing. These uses and other day use recreational opportunities are primarily located at 28 developed areas (NPS 2002).

In 2002, the NPS estimated 112,498 boating visits. Park staff estimate personal watercraft (PWC) use as 4 percent of boating activity. PWC are banned from the Kettle River. Houseboat rental is popular and rental houseboats are available at three locations along the lake. See Table 5-8 for minimum usable boat ramp elevations.

The visual resources at Lake Roosevelt are one of the primary attractions for most visitors. The landscape adjacent to Lake Roosevelt is relatively natural and undeveloped except for occasional farms and small communities (NPS 1997).

Mainstem Columbia River Downstream From Grand Coulee Dam

Lake Rufus Woods

Lake Rufus Woods recreational facilities include Bridgeport State Park, Brandts Landing, Rocky Flats, and viewpoints at the dam. Annual visitation at Corps recreation facilities has averaged 30,800 visitor days from 1987 to 1993 (BPA *et al.* 1995), and 47,900 at Bridgeport State Park from 1989 to 2003 (Corps 2005).

Seven developed sites provide land and river access. Recreation activities include boating, fishing, camping, picnicking, biking, and swimming (BPA *et al.* 1995).

Table 5-8. Lake Roosevelt boat ramp minimum elevations.

Boat Ramp	Lowest Usable Elevation (feet)	Feet below full pool
Crescent Bay	1265	25
Spring Canyon	1222	68
Keller Ferry (marina)	1229	61
Hansen Harbor	1253	37
Jones Bay	1282	8
Lincoln Mill	1245	45
Hawk Creek	1281	9
Seven Bays (marina)	1227	63
Fort Spokane	1247	43
Porcupine Bay	1243	47
Hunters Camp	1230	60
Gifford	1249	41
Daisy	1265	25
Bradbury Beach	1251	39
Kettle Falls (marina)	1234	56
Marcus Island	1281	9
Evans	1280	10
North Gorge	1280	10
Snag Cove Camp	1277	13
French Rocks	1265	25
Napoleon Bridge	1280	10
China Bend	1277	13
Two Rivers (marina)	1280	10

Four boat ramps are on Lake Rufus Woods. Two of the ramps (Bridgeport State Park on the north shore and the upstream boat ramp on the south shore) are near Chief Joseph Dam. The other two ramps are the Seatons Grove boat ramp and the River Mile 581 boat ramp (Corps 2004c). The River Mile 581 ramp is a gravel launch; the other listed ramps are paved. Minimum usable boat ramp elevations at the lake are listed in Table 5-9.

Table 5-9. Lake Rufus Woods minimum usable boat ramp elevations.

Boat Ramp	Minimum Usable Elevation (feet)
River Mile 581	952
Seatons Grove Boat Ramp	950
Bridgeport State Park	937
Upstream Boat Ramp	930

Downstream from Chief Joseph Dam, the Columbia River passes through the flatlands of central Washington, also called the Channeled Scablands. As the river passes through the Columbia River Gorge, the surrounding areas become more heavily urbanized, and a greater number of year-round recreational opportunities are available.

Camping, picnicking, swimming, boating, and fishing are common recreation activities in the mid-Columbia (Chelan PUD 1999). There are many recreational facilities and areas including boat ramps, and water-related access associated with lower Columbia dams and reservoirs (Corps 2004c).

5.2.9 Environmental Health

Mainstem Columbia River Upstream From Grand Coulee Dam

Contaminated Sediments

Several studies in the late 1980s and 1990s documented elevated concentrations of trace elements such as arsenic, cadmium, copper, lead, mercury, and zinc in the bed sediments in Lake Roosevelt and the upper Columbia River. Concentrations of organic compounds such as dioxins, furans, and polychlorinated biphenyls (PCBs) have also been documented in lake sediments. The EPA has identified numerous mining and milling activities along tributaries and the mainstem of the Columbia River which have released or discharged contaminants into the upper Columbia River and Lake Roosevelt. (EPA 2003)

One of the largest contributors of contaminated sediments to Lake Roosevelt and the upper Columbia River system is Tech Cominco Ltd. (Cominco). The Cominco Trail complex routinely discharged the effluent from plant operations into the Columbia River from 1896 to mid-1995. Since the completion of Grand Coulee Dam, it is estimated that 11,794,455 tons of smelter slag (a glassy material containing copper, lead, and zinc) has been produced and may have been discharged to the upper Columbia River. The routine discharge of slag into the Columbia River was discontinued in mid-1995. However, there have been frequent accidental releases of contaminants into the river since that time (EPA 2003).

In addition to the smelter and historic mining/milling operations, the Celgar Pulp Mill located in Castlegar, British Columbia, released untreated effluent containing dioxins, furans, and PCBs into the Columbia River from 1961 until mid-1993 (USGS 2004). Modernization of the mill and the installation of effluent treatment systems in 1993 eliminated dioxins and furans from the mill effluent.

In a 1994 USGS study (USGS 2004), copper, manganese, mercury, selenium, and zinc were detected in fillets of walleye, trout, and smallmouth bass. Only mercury was found at concentrations to be of concern to human health, and the Washington State Health Department issued an advisory for the consumption of fish from Lake Roosevelt. Cadmium, copper, lead, and zinc were found in the liver tissue of these same fish, but no physiological effects were noted. Studies by other agencies around the same time found elevated levels of dioxins, furans, and PCBs in the fish fillets. Follow-up studies in 1998 indicated significant decreases in concentrations of mercury, dioxins, and furans in fish fillets. PCB concentrations do not appear to have changed between the 1994 and 1998 sampling events.

Water quality conditions, including the dispersal of hazardous substances, can be affected by reservoir operations. Coarser sediments entering a reservoir typically are deposited first. The finer sediments, such as silt and clay, are deposited closer to or are transported past the dams. Pollutants entering the mainstem can adsorb to fine sediments and be transported and accumulate with them. When lake levels are lowered significantly, the accumulated sediments can become resuspended or dissolved in the water column (EPA 2003).

Air Quality

From about January through June each year, the water level in Lake Roosevelt is drawn down for flood-control purposes and, based on the extent of the drawdown, exposes large areas of shoreline and flats containing contaminated sediments. Table 5-10 shows the approximate acreage exposed during drawdown.

Table 5-10. Approximate acreage exposed during drawdown.

Lake Elevation (feet)	1290	1280	1270	1260	1250	1240	1230	1220	1210
Exposed Land Areas (acres)	0	4,500	8,800	12,000	16,000	21,000	26,000	29,000	34,000

Based on Landsat imagery, both Marcus Flats and the area from Two Rivers down to Seven Bays are partially exposed when water levels reach 1240 feet elevation. Both areas are completely exposed when lake elevations reach 1230 feet (USGS 2003).

When the exposed sediments dry, the fine-grained material can become airborne and be transported by prevailing winds. Drawdown of the lake elevation for power generation, flood control, and other purposes increases the amount of exposed shoreline. This exacerbates the potential for air dispersion of contaminated sediments during wind events. In its conclusion of the Expanded Site Investigation, EPA stated "[A]dditional concerns include potential threats to human health posed by contact with slag on the beaches of the upper Columbia River and contact with contaminated sediments exposed during low draw down periods. Routes of human exposure to slag and contaminated sediments include inhalation of airborne particles, dermal contact, and ingestion" (EPA 2003).

Air Monitoring Study

To address these concerns, the USGS, in cooperation with the CCT, Lake Roosevelt Water Quality Council, Reclamation, and NPS initiated a study to assess the contributions from trace elements in exposed bed sediments to elemental concentrations of airborne particles measured during ambient and high wind conditions.

The EPA has established long-term and short-term air quality standards for many pollutants. The EPA Ambient Air Quality Standards are for total particulate at and below the respirable range ($\leq$ 10 microns in diameter). These PM10 standards are for the fraction of particles with a mean diameter of less than or equal to 10 micrometers (µm). Particulates of less than or equal to 10 µm are small enough to be inhaled into the lungs of a normal person. The PM10 short-term standard is 150 micrograms per cubic meter of air (µg/m3) and the long-term standard is 50 µg/m3. A total particulate regulatory threshold does not take into consideration the relative toxicity of the various trace elements present in the contaminated bed sediments.

Preliminary results provided by USGS for the 2002 air monitoring season revealed that none of the sites exceeded the short-term standard (150 µg/m3). Long-term averages for the sampling period were 14 µg/m3, 23 µg/m3, and 13 µg/m3 for Kettle Falls, Inchelium, and Seven Bays, respectively. None of the three sites exceeded the long-term standard for PM10. There were several occasions where the PM10 levels at one or more of the sampling sites peaked at concentrations which were greater than 50 µg/m3. Discussions with USGS indicate that similar sampling results were observed during the 2003 monitoring season. EPA has classified only one trace element as a hazardous air pollutant (lead (Pb) at concentrations of 1.5 µg/m3). The mean (average) concentration observed at all three sites for the sampling season of 2002 was several orders of magnitude lower than this value. The EPA and California EPA have established chronic inhalation reference levels for other slag related trace elements including arsenic (As 0.03 µg/m3), and cadmium (Cd - 0.02 µg/m3). Again, air samples taken during the 2002 sampling season were one or more orders of magnitude less than these threshold values (USGS 2003).

Lake elevations for the 2002 and 2003 air monitoring seasons were drawn down to approximately 1240.35 feet, and 1265.35 feet, respectively. The average drawdown for flood control during the period of record was an elevation of 1248.46 feet. At a lake elevation of 1240 feet approximately 21,000 acres of beach and bed sediments are exposed, while at an elevation of 1265 feet less than 12,000 acres are exposed. In both 2002 and 2005, the large flats near Marcus, Seven Bays, and Kettle Falls were either partially or fully submerged.

5.2.10 Cultural Resources

Mainstem Columbia River Upstream From Grand Coulee Dam

Prehistory

The area around what is now Lake Roosevelt has seen human occupation since the first Americans hunted and gathered there about 11,000 years ago. Between 10,500 and 7,000 years ago, hunting and gathering populations grew in size, leading to smaller home territories for ethnic groups and a growing focus on fish resources. Emphasis on plants and smaller game indicates that people targeted an increasingly broader variety of foods. From 7,000 to about 1,500 years ago, fishing became central to subsistence, and fishing locations doubled as important trading centers. Archaeological remains of large multi-season fish camps, which were supplemented by upland hunting and gathering, evidence seasonal procurement of resources. Native population levels began to decline in the 16th century. They continued to drop steeply in the mid 19th century as an apparent result of epidemics, land loss, and other demographics related to waves of Euro-American immigration.

Ethnographic Presence

Tribes historically inhabiting the area around what is now Lake Roosevelt include the Wenatchee, Nespelem, Moses-Columbia, Methow, Colville, Okanogan, Palus, San Poil, Entiat, Chelan, Nez Perce, and Lake (Figure 5-5). Historic observers like David Thompson, an employee of the British North West company and the first Euro-American to visit the area in 1811, were impressed by the seasonal crowds who gathered there to fish, trade, marry, and exchange information (Emerson 1994a).

Trading at fishing camps provided a wide variety of exotic trade goods, including those of European make. A core group usually occupied large fishing camps year-round, but many left to hunt and gather in the fall, and move to winter camps (Galm and Nials 1994). Between the mid-19th and early 20th centuries, Native Americans in the Lake

Roosevelt area were forcibly settled, which disrupted their seasonal round of subsistence from river to uplands, and their ability to trade with neighbors. At present, the Spokane Tribe of Indians (STI) and the CCT reside on reservations whose lands directly abut Lake Roosevelt. These tribes continue to maintain strong ethnic and community identity.

Historic Euro-American Period

Fur trade was the impetus for the first European establishment in the Lake Roosevelt area. Fort Spokane was built between 1807 and 1810 at the confluence of the Spokane and Little Spokane Rivers, and Fort Colville was established soon afterward at Kettle Falls. By the late 19th century, farmers and loggers had settled widely in central Washington. Chinese immigrant miners and other laborers also found their way to Washington at this time. By the early 19th century, irrigation-dependent farming had increased to the point that a Depression-era drought devastated local economies. A western power shortage associated with World War II led Franklin D. Roosevelt to authorize the Columbia Basin Project, including Grand Coulee Dam and Banks Lake, a holding reservoir.

Previous Cultural Resources Surveys

Archeological investigation of the Lake Roosevelt area dates back to the 1930s, when Native American human remains were moved in preparation for the inundation of the reservoir. The Columbia Basin Archeological Survey undertaken beginning in 1939 for the same purpose consisted of rapid surveys of archeological sites over a period of less than two years.

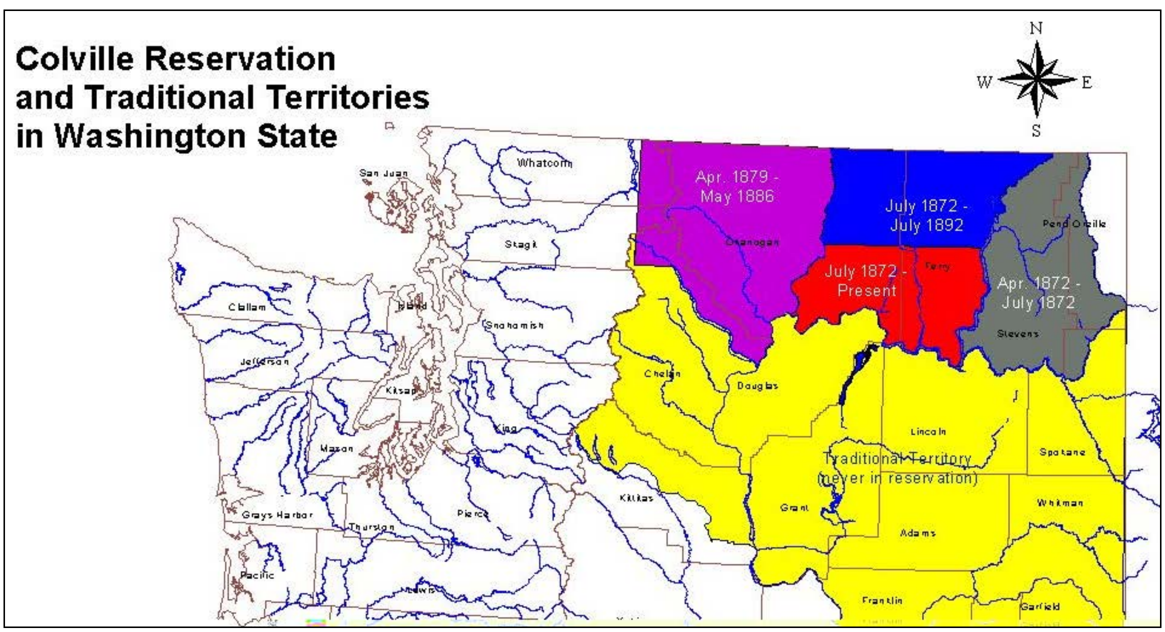

Figure 5-5. Map of the Colville Reservation and traditional territories in

From the 1960s to the early 1990s, the NPS and various universities conducted a series of surveys to document a number of new sites as well as some already known.

The Lake Roosevelt Cooperative Management Agreement of 1990 outlined responsibilities for management of cultural resources and other resources and was signed by Federal agencies and local tribes. This led to the Direct Funding Agreement of 1996, under which the Corps, Reclamation, and BPA agreed to fund cultural resources management at the reservoirs. Subsequent contracts provided management funds to the tribes from the Federal agencies under Section 106 of the National Historic Preservation Act of 1966.

Historic Properties

Current data compiled from the Lake Roosevelt National Recreation Area, the Washington Office of Archaeology and Historic Preservation (OAHP), the CCT, the STI, and Reclamation show a total of 497 sites known for the Lake Roosevelt management area. Of these, approximately 69 percent are prehistoric sites, 14 percent historic, and the remaining 17 percent mixed prehistoric and historic. These sites represent mid-to upper-terrace and upland occupations; the largest, densest sites at the level of the original riverbank are currently under water. Eighteen sites comprising the Kettle Falls Historic District are listed on the National Register. Currently, 43 sites are recommended in cultural resources management reports as eligible to the Register and Determinations of Eligibility are in preparation for six of these sites. These sites would be formally evaluated for eligibility in consultation with the Washington State Historic Preservation Office (SHPO) in annual phases. Twenty-three sites are recommended in reports as ineligible to the Register, and these are to be scheduled for formal determinations of eligibility.

Figure 5-6 shows the elevation ranges of 188 sites at Lake Roosevelt where elevation ranges are available. The majority of sites known for the Lake Roosevelt shoreline are located at elevations between about 1220 and 1320 feet. The 1280 feet elevation mark appears to be particularly dense in sites. This pattern may reflect real site distributions, but is likely also influenced by reservoir operations that fluctuate in this zone and, therefore, reveal cultural resources.

The NPS and OAHP databases represent only a portion of known sites for the project area. When sites are discovered on land managed by the NPS, they are recorded and the data sent to the NPS and the OAHP. However, when sites are found on tribal reservation lands, data are maintained in a separate tribal database. Reclamation is working with the tribes and the Bonneville Power Administration to develop a master database of over 500 sites that includes tribal site data, but for the purposes of this document the figure of 497 sites should be considered a minimum.

Traditional Cultural Properties

The CCT have identified 412 named places along the shoreline of Lake Roosevelt. Reclamation currently does not have data on the number of CCT named places that are considered Traditional Cultural Properties (TCPs) under Federal definitions. Reclamation currently has no data on the exact number of STI-TCPs at Lake Roosevelt.

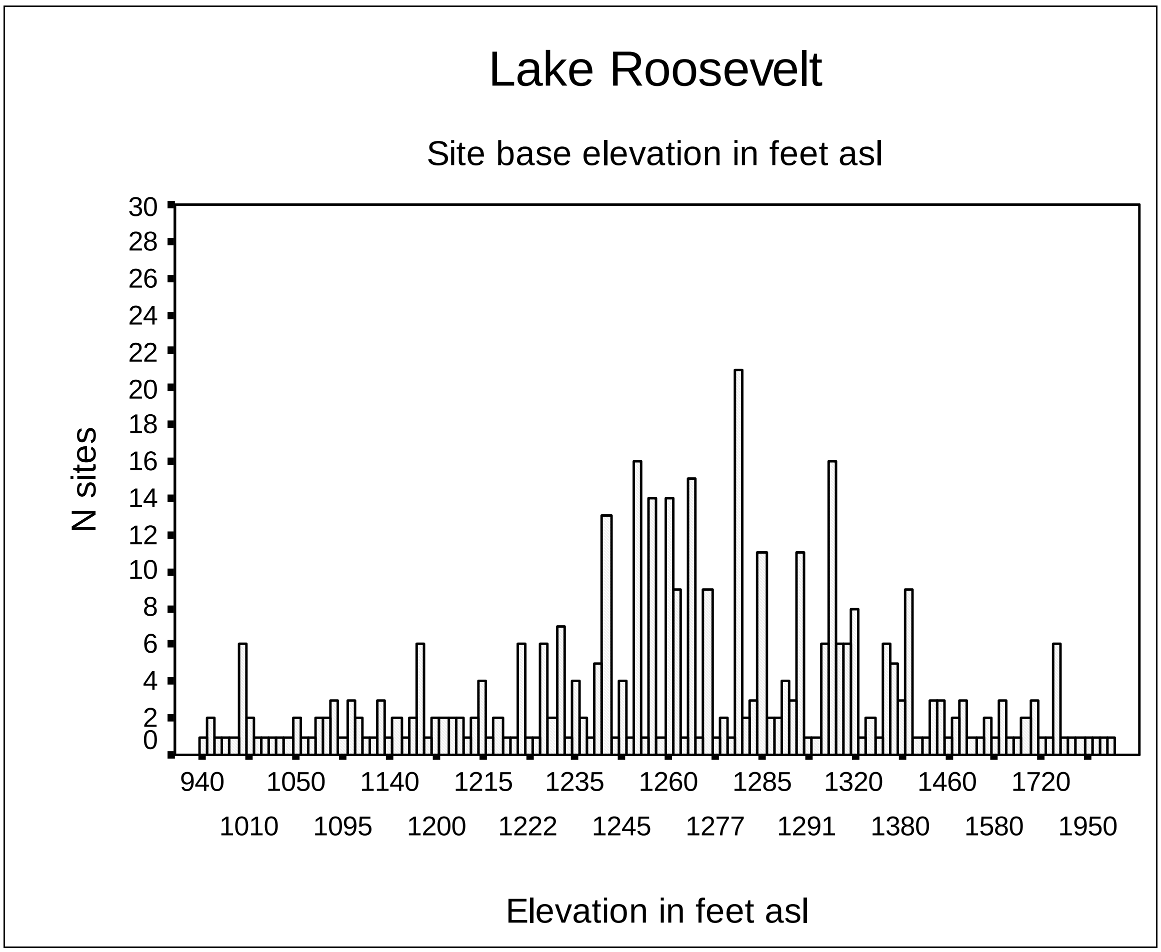

Figure 5-6. Elevation distribution of archaeological sites at Lake Roosevelt.

Mainstem Columbia River Downstream From Grand Coulee Dam

Grand Coulee Dam Tailrace

Reclamation has jurisdiction over shoreline lands 6-miles downstream from Grand Coulee Dam, extending to the boundary of Corps jurisdiction (upriver extent of Lake Rufus Woods). Several sites along the 6-mile downstream stretch below Grand Coulee have been identified in the shoreline or areas immediately upslope. Studies associated with the armoring of the east shore of the downstream area (Bryant 1978, Leeds *et al*. 1980, Galm and Lyman 1988) identified about 50 historic and prehistoric sites at or immediately above the shoreline according to report maps. However, the armoring project buried most of the sites on the east bank.

Lake Rufus Woods

The CCT Historic Preservation Office contracted survey work more recently on the west bank above Lake Rufus Woods (Roulette *et al.* 2001), resulting in the identification of three sites, two new and one previously known. The lack of visibility of additional west bank sites discovered in the 1970s and 1980s surveys indicates that armoring the east bank has possibly altered the erosion patterns or vegetation cover has increased.

Regarding Lake Rufus Woods, the following is taken from the SOR EIS (BPA *et al.* 1995):

> Professional archeological work at Lake Rufus Woods began with the Smithsonian Institution’s River Basin Surveys in the early 1950s. The National Park Service sponsored an inventory and evaluation of these areas in the late 1960s and early 1970s to identify significant sites that might be affected by a 10-foot (3.05 meters) rise in pool elevation. Since the mid-1970s, the Seattle District of the Army Corps of Engineers has carried out a program to identify, test, and recover data from areas that could be affected by project operation. Nearly 300 prehistoric and historic sites are present. The University of Washington tested over 100 of these to identify their age and importance. They performed major excavation at 18 of the most important prehistoric sites. Between 1982 and 1984, Central Washington University tested several more sites in the upper reach of the project near Columbia River (RM 590). Nineteen sites recommended earlier for data recovery but which could not be investigated further have been monitored since the pool was raised in 1981. Burial relocation or site evaluations have been carried out at three sites since the pool was raised. The reservoir is included within the Rufus Woods archeological district, determined eligible for the National Register in 1978. A cultural resource management plan has also been developed for this project.

BPA *et al.* (1995) cited a total of 95 shoreline sites, and 76 inundated sites around Lake Rufus Woods.

5.2.11 Indian Sacred Sites

Reclamation currently has no data concerning sacred sites as defined by Executive Order 13007 for the Lake Roosevelt shoreline. The Corps has been conducting studies of traditional cultural properties of member bands of the CCT, including potential sacred sites, by contract with the CCT History and Archaeology Department since 2003, and to date has not identified sacred sites that could be affected by alternative and benchmark combinations.

5.2.12 Other Affected Tribal Interests

In addition to cultural resources and Indian sacred sites, Lake Roosevelt also retains resources that support hunting, fishing, and gathering activities of importance to the CCT and STI, the primary tribes historically associated with the Franklin D. Roosevelt Lake area.

The United States has a fiduciary responsibility to protect and maintain rights reserved or granted to Indian Tribes by treaties, statutes, and executive orders. This responsibility is sometimes further interpreted through court decisions and regulations. This trust responsibility requires that Federal agencies ensure that Indian rights are given full consideration.

5.2.13 Socioeconomics

Mainstem Columbia River

The following socioeconomic discussion of the mainstem Columbia River focuses primarily on the reach from the mouth of the Kootenay River to Chief Joseph Dam. The reason for this focus is that any planned variation in discharge volume and timing from Libby and Hungry Horse Dams would be reregulated mainly at Grand Coulee Dam, thus minimizing any effects downstream from that point. There may be some minor effects immediately downstream from Grand Coulee Dam, thus the primary affected reach includes the area from Grand Coulee Dam to Chief Joseph Dam. Minor or secondary effects may occur downstream from Chief Joseph Dam to the mouth of the Columbia River.

Demographics

The mainstem Columbia River from Castlegar to the border primarily flows through the Kootenay Boundary Regional District in British Columbia. The mainstem Columbia River flows through or adjacent to 18 counties in Washington. The reach from the mouth of the Kootenay River to Chief Joseph Dam includes those six counties upstream from Chief Joseph Dam. These counties are Stevens, Ferry, Lincoln, Douglas, Grant, and Okanogan. The STI reservation occupies a major portion of Stevens County, as does the CCT reservation in Ferry County. Selected demographic data for British Columbia and six Washington counties from the mouth of the Kootenay River to Chief Joseph Dam are shown in Table 5-11.

Employment and Income

The area of interest along the mainstem Columbia River is highly diverse. From the mouth of the Columbia River to the mouth of the Kootenay River, agriculture is a major industry, as are manufacturing, government, tourism, retail trade, transportation, navigation, and commercial/sport fishing (Table 5-12).

Floods

Flood risk areas include agricultural lands, scattered urban areas, and transportation facilities such as railroads, highways, air terminals, and navigation/port facilities. Bank erosion is a chronic problem for many leveed areas along the mainstem Columbia River. The potential for economic losses from flooding are greatest along the lower Columbia River from the Portland/Vancouver area to the mouth of the river. This area suffers winter rainfall floods as well as snowmelt floods from the Columbia River. Tides influence the lower upstream to Bonneville Dam (RM 146). In addition to system flood control provided by system operations, major levee systems also protect many floodplain areas.

Agriculture and Irrigation

The mainstem Columbia River reach from the mouth of the Kootenay River to Chief Joseph Dam includes southern British Columbia and the six Washington counties. The cost to the Federal Government for irrigation pumping from Lake Roosevelt to Banks Lake in Douglas County, Washington, is the only agriculture related economic activity likely to be affected by any of the alternative and benchmark combinations. Table 5-13 provides a summary of agriculture and irrigation data.

Table 5-11. Selected demographic and socioeconomic information.

	Population Estimate[1]	Population estimate for 2025[1]	Median Per Capita Income[2]	Percent Median State/ Province Income[2]	Percent Below Poverty Line[2]	Percent Minority Population[2]
States/Provinces						
British Columbia	4,146,580		$22,095	n/a		26.0%
Washington	6,131,445		$22,973	n/a	10.6%	18.2%
Oregon	3,559,596		$20,940	n/a	11.6%	13.4%
Affected Cities/ Counties/Regional Districts In Area 3						
Kootenay-Boundary Regional District	33,227	30,582-42,159	$19,668	89.0%	no data	3.0%
Trail	8,167		$20,003	90.5%	no data	9.0%
Montrose	1,098		$23,714	107.3%	no data	3.0%
Stevens County, Washington	40,776	44,905-53,010	$15,895	69.2%	15.9%	10.0% (Native American & Hispanic)
Northport	332		$11,679	50.8%	27.7%	5.1%
Kettle Falls	1,545		$13,614	59.3%	21.1%	8.7%
Ferry County, Washington	7,417	8,400-9,645	$15,019	65.4%	19.0%	24.6% (Native American & Hispanic)
Lincoln County, Washington	10,201	10,325-13,260	$17,888	77.9%	12.6%	4.4% (Native American & Hispanic)
Douglas County, Washington	33,753	42,865-43,880	$17,148	74.6%	14.4%	15.3% (Hispanic)
Bridgeport	2,051		$10,302	44.8%	33.2%	39.2%
Grant County, Washington	78,691	102,305-111,750	$15,037	65.5%	17.4%	23.5% (Hispanic)
Grand Coulee/Electric City	1,877		$16,513	71.9%	15.8%	14.5%
Okanogan County, Washington	39,134	36,105-50,875	$14,900	64.9%	21.3%	24.7% (Native American & Hispanic)
Brewster	2,154		$9,555	41.6%	31.7%	45.1%

1 U.S. State and county population estimates are for 2003 from U.S. Census Annual Population Estimates, Release Date: April 9, 2004.
U.S. city/town population estimates are for 2003 from U.S. Census Annual Population Estimates FRO Incorporated Places, Release Date: June 24, 2004.
Canadian Province, Regional District, and city/town population data are for 2003 from BC Stats Community Facts, release date October 06, 2004.
2 Canadian income and minority population data are for 2000 from the 2001 Census
U.S. data on income, poverty, and minority population are for 1999 from the 2000 Census.

Table 5-12. Percent of employment by industry–United States portion of the mainstem Columbia River

	Stevens County, WA	Ferry County, WA	Lincoln County, WA	Grant County, WA	Douglas County, WA	Okanogan County, WA	Average (U.S.)
Agriculture	17.4	16.3	34.0	22.4	31.7	26.6	24.7
Forestry And Fishing	5.2	D	2.5	D	6.3	7.9	5.5
Mining	0.5	D	0.2	D	0.1	0.3	0.3
Construction	5.4	D	3.8	3.6	5.4	4.5	4.5
Manufacturing	11.5	D	2.3	11.5	2.1	1.3	5.7
Retail Trade	10.5	10.0	9.5	9.8	10.8	9.8	10.1
Transportation/Warehousing	2.6	D	D	2.6	3.4	1.3	2.5
Information	1.1	0.6	0.5	0.7	0.5	0.7	0.7
Finance/Insurance	2.0	1.2	4.3	1.7	1.7	1.8	2.1
Real Estate	3.6	4.0	3.2	2.5	1.7	3.4	3.1
Professional/Technical	2.7	D	3.6	D	2.3	2.6	2.8
Education	0.7	D	L	0.6	0.9	0.5	0.7
Health Care/Social Assistance	10.4	3.6	D	7.2	4.9	6.5	6.5
Recreation/Entertainment	1.4	D	1.5	1.3	2.8	1.4	1.7
Accommodation/Restaurant	4.4	D	3.3	4.6	6.4	5.8	4.9
Other Services	1.2	31.4	3.7	13.8	1.3	1.0	8.7
Government	19.5	33.0	27.5	17.9	17.8	24.4	23.4

Notes: (D) Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.
(L) Less than 10 jobs, but the estimates for this item are included in the totals.
Source: Employment data is for 2002 as presented in Table CA25N – Total full-time and part-time employment by industry, Bureau of Economic Analysis Regional Economic Information System, Table CA25 (NAICS,), May 2004.

Table 5-13. Agricultural and irrigation summary statistics—United States.

County, State	Land In Farms	Total Cropland	Harvested Cropland	Irrigated Acres	Irrigated Acres As Percent Of Harvested Cropland	County's Net Cash Farm Income
Stevens, WA	528,402	116,370	72,272	11,553	16	$7,441,000
Douglas, WA	878,867	550,085	213,942	24,049	11	$29,345,000
Ferry, WA	799,435	23,644	11,705	4,184	36	-$765,000
Franklin, WA	664,875	475,804	288,963	241,063	83	$88,144,000
Grant, WA	1,074,074	804,793	599,943	485,459	81	$178,799,000
Lincoln, WA	1,233,377	854,791	510,356	52,991	10	$31,037,000
Okanogan, WA	1,241,316	139,753	71,149	48,416	68	$33,467,000

Source: NASS 2002

Hydropower Benefits

Power generated by the FCRPS is marketed and sold by BPA through a transmission grid that is interconnected throughout the western United States and Canada. Power is sold outside the Pacific Northwest only when the power is surplus to regional needs. Power is sold to a variety of utilities, direct service industries, and other power marketers. Power prices are based on supply and demand as determined through an electricity “trading floor” that does short-term commodity-type trading. The trading floor brings together current West Coast electricity market conditions, up-to-the-minute hydro and power system status, and short-term weather and streamflow projections to develop daily marketing strategies (BPA *et al*. 2001). Accordingly, changes in the timing of power generation would affect the prices and economic return from the sale of that power. For example, power prices are generally higher in the winter due to high power demand, and lower during the spring due to low power demand coupled with a large power supply generated by spring runoff.

Tribal Socioeconomics

The recognized Native American tribes located along the mainstem Columbia River, or with mainstem Columbia River interests, include the CCT, STI, Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, and Confederated Tribes of the Warm Springs Reservation of Oregon. Only the CCT and the STI are discussed in detail since they have potential to be affected by the alternative and benchmark combinations.

The Colville Indian Reservation is along the west bank of the Columbia River and Lake Roosevelt from a few miles south of Kettle Falls, Washington, to the Okanogan River confluence. Major tribal business enterprises and employers include the timber and construction industries and social and tribal services (K. Desautel, Colville Tribes, pers. comm. 11/04). The Tribe operates a small fish hatchery near Bridgeport. The Tribe also operates a number of boat ramps, a campground, and two marinas under contract with the NPS. It operates the Inchelium ferry year-round. A total of 16 boat docks/ramps on Lake Roosevelt are on tribal lands. Five water intakes are located on Lake Roosevelt and 17 intakes are located on Rufus Woods Lake downstream from Grand Coulee Dam. Most of the boat docks are not usable during low lake elevations (Fulcrum Environmental Consulting Inc. 2004).

The STI reservation is on the east bank of Lake Roosevelt and the north bank of the Spokane River. A boat ramp, marina, and 11 campgrounds on Lake Roosevelt are located on tribal lands adjacent to Lake Roosevelt; the remainder of the shoreline is fairly undeveloped, although there are a number of undeveloped fishing access locations.

5.2.14 Municipal Water and Wastewater Treatment

Towns adjacent to Lake Roosevelt draw water from a mix of surface and groundwater sources. Major municipalities discharging secondary treated wastewater to Lake Roosevelt or streams tributary to Lake Roosevelt include Northport and Kettle Falls, Washington.

5.2.15 Transportation

Mainstem Columbia River Upstream From Grand Coulee Dam

Commercially operated, nonrecreational waterborne transportation at Lake Roosevelt consists of two public ferries that cross Lake Roosevelt year-round.

The Keller Ferry is operated by the Washington State Department of Transportation. It crosses the Columbia River at its confluence with the Sanpoil River from Ferry County and the Colville Indian Reservation on the north bank to Lincoln County on the south. Approximately 60,000 vehicles travel on the Keller Ferry each year. During normal lake elevation of 1290 feet to approximately 1248 feet, ferry service runs on-demand, thereby avoiding unnecessary empty runs. When lake elevation drops below 1248 feet, the north landing is moved a short distance up the Sanpoil River, extending the normal 10 minute crossing to about 20 minutes. The ferry can operate with lake levels as low as 1208 feet. With some special provisions in the ferry operations, it can be operated on a limited basis with levels as low as 1180 feet.

The Inchelium Ferry is operated by the CCT and provides access between Inchelium, Washington, and Highway 25. This small car ferry cannot operate when the reservoir level drops below 1225 feet.

Mainstem Columbia River Downstream From Grand Coulee Dam

Significant commercial navigation occurs downstream from the confluence with the Snake River. Navigation projects in this reach are classified as either deep or shallow draft.

Deep draft navigation occurs in the lower portions of the Columbia River from the mouth upstream to Vancouver. The deep draft channel is used extensively by ocean going vessels transporting products to and from national and international markets. Waterborne commerce for deep draft projects is primarily composed of wheat, grain, corn, automobiles, containerized products, logs, petroleum, chemicals, and other miscellaneous goods.

Shallow draft navigation using tugs, barges, and log rafts occurs upstream from Vancouver through Bonneville Dam, and continues upstream from McNary Dam to connect with the mainstem Snake River. Access to the inland areas is made possible through a series of locks on the dams. Products shipped on the shallow draft channel comprise mainly wheat, grain, wood products, petroleum, chemicals, and other agricultural products.

No bridges, roads or other land-based navigation features are expected to be affected by any of the alternative and benchmark combinations.

5.3 Environmental Consequences

For the analysis of the environmental consequences upstream from Grand Coulee Dam, the mainstem Columbia River downstream from the dam, and the Columbia Basin Power System (FCRPS) the following alternative combinations were derived from Libby Dam and Hungry Horse Dam alternatives:

- Alternative Combination LS1+HS represents the combination of the no action alternatives from Libby and Hungry Horse dams, and uses Standard FC.
- Alternative Combination LV1+HV represents the combination of the VARQ alternatives from Libby and Hungry Horse dams.
- Alternative Combination LS2+HS
- Alternative Combination LV2+HV

In response to the release of the 2006 USFWS Biological Opinion for Libby Dam (following release of the draft EIS), two alternatives (LSB and LVB) were added as explained in Section 2.2. Both alternatives provide for up to 10,000 cfs above powerhouse capacity from Libby to benefit endangered Kootenai River white sturgeon. LVB is now the preferred alternative for Libby operation. For consideration of mainstem impacts, the alternative combinations that result are:

- Alternative Combination LVB+HV, the combination of the preferred alternatives from Libby and Hungry Horse dams.

- Alternative Combination LSB+HS

In addition, two benchmark combinations (LS+HS and LV+HV) are provided as a basis for determination of the effects of Libby Dam fish flows as a component of the alternative combinations.

Chapter 2 discusses these alternative combinations and benchmark combinations in detail.

This analysis addresses the effects of the alternative combinations. The FCRPS has resulted in many significant impacts since its creation. Evaluation of effects of the alternative combinations assumes this, and focuses on impacts relative to the no action alternative combination. Significance is considered in that context. No effects of any alternative combination are considered significant unless specifically stated as such.

If alternative combination LVB+HV could be provided every year, as assumed in the case of alternative combinations LV1+HV and LV2+HV, then its effects for the mainstem would be the same as LV2+HV. However, under LVB the frequency as well as the magnitude of flow above Libby powerhouse capacity in some years would be intermediate between alternatives LV1 and LV2 at Libby. Therefore, it is important to note that for system and mainstem resources discussed below, the effects of alternative combination LVB+HV generally fall between those of LV1+HV and LV2+HV. Similarly, the effects of alternative combination LSB+HS generally fall between those of LS1+HS and LS2+HS.

5.3.1 Hydrology and Flood Control

System Flood Control and Hydropower Models

Two separate analyses were completed to evaluate the effects of system flood control and system hydropower operations. The Streamflow Synthesis and Reservoir Regulation (SSARR) model computes daily flows at Birchbank, British Columbia, and The Dalles, Oregon. These are key system flood control points on the Columbia River. The Hydro System Seasonal Regulation Program (HYSSR) is a monthly model and was used to analyze hydropower operations.

Power drafts need to be considered to get an accurate understanding of Grand Coulee Dam operations. The size of the draft at Grand Coulee Dam is dependent upon the available storage space in upstream dams. When Canadian dams draft for power operations (these are deeper than flood control drafts), Grand Coulee Dam does not need to draft as deeply for flood control. Since the daily system flood control analysis does not incorporate the multipurpose operations of the system as well as the hydropower modeling analysis, analysis and evaluation of operational effects of alternative Libby and Hungry Horse Dam operations on Grand Coulee Dam rely on the hydropower modeling analysis.

An analysis of system flood control and the effects of implementation of VARQ FC with fish flows was completed for the Corps' 2002 EA. Documentation of the EA system flood control analysis was reviewed and it was determined that, although some things could be improved upon if the analysis were to be redone, the conclusions presented in the EA continue to provide a reasonable and sufficient level of analysis for evaluation of system flood control impacts (summarized below). The limitations in the system flood control analysis include:

1. For the fish flow alternatives, only a handful of years were analyzed, based on those which were thought to have the greatest differences in peak 1-day flows between Standard FC and VARQ FC. The intent was to capture the biggest impacts to downstream flood control operations. By choosing only the 10 years that were thought to have the greatest difference in flows, the data do not necessarily represent the full range of water conditions.

2. The daily system flood control modeling is based on the Kuehl-Moffit water supply forecast. This forecast was updated in the EIS to the Wortman-Morrow forecast for Libby Dam operations and Reclamation's forecast for Hungry Horse operations. Both the Wortman-Morrow and Reclamation forecasts reduce forecast errors from those occurring due to the Kuehl-Moffit water supply forecast. Modeling results based on the updated forecast procedures would result in smaller differences in peak 1-day flows between the Standard FC and VARQ FC in years that were under-forecasted.

3. The system flood control modeling with fish flows used a different period of record than was used for hydro-regulation modeling studies of Libby and Hungry Horse Dam operations and the system hydropower analysis. If a full range of years were considered, this should have little to no effect as both periods of record cover dry and wet cycles; however, by limiting to the 10 years that were selected, individual results may be different.

4. Input errors in the system flood control model were corrected for the hydropower analysis. Errors affected operations of Grand Coulee Dam and resulted in greater differences in flood control draft between VARQ FC and Standard FC than would actually occur. The updated model resulted in deeper drafts at Grand Coulee Dam by an average of about 4 feet for VARQ FC and Standard FC.

5. For the Riverware model described in chapter 4 and the HYSSR model, alternative combinations LS+HS and LV+HV included flood control only at Libby Dam and flood control plus fish flows at Hungry Horse Dam. For the system flood control modeling, these same alternative combinations were modeled for flood control only at both projects. To distinguish between the Riverware and HYSRR models and the system flood control modeling, alternative combinations that rely on the system flood control modeling results are designated as LS+HS* and LV+HV*, with the asterisk (*) representing operation of Hungry Horse Dam for flood control without fish flows. The differences between LS+HS* and LV+HV* in the system flood control modeling are greater than what would result if Hungry Horse Dam fish flows were introduced.

System flood control impacts were evaluated on a flood-control-only basis over a 60-year period of record (1929-1989). This means that the various alternatives and alternative combinations were modeled with the assumption that all prescribed storage reservoir drafts were for flood control purposes (for the other modeling studies done for this EIS, the LS+HS and LV+HV benchmarks were for flood control without fish flows at Libby, but for flood control plus fish flows at Hungry Horse). For the system flood control modeling analysis, dam operations were guided strictly by the 1999 FCOP (Corps 1999) and by the IJC Order of 1938 regarding Kootenay Lake. Additional storage space associated with possible power drafts was not taken into consideration.

The system was also operated for flood control with fish flow operations at Libby and Hungry Horse Dams (LS1+HS, LV1+HV, LS2+HS, LV2+HV). System flood control objectives superseded fish flow operations if they were in conflict. For the Libby Dam fish flow operations, the system flood control analysis concentrated on developing an understanding of how forecast error or early/delayed spring freshets might compound effects of VARQ FC. For this reason, modeling of system impacts was completed for 10 years which were selected based on the following criteria:

1. The VARQ FC draft targets at Libby Dam had to be different from the Standard FC draft targets. Years with Libby Dam water supply forecasts greater than 8.0 maf were eliminated from consideration, since the Lake Koocanusa draft targets are identical for forecasts of 8.0 maf and greater.

2. The water supply forecast had to be large enough so that sturgeon volumes would be provided. The sturgeon flow augmentation water volumes are based on the Libby April-August water supply forecast issued in May, and sturgeon flow augmentation is provided only when that forecast is 4.8 maf or greater. Therefore, years with May water supply forecasts less than 4.8 maf were eliminated from consideration.

3. The simulated maximum stage at Bonners Ferry for LV had to be between 1757 and 1765 feet. The low end of this range was selected as the approximate elevation at which agricultural impacts from high groundwater begin to occur. The high end of the range was selected because previous modeling suggested that the VARQ FC and Standard FC frequency curves converge for large water years when the stage at Bonners Ferry exceeds 1764 feet.

Each of the 10 years also met at least one of the following criteria:

1. The forecast representing the April-August Libby inflow volume (as issued in May) had to be over-forecasted by at least one million acre feet or under-forecasted by at least one million acre feet. This way, the impact of a “misforecast” could be assessed. (Use of new water supply forecasting models would change which years were selected based on this criterion.)

2. The ICF at The Dalles had to be reached early enough so that refill was initiated in April (considered early), or late enough so that refill did not begin until after 15 May (considered normal to later than normal.)

3. The average June flows at The Dalles had to be greater than 625 kcfs, thereby indicating a large, late freshet.

4. In the flood control only simulations, the draft at Grand Coulee Dam had to be at least 4-feet deeper with VARQ FC than with Standard FC (correction of error in flood control modeling would impact this criterion).

The 10 years that met these screening criteria were: 1933, 1948, 1949, 1955, 1968, 1971, 1975, 1981, 1986, and 1989. Even though 1942 met the screening criteria, it was not chosen because it was a low volume year with minimal flood control draft at Grand Coulee Dam and an initial controlled flow less than 220 kcfs. It was replaced by 1948, a year that is particularly interesting because of its record high runoff.

All modeling of the Columbia River system assumed that the influence of the Willamette River on the nature of the stage-frequency relationship at Portland/Vancouver harbor was insubstantial for the spring runoff season.

While the daily system flood control modeling provides the best representation of the flood control impacts (i.e., peak daily stages in the vicinity of flood stage) from the different Libby and Hungry Horse Dam operations, impacts to hydrologic parameters are generally best represented by the monthly modeling done for the system hydropower study which better accounts for multipurpose operation of the Columbia River system. The monthly time step used in the hydropower modeling allows comparison of monthly average flows, discharges, and stage/elevation at various points throughout the entire system.

Flood Control Upstream From Grand Coulee Dam

Birchbank, British Columbia, near Trail, British Columbia, is upstream from the confluence of the Columbia River with the Pend d'Oreille River. Therefore, impacts at Birchbank are related to Libby Dam operations and not Hungry Horse Dam operations.

The probability that a flood flow of 225,000 cfs at Birchbank would be equaled or exceeded in a given year is 6 percent for benchmark LS and 7 percent for benchmark LV. The frequency curves for benchmarks LS and LV begin to converge in the neighborhood of 1 percent exceedance (Table 5-14). This feature reflects the gradual merging of VARQ FC and Standard FC procedures for above normal runoff conditions at Libby Dam. In the modeling for benchmark LS, a flood flow of 225,000 cfs (6 percent exceedance) was exceeded only once during the 1928-1989 period. That flood flow on June 1948 was calculated at 240,000 cfs. In the benchmark LV modeling, a flood flow of 225,000 cfs (7 percent exceedance) was exceeded two times during the same period. The first flood flow on June 1948 was calculated at 254,900 cfs, while the second flood flow on July 1954 was calculated at 226,100 cfs. Since flood control operations superseded fish flow operations if they were in conflict, the frequencies of exceeding the flood flow threshold at Birchbank for alternatives LS1, LS2, and LSB would be no greater than those described for benchmark LS. Similarly, the frequencies of exceeding the flood flow threshold at Birchbank for alternatives LV1, LV2, and LVB would be no greater than those described for benchmark LV.

Table 5-14. Peak 1-day discharge frequency analysis at Birchbank for Libby Dam Standard FC and VARQ FC alternatives.

Exceedance Frequency (%)	LS (cfs)	LV (cfs)	Difference (cfs)
99	93,600	95,100	1,500
50	162,500	167,000	4,500
20	191,900	199,100	7,200
10	208,400	217,600	9,200
2	239,000	242,000	3,000
1	250,000	251,000	1000
0.5	261,000	261,000	0
0.2	274,000	274,000	0

Table 5-15 shows the peak daily discharge at Birchbank for each of the ten years for all alternatives with fish flows (LS1, LV1, LS2, LV2). Under all alternatives, 1 in 10 years would exceed the 225,000 cfs flood flow threshold at Birchbank. Peak flows remain below the major flood flow of 280,000 cfs in all study years.

Table 5-15. Peak 1-day discharge at Birchbank, British Columbia. Discharge for Alternative LVB would range between alternatives LV1 and LV2, and Alternative LSB would range between alternatives LS1 and LS2..

YEAR	LS1	LV1	LS2	LV2
1933	199,900	201,900	201,400	203,100
1948[1]	238,900	254,900	240,500	254,900
1949	115,600	121,200	122,900	121,200
1955	209,900	207,400	209,800	207,400
1968	186,300	186,400	203,200	186,400
1971	183,500	190,100	187,500	190,100
1975	173,700	177,200	178,000	177,200
1981	183,000	183,900	181,900	183,900
1986	191,200	172,400	177,900	172,400
1989	130,000	137,600	130,000	137,600

[1] In 1948 flows were in excess of the flood flow threshold of 225 kcfs at Birchbank

Water year 1948, the year with the highest simulated peak flows, is one of the largest on record. It also had one of the larger forecast errors under the Kuehl-Moffit forecast used for the system flood control modeling. The newer Wortman-Morrow and Reclamation forecasts greatly reduce the forecast error for 1948 and consequently have increased the ability to reduce the flood control peak. Compared to the system flood control analysis which uses the Kuehl-Moffit forecast, the hydrologic analysis for Libby Dam daily hydroregulation modeling using the Wortman-Morrow forecast shows no difference between VARQ FC and Standard FC peak 1-day flow from Libby Dam, which would translate to points downstream (i.e., Birchbank, The Dalles, Portland/Vancouver).

Downstream from the confluence of the Columbia River with the Pend Oreille River, operations are influenced by operations of Libby and Hungry Horse Dams.

Grand Coulee Dam and Lake Roosevelt

An indirect effect of implementing VARQ FC at Libby and Hungry Horse Dams is that slightly more flood control space is required by the storage reservation diagrams at Grand Coulee Dam to partially offset the impact to system flood control. Grand Coulee flood control draft is based on the runoff forecast at The Dalles modified by the amount of upstream storage space that is available. For the Grand Coulee and Lake Roosevelt analysis, the Corps factored in all of the operational considerations, which can influence the operation of Grand Coulee Dam including flood control, power requirements, irrigation, and endangered species. Therefore, this analysis is based on multi-purpose modeling (based on 1948-1999 HYSSR appendix J), rather than the system flood control modeling (based on 1929-1989 SSARR; Corps 2002).

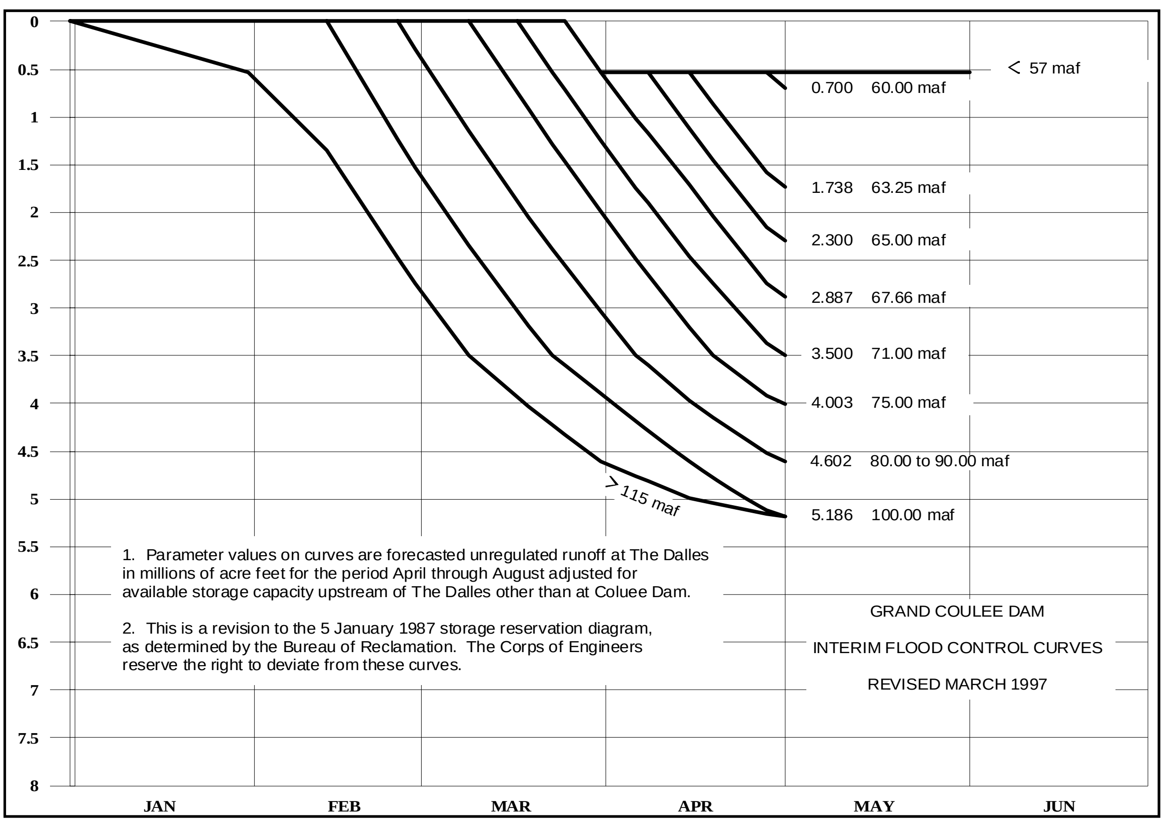

Figure 5-7. Storage reservation diagram for Grand Coulee Dam and Lake Roosevelt.

System flood control space required at Grand Coulee Dam is dependent on the amount of flood control space available at other upstream reservoirs. An effect of implementing VARQ FC at Libby and Hungry Horse Dams is that slightly more flood control space is required at Grand Coulee Dam/Lake Roosevelt to maintain system flood control. Grand Coulee Dam's flood control draft is based on the runoff forecast at The Dalles modified by the amount of available upstream storage space (Figure 5-7).

Grand Coulee Dam is the key structure of Reclamation's Columbia Basin Project, a multipurpose development utilizing a portion of the resources of the Columbia River. Flood control is one of several factors which can affect operation of Grand Coulee Dam. Other factors such as power needs and flow objectives for listed species can influence reservoir operations during the winter and spring as much, if not more, than flood control requirements. In other words, the effects of VARQ FC at Libby and Hungry Horse on Lake Roosevelt elevations are overshadowed by other considerations.

Only the differences between Standard FC and VARQ FC are discussed in the following text. The Libby Dam fish flows occur after Grand Coulee Dam flood control draft is completed and; therefore, have minimal effect on Lake Roosevelt elevations.

For this analysis, the Corps factored in all of the operational considerations, which can influence the operation of Grand Coulee Dam including flood control, power requirements, irrigation, and listed species. The modeled minimum, maximum and average forebay elevations at Grand Coulee Dam for Standard FC and VARQ FC (end of period, January through May) are provided in Table 5-16. As this table indicates, there is no difference in the operating range for Grand Coulee Dam. The annual maximum and minimum elevations are the similar over the 52-year period for both Standard and VARQ FC. There is a small difference in the long-term average water surface elevation.

Table 5-16. Grand Coulee simulated minimum, maximum, and average forebay elevations, modeled (1948-1999).

Flood Control Operation	Grand Coulee Forebay Elevations (feet)					
	Jan	Feb	Mar	Apr 15	Apr	May
Standard FC						
minimum	1260.0	1246.3	1220.4	1212.2	1208.0	1208.0
maximum*	1290.0	1290.0	1283.1	1283.1	1280.0	1288.6
average	1268.3	1264.1	1260.8	1253.5	1244.0	1254.0
VARQ FC						
minimum	1260.0	1245.0	1220.3	1212.3	1208.0	1208.0
maximum	1290.0	1290.0	1283.1	1283.1	1280.0	1288.5
average	1268.4	1263.6	1259.6	1251.9	1242.4	1252.8
Difference (VARQ FC– Standard FC)						
minimum	0.0	-1.3	-0.1	0.1	0.0	0.0
maximum	0.0	0.0	0.0	0.0	0.0	-0.1
average	0.1	-0.5	-1.2	-1.6	-1.6	-1.2

*1290 is the maximum water surface

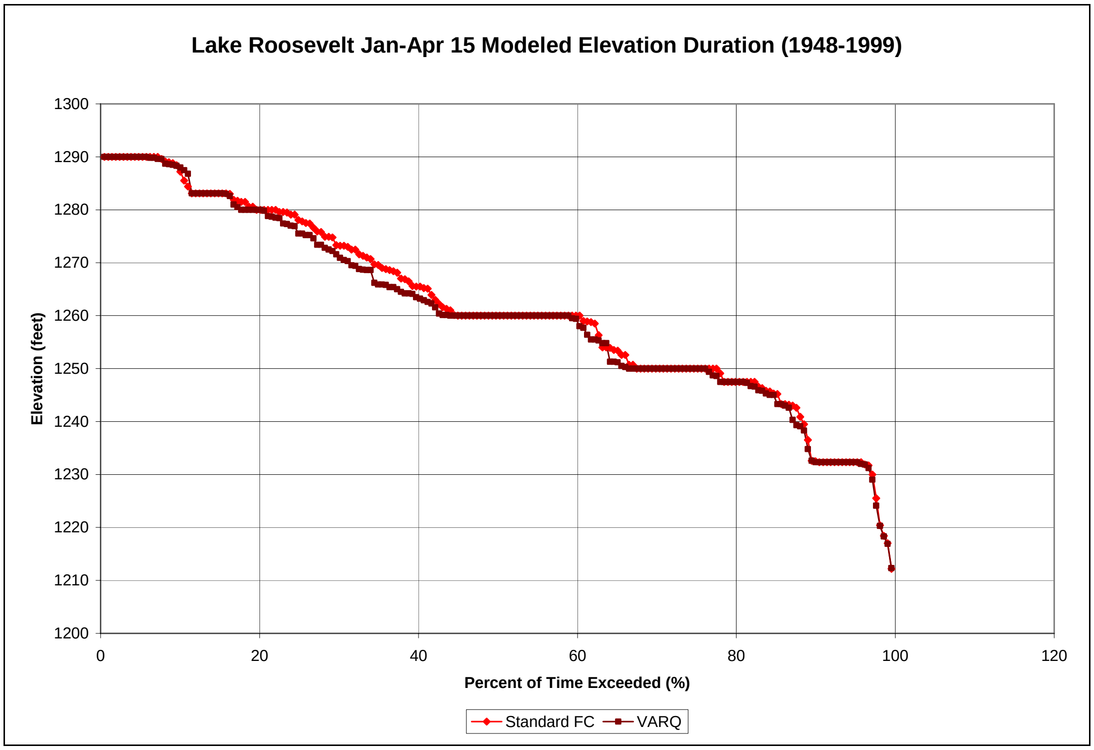

Figure 5-8. Lake Roosevelt modeled elevation duration analysis (1948-1999).

Figure 5-8 is an elevation duration analysis for Lake Roosevelt for the January through April 15 period. There are only minor differences between Standard FC and VARQ FC. Figure 5-9 shows the Lake Roosevelt elevation percent exceedance curves for the end of April for each alternative combination. April 30 elevations are generally a little higher under Standard FC.

Figure 5-10 and Table 5-17 show the differences in modeled Lake Roosevelt elevations between Standard FC and VARQ FC. The median difference between Standard FC and VARQ FC on April 30 is that Lake Roosevelt would be 0.4 feet lower under VARQ FC (modeled, 1948-1999). The maximum difference on April 30 is that Lake Roosevelt would be 6.1 feet lower under VARQ FC (modeled, 1948-1999).

Summary

An analysis of the implementation of VARQ FC at Hungry Horse and Libby Dams has shown that there would be some minor effects on Lake Roosevelt elevations during the January through May period. These effects would not occur in every year and are not always evident due to other operational considerations such as power needs and flow objectives for sensitive, threatened and endangered species that can overshadow flood control operations and drive the operation of Grand Coulee Dam. Generally, the largest effects caused by VARQ FC occur at the end of April, when the largest flood control

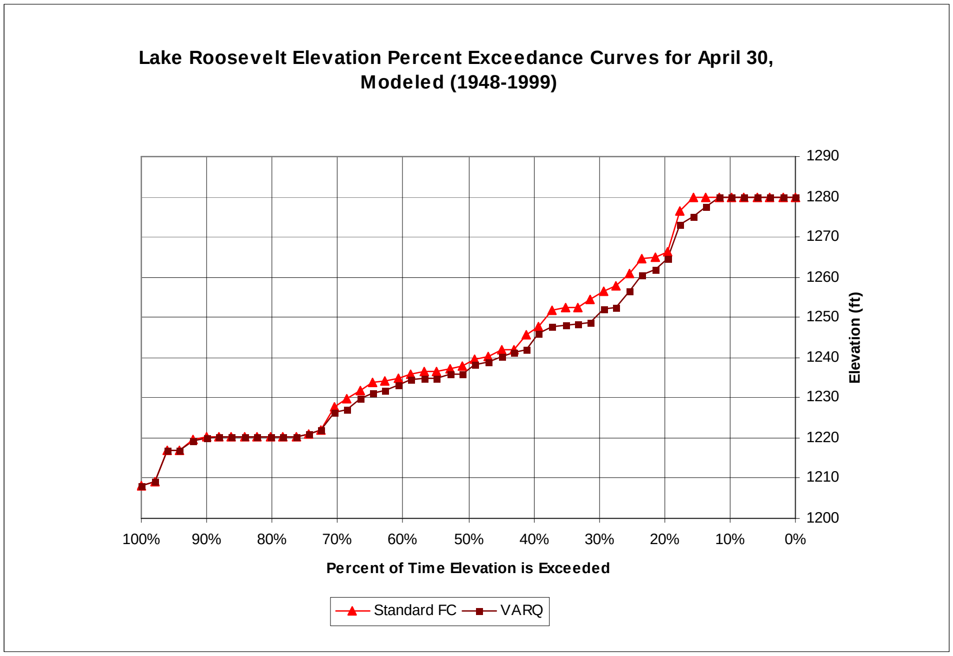

Figure 5-9. Lake Roosevelt elevation exceedance for April 30.

drafts occur. The median modeled elevation difference between Standard FC and VARQ FC on April 30 on Lake Roosevelt is 0.4 feet lower under VARQ FC. The maximum modeled difference on April 30 on Lake Roosevelt is 6.1 feet lower under VARQ FC compared to Standard FC.

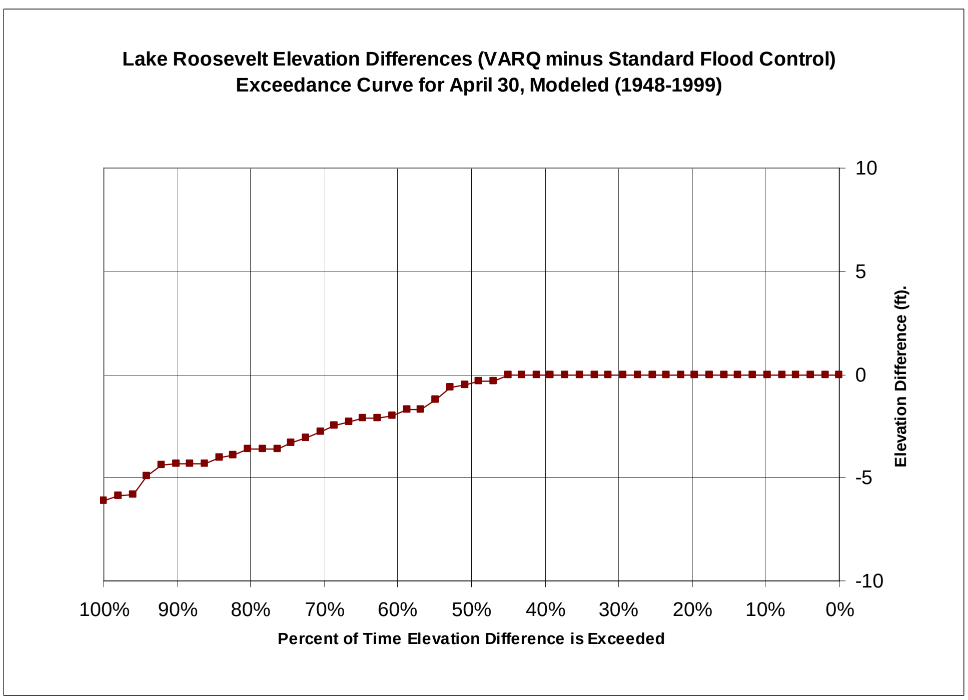

Figure 5-10. Lake Roosevelt elevation differences (VARQ FC minus Standard FC) exceedance curves for April 30.

Table 5-17. Modeled April 30 Lake Roosevelt elevations.

YEAR	VARQ FC	Standard FC	Difference
1948	1229.7	1231.8	-2.1
1949	1226.3	1229.9	-3.6
1950	1220.3	1220.3	0.0
1951	1219.3	1219.7	-0.4
1952	1241.8	1241.8	0.0
1953	1252.3	1256.5	-4.2
1954	1220.3	1220.3	0.0
1955	1277.5	1280.0	-2.5
1956	1221.1	1221.1	0.0
1957	1234.8	1236.6	-1.8
1958	1241.4	1245.6	-4.2
1959	1222.1	1222.1	0.0
1960	1238.8	1241.9	-3.1
1961	1235.0	1237.3	-2.3
1962	1238.3	1239.5	-1.2
1963	1280.0	1280.0	0.0
1964	1231.9	1233.9	-2.0
1965	1235.7	1235.7	0.0
1966	1248.6	1252.4	-3.8
1967	1220.3	1220.3	0.0
1968	1252.2	1258.0	-5.8
1969	1240.2	1240.2	0.0
1970	1262.0	1264.8	-2.8
1971	1216.8	1216.8	0.0
1972	1216.8	1216.8	0.0
1973	1280.0	1280.0	0.0
1974	1209.1	1209.1	0.0
1975	1220.3	1220.3	0.0
1976	1220.3	1220.3	0.0
1977	1264.6	1264.6	0.0
1978	1231.0	1234.2	-3.2
1979	1260.4	1266.2	-5.8
1980	1247.8	1251.7	-3.9
1981	1275.1	1280.0	-4.9
1982	1220.1	1220.3	-0.2
1983	1220.3	1220.3	0.0
1984	1248.1	1252.5	-4.4
1985	1235.8	1237.9	-2.1
1986	1248.5	1254.6	-6.1
1987	1280.0	1280.0	0.0
1988	1280.0	1280.0	0.0
1989	1233.1	1236.7	-3.6
1990	1246.1	1247.8	-1.7
1991	1234.5	1234.8	-0.3
1992	1280.0	1280.0	0.0

YEAR	VARQ FC	Standard FC	Difference
1993	1280.0	1280.0	0.0
1994	1280.0	1280.0	0.0
1995	1256.6	1260.9	-4.3
1996	1227.2	1227.8	-0.6
1997	1208.0	1208.0	0.0
1998	1273.0	1276.5	-3.5
1999	1220.3	1220.3	0.0

Mainstem Columbia River Downstream From Grand Coulee Dam

The Dalles, Oregon

The chance that a flood level flow of 450,000 cfs at The Dalles would be equaled or exceeded in a given year increases from 32 percent for benchmark combination LS+HS* (HS* and HV* indicate that these alternatives as modeled in the daily flood control study did not consider Hungry Horse fish flows) to 35 percent for benchmark combination LV+HV*, but well within modeling sensitivity (Table 5-18). The LS+HS* and LV+HV* frequency curves converge in the neighborhood of 1 percent exceedance. This feature reflects the gradual merging of VARQ FC and Standard FC procedures at Libby and Hungry Horse Dams for above-normal runoff conditions. Since flood control operations superseded fish flow operations if they were in conflict, the frequencies of exceeding the flood flow threshold at The Dalles for alternative combinations LS1+HS, LS2+HS, and LSB+HS would be no greater than those described for benchmark combination LS+HS*. Similarly, the frequencies of exceeding the flood flow threshold at The Dalles for alternative combinations LV1+HV, LV2+HV, and LVB+HV would be no greater than those described for benchmark combination LV+HV*.LVB

Table 5-18. Peak 1-day discharge frequency analysis at The Dalles for Standard FC and VARQ FC operations (benchmark combinations) at Libby and Hungry Horse Dams.

Exceedance Frequency (%)	LS+HS* (cfs)	LV+HV* (cfs)	Difference (cfs)
99	205,000	211,000	6,000
90	286,000	292,000	6,000
70	351,000	360,000	9,000
50	401,000	411,000	10,000
20	490,000	501,000	11,000
10	541,000	550,000	9,000
2	635,000	639,000	4,000
1	670,000	670,000	0
0.5	703,000	703,000	0
0.2	743,000	743,000	0

*Daily system flood control modeling did not consider Hungry Horse fish flow operations.

Table 5-19 shows the peak daily discharge at The Dalles for each of the 10 years for alternative combinations with fish flows (LS1+HS, LV1+HV, LS2+HS, LV2+HV). Alternative combination LVB+HV discharges would range between those shown for LV1+HV and LV2+HV, and alternative combination LSB+HS would range between those shown for LS1+HS and LS2+HS. Under all of the alternative combinations with fish flows, 4 of 10 study years would exceed the 450,000 cfs flood flow threshold at The Dalles. One in ten years modeled would exceed the major damage level of 600,000 cfs. Improved forecast methods would have reduced the differences between Standard FC and VARQ FC modeled for 1948.

Figure 5-11 shows the average annual flow pattern at The Dalles for alternative combinations. Alternative combination LVB+HV would fall between LV1+HV and LV2+HV. Alternative combination LSB+HS would fall between LS1+HS and LS2+HS. Overall, differences in flow at The Dalles between alternative combinations are small. Flows during January would tend to be higher under all Standard FC alternative and benchmark combinations than all VARQ FC alternative and benchmark combinations, primarily because of the deeper flood control draft requirements of Standard FC operation. During spring, flows under all the Standard FC would tend to be slightly lower than all VARQ FC alternative combinations and benchmark combinations due to lower discharges during refill of Libby and Hungry Horse Dams with Standard FC. The other notable difference is lower average monthly flow (by about 13,000 cfs) in September with alternative combinations with fish flows, compared to nonfish flow benchmark combinations. The lower September flows result from fish flow operations drafting Lake Koocanusa to 20 feet below full pool at the end of August. Thus, beginning in September, Libby Dam goes to minimum flow of 4 kcfs. For benchmark combinations, Lake Koocanusa tends to remain full through the summer and Libby Dam starts to draft (greater than 4 kcfs) in September.

Vancouver, Washington

Benchmark combination LV+HS* shows an average increase in river stage of about 0.2 feet for the 1929-1989 hydro-regulations. The chance that a stage of 16 feet (flood stage) would be equaled or exceeded in a given year increases from 19 percent for benchmark combination LS+HS* to 22 percent for benchmark combination LV+HV*, but well within modeling sensitivity. The frequency curves converge for larger, more infrequent flood events; in this case, as exceedance probabilities approach 2 percent. Since modeled flood control operations superseded fish flow operations if they were in conflict, the frequencies of exceeding flood stage at Vancouver for alternative combinations LS1+HS, LS2+HS, and LSB+HS would be no greater than those described for benchmark combination LS+HS*. Similarly, the frequencies of exceeding the flood stage at Vancouver for alternatives LV1+HV, LV2+HV, and LVB would be no greater than those described for benchmark combination LV+HV*.

Table 5-19. Peak 1-day discharge (cfs) at The Dalles, Oregon, for alternative combinations. Alternative combination LVB+HV would fall between LV1+HV and LV2+HV, and alternative combination LSB+HS would fall between LS1+HS and LS2+HS.

Year	LS1+HS	LV1+HV	LS2+HS	LV2+HV
1933[1]	453,800	458,100	455,400	459,600
1948[1,2]	761,300	775,100	766,100	775,100
1949	403,900	409,900	403,200	411,400
1955	406,800	405,400	406,100	406,800
1968	359,400	365,500	359,800	366,200
1971[1]	541,300	549,200	541,800	548,000
1975[1]	481,000	488,700	483,400	489,800
1981	390,400	399,200	389,900	401,200
1986	425,800	434,500	434,300	434,500
1989	376,200	383,700	375,400	384,000

[1] In years 1933, 1948, 1971, and 1975, flows were in excess of the flood flow threshold of 450,000 cfs at The Dalles, Oregon.

[2] The system flood control analysis (Corps 2002) estimated the effects of the different alternative combinations and benchmark combinations on Grand Coulee Dam operations, but these estimates do not incorporate the multi-purpose operation of the system as well as the hydropower modeling analysis does. Accordingly, analysis and evaluation of the operational effects of Libby and Hungry Horse operations at Grand Coulee rely on the hydropower modeling analysis (Appendix J, Hydropower Generation Report).

Table 5-20 shows the peak daily elevations at Vancouver, Washington, for each of the 10 years for alternative combinations LS1+HS, LV1+HV, LS2+HS, LV2+HV. Alternative combination LVB+HV would fall between LV1+HV and LV2+HV. Alternative combination LSB+HS would fall between LS1+HS and LS2+HS. Under all alternative combinations, 2 of 10 study years would exceed the flood level at Vancouver.

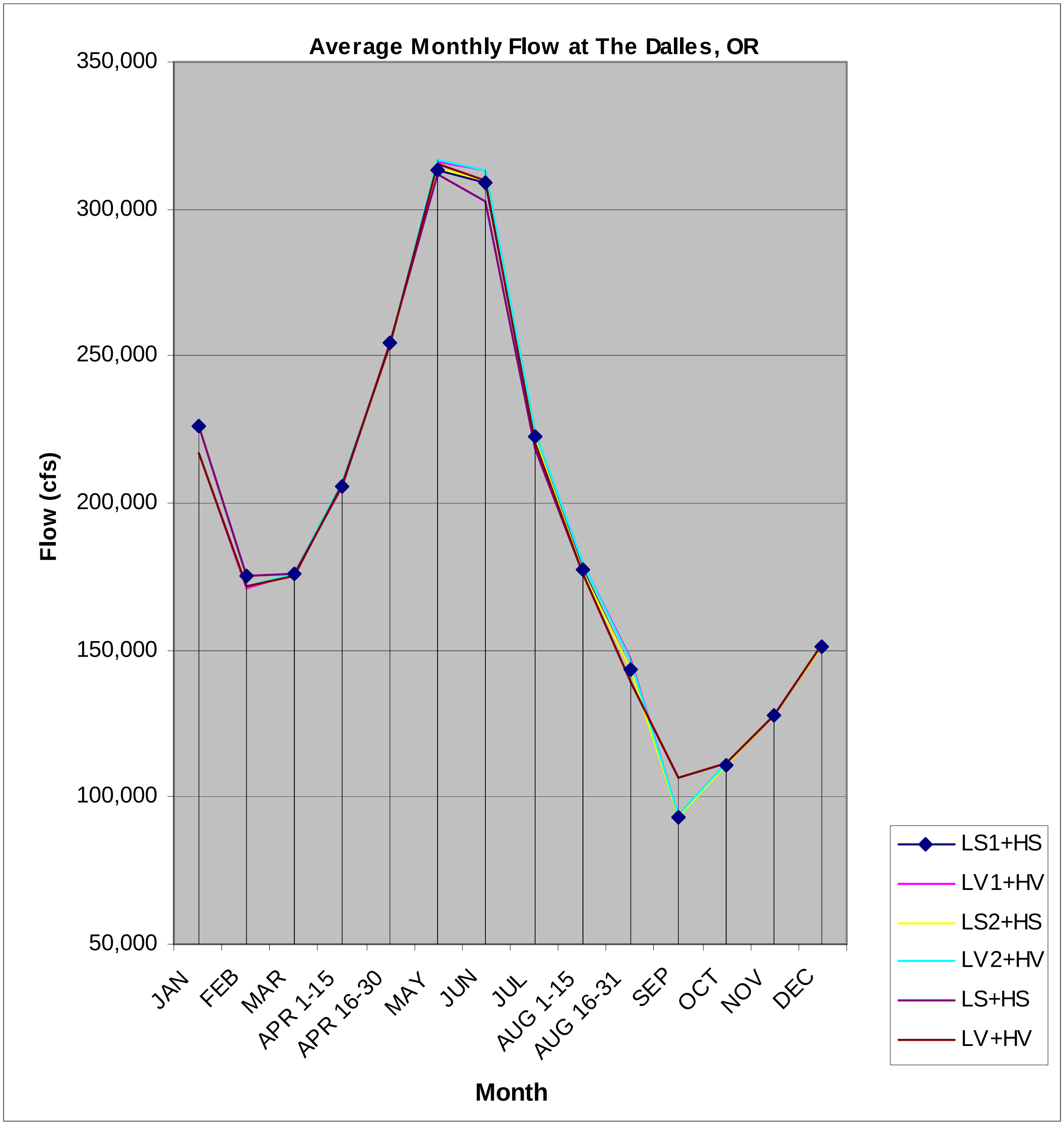

Figure 5-11. Average monthly flow at The Dalles for all alternative combinations and benchmark combinations. Alternative combination LVB+HV would fall between LV1+HV and LV2+HV. Alternative combination LSB+HS would fall between LS1+HS and LS2+HS.

Table 5-20. Peak 1-day elevations at Vancouver, Washington. Alternative combination LVB+HV would fall between LV1+HV and LV2+HV. Alternative combination LSB+HS would fall between LS1+HS and LS2+HS.

YEAR	LS1+HS	LV1+HV	LS2+HS	LV2+HV
1933	14.86	14.97	14.90	15.07
1948[1,2]	24.67	25.08	24.80	25.08
1949	13.05	13.29	13.03	13.33
1955	13.19	13.12	13.18	13.17
1968	11.97	12.16	11.97	12.16
1971[1]	17.97	18.20	17.97	18.20
1975	15.87	16.17	15.96	16.21
1981	12.23	12.56	12.21	12.61
1986	13.86	14.19	14.19	14.19
1989	11.82	12.13	11.82	12.13

[1] In 1948 and 1971 peak elevations were above flood stage 17.8 feet (NGVD) at Vancouver, Washington.

[2] The system flood control analysis (Corps 2002) estimated the effects of the different alternative combinations and benchmark combinations on Grand Coulee Dam operations, but these estimates do not incorporate the multi-purpose operation of the system as well as the hydropower modeling analysis does. Accordingly, analysis and evaluation of the operational effects of Libby and Hungry Horse operations at Grand Coulee rely on the hydropower modeling analysis (Appendix J, Hydropower Generation Report).

5.3.2 System Power

To evaluate system power generation, the Pacific Northwest reservoir system was modeled using the Corps' Hydro System Seasonal Regulation (HYSSR) model. The model calculates power generation, flows, and reservoir levels for 14 periods. A period consists of one month except April and August, which are split in half months (abbreviated: Apr1 and Apr2 representing first and second halves of April, and Aug1 and Aug2, representing first and second halves of August). Model runs cover a 52-year period from August 1, 1947, through July 31, 1999 (August through July is the operating year for hydropower planning studies). All alternative combinations are continuous-type studies where the July end-of-month elevations are used as the starting elevations for the following August. All reservoirs were started full on July 31st of 1947; however, the reservoirs at Grand Coulee, Hungry Horse, and Dworshak (in all alternative and benchmark combinations) and at Libby (in the alternative combinations) started at their draft limits for McNary Dam flow objectives. The reservoir at Libby Dam started full in the benchmark combinations.

Operation of water storage projects for power generation in the Columbia River Basin is coordinated through the PNCA. The agreement states the operators of the dams in the Columbia River Basin have agreed to plan, coordinate, and operate their systems to optimize power production taking into consideration nonpower requirements (*i.e.*, flood control). All alternative combinations modeled the system using power operations for all dams as submitted in accordance with the PNCA, except for Libby and Hungry Horse Dams. Hungry Horse Dam was modeled to end-of-month elevations specified in the Riverware model addressed in chapter 4 and Appendix H. Libby Dam was modeled to power operations in accordance with the PNCA for September through November; flood control targets from December through April; and to end-of-month elevations specified in the SSARR (chapter 3 and Appendix B) for May through August. Operating criteria for non-Federal dams are as submitted by dam operators for the operating year 2003-2004 or as otherwise stated in Appendix J.

The HYSSR model operates so dams run according to their operating rule curve (ORC) or draft as necessary to meet the power load. The ORC is a combination of curves made up of flood control curves, refill curves, and power critical rule curves. The dams that operate for power first run to their ORCs, and if the energy produced is greater than or equal to the load, then the model run is complete. If the energy produced by running to the ORC is less than the load, then the dams draft until the load is just met. Dams that operate specifically for fish flows do not operate to ORCs, but still generate power, which contributes toward meeting the load.

The power modeling performed for this document supersedes the hydropower study prepared for the 2002 EA for interim implementation of VARQ FC (Corps 2002). Differences from the 2002 hydropower modeling are as follows:

1. Mica and Arrow dams flood control allocation changed from 2.08 maf/5.1 maf to 4.08 maf/3.6 maf for Standard FC and VARQ FC curves to reflect the allocation now used in actual operations.

2. VARQ FC and Standard FC curves were updated with the Wortman-Morrow forecast procedure for Libby Dam, and with Reclamation's forecast for Hungry Horse Dam, for system flood control in the drawdown period, and used the Corps' and Reclamation's refill curves. (For the rest of the system, the Kuehl-Moffitt forecast method remains in effect.)

3. VARQ FC refill start dates varied each year, as determined by the initial controlled flow. By contrast, these dates were set at May 1st in all years for the 2002 Interim EA.

4. Historic natural flows were updated from the 1990 level to the 2000 level.

5. The study period was changed from 1928-1987 to 1947-1999. The study period is defined by the availability of the Wortman-Morrow water supply forecasts for Libby Dam, developed to water year 1948, which begins on Oct 1, 1947.

6. Canadian operation was updated from the operating year (OY) 2002-2003 to 2007-2008 to reflect future operation planned for flows at the United States/Canadian border.

7. United States system critical rule curves (to meet firm energy requirements) and project operating criteria were updated from OY 2002-2003 to OY 2003-2004, which are the most current data available.

8. An update was incorporated to use 52 years of PNCA coordinated system loads instead of one set of Federal loads used for each year. This allows the total coordinated system to draft for load as needed depending on water year. In the 2002 Interim EA, Federal dams served the same Federal firm energy load carrying capability (FELCC) in every year, regardless of water availability. In this study for this document, the PNCA coordinated system serves the coordinated system load to better simulate the system operation for each combination.

9. Libby Dam and Hungry Horse Dam operations were updated based on recent hydroregulation modeling of these projects by the Corps and Reclamation, respectively, for all alternative and benchmark combinations.

Summary results are provided here. Results are in megawatts, averaged over the time intervals (months or years) of interest[75]. See Appendix J for more detailed discussion of consequences to the power system from the different alternative combinations.

Although operations for a given alternative at Hungry Horse Dam would produce the same power at Hungry Horse, adjustments in Kerr Dam operations due to system load requirements may vary due to Libby Dam operations. These differences affect generation at Kerr Dam and all projects downstream of Kerr. To account for the coordinated system operation of hydropower generation, results for generation by Canadian projects on the Kootenay and Pend d'Oreille rivers are provided based on the alternative combinations, rather than the specific alternatives at Libby and Hungry Horse.

Results

System generation results for alternative and benchmark combinations are shown in Figure 5-12, which depicts system average power generation and Figure 5-13, which depicts the system median power generation for all projects in the United States. Overall, United States system differences are minor among the alternative combinations. Figure

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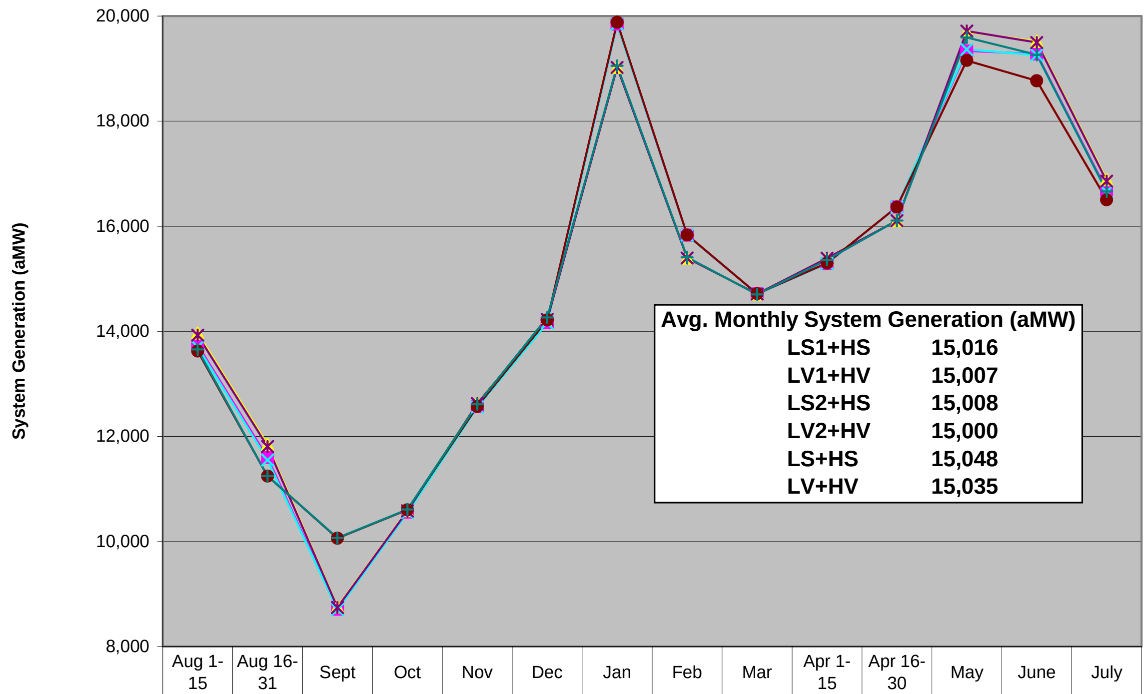
[75] Power generation at large dams is most often measured in megawatts. Because generation is continuous, the output for a dam or the system can be measured instantaneously, similar to the manner in which the speed of a car is measured in miles per hour. Power generation measurements taken at desired time intervals are averaged over the appropriate period of time to derive average megawatts. In this analysis, the monthly/period generation numbers are average MW over that month/period, and each year's average annual generation is computed based on a daily weighted average for that year.

5-14 and Figure 5-15 depict hydropower generation for Canadian projects on the Kootenay and Pend d'Oreille rivers, respectively.

Alternative Combination LS1+HS

In general, winter power generation generally modeled higher under Standard FC operations than under VARQ FC operations because wintertime flood control drafts at Libby and Hungry Horse Dams under Standard FC tend to be deeper than those under VARQ FC in medium runoff years. Accordingly, alternative combination LS1+HS (no action alternative combination) would generate relatively more power in winter compared with LV1+HV or LV2+HV. Power generation during the spring and summer would be intermediate when compared to the other alternative combinations. Compared to benchmark combination LS+HS, the addition of fish flows under LS1+HS would have minimal effects on winter generation, tend to slightly increase spring and summer generation, and tend to decrease generation in September. The average annual decrease in United States system generation due to fish flows at Libby powerhouse capacity with Standard FC would be 31 MW, with most of the reduction compared to the benchmark combinations occurring in September.

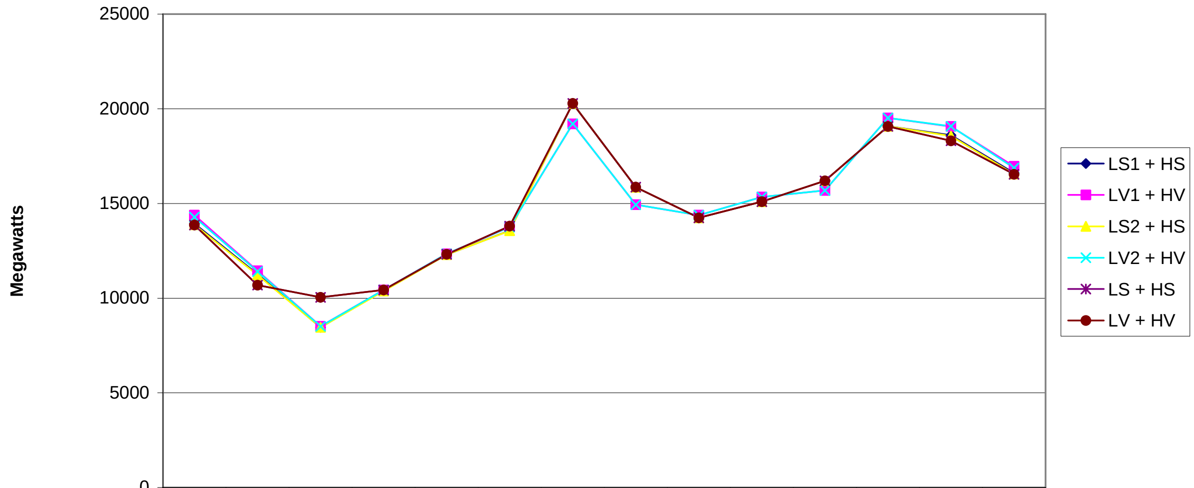
Average System Generation (aMW) for All Alternative Combinations



	Aug 1-15	Aug 16-31	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-15	Apr 16-30	May	June	July
LS1+HS	13,743	11,600	8,712	10,557	12,566	14,166	19,849	15,831	14,716	15,290	16,366	19,337	19,279	16,683
LV1+HV	13,965	11,846	8,755	10,586	12,631	14,229	19,025	15,394	14,711	15,390	16,106	19,698	19,521	16,885
LS2+HS	13,703	11,551	8,705	10,549	12,558	14,159	19,847	15,831	14,715	15,290	16,366	19,365	19,259	16,655
LV2+HV	13,927	11,808	8,743	10,583	12,626	14,227	19,024	15,393	14,710	15,391	16,106	19,717	19,497	16,858
LS+HS	13,627	11,244	10,061	10,603	12,570	14,217	19,882	15,833	14,715	15,299	16,365	19,155	18,769	16,503
LV+HV	13,655	11,246	10,068	10,610	12,611	14,263	19,053	15,410	14,704	15,362	16,110	19,594	19,264	16,662

Figure 5-12. Monthly system generation averages (Mw) for alternative and benchmark combinations (alternative combination LVB+HV would fall between alternative combinations LV1+HV and LV2+HV, and alternative combination LSB+HS would fall between LS1+HS and LS2+HS).

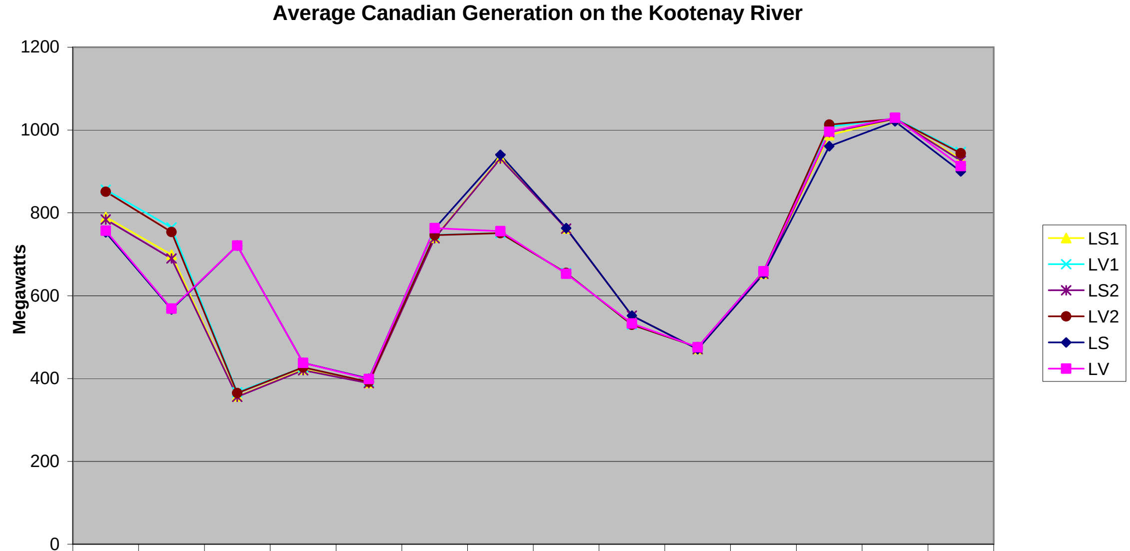
Median System Generation by Alternative and Benchmark Combination



	1-Aug	2-Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	1-Apr	2-Apr	May	Jun	Jul
LS1 + HS	13928	11269	8460	10429	12299	13573	20292	15857	14243	15098	16199	19076	18605	16610
LV1 + HV	14384	11445	8516	10434	12346	13761	19204	14935	14387	15347	15686	19514	19068	16965
LS2 + HS	13880	11225	8456	10382	12299	13560	20292	15857	14243	15098	16199	19076	18564	16551
LV2 + HV	14286	11407	8510	10434	12346	13758	19204	14935	14387	15347	15686	19514	19076	16877
LS + HS	13861	10689	10043	10434	12315	13805	20286	15863	14243	15099	16199	19073	18308	16539
LV + HV	13861	10689	10043	10434	12315	13805	20286	15863	14243	15099	16199	19073	18308	16539

Months (April and August each have 2 time steps)

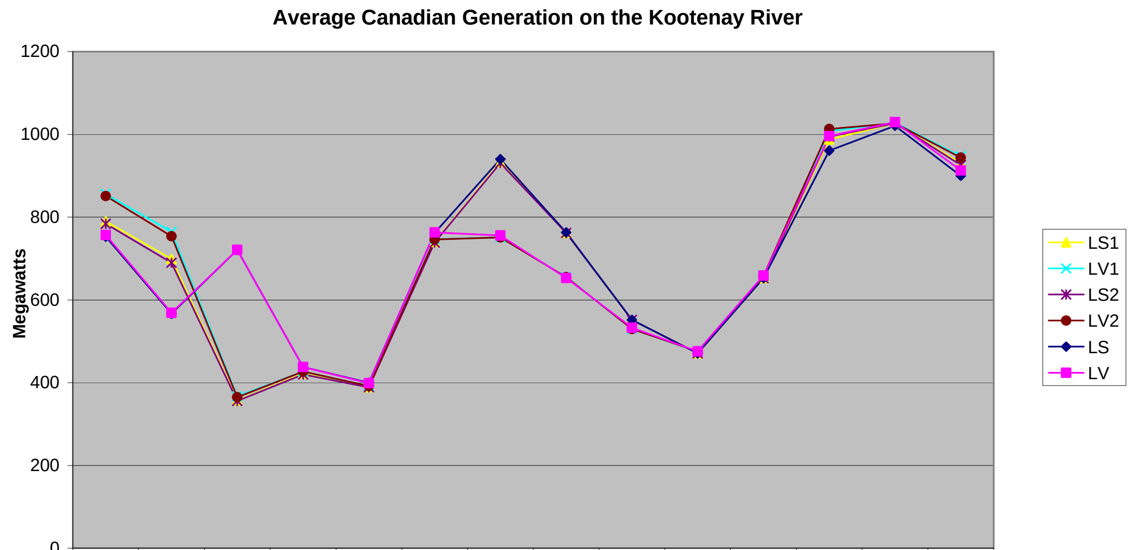
Figure 5-13. Monthly system generation median values (Mw) for alternative and benchmark combinations Alternative combination LVB+HV would fall between alternative combinations LV1+HV and LV2+HV, and alternative combination LSB+HS would fall between LS1+HS and LS2+HS.



	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL
LS1	790	699	357	422	389	740	933	762	552	471	653	988	1027	930
LV1	856	765	367	427	392	747	751	655	530	476	659	1008	1028	947
LS2	784	690	356	420	389	739	931	762	552	471	653	995	1027	926
LV2	851	754	365	427	392	746	751	655	530	476	659	1013	1027	944
LS	753	567	721	438	400	762	940	763	552	471	653	961	1021	900
LV	757	569	721	438	399	763	756	653	533	476	659	996	1030	913

Months (April and August each have 2 time steps)

Figure 5-14. Monthly average generation values (Mw) for Canadian projects on the Kootenay River for alternative and benchmark combinations. Alternative combination LVB+HV would fall between alternative combinations LV1+HV and LV2+HV, and alternative combination LSB+HS would fall between LS1+HS and LS2+HS.



	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL
LS1	790	699	357	422	389	740	933	762	552	471	653	988	1027	930
LV1	856	765	367	427	392	747	751	655	530	476	659	1008	1028	947
LS2	784	690	356	420	389	739	931	762	552	471	653	995	1027	926
LV2	851	754	365	427	392	746	751	655	530	476	659	1013	1027	944
LS	753	567	721	438	400	762	940	763	552	471	653	961	1021	900
LV	757	569	721	438	399	763	756	653	533	476	659	996	1030	913

Months (April and August each have 2 time steps)

Figure 5-15. Monthly average generation values (Mw) for Canadian projects on the Pend d'Oreille River for alternative and benchmark combinations. Alternative combination LVB+HV would fall between alternative combinations LV1+HV and LV2+HV, and alternative combination LSB+HS would fall between LS1+HS and LS2+HS.

Canadian power generation would be compromised for Kootenay Lake elevations at or below 1744 feet (BC Hydro *et al*. 2004). Kootenay Lake levels would be influenced by the alternative operations at Libby Dam. Under alternative LS1, decreased power generation opportunities due to Kootenay Lake levels below 1744 feet would occur about 48 percent of the time in May, 10 percent of the time in June, and 44 percent of the time in July (Appendix B). Overall, Kootenay Lake levels below 1744 feet under alternative LS1 would occur more frequently than under either of the VARQ FC alternatives. The lower July elevations are due to Corra Linn Dam being on free-flow, and lower inflow in July as snowmelt subsides. The IJC Order of 1938 governs maximum Kootenay Lake levels for much of the remainder of the year, resulting in minimal differences in Kootenay Lake elevation between the alternatives.

The patterns of power generation in Canada are similar to those in the U.S. Given proximity to Libby Dam, potential differences in generation are more pronounced on the Kootenay River. The average annual decrease in Canadian generation due to Libby fish flows at powerhouse capacity with Standard FC (Alt. LS1) would be 21 MW, with the most pronounced reduction in generation occurring in September.

Alternative Combination LV1+HV

Combination LV1+HV would generate somewhat less power in winter, with relatively enhanced spring and summer power generation compared to LS1+HS. LV1+HV would also result in somewhat higher August power generation than LS1+HS or LS2+HS. This is due to provision of salmon flow augmentation, which VARQ FC facilitates by better providing for reservoir refill at Libby and Hungry Horse. Compared to benchmark combination LV+HV, the fish flows in this alternative combination would have minimal effects on winter generation, and tend to slightly increase spring and summer generation, and tend to decrease September generation. The average annual reduction in system generation due to fish flows up to powerhouse capacity (compared to benchmark combinations) under VARQ FC would be 27 MW.

Under alternative LV1, decreased power generation opportunities due to Kootenay Lake levels below 1744 feet (BC Hydro *et al*. 2004) would occur about 38 percent of the time in May, 10 percent of the time in June, and 36 percent of the time in July (Appendix B). Information supplied by BC Hydro indicates that LV1+HV would reduce average annual generation for Canadian projects on the Kootenay River by about 9.1 MW when compared to LS1+HS (estimates from the Corps hydropower modeling indicate a potential reduction in average annual generation on the Kootenay River in Canada of 14.2 MW). On the Pend d’Oreille River in Canada, BC Hydro estimates LV1+HV would result in a reduction in average annual generation of between 5.7 and 6.9 MW when compared to LS1+HS (estimates from the Corps hydropower modeling indicate a potential reduction in average annual generation on the Pend d’Oreille River in Canada of

4.1 MW). The average annual decrease in Canadian generation due to Libby fish flows at powerhouse capacity (compared to benchmark combination LV+HV) with VARQ FC would be 16 MW, with the most pronounced reduction in generation occurring in September.

Alternative Combination LS2+HS

Winter generation under this combination would be the same as LS1+HS and because of relatively deep flood control drafts in the winter under Standard FC, higher than under LV1+HV and LV2+HV. In comparison with benchmark combination LS+HS, the fish flows in this alternative combination would tend to slightly decrease generation during September and the winter, and slightly increase spring and summer generation. The average annual reduction in system generation due to fish flows up to powerhouse capacity plus 10 kcfs (compared to benchmark combinations) under Standard FC would be 38 MW[76].

Under Alternative LS2, decreased power generation opportunities due to Kootenay Lake levels below 1744 feet (BC Hydro *et al*. 2004) would occur 48 percent of the time in May, 11 percent of the time in June, and 44 percent of the time in July (Appendix B), which are very similar to impacts under LS1. Compared to LS1+HS, LS2+HS would increase Canadian generation during May and decrease Canadian generation during the summer. Over the course of a year, average annual generation in Canada under Alternative LS2+HS would be similar to that under LS1+HS. The average annual reduction in Canadian generation due to Libby fish flows up to powerhouse capacity plus 10 kcfs (compared to benchmark combination LS+HS) under Standard FC would be 22 MW, with the most pronounced reduction in generation occurring in September.

Alternative Combination LV2+HV

This alternative combination would result in less winter generation than LS1+HS or LS2+HS. As with LV1+HV, LV2+HV would also result in somewhat higher August power generation when compared to LS1+HS or LS2+HS. Compared to benchmark combination LV+HV, the fish flows in this alternative combination would have minimal effects on winter generation, tend to slightly increase spring and summer generation, and tend to decrease September generation. The average annual reduction in system generation due to fish flows up to Libby powerhouse capacity plus 10 kcfs under VARQ FC would be 33 MW[77].

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[76] The difference of in system generation for LS2+HS compared to LS1+HS is primarily due to the assumption that the additional 10 kcfs of sturgeon flow release is spilled at Libby Dam. An assumption on this operation was necessary for the system power analysis, but is not made for the EIS in general, because the mechanism for achieving the additional 10 kcfs is not known at this time.

[77] The difference of in system generation for LV2+HV compared to LV1+HV is primarily due to the assumption that the additional 10 kcfs of sturgeon flow release is spilled at Libby Dam.

Under Alternative LV2, decreased power generation opportunities due to Kootenay Lake levels below 1744 feet (BC Hydro *et al*. 2004) would occur 38 percent of the time in May, 10 percent of the time in June, and 37 percent of the time in July (Appendix B), which are similar to impacts under LV1. Compared to LV1+HV, LV2+HV would increase Canadian generation during May and decrease Canadian generation during the summer. Over the course of a year, average annual generation in Canada under LV2+HV would be similar to that under LV1+HV. The average annual reduction in Canadian generation due to Libby fish flows up to powerhouse capacity plus 10 kcfs (compared to benchmark combination LV+HV) under VARQ FC would be 17 MW.

Alternative Combination LSB+HS

Power generation values under this alternative combination would be somewhere in between those for LS1+HS and LS2+HS, because of the variation in frequency and magnitude of flows above powerhouse capacity (spill) at Libby to achieve this alternative combination.

Alternative Combination LVB+HV (Preferred Alternative Combination)

Power generation values under this alternative combination would be somewhere in between those for LV1+HV and LV2+HV, because of the variation in frequency and magnitude of flows above powerhouse capacity (spill) at Libby to achieve this alternative combination.

Summary

Standard FC alternative and benchmark combinations at Libby and Hungry Horse Dams (LS1+HS, LS2+HS, LS+HS), would generate more power in winter, due to greater flood control drafting of Libby and Hungry Horse Dams, than would VARQ FC alternatives or benchmark combinations (LV1+HV, LV2+HV, LV+HV). The Libby fish-flow components of alternative combinations would tend to result in increased system generation in spring and summer as water released for fish flow augmentation adds to power generation. Due to rapid flow decreases at the end of the fish flow augmentation period on August 31, September power generation is noticeably less under the alternative combinations than with the benchmark combinations, which do not include Libby fish flows.

In winter and early spring, water storage at Libby and Hungry Horse Dams would result in less overall generation for alternative combination LV1+HV. In May through August, Libby and Hungry Horse Dams would pass more flow under VARQ FC, resulting in more generation than under Standard FC. For September, slightly more water would be released in some years[78] so slightly more generation would be produced with VARQ FC because Libby's ending elevation in August would be higher under VARQ FC than under Standard FC. The average annual decrease in United States power generation due to VARQ FC, compared to Standard FC, with Libby fish flows at powerhouse capacity would be 8 MW. The average annual decrease in Canadian power generation due to VARQ FC, compared to Standard FC, with Libby fish flows at powerhouse capacity would be 18.3 MW.

Fish flows at Libby Dam would result in more flow and generation for May and June because the sturgeon flow at Libby would be greater than under the benchmark combinations. There would be more overall flow in July at Libby with alternative LS1 than with benchmark LS and Kootenay Lake would pass this water, as it could within the channel capacity limitations. More flow would be released from Kootenay Lake in July, which would carry through the system and result in higher system generation in July for the alternative combinations as a result of the Libby fish flows. In both halves of August, Libby would release more flows under all alternatives than with benchmarks because the benchmarks would operate to maintain elevation 2459 feet from the end of July through the end of August, passing only natural flows. Since the alternative combinations begin September at lower pool levels, they would tend to pass inflow (rather than begin drafting) in September and result in less flow and generation in the alternative combinations than for the benchmark combinations. For October through December, on average, small generation differences would occur when the system drafts only to meet load. In a few years in January through April, some residual effects of the prior years show up, but for the most part, operation of the dams under VARQ FC combinations would be similar, and operation under Standard FC combinations would be similar.

Because of the fact that flows above powerhouse capacity at Libby may not be achieved (or provided) every year, and the magnitude would vary when it was used, the effect on the power system from alternative combination LVB+HV would be within the range between LV1+HV and LV2+HV. For this same reason, the effect on the power system from alternative combination LSB+HS would be within the range between LS1+HS and LS2+HS.

[78] The modeled end-of-August target elevation at Libby for the alternative combinations was 2439 feet in years when salmon flow augmentation was provided. Modeled Libby reservoir elevations at the end of August tended to be higher under VARQ FC than under Standard FC operations primarily in years when the reservoir level would not have refilled above 2439 feet at any time during July or August under the Standard FC alternative combinations. VARQ FC would allow refill to 2459 feet more often than would Standard FC, and if high inflows were required to be passed (while avoiding spill), the pool level might not drop to 2439 feet by September. Providing summer flows for bull trout under Standard FC in low-flow years might also result in more likelihood of a lower September pool elevation. September pool levels below 2439 feet (more likely with Standard FC) would result in lower outflows and power generation. Differences in system generation resulting from the end-of-August reservoir elevation at Libby tended to be less than the generation differences between the alternative combinations in the winter or summer.

5.3.3 Water Quality

Mainstem Columbia River Upstream From Grand Coulee Dam

Total dissolved gas levels in the Columbia River below the international boundary cumulatively take into account influences from the Kootenai and Pend Oreille Rivers as well as operational influences from the Canadian impoundments. Monthly average TDG levels at the international boundary from the years 1998-2004 range from 77 percent saturation to 130 percent saturation, with most excursions beyond 110 percent occurring in the months of May, June, July, and August. Total dissolved gas levels typically fall below 110 percent in September and continue to decline until December. In December, levels begin to increase again and eventually exceed 110 percent by April.

Since the Columbia River is the primary contributor of water to Lake Roosevelt it has a significant influence on TDG levels in the lake. However, from a TDG processing standpoint within the lake itself, thermal stratification also plays a sizable role in TDG levels. Early in the year there are relatively few variations in water temperature or TDG levels with depth. However, during July and August the lake stratifies from the dam to slightly above the confluence with the Spokane River. The stratification results in lower TDG saturation levels at the surface of the lake than near the bottom. This may occur due to degassing at the surface. Total dissolved gas near the middle and bottom gradually decrease as the year moves on until concentrations once again become static throughout the reservoir (Frizell 1996). Longitudinally, TDG levels near the dam are less than upstream levels. This is likely due dilution and degassing as additional water enters the lake (Frizell 1996).

Figure 5-16 shows the monthly mean TDG saturation levels at the international boundary as compared to the Grand Coulee Dam forebay for the years 1998-2004.

Mainstem Columbia River Downstream From Grand Coulee Dam

The spill and TDG information for the mainstem Columbia River is based on the hydropower modeling analysis, from which spill values were developed for Federal (FCRPS) and non-Federal dams in the United States. The assumptions and framework contained in the power analysis also apply to the evaluation of TDG generation as an environmental consequence of the alternative combinations and combinations. For spill, the period of analysis is April through August, which corresponds with the peak runoff period of the mainstem Columbia River and provisions for voluntary spill for the benefit of juvenile salmon migration. Seven periods were evaluated; one period for each month except April and August, which are split into half-months due to the dynamics of system operation for power.

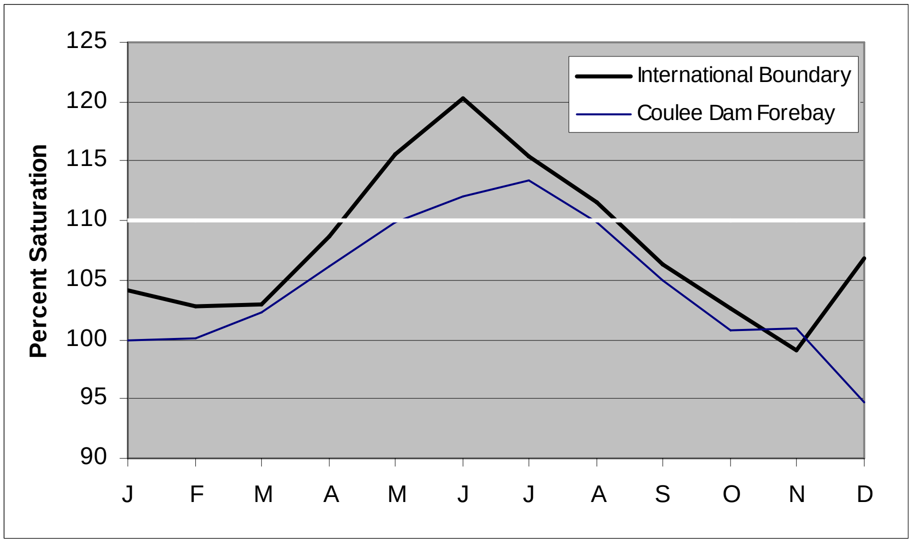

Figure 5-16. Monthly mean gas saturation levels at the international boundary as compared to the Grand Coulee Dam forebay for the year 1998-2004.

Because the spill information is based on monthly averages, it masks the occurrence of individual events that exceed certain TDG levels (i.e., the typical state standard of 110 percent TDG saturation or the 120 percent TDG saturation typically applied to voluntary spill during the fish spill season). Therefore, it is not possible to identify whether there would be an increase in individual spill events that exceed maximum TDG standards on a real-time basis as a result of the alternative combinations. However, exceedances of spill caps as indices of spill events that may produce high TDG levels affecting water quality were evaluated.

For Federal dams downstream from Chief Joseph Dam, the model constrained spill according to prorated spill caps developed for the February 2003 PNCA data submittal on 2004 operations (Corps 2003). Dam spill is based on instantaneous gas caps and maximum spill for daytime and nighttime hours. To account for the monthly time step in the hydropower modeling, spill caps and percentages used in the spill analysis are prorated for the number of spill days in each period and the preferred spill timing allotted to daytime and nighttime hours in the Corps fish passage plan (Corps 2005a). Spill for non-Federal dams was based on information submitted by dam operators in the February 2003 data submittal and is not restricted to certain times during the day. For Grand Coulee and Chief Joseph Dams, spill caps are based on the 2004 water management plan for the Columbia River (Corps 2004). Table 5-21 summarizes the prorated spill caps for each dam and time period that were used to develop the spill indices for the water quality analysis.

For the purposes of the analysis, periods where the monthly average spill would exceed the prorated spill cap are tallied to calculate an index of possible instances with adverse impacts to water quality from elevated TDG. Alternative and benchmark combinations with more instances of spill in excess of the prorated spring/summer spill caps would be expected to have relatively higher adverse impacts to water quality due to elevated TDG.

The hydropower analysis was used as the basis for comparison of spill quantities among the various alternative combinations. Monthly spill quantities over a 52-year period were averaged and compared to the prorated spill caps from the February 2003 PNCA Data submittal (Corps 2003) for dams downstream from Chief Joseph Dam, and to spill caps based on the 2004 water management plan (Corps 2004) for Chief Joseph and Grand Coulee Dams. This produced a spill cap exceedance index comprising the number of times over the 52-year period of record (1948-1999) that the monthly average spill might

Table 5-21. Prorated dam average spill cap and maximum percent spill.

Dam	Apr1	Apr2	May	June	July	Aug1	Aug2
Grand Coulee	0	30,000	30,000	30,000	30,000	30,000	30,000
Chief Joseph	0	30,000	30,000	30,000	30,000	30,000	30,000
Wells*	0	10,200	10,200	0	10,200	10,200	0
	0%	6.50%	6.50%	0	6.50%	2.50%	0%
Rocky Reach	0%	15.00%	21.80%	15%	15.00%	15.00%	0%
Rock Island	0%	20%	20%	20%	20%	20%	0%
Wanapum	0%	43%	43%	46%	49%	49%	49%
Priest Rapids	0%	61%	61%	50%	39%	39%	39%
McNary	34,000	85,000a	85,000a	85,000a			
John Day*	28,000	70000b	66,801b	64,167b	64,167b	70,000b	70,000b
	12%	30%	29%	28%	28%	30%	30%
The Dalles*	42,800	107,000	107,000	107,000	107,000	107,000	107,000
	40%	40%	40%	40%	40%	40%	40%
Bonneville	38,483	95,292c	95,474c	93,906c	93,750c	95,375c	95,938c

The spill cap is the smaller of the flow (cfs) amount or the specified percentage of the total regulated flow past the dam. For example, if total monthly average flow past John Day in a given May is 200,000 cfs, the percentage-based spill cap would be 58,000 cfs (29% of 200,000). Since this is smaller than the spill cap flow of 66,801 cfs, the actual spill cap for that May would be 58,000 cfs.

a The instantaneous spill cap at McNary is 170,000 cfs. This has been prorated based on 12 hours of spill at night that, at the spill cap, works out to an average of 85,000 cfs daily average. Over the course of a month, spill at the cap during the night only would result in a monthly average of 85,000 cfs. Note that it is possible to exceed the monthly 85,000 spill cap within the 170,000 cfs instantaneous spill cap by providing spill during both day and night instead of only at night.

b The instantaneous spill cap at John Day is 140,000 cfs. This has been prorated based on 11 to 12 hours of spill at night during specific periods during the spring and summer. Similar to Note (a), it is possible to exceed the noted spill caps within the 140,000 cfs instantaneous spill caps by providing spill during both day and night instead of only at night.

c The instantaneous spill cap at Bonneville is 75,000 cfs during the day and 105,000 cfs during the night. The day limit is intended to limit fall back of adult salmon through the spillway. The night limit is a TDG cap. It is possible to exceed the prorated spill caps within the 105,000 cfs instantaneous spill caps for TDG by providing more than 75,000 cfs of spill during the day.

exceed the specified spill caps for each of the 7 time periods between April and August at each dam. The spill cap exceedance index allows comparison of the possible effects of the various alternative and benchmark combinations on spill and TDG.

Summary

Table 5-22 depicts the dam-specific index tallying the number of monthly time steps for each alternative and benchmark combination where average spill would exceed the prorated spill cap. In general, the spill cap exceedance indices indicate that instances where spill exceeds the instantaneous spill caps would be infrequent under all alternative and benchmark combinations and would be relatively consistent at each of the dams under each of the alternative and benchmark combinations. The differences between highest and lowest spill cap exceedance indices at a given dam are less than 1.1 percent in all cases, which would result in small changes in TDG levels between any of the alternatives. Among alternative and benchmark combinations, Wells, Rocky Reach, Rock Island, McNary, and Bonneville Dams exhibited the most variation in the spill cap exceedance indices. Differences in the spill cap exceedance index among the alternative and benchmark combinations occurred most often in June.

For all alternative and benchmark combinations, Wells, McNary, and Bonneville Dams clearly had the highest indices of spill cap exceedances. The indices for these dams ranged from spill in excess of prorated monthly average spill caps for about 15 percent of the May and June periods for McNary Dam, to indices in excess of the cap for about 7 percent in April through June for Bonneville Dam. Although the differences in spill cap exceedances among benchmark and alternative combinations tend to be small, the relatively high likelihood of exceeding the spill cap at Wells, McNary, and Bonneville Dams indicates that TDG levels in excess of 120 percent may occur for long durations at these projects.

It should be noted that there have been instances of involuntary spill at some lower Columbia dams before and after interim implementation of VARQ FC at Libby and Hungry Horse Dams. It is difficult to attribute a relationship to VARQ FC, because of other influences, for instance Snake River dam operation. Therefore this EIS relies on modeling results to derive relative probabilities of involuntary spill among the alternative combinations.

Table 5-22. Index numbers of spring and summer time steps* during the 1948-1999 period of record with spill in excess of prorated monthly average spill caps. Alternative combination LVB+HV would fall within the range between LV1+HV and LV2+HV. Alternative combination LSB+HS would fall within the range between LS1+HS and LS2+HS.

	Alternative Combinations				Benchmark Combinations		
Dam	LS1+HS	LV1+HV	LS2+HS	LV2+HV	LS+HS	LV+HV	Periods with differences between combinations
Grand Coulee	1	1	1	1	0	1	June
Chief Joseph	2	2	2	2	2	2	n/a
Wells	32	34	32	34	30	31	May, June, July
Rocky Reach	10	11	10	11	8	11	June, July
Rock Island	5	6	5	7	4	5	June
Wanapum	3	3	3	3	3	3	n/a
Priest Rapids	3	3	3	4	3	3	Apr 16-Apr 30
McNary	54	55	55	55	52	54	May, June
John Day	8	9	8	9	7	9	June
The Dalles	6	7	7	7	6	6	June
Bonneville	23	25	24	25	22	25	Apr 1-Apr 15, May, June

*Based on seven possible time steps or periods each year between April and August. April and August are divided into two time steps; May, June, and July are one time step each.

Alternative Combinations LS1+HS, LS2+HS, and LSB+HS

Compared to the other alternative combinations, LS1+HS (no action combination) and LS2+HS would result in relatively moderate levels of TDG exceedances but would generally result in a lower TDG exceedance index than that for VARQ FC alternative combinations of LV1+HV, LV2+HV. In general, spill amounts under LS2+HS would be slightly higher than LS1+HS, and both would have higher spill amounts than LS+HS. At most dams, the fish flows in alternative combinations LS1+HS and LS2+HS (compared to benchmark combination LS+HS) would tend to slightly increase the spill cap exceedance index and the amount of spill in excess of the spill cap. Alternative combination LSB+HS would result in values within the range exhibited by LS1+HS and LS2+HS.

Alternative Combinations LV1+HV, LV2+HV, and LVB+HV

LV1+HV (preferred action combination) and LV2+HV would result in the highest spill cap exceedance index. In general, the spill cap exceedance index under LV1+HV would be similar to that under LV2+HV, except at Rock Island and Priest Rapids Dams where the spill cap exceedance index under LV2+HV would be slightly higher (with one more incidence of spill cap exceedance over the 52-year period of record). Spill amounts under LV1+HV and LV2+HV would tend to be higher than that under any of the Standard FC combinations. The fish flows in alternative combinations LV1+HV and LV2+HV (compared to benchmark combinations LV+HV) would tend to slightly increase the spill cap exceedance index and the amount of spill in excess of the spill cap. Alternative combination LVB+HV would result in values within the range exhibited by LV1+HV and LV2+HV.

5.3.4 Aquatic Life

Mainstem Columbia River Upstream From Grand Coulee Dam

Entrainment through Grand Coulee Dam probably is the most important factor limiting the Lake Roosevelt kokanee and rainbow trout fishery, and water retention time is the most important predictor of entrainment (GEI 2004b). The January through May time period is when there would be differences in reservoir level and water retention time at Grand Coulee when comparing VARQ and Standard FC. Entrainment increases as water retention time falls below 30 days, especially if it occurs in late spring (May) after net pen and hatchery fish are released. Under all VARQ FC alternative combinations, average water retention time would increase for the months of January and February (Table 5-23) when compared to Standard FC alternative combinations. Average water retention time would decrease in March, April, and May, with the latter two months being when flood control releases are usually highest and reservoir levels and retention time lowest. The average difference in retention times between the VARQ FC and Standard FC alternative and benchmark combinations is about one day or less for the March-May period.

Table 5-23. Average monthly retention time in days for water in Lake Roosevelt-multipurpose operation under alternative combinations. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

Alternative Combinations	Jan	Feb	Mar	Apr1	Apr2	May
LS1+HS and LS2+HS	29.4	47.4	46.7	40.7	28.0	22.1
LV1+HV and LV2+HV	31.2	49.5	46.3	39.6	27.8	21.4
Difference	+1.8	+2.1	-0.4	-1.1	-0.2	-0.7

Retention time was computed using reservoir outflow and total reservoir storage at a given elevation. Apr1 represents April 1-15, and Apr2 represents April 16-30.

While retention times are approximately 30 days or longer for all alternative combinations during the months of January through mid-April, they decline below 30 days from mid-April through the end of May, with May averaging about 22 days for all standard flood control alternative combinations and about 21 days for all VARQ FC alternative combinations. These differences in retention times, especially from mid-April through the end of May, are fairly minor and any increase in entrainment and adverse effect to rainbow and kokanee would likely not be measurable. In very high water years, when flood control operations require large releases and deep drafts, and fish entrainment is highest, there would be no difference in reservoir elevation, water retention times or entrainment rates between Standard FC and VARQ FC alternative combinations.

Underwood and Shields (GEI 2004b) demonstrated that zooplankton density in Lake Roosevelt generally decreases as water retention time decreases below 30 days. Zooplankton is the primary food source for kokanee and for fry fishes of all species. Therefore, dam operations which reduce water retention time and food availability for fish also reduce the lake's fish carrying capacity. While the VARQ FC alternative combinations do not appreciably lower retention times when compared to the Standard FC alternative combinations, the May retention times of 21-22 days for all alternative combinations are low and likely would limit zooplankton density and the reservoir fishery.

Limited information is available for white sturgeon in Lake Roosevelt. Primary impacts to sturgeon would most likely be growth-related due to minor increases in drawdown and related effects to benthic and other food sources. In general, the relatively small increases in drawdown are unlikely to cause major reductions in food availability and fish growth rates for any species in Lake Roosevelt.

Alternative Combinations LS1+HS, LS2+HS, and LSB+HS

The present habitat characteristics, species assemblages, and population dynamics at Lake Roosevelt generally would remain unchanged if LS1+HS (no action combination) and LS2+HS alternative combination were implemented. Lake Roosevelt would continue to experience fluctuations of the water surface elevation up to 82 feet, which would continue to limit the natural reproduction of many fish species in the reservoir. Some of the nutrients entering the reservoir would continue to be flushed through (especially in late April and May), and would remain unavailable for phytoplankton production (GEI 2004b). Low spring reservoir elevations would continue to limit growth of kokanee, rainbow trout and other fish species. Entrainment out of the reservoir would continue whenever drafting occurs. Benchmark combination LS+HS would result in similar effects.

Alternative Combinations LV1+HV, LV2+HV and LVB+HV

Alternative combination LV1+HV, LVB+HV (preferred alternative combination),and LV2+HV would result in essentially identical hydrologic and aquatic resource effects at Lake Roosevelt and are discussed together.

Increases in spring drawdowns at Lake Roosevelt under LV1+HV, LV2+HV, and LVB+HV could result in small reductions in present levels of spawning success for smallmouth bass, yellow perch, and shoreline spawning kokanee. Increases in drafts under these alternative combinations would be relatively small in terms of present average end of April and end of May reservoir elevations. While walleye spawning is not likely to be affected by increased drawdowns, minor reductions in water retention times in some years may result in periodic increases in the loss of nutrients from the reservoir which in turn may lead to periodic, minor decreases in growth rates for walleye and other fish species. Benchmark combination LV+HV would result in similar effects.

Alternative Combination LSB+HS

Alternative combination LSB+HS would be similar to LS1+HS an LS2+HS.

Mainstem Columbia River Downstream From Grand Coulee Dam

The alternative and benchmark combinations have the potential to cause minor changes in the timing and magnitude of flows in the mainstem Columbia River. Downstream from Chief Joseph Dam there are periods of time when spill exceeds the gas caps under all alternative and benchmark combinations. This may create gas bubble disease for aquatic life such as resident and anadromous fish. There is very little difference between the alternative combinations and LS1+HS (no action alternative combination).

Based on available information, there is likely to be little discernible difference in effect on lamprey migration among the alternative combinations. Moser *et al.* (2003) indicated that there appears no clear effect of flow or temperature on rates of lamprey passage through dam facilities. American shad are an abundant non-native anadromous species in the Columbia. According to Scott and Crossman (1973), shad cue on temperature for their spawning activity, and there appears to be a relationship to temperature in migration timing for Bonneville, McNary and Priest Rapids dams, based on data from the University of Washington (2006). Since it is difficult to discern a temperature effect from the alternative combinations, direct effects and differences among the alternative combinations to shad spawning are not likely.

The minor changes in seasonal river flows on the mainstem Columbia River are not expected to alter the daily load-following operations of Priest Rapids Dam that can cause flow fluctuations in the Hanford Reach, and should not affect fish entrapment or stranding identified in Anglin *et al.* (2005).

Effects of alternatives on salmon and steelhead populations are discussed below in Section 5.3.5.

5.3.5 Sensitive, Threatened and Endangered Species

Mainstem Columbia River Upstream From Grand Coulee Dam

Section 5.2.5 identifies sensitive, threatened and endangered species present in the Columbia River Basin, including a number of species not likely to be affected by operation of the FCRPS. This section focuses of those species which may be affected.

Alternative Combinations LS1+HS, LS2+HS, and LSB+HS

Under LS1+HS (no action combination) and LS2+HS, the present habitat characteristics, species presence, and population dynamics at Lake Roosevelt generally would remain unchanged. This is also the case for alternative combination LSB+HS. Lake Roosevelt would continue to experience annual fluctuations in the water surface elevation up to 82 feet, which would continue to limit benthic productivity and could also continue to limit the juvenile-growth potential of bull trout in the reservoir. Bald eagle numbers and distribution would be expected to continue unchanged. Benchmark combination LS+HS would result in similar effects.

Alternative Combinations LV1+HV, LV2+HV, and LVB+HV

Alternative combinations LV1+HV, LV2+HV, and LVB+HV (preferred alternative combination) would result in essentially identical hydrologic and aquatic resource effects at Lake Roosevelt and are discussed together.

Increase in spring drawdowns at Lake Roosevelt under these alternative combinations could result in small reductions in present levels of benthic productivity. Increases in drafts under these alternative combinations would be relatively small in terms of present average end of April and end of May reservoir elevations. Benchmark combination LV+HV would result in similar effects.

Primary impacts to bull trout would most likely be growth-related due to minor increases in drawdown and related effects to benthic and other food sources. In general, the relatively small increases in drawdown are unlikely to cause major reductions in food availability and fish growth rates for any species in Lake Roosevelt. The fish prey base for bald eagles is not likely to be noticeably affected, and bald eagle numbers and distribution would likely remain unchanged.

Mainstem Columbia River Downstream From Grand Coulee Dam

The alternative and benchmark combinations have the potential to affect the timing and magnitude of flows in the mainstem Columbia River downstream from Grand Coulee Dam. Under any of the alternative and benchmark combinations, changes in flow patterns would be within the current range of river operations and the effect on listed species would be similar for most of the threatened and endangered species that are likely to be present along the mainstem Columbia River. These operations are within the consultation range of the 2000 USFWS FCRPS Biological Opinion.

Marbled murrelet, northern spotted owl, grizzly bear, gray wolf, woodland caribou, northern Idaho ground squirrel, Canada lynx, MacFarlane's four o'clock, Spalding's catchfly, water howellia, Ute ladies'-tresses, Kincaid's lupine, Nelson's checkermallow, Wenatchee Mountains checkermallow, and showy stickseed may occur in the vicinity of the mainstem Columbia River but do not rely on or generally utilize habitats and resources provided by the river. Accordingly, these species would not be affected by any of the alternative or benchmark combinations.

Bull Trout

Changes in flow patterns would not greatly affect the quality or quantity of available bull trout habitat, nor would changes in water temperature likely occur for the various alternative and benchmark combinations. Spill (both involuntary and voluntary, depending on location) may result in impacts to bull trout. Total dissolved gas levels above 120 percent saturation for extended times could be of greater concern for possible negative effects to bull trout.

White Sturgeon

Upper Columbia white sturgeon spawn directly below Waneta Dam at the mouth of the Columbia River and they likely key in on high velocities and turbulence resulting from high flows during the spring freshet. The hydroregulation modeling indicates that Waneta Dam discharge would remain essentially identical under all alternatives and therefore no adverse effects on spawning white sturgeon would occur. Other life history stages of sturgeon would be similarly unaffected by the different alternatives.

Bald Eagle

Effects on bald eagles along the mainstem Columbia River downstream from Grand Coulee Dam would be similar among all alternative and benchmark combinations, since flow patterns would be generally similar, with similar effects on food resources for bald eagle.

Columbian White-tailed Deer

Columbian white-tailed deer are vulnerable to flooding of their lowland habitats adjacent to the lower Columbia River. The risk of flooding in these areas is similar under all of the alternative and benchmark combinations.

Anadromous Fish

Multipurpose system operations (HYSSR) evaluation was used to determine frequency with which flow objectives for anadromous fish were met at Priest Rapids and McNary dams. These objectives were set by NOAA Fisheries in the 2004 NOAA Fisheries FCRPS Biological Opinion and 2004 UPA (NOAA Fisheries 2004). The flow objectives are intended to assist smolt outmigration in the mainstem Columbia River, and provide point of reference for seasonal water management in the Columbia Basin, but cannot be met in many years because there is limited water and reservoir storage.

The flow objectives are used as an indicator for benefits to anadromous fish because the means to quantify the direct biological effects on anadromous fish does not exist. Although the flow objectives cannot always be met, the alternative combinations provide some difference in the flow levels at Priest Rapids and McNary Dams. To the extent that increases in flow benefit smolt migration and survival, any operational flow benefits from the alternative combinations would be expected to extend to anadromous fish.

Flows as modeled for Priest Rapids and McNary Dams for the alternative and benchmark combinations were compared against existing flow objectives (Table 5-24) over the 52-year period of record used for the modeling. Each alternative combination was evaluated on a monthly basis (first half of April, second half of April , May, June, July, first half of August, and second half of August) for how often it met the objectives in the period of record (Table 5-25 and Table 5-26).

Flow objectives at Priest Rapids and McNary Dams would be met as depicted in Figure 5-17 through Figure 5-27. These frequency exceedance curves show percentages of years of the 52-year period of record in which the objectives would be met. Differences were generally not large among the alternative and benchmark combinations.

Table 5-24. Flow objectives for salmon and steelhead outmigration at Priest Rapids and McNary Dams on the Columbia River.

Location	Spring		Summer	
	Dates	Objective	Dates	Objective
Columbia River at Priest Rapids Dam	10 April to 30 June	135 kcfs	N/A	N/A
Columbia River at McNary Dam	10 April to 30 June	220-260 kcfs	1 July to 31 Aug	200 kcfs

For the system modeling on which this analysis was based, April and August each have two time steps due to the complexities of power system operation during those months.

Table 5-25. Number of years of the total 52 years that the Priest Rapids Dam flow objective was achieved. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

Alternative Combination	Apr1	Apr2	May	Jun
LS1+HS	35	32	49	42
LV1+HV	35	32	49	42
LS2+HV	35	32	49	42
LV2+HV	35	32	49	42
Benchmark Combination				
LS+HS	35	32	47	39
LV+HV	35	32	49	42

Table 5-26. Number of years out of the total 52 years that McNary Dam flow objective was achieved. Alternative combination LVB+HV would fall within the range between LV1+HV and LV2+HV. Alternative combination LSB+HS would fall within the range between LS1+HS and LS2+HS.

Alternative Combination	Ap1	Apr2	May	Jun	Jul	Aug1	Aug2
LS1+HS	42	22	36	33	31	12	4
LV1+HV	42	22	37	34	31	14	4
LS2+HV	42	22	36	33	30	13	4
LV2+HV	42	22	37	34	32	16	3

For Priest Rapids Dam, the likelihood of achieving April, May, and June flow objectives would be the same under all alternative combinations. During the first half of April, modeling indicates the objectives would be met in 35 of 52 years for all alternative combinations. For the second half of April the pattern would be essentially the same for 32 of 52 years. In May, all alternative combinations would meet objectives in 49 of 52 years. In June, the alternative combinations would meet objectives 42 of 52 years. In May and June, the fish flows in the Standard FC alternative combinations increase the likelihood of meeting May flow objectives at Priest Rapids when compared with the benchmark combination LS+HS. Benchmark combination LV+HV would achieve flow objectives in the same number of years as all other alternative combinations.

At McNary Dam, the different alternative combinations would meet flow objectives best in the first half of April (Apr1) and in May, and success would decline from there through August. The likelihood of meeting flow objectives would be identical for all alternative and benchmark combinations in April (42 of 52 years in the first half of April, and 22 of 52 years in the second half of April). In May, LV1+HV and LV2+HV would show slightly greater success than the Standard FC alternative combinations (37 versus 36 years of 52 years), with the benchmark combinations showing the same likelihoods and patterns. During June, July, and August, results would be similar in that VARQ FC alternative combinations would equal or slightly better Standard FC alternative combinations.

Success in meeting the flow objectives would decline in August. The modeling indicates Priest Rapids flows would be above the objectives in 12-16 of 52 years during the first half of the August (with slightly better success under the VARQ FC alternative combinations), and above the flow objectives in only 3 or 4 of 52 years during the second half of August. From June through August, the fish flows in the alternative combinations result in meeting flow objectives slightly more often (as compared to the benchmark combinations). Relative to the LS+HS benchmark combination, the highest increase in the likelihood of achieving the flow objectives under the Standard FC alternative combinations would occur during June. Relative to the LV+HV benchmark combination, the highest increase in the likelihood of achieving the flow objectives under the VARQ FC alternative combinations would occur during the first half of August.

Summary

In general, providing additional flows during the migration period is considered to be beneficial to anadromous fish outmigration in the mainstem Columbia River, and implementation of VARQ FC at Libby and Hungry Horse Dams is intended to facilitate this. Specifically, the July and August salmon drafts at Libby and Hungry Horse Dams, and the spring sturgeon flow at Libby Dam, would help provide increased flows in the mainstem Columbia River, and would most likely benefit salmon to the extent flows are provided. Since VARQ FC helps ensure water storage to meet the July-August salmon flows, it is assumed it would also benefit salmon and steelhead outmigration in the mainstem Columbia River and aid recovery of listed ESUs. Alternative combinations with higher indices of spill cap exceedance would have greater likelihood of adverse impacts to anadromous fish.

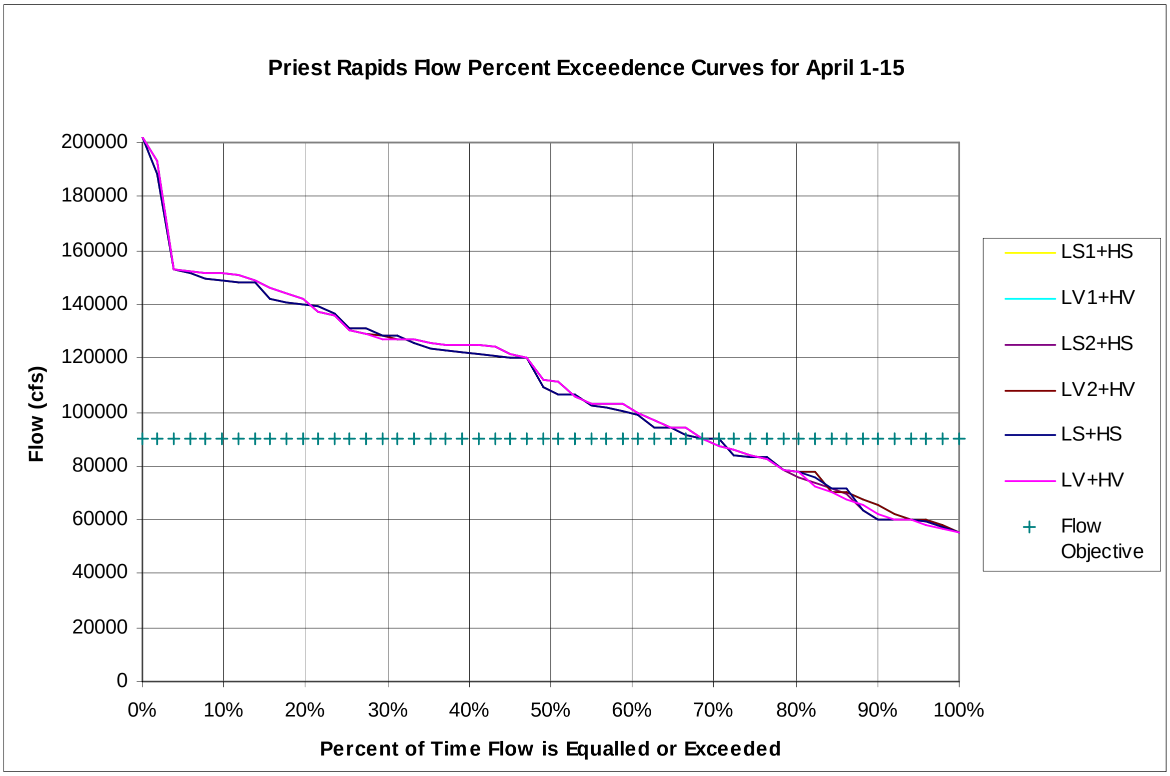

Figure 5-17. Exceedance frequencies for alternative and benchmark combinations in meeting Priest Rapids flow objectives for anadromous fish in the first half of April (Apr1). Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

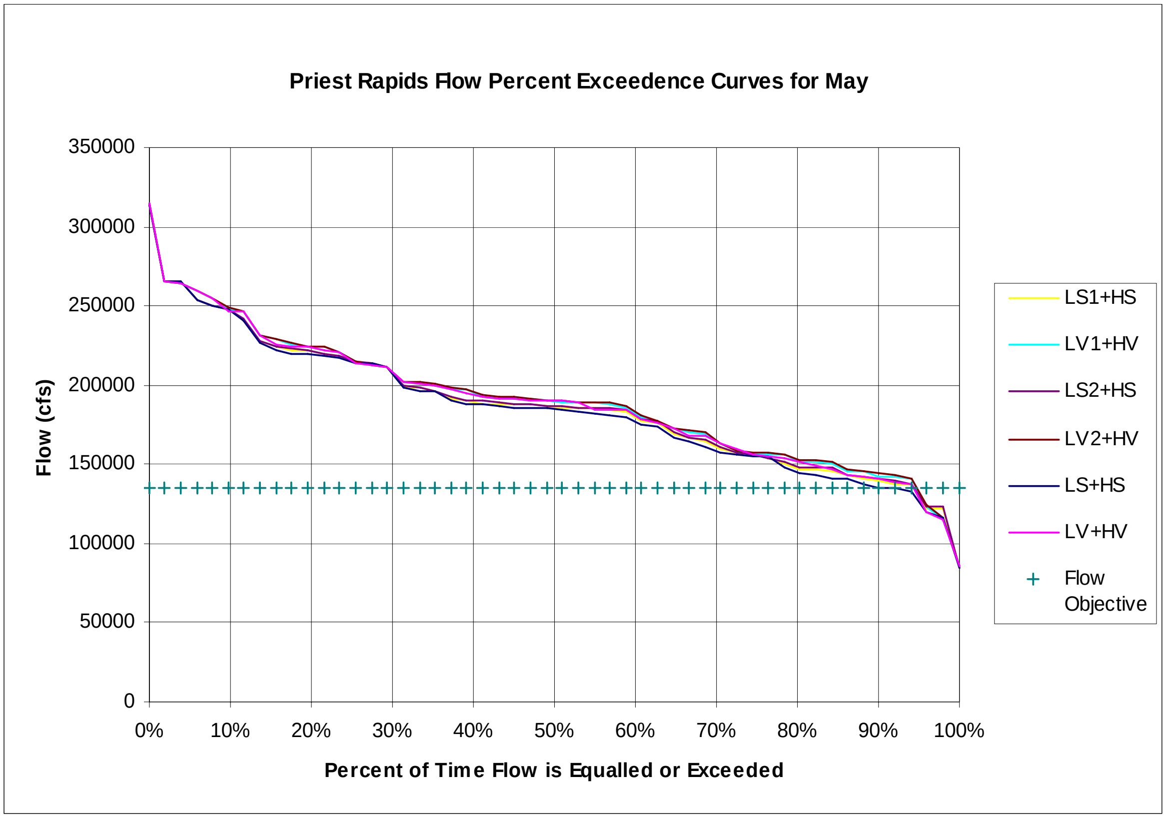

Figure 5-18. Exceedance frequencies for alternative and benchmark combinations in meeting Priest Rapids flow objectives for anadromous fish in May. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

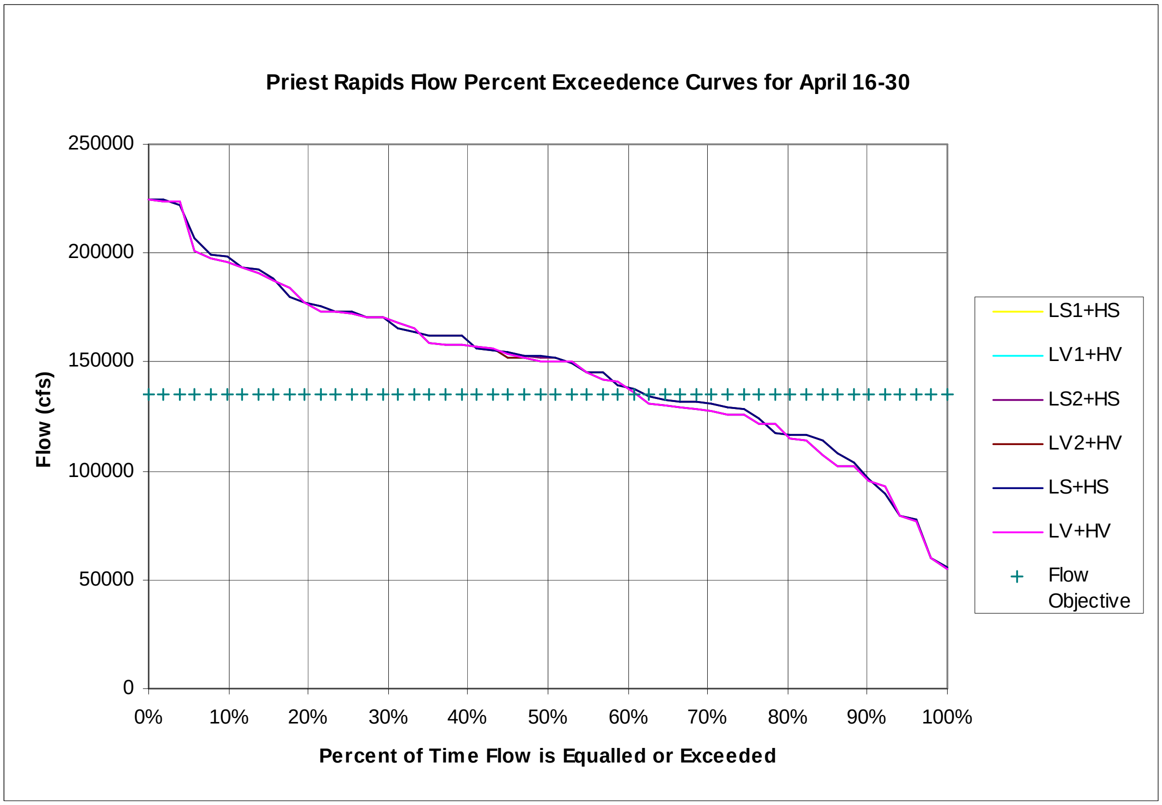

Figure 5-19. Exceedance frequencies for alternative and benchmark combinations in meeting Priest Rapids flow objectives for anadromous fish in the second half of April (Apr2). Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

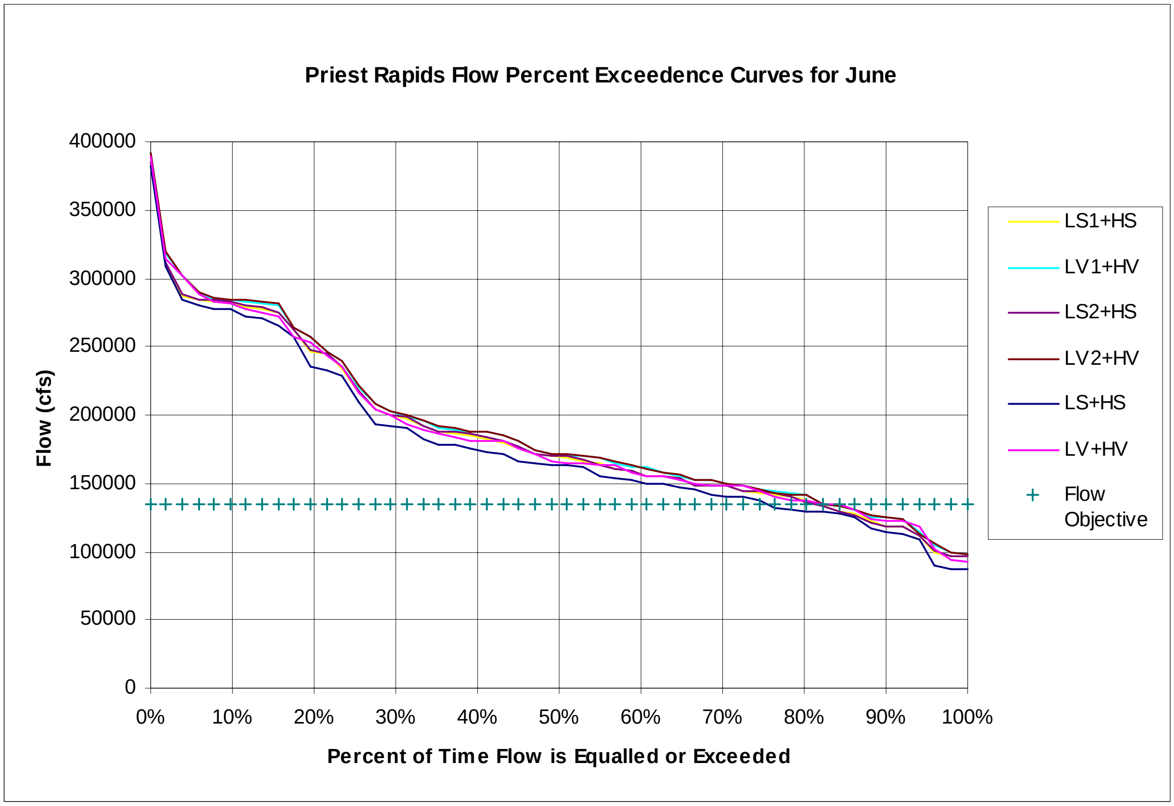

Figure 5-20. Exceedance frequencies for alternative and benchmark combinations in meeting Priest Rapids flow objectives for anadromous fish in June. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

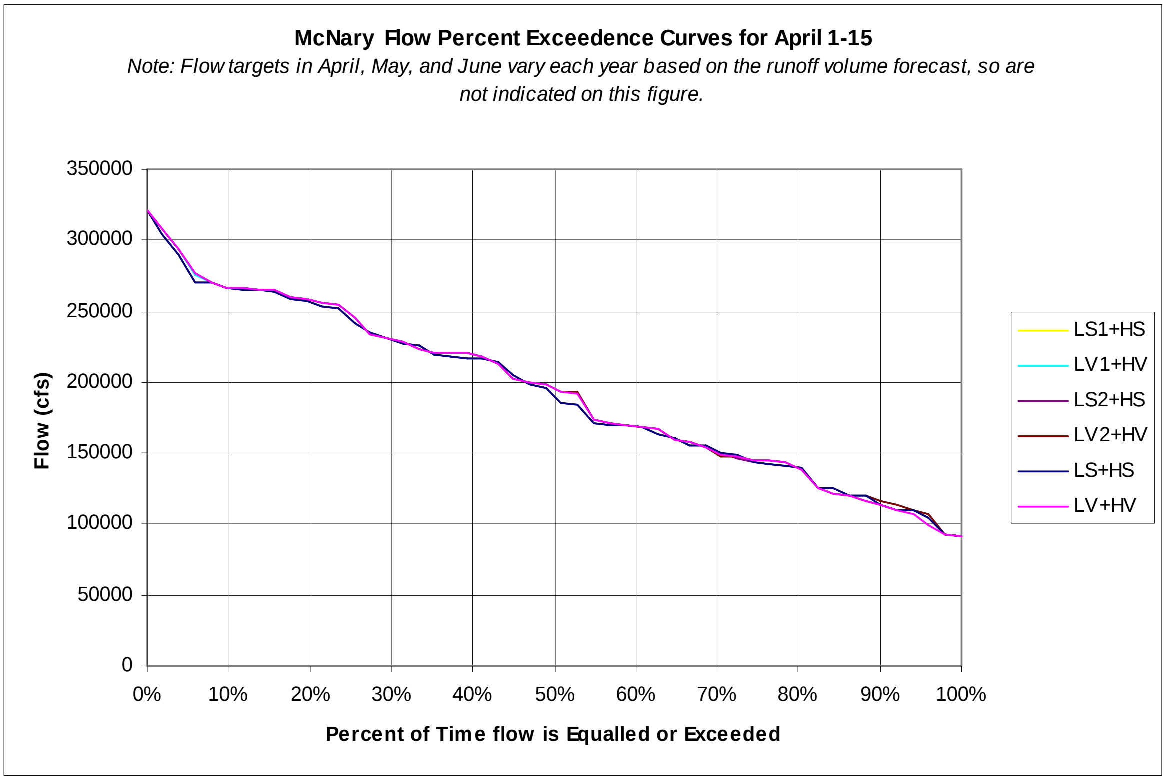

Figure 5-21. Exceedance frequencies for alternative and benchmark combinations in meeting McNary Flow objectives for anadromous fish in the first half of April. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

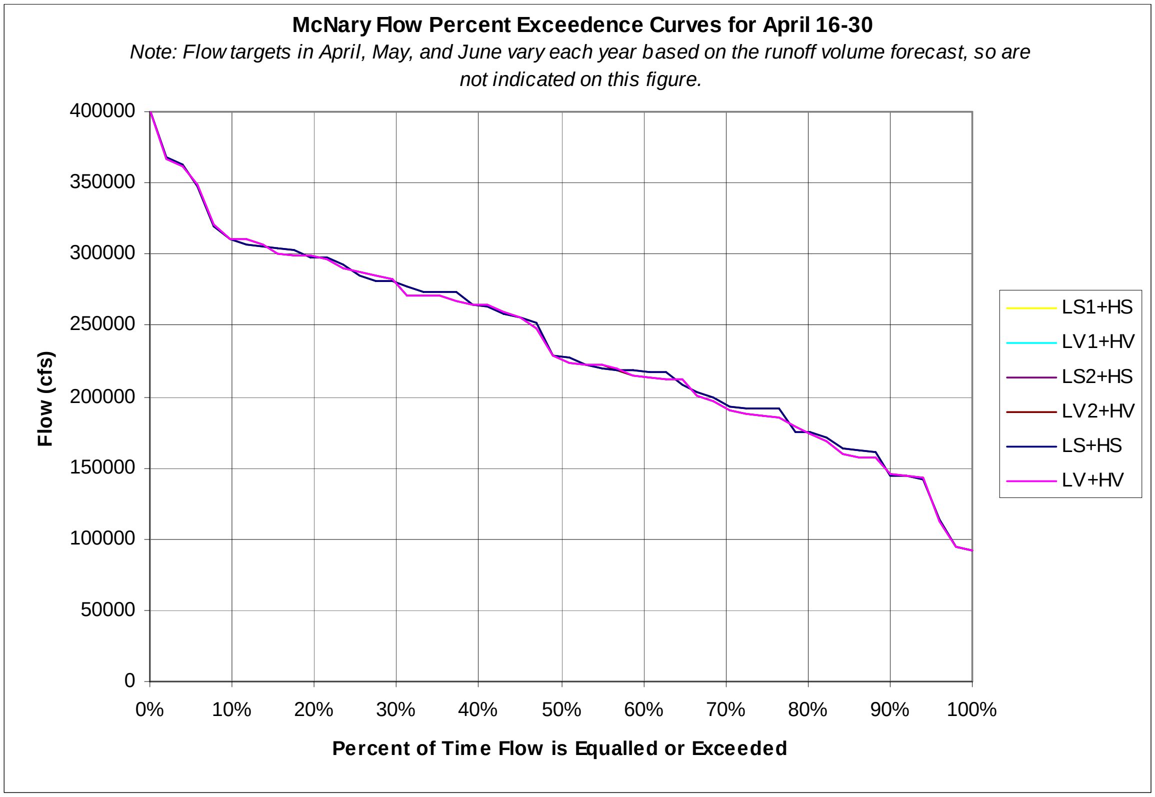

Figure 5-22. Exceedance frequencies for alternative and benchmark combinations in meeting McNary flow objectives for anadromous fish in the second half of April. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

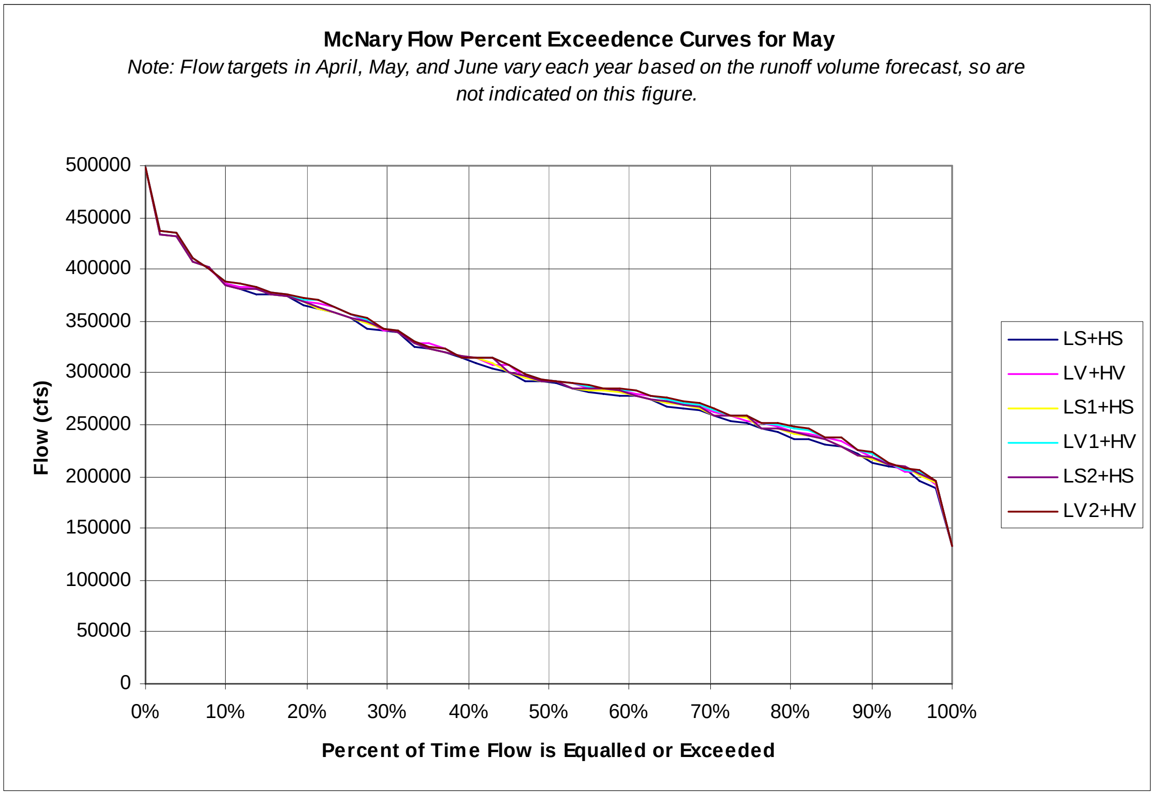

Figure 5-23. Exceedance frequencies for alternative and benchmark combinations in meeting McNary flow objectives for anadromous fish in May. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

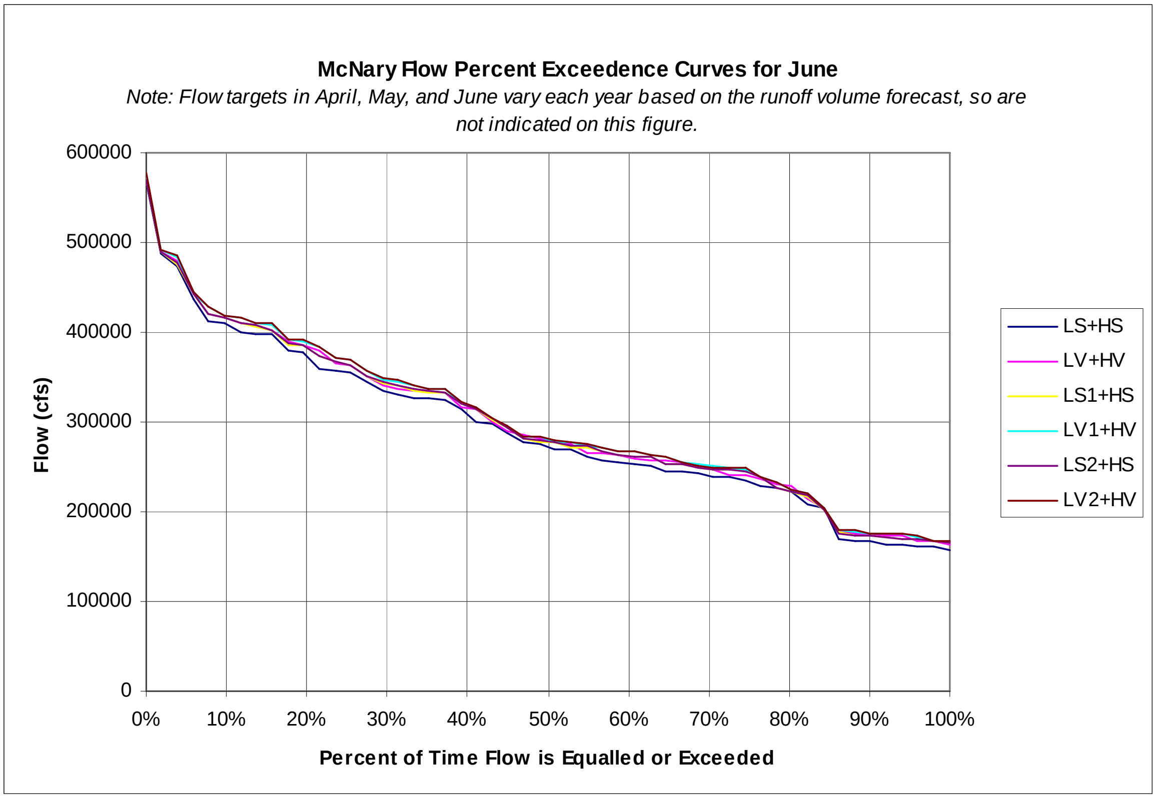

Figure 5-24. Exceedance frequencies for alternative and benchmark combination in meeting McNary flow objectives for anadromous fish in June. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

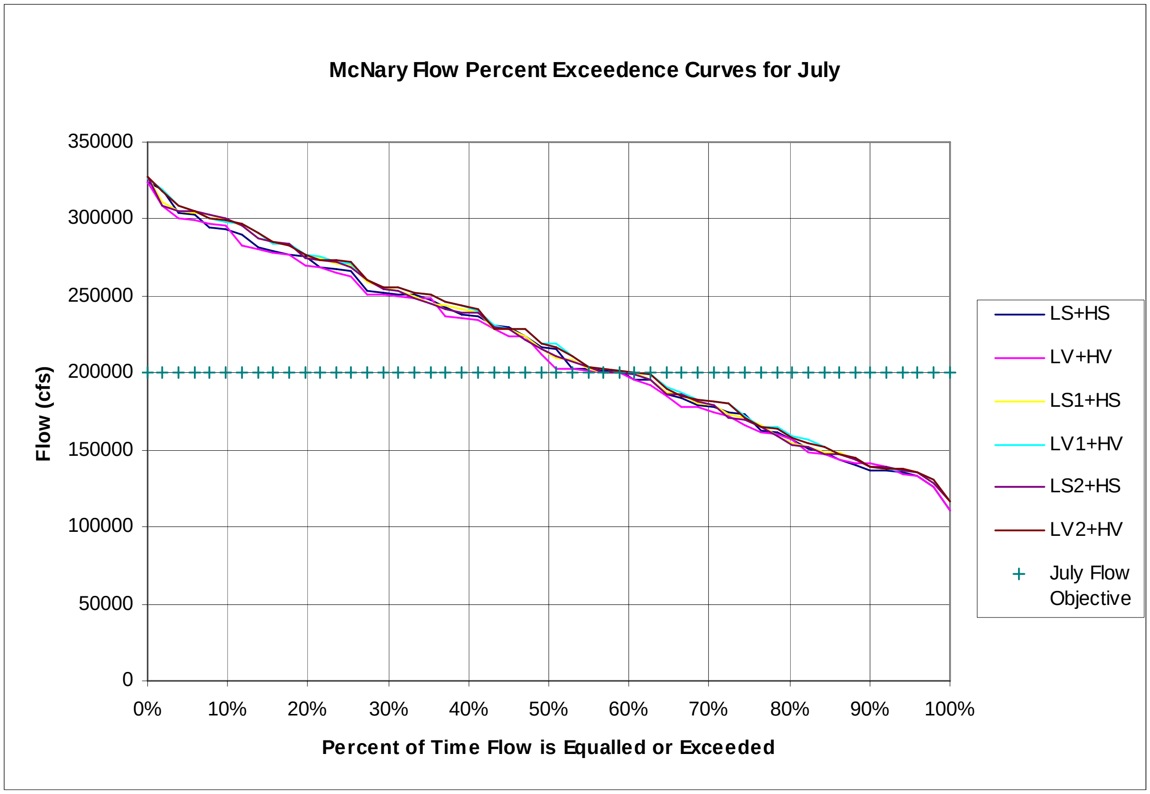

Figure 5-25. Exceedance frequencies for alternative and benchmark combinations in meeting McNary flow objectives for anadromous fish in July. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

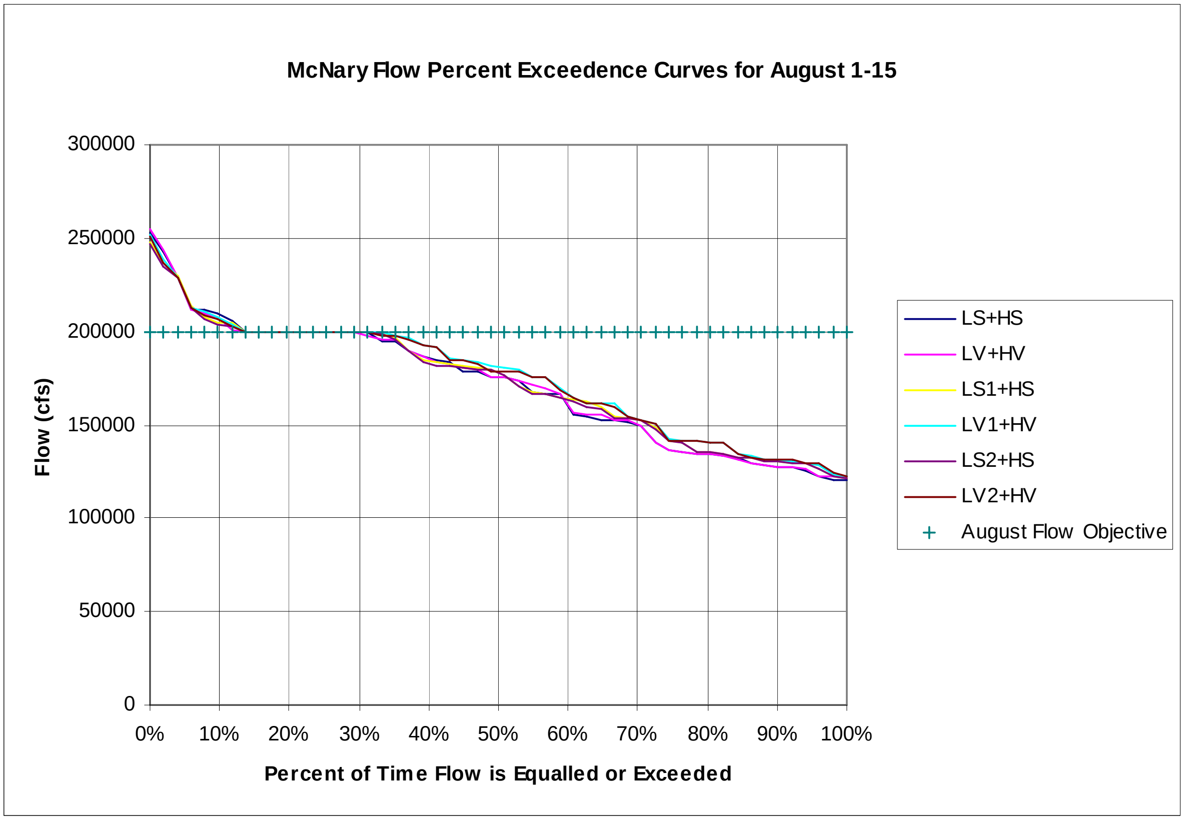

Figure 5-26. Exceedance frequencies for alternative and benchmark combinations in meeting McNary flow objectives for anadromous fish in the first half of August. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

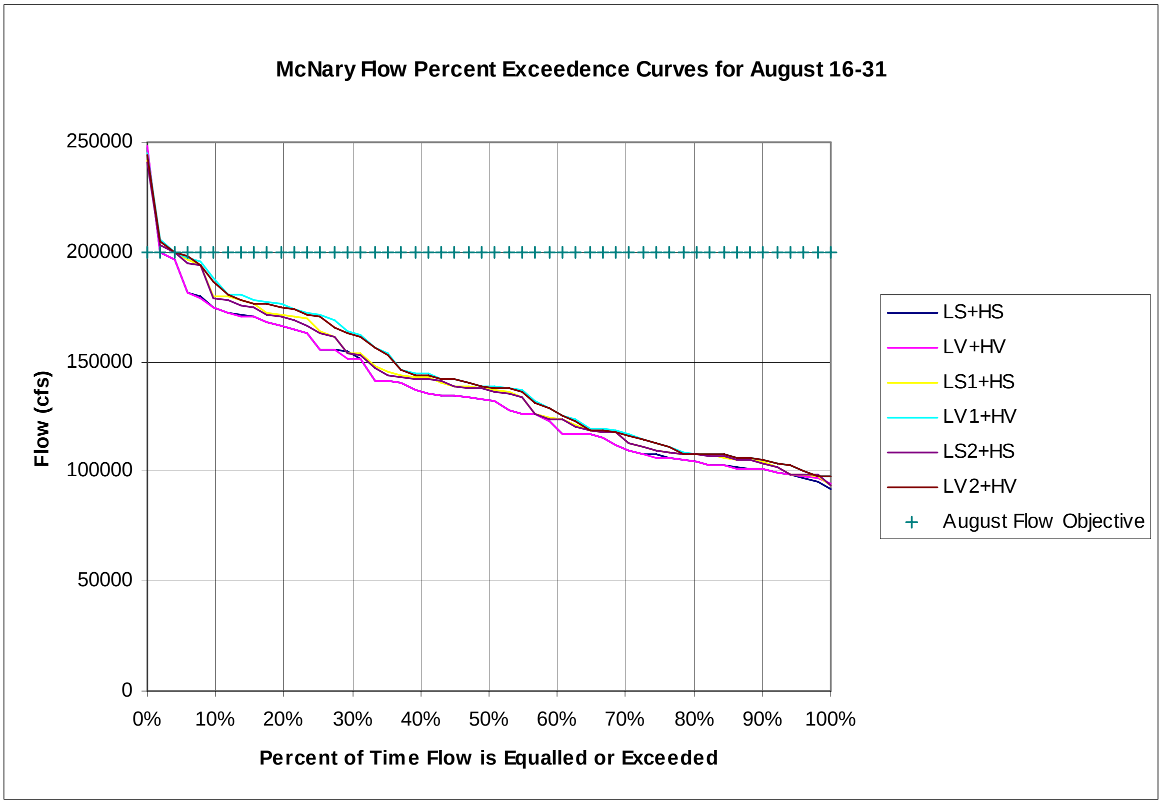

Figure 5-27. Exceedance frequencies for alternative and benchmark combinations in meeting McNary Flow Objectives for Anadromous Fish in the Second Half of August. Alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

Water quality impacts of alternative combinations are based on TDG generation. Spill resulting in saturation levels above 120 percent for a period of time may be harmful to aquatic life. Analysis of TDG impacts on anadromous fish was based on spill cap exceedance indices shown in table 5-28. These indices indicate when TDG levels approach or exceed harmful levels (120 percent saturation) for fish. Among the alternative and benchmark combinations, differences in potential adverse impacts to aquatic life from elevated TDG levels are expected to be minimal since there are only minor differences among the alternative and benchmark combinations in terms of spill cap exceedance.

The actual effects on fish for different saturations are variable depending on several factors including fish species, life stage, condition, proximity of the fish to the surface, and temperature. Because the analysis is based on monthly time step data, it does not draw conclusions about the effects of individual or short-term spills.

Individual incidents of involuntary spill, causing TDG levels to exceed 110 percent saturation or 120 percent saturation, are possible under any alternative combination. However, the installation of flow deflectors at Chief Joseph Dam and the operational shifting of generation to Grand Coulee Dam and spill to Chief Joseph Dam should help keep TDG levels below 120 percent as far downstream as Priest Rapids Dam during involuntary spill. Voluntary spill for fish passage at the other FCRPS dams is managed to stay below the gas caps to the extent possible.

5.3.6 Vegetation

Mainstem Columbia River Upstream From Grand Coulee Dam

The vegetation surrounding Lake Roosevelt would likely remain unchanged under any of the alternative and benchmark combinations because there is no modification to the overall full pool elevation, the typical range of winter flood control draft (up to 82 feet below full pool elevation of 1290 feet under all alternatives), or the time period during which the reservoir is at full pool (which usually would occur between June 30 and July 31 under all alternatives). Under all alternative and benchmark combinations, the riparian interface around Lake Roosevelt would be similar to that already established. Similarly, wetland extent and type would generally remain unchanged.

Mainstem Columbia River Downstream From Grand Coulee Dam

Downstream from Grand Coulee Dam, under all alternative and benchmark combinations, localized flow patterns would be similar to LS1+HS, the no action combination, and within the current range of river operations. Effects on vegetation would be minimal.

5.3.7 Wildlife

Mainstem Columbia River Upstream From Grand Coulee Dam

The vegetation surrounding Lake Roosevelt, including riparian and wetland habitats, is expected to remain unchanged under any of the alternative and benchmark combinations. Given no change in habitats, associated terrestrial wildlife populations also are likely to remain unchanged by any of the alternative and benchmark combinations.

Mainstem Columbia River Downstream From Grand Coulee Dam

The various alternative combinations have the potential to affect the timing and magnitude of flows in the mainstem Columbia River. However, under any of the alternative and benchmark combinations, changes in the flow patterns would be within the current range of river operations and effects on wildlife species would be extremely minimal and are considered nonexistent. These small changes in flow patterns would not affect the quality or quantity of available wildlife habitat.

5.3.8 Recreation

Mainstem Columbia River Upstream From Grand Coulee Dam

All Alternative Combinations

Analysis of average daily stages showed very little change in usable boat ramp days at Lake Roosevelt during the summer. Table 5-27 shows the number of usable boat ramp days per month. The ramp days for all alternative combinations are within 0.5 percent of each other across the alternative combinations. All boat ramps are in the water during June and July under all alternative combinations. Under both Standard FC and VARQ FC alternative combinations, 6 of 22 boat ramps are out of the water in August. All boat ramps are again accessible in September under all alternative combinations. No discernible effects are expected for recreation or aesthetics under any of the alternative combinations at Lake Roosevelt.

A slight degradation in visual resources may be noticeable in May. No change is expected for the rest of the summer season.

Mainstem Columbia River Downstream From Grand Coulee Dam

The system power generation modeling effort provided the flow information used in this analysis of recreation impacts. The assumptions and templates used in the power generation evaluation (Appendix J) are implicit in the recreation evaluation.

Table 5-27. Lake Roosevelt average usable boat ramp days per month. LVB+HV would be the same as LV1+HV and LV2+HV. LSB+HS would be the same as LS1+HS and LS2+HS.

	Alternative Combinations				**Benchmark Combinations**	
Month	LS1+HS	LV1+HV	LS2+HS	LV2+HV	LS+HS	LV+HV
May	349	336	349	336	349	337
June	695	694	695	694	695	694
July	744	744	744	744	744	744
August	650	650	650	650	647	647
September	720	720	720	720	720	720
Total	3,158	3,144	3,158	3,144	3,155	3,142

Notes: a) Boat ramp days are the sum of conditions that allow use of 24 boat ramps each month, so the maximum possible number of boat ramps is 720 days in June and September (30 days long) and 744 in May, July, and August.

Flows from Grand Coulee Dam are the basic indicator of effects on recreation in the mainstem Columbia River. The reservoirs below Grand Coulee Dam are run-of-the-river and their surface elevations do not change except within the few feet of their normal operating ranges.

Average monthly discharges from Grand Coulee Dam with alternative and benchmark combinations were modeled and are presented in Table 5-28.

Table 5-28. Grand Coulee Dam monthly average discharge. Effects of alternative combination LVB+HV would be similar to LV1+HV and LV2+HV. Effects of alternative combination LSB+HS would be similar to LS1+HS and LS2+HS.

	Alternative Combinations				Benchmark Combinations	
Month	LS1+HS	LV1+HV	LS2+HS	LV2+HV	LS+HS	LV+HV
May	161,380	164,241	161,380	164,733	159,489	163,145
June	149,241	153,132	149,696	153,537	142,543	149,566
July	142,840	144,821	142,612	144,591	139,211	141,149
August	111,443	114,127	110,948	113,673	108,618	108,761
September	59,886	60,178	59,820	60,068	72,969	72,985

During the summer recreation season from May to September, VARQ FC alternative and benchmark combinations would result in slight increases in discharge from Grand Coulee Dam compared to Standard FC alternative combinations. Based on average flow values from Grand Coulee Dam (Table 5-28) recreational effects at Lake Rufus Woods would be similar among alternative combinations. Differences are similarly very minor among alternative combinations in a high-flow year (1996), a medium-flow year (1995), and a low-flow year (1977). Boating and shoreside recreation would take place under all alternative combinations as they currently do at Lake Rufus Woods. It is also expected that at other downstream locations current conditions would continue and there would be little difference among the alternative combinations. There are no major differences between the benchmark combinations and their alternative combination counterparts.

5.3.9 Environmental Health

Mainstem Columbia River Upstream From Grand Coulee Dam

The following discussion compares the environmental health effects of Standard FC alternative combinations (LS1+HS, LS2+HS, LSB+HS) with VARQ FC alternative combinations (LV1+HV, LV2+HV, LVB-HV) at Lake Roosevelt. As described in the hydrology and flood control section, all Standard FC alternative combinations would result in essentially identical reservoir operations at Lake Roosevelt. Similarly, all VARQ FC alternative combinations would result in essentially identical reservoir operations.

Airborne Contaminated Bed Sediments

When compared to Standard FC alternative combinations, model results indicate that VARQ FC alternative combinations would generally result in slightly lower reservoir pool levels during the spring flood control draft in average to moderately dry water years. However, power needs and flow augmentation for endangered species can influence reservoir operations during the winter and spring to the extent that these requirements result in drawdown greater than those required for flood control, particularly for dry years.

Figure 5-10 shows the probability of additional draft at Lake Roosevelt as a result of implementation of VARQ FC alternative combinations. There is an approximate probability of 40 percent that Lake Roosevelt would be drafted an additional two feet as a result of VARQ FC when compared to Standard FC. In extremely rare cases the additional draft may be as much as six feet below the projected requirements for Standard FC. Again, power demands and flow augmentation for endangered species may exceed or overshadow the drawdown requirements for either Standard FC or VARQ FC alternative and benchmark combinations in some years.

Figure 5-9 illustrates the probability for differences in the lake elevation curve between Standard FC and VARQ FC alternative and benchmark combinations. The greatest potential for change is in the range of lake elevations between 1255 feet and 1270 feet and again, to a lesser extent, between 1230 feet and 1235 feet. The probability that the lake elevation would be at or below 1270 feet to 1255 feet by the end of April ranges from about 70 to 80 percent. There is a reduced probability (about 30 to 40 percent) that the lake elevation would be at or below 1235 feet to 1230 feet.

In both cases VARQ FC alternative and benchmark combinations would slightly increase the exposed land mass acreage around these lake elevations during some years.

Approximately 8,800 acres of reservoir bottom is exposed when the lake elevation is at 1270 feet (20 feet below full pool). As the lake is further drawn down to 1250 feet, an estimated total of 16,000 acres is exposed. (Reclamation 2003) On average, an additional 720 acres is exposed for every 2 feet of reduction between 1270 feet lake elevation and 1250 feet lake elevation. A two foot reduction in lake elevation can be expected approximately 40 percent of the time under the VARQ FC alternative and benchmark combinations.

Information provided by the USGS air monitoring study has shown that the exposed bed-sediment areas were not large nor did the exposed areas dry out thoroughly when seasonal lake drawdown elevations were above 1240 feet. At these elevations, bed sediment particles entrained into the atmosphere during high-wind events have not been found to have a demonstrable impact upon human health.

Figure 5-9 shows that for Standard FC and VARQ FC alternative and benchmark combinations, there is a projected probability of 45 to 50 percent for minimum lake elevations to be at or below 1240 feet and a projected probability of 30 to 35 percent to be at or below 1230 feet. Based on Landsat imagery, Marcus Flats and the area from Two Rivers down to Seven Bays are partially exposed when water levels reach elevation

1240 feet. Both areas are completely exposed when lake elevations reach 1230 feet (USGS 2003).

Presently, the USGS air monitoring study has not recorded any sampling events where the lake elevation was below 1240 feet. Future monitoring during drawdown to these lower elevations may or may not demonstrate a potentially higher impact upon human health and the environment. The air monitoring study would be continued through the year 2005 and possibly longer, dependent upon funding. The EPA Remedial Investigation and Feasibility study (RI/FS) would utilize the air monitoring data as appropriate.

Given the effects of VARQ FC relative to Standard FC, the probability of measurable impacts to human health and the environment due to airborne contaminated bed sediments is expected to be extremely low.

Direct Contact and Incidental Ingestion

Previous studies have shown that contaminated bed sediments are located on many Lake Roosevelt beaches (USGS 2003). Over the next several years, EPA will be looking at the potential for incidental ingestion, dermal contact, and inhalation as part of the Remedial Investigation, Human Health and Ecological Risk Assessment. This investigation is expected to be performed under the parameters of normal operating conditions. The Remedial Investigation is expected to last 3-5 years.

As previously stated, VARQ FC alternative and benchmark combinations would slightly increase the exposed land mass acreage during some years when lake elevations are in the ranges of 1250 to 1270 feet and between 1230 feet to 1235 feet.

Given the effects of VARQ FC alternative and benchmark combinations relative to Standard FC alternative and benchmark combinations, the probability of measurable impacts to human health and the environment (due to recreation, uptake by plants and animals, and subsistence gathering and harvesting of fish and other food sources) is expected to be extremely low. Reevaluation would be needed as additional information becomes available.

5.3.10 Cultural Resources

Mainstem Columbia River and Lake Roosevelt

For the purposes of the cultural resources effects analysis, alternative combinations LS1+HS (no action alternative combination),LS2+HS, and LSB+HS all incorporate Standard FC and are identical to each other in terms of their potential effects to historic properties. Benchmark combination LS+HS would be similar to alternative combinations LS1+HS, LS2+HS, and LSB+HS. Alternative combinations LV1+HV, LV2+HV, and

LVB+HV (preferred alternative combination) would have effects that differ from Standard FC, and are identical to each other in terms of their potential effects to historic properties. Benchmark combination LV+HV would be similar to LV1+HV, LV2+HV, and LVB+HV.

Under alternative combinations LS1+HS and LS2+HS Grand Coulee Dam would operate as it has under recent historic operations. Similarly it would operate as it has under benchmark combination LS+HS.

Under alternative combinations LV1+HV, LV2+HV and LVB+HV, Lake Roosevelt would be drafted lower in some years than under Standard FC. It would operate as it has under recent historic operations during wet winters (above 120 percent of average run-off) or dry winters (below 80 percent of average runoff) which collectively make up 15 percent of all years. There would be changes in effects to the Lake Roosevelt shoreline, and cultural resources, an estimated 54 percent of all years. In those years, the implementation of VARQ FC upstream would increase the amount of time that Lake Roosevelt would be drafted deeper during March and April (Table 5-29). Hydrological projections indicate that shoreline areas between 1240 and 1280 feet would be affected, with the zone between 1245 and 1265 feet varying the most from Standard FC operations (up to 6.1 feet lower by April 30). The same effects are expected for benchmark combination LV+HV.

Table 5-29. End of April percent probability that Lake Roosevelt would not go above stated elevation. Alternative combination LVB+HV would be the same as LV1+HV and LV2+HV. Alternative combination LSB+HS would be the same as LS1+HS and LS2+HS.

	Alternative Combinations				Benchmark Combinations	
Elevation (feet)	LS1+HS	LV1+HV	LS2+HS	LV2+HV	LS+HS	LV+HV
1280	100%	100%	100%	100%	100%	100%
1270	81%	81%	81%	81%	81%	81%
1260	73%	75%	73%	75%	73%	75%
1250	62%	69%	62%	69%	62%	69%
1240	52%	54%	52%	54%	52%	54%
1230	33%	35%	33%	35%	33%	35%
1220	10%	10%	10%	10%	10%	10%
1210	4%	4%	4%	4%	4%	4%

Differences in lake elevation frequencies appear to be due solely to VARQ FC versus Standard FC, rather than to inclusion of Libby fish flows (alternative combinations vs. benchmark combinations).

Area of Potential Effect

Historic operating parameters at Lake Roosevelt bracket elevations 1208 to 1290 feet, with an average spring draft to 1244 feet and a maximum spring draft to about 1209 feet. Alternative combinations LV1+HV, LV2+HV and LVB+HV are not expected to affect shoreline elevations above 1280 feet, nor is benchmark combination LV+HV. The APE at Lake Roosevelt for implementing VARQ FC upstream is defined as those shoreline lands that are directly impacted by the operations of Grand Coulee Dam (*i.e.*, below 1290 feet) and on adjacent nonproject lands, tributaries, and downstream reaches to the extent that the effect is demonstrably caused by dam operations. The effects of erosion from wave action range upslope from the water line, and in certain cases, secondary effects of erosion may occur above elevation 1310 feet. Impacts to historic properties above the 1310-foot-line would be addressed on a case-by-case basis.

The APE for indirect effects to the character of historic properties (such as visual effects) is expected to be the same as under Standard FC. In consultation with the CCT, an APE for indirect effects to historic properties (such as TCPs) in the CCT area of interest has been agreed upon as all lands contained within a perimeter set at 1.5 miles from the centerline of the Columbia River and its major tributaries within the Grand Coulee Dam Project reservoir and the downstream tailrace to River Mile 590.

In consultation with the Spokane Tribe of Indians (STI), an APE for indirect effects to historic properties in the STI area of interest has been agreed upon as all lands contained within a perimeter set at 1.5 miles from the centerline of the Spokane River and its tributaries to the confluence of the Columbia/Spokane Rivers and northward through the northwest corner of the Reservation for the Spokane Tribe of Indians, along the easterly portion of Lake Roosevelt, up to and including Hunters Creek; and also on the Spokane River from Little Falls eastward, to within a perimeter set at 1.5 miles from the centerline of the that river and its tributaries. Boundaries were selected through professional judgment of the definition for APE in the Federal regulations, the impacts to the people of the Spokane Tribe of Indians, and previous anthropological and traditional places researched in the project area. The above APEs for indirect effects are expected to require adjusting as issues arise and information accumulates through the coming years.

Historic Properties at Lake Roosevelt

This analysis assumes that the known inventory of historic properties at Lake Roosevelt represents the complete number. The shoreline has received nearly 100 percent complete inventory, but due to the dynamic nature of shoreline sediments there may be additional properties not yet identified. Also, some historic properties on tribal land may not be represented due to lack of data.

Another assumption is that the vertical distribution of sites is accurate. Due to the dynamic nature of the shoreline, some known sites may have greater elevational spans than current data show.

Finally, this analysis assumes that the hydrological models for VARQ FC implementation are reasonably accurate in their estimations of timing, duration, and degree of shoreline exposures.

The impact indicators selected for analysis are considered for VARQ FC (alternative combinations LV1+HV, LV2+HV, LVB+HV) relative to base conditions, *i.e.*, Standard FC (alternative combinations LS1+HS, LS2+HS, LSB+HS). The indicators are:

- number and percentage of historic properties impacted
- type of impacts
- probability of impact
- frequency and timing of impact

The analysis for impacts to historic properties at Lake Roosevelt is based upon the latest data derived from cultural resources management reports from the NPS, the CCT, the STI, and the Washington SHPO. Summary data in GIS format representing all these sources were compiled in 2003 and 2005 under contract to BPA, and represent all known properties on lands administered by the NPS. Reclamation's hydrologic projections of timing and extent of reservoir elevation changes under VARQ FC implementation were also used. Reclamation consulted in person with Section 106 interested parties to ensure that no historic properties or impacts were omitted from consideration (such as historic properties on tribal lands that are not yet entered into the summary database). GIS and other data from Reclamation's Pacific Northwest Regional Office data base were used to determine which sites would be affected by elevation zone, and the nature of the effects. Only percentages were calculated in this analysis.

See Figure 5-6 for the elevation distribution of Lake Roosevelt sites. All sites currently known for the Lake Roosevelt shoreline have been impacted by the operations of the reservoir since it was flooded in 1942. The physical integrity of sites is affected by deflation of sediments, displacement of artifacts, loss of features and organics, and weathering caused by constant drying, rewetting, and exposure to dissolved chemicals in the water. Recreational use of the reservoir exposes artifacts to casual or focused collecting activity. However, the sites retain analytical and cultural value and are currently managed under a Section 106 compliance program administered by the BPA and jointly funded by BPA and Reclamation. The NPS, the CCT and the STI participate in planning for management actions on a regular basis.

Available data show that 213 archaeological sites with reliable location data, or 43 percent of the total (N=497), have potential to be affected by the average decrease in pool level at the end of April at shoreline elevations between 1240 and 1280 feet (Figure 5-28).

Table 5-30 shows the percent of increased bank exposure by elevation under alternative combinations LV1+HV and LV2+HV. Similar effects would be expected under benchmark combination LV+HV. Summarized by percentage,

- Sites between 1230 and 1239 feet a.s.l. (5 percent of total N known sites) are projected to have 2 percent probability of experiencing effects
- Sites between 1240 and 1249 feet (4 percent of total N known sites) have 7 percent probability of experiencing effects
- Sites between 1250 and 1259 (8 percent of total N known sites) have 2 percent probability of experiencing effects
- Sites between 1260 and 1269 (11 percent of total N known sites) have 0 percent probability of experiencing effects
- Sites between 1270 and 1280 (15 percent of total N known sites) have 0 percent probability of experiencing effects

The majority of known sites at Lake Roosevelt have not been evaluated for eligibility to the National Register of Historic Places. Effects under alternative combinations LV1+HV and LV2+HV, as well as LVB+HV, are expected to be increased aerial exposure of sites and associated weathering. Patterns of wave action and erosion may also be altered. The end of April is not a busy recreation season, and increased loss of artifacts through looting is not anticipated. These numbers do not represent all sites that may be located on tribal land, sites that are not in NPS or state records, or sites for which Reclamation does not have recent location data. Also, several sites do not have current elevation information. Therefore, this assessment represents a minimum estimate of impacts. Similar effects would be expected for benchmark combination LV+HV.

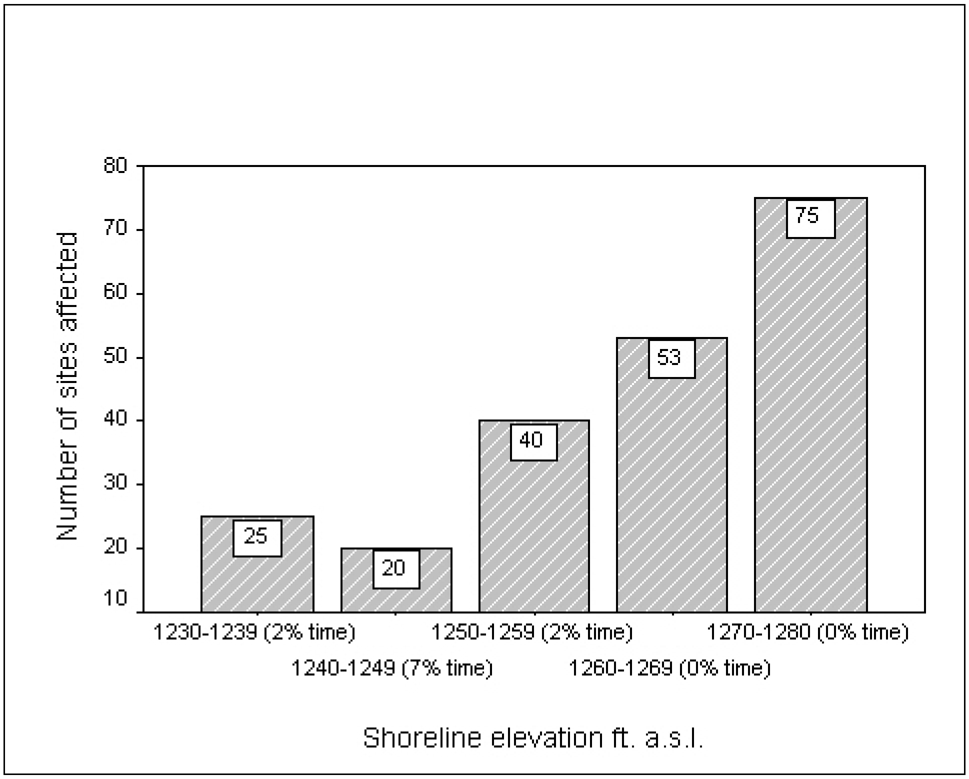

Figure 5-28. Number of sites projected as affected by VARQ FC operations at Lake Roosevelt and percentage of the time they would be affected.

Table 5-30. Percent change of additional bank exposure by elevation in 10 foot increments. LVB+HV would be similar to LV1+HV and LV2+HV. LSB+HS would be similar to LS1+HS and LS2+HS.

Lake Roosevelt shoreline elevation (feet)	Probability of additional exposure under LV1+HV and LV2+HV, compared to LS1+HS and LS2+HS
1270-1280	0%
1260-1270	0%
1250-1260	2%
1240-1250	7%
1230-1240	2%

Traditional Cultural Properties at Lake Roosevelt

The named places identified by the CCT are still being documented and must be evaluated for their status as TCPs. Also, Reclamation does not currently have sufficient information about their elevational extent to make a determination of the effects of alternative combinations LV1+HV and LV2+HV, or LVB+HV. The same applies to STI ethnographically documented areas; TCP determinations must still be made, and elevation data are still being gathered. It is expected that there is most potential for increased exposure of potential TCPs at elevations in the zone between 1240 and 1249 feet.

Mainstem Columbia River Downstream From Grand Coulee Dam

Evaluations are based on hydrologic modeling of Grand Coulee Dam outflow in the power generation report (Appendix J); assumptions and framework are thus those built into the modeling.

Impacts to cultural resources would be associated with potential for erosion as a function of flows from Grand Coulee Dam into Lake Rufus Woods.

Alternative combination LS1+HS corresponds to the preferred alternative implemented after the SOR EIS (BPA *et al.* 1995). Effects of operations would be essentially the same among all alternative combinations.

All Alternative Combinations

Chief Joseph Dam would be operated at a steady reservoir level, with up to 5 feet of fluctuation for fine-tuning operations. The 95 sites located on its shoreline would experience both shoreline erosion and site exposure all of the time. The remaining 76 sites in its pool would be inundated all of the time.

5.3.11 Indian Sacred Sites

Under Executive Order 13007 of 1996, Federal agencies must, consistent with essential mission functions, accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and avoid adversely affecting the physical integrity of such sacred sites. Existing operations, which are a Reclamation essential mission, have compromised access to and physical integrity of sacred sites. In consultations for this EIS with the CCT and STI, no sacred sites were specifically named. Therefore the effects of alternative combinations are not assessed for this category of cultural resources in this EIS.

5.3.12 Other Affected Tribal Interests

Lake Roosevelt operation would remain in the normal range of elevations, from 1208 feet to 1290 feet above sea level for all alternative combinations. Therefore, effects to resources important to Indian tribes would be similar under all alternative combinations.

Tribal interests in fishing would be affected by all alternative combinations to the extent that salmon and steelhead survival and recovery are affected. VARQ alternative combinations could result in minor drawdown-related effects on resident fish in Lake Roosevelt, including small impacts to shore spawning, as well as possible reduced growth from decreased water retention time. Impacts to lamprey, another species important to the tribes, would be similar under all alternatives. The analysis for anadromous fish discusses how the flow objectives at McNary and Priest Rapids dams are achieved by the various alternative combinations. Fish flows from Libby and Hungry Horse in July and August are intended to assist salmon migration. Spring flow augmentation for Kootenai River white sturgeon also can assist in meeting flow objectives in the lower Columbia River. Little difference among alternative combinations should be apparent for resident fish and other aquatic resources below Grand Coulee Dam.

5.3.13 Socioeconomics

Cost and benefit data were based upon October 2004 prices and conditions. Methodologies for evaluating direct socioeconomic impacts and their indirect impacts on regional employment and income are summarized below and described in detail in Appendix F.

Impact indicators and methods for the navigation, agriculture and irrigation, municipal and industrial water supply, employment and income, and tribal socioeconomics were generally similar to those used for the Kootenai and Pend Oreille basins. No impacts were identified for navigation, agriculture, M&I pumping costs, or tribal socioeconomics along the mainstem Columbia River. See Appendix F for more detailed discussion.

Differences or additional resource evaluations are discussed below.

Flood Impacts

The following evaluation of economic losses from flooding is based upon modeling of full system hydroregulations for the period of record as described in Section 5.3.1 and a detailed economic study conducted for the Columbia River SOR EIS (BPA *et al*. 1995). This evaluation considers flood damages occurring only within the major levee systems which protect large urban centers on the lower Columbia River. These major levee systems comprise only six of the 53 drainage districts which exist between Bonneville Dam and the mouth of the Columbia River. Five of the six areas considered are located within the Portland-Vancouver metropolitan area. The remaining 47 drainage districts generally protect agricultural areas with levees built to lower elevations than the major levee systems.

System modeling was conducted so that flood control operations supersede fish flow operations if the two are in conflict. Thus, alternative combinations LS1+HS, LS2+HS, and LSB+HS are considered equivalent for large flood events that may induce damage. Benchmark combination LS+HS is similar to the Standard FC alternative combinations. . For this same reason, alternative combinations LV1+HV and LV2+HV, as well as

LVB+HV, are equivalent. Benchmark combination LV+HV is similar to the VARQ FC alternative combinations. Therefore, this socioeconomic evaluation compares only the effects of Standard FC vs. VARQ FC themselves, as opposed to the fish flow operations.

VARQ FC operations (benchmark combination LV+HV*)[79] cause a small change in flow at The Dalles during the winter drawdown and spring runoff season, compared to Standard FC without Libby fish flows (benchmark combination LS+HS*). During the spring runoff, VARQ FC would add less than 10,000 cfs, on average, to the peak flow at The Dalles. This effect diminishes for larger events, and the frequency curves converge in the neighborhood of one-percent exceedance. This means that for 100-year events and larger floods there is no difference in flows between Standard FC and VARQ FC.

For period-of-record modeling, VARQ FC operations increase peak river stages in the Portland/Vancouver area by an average of 0.2 feet compared to Standard FC operations. However, as floods become more extreme, this difference diminishes and is negligible or zero for events larger than the 50-year flood.

No flood damages to mainstem levee protected areas, beyond those that would be anticipated to take place under Standard FC operations, would be anticipated to take place under VARQ FC operations. Levee crest elevations in the six areas evaluated range from 28.9 to 45 feet NGVD; these levees were designed to have several feet of levee freeboard during a 500-year discharge. Any increases in flood stage attributable to VARQ FC operations would be small (less than one foot) and occur during higher-frequency flood events when there is substantial levee freeboard available. During larger flood events, there is no difference in stage between VARQ FC and Standard FC operations.

Discharges exceeding 700,000 cfs would inundate unleveed areas outside the 100-year floodplain. For events of this size, there is no difference in stage between Standard and VARQ FC operations.

When there is no conflict with flood control objectives, the alternative combinations (which include Libby fish flows) may increase the magnitude and/or duration of releases below the flooding threshold. They could, therefore, impact protective works at certain locations in terms of increased levee saturation and erosion. This may affect the cost of levee maintenance. Potential increased maintenance costs are expected to be relatively minor.

Canadian interests have not provided quantitative evaluation of flood damages along the Columbia River in Canada. However, given the small differences in the frequencies of reaching the 225,000 cfs flood flow at Birchbank, BC and the small changes in the peak

[79] Daily system flood control modeling did not consider Hungry Horse fish flow operations and are noted as LS* and LV* as appropriate.

flows in Canada under the different flood control operations, substantial increases in flood damage are not anticipated under any of the alternatives.

Agriculture

No impacts were identified from any alternative combination on agriculture along the Columbia River.

Hydropower Benefits

Impacts to Columbia River Basin system hydropower economic benefits caused by all alternative combinations were evaluated in this study. The term "benefits" refers to payback of costs for the hydropower system.

Benefits impacts were quantified during "on-peak" and "off-peak" generation periods designated as heavy load hours (HLH) and light load hours (LLH), respectively. Total hydropower benefits were computed by summing the HLH and LLH impacts. System, Federal and non-Federal dam groupings were evaluated. Total average annual hydropower benefits impacts due to various alternative combinations are summarized below in Table 5-31, Table 5-32 and Table 5-33 for system, Federal and non-Federal dams, respectively, in the U.S. More details may be found in Appendix K. BC Hydro provided estimates of impacts to hydropower benefits for Canadian projects on the Kootenay and Pend d'Oreille River that are affected by Libby and Hungry Horse operations.

Results are as follows for all power groupings. Note that Federal and non-Federal benefits do not necessarily add up to system benefits because there are other dams in the system besides those which needed to be evaluated for this effort.

Alternative Combinations LS1+HS, LS2+HS, and LSB+HS

The LS1+HS (no action combination), LS2+HS, and LSB+HS alternative combinations would be similar to each other; LV2+HV would be slightly lower due to higher flows during the low-value spring season. As Standard FC alternative combinations, their power benefits would be higher than VARQ FC alternative combinations (LV1+HV, LV2+HV, LVB+HV) because they would allow more generation in winter, when power is valued higher. They would result in lower power benefits in winter and more in spring summer than would benchmark combination LS+HS.

Alternative Combinations LV1+HV, LV2+HV, and LVB+HV

Alternative combinations LV1+HV and LV2+HV would be similar to each other, as would alternative combination LVB+HV (preferred alternative combination). They would be lower than Standard FC alternative combinations, because they would store water in winter at Libby and Hungry Horse dams, generating less power at that high-value time of year than would their counterpart Standard FC alternative combinations (LS1+HS, LS2+HS, LSB+HS). These alternative combinations would result in similar power benefits values as benchmark combination LV+HV in winter, and somewhat greater power benefits in spring/summer. Information supplied by BC Hydro indicates that LV1+HV would reduce annual power benefits in Canada on the order of $10 to 14 million (CDN), compared to LS1+HS. The interim implementation of Libby VARQ FC during 2005 (equivalent to LV1+HV) reduced actual Canadian power benefits at approximately $4 to 5 million (CDN) relative to Libby operations under Standard FC (equivalent to LS1+HS).

Confederated Colville Tribe Power Benefits

Although generation varies from month to month for the different operations, the effect on annual average production is relatively low. This is to be expected as the different alternative and benchmark combinations do not change the total quantity of water released, just the timing of the releases. As payments to the Confederated Colville Tribe are based upon annual generation, the average annual megawatt difference is appropriate to use in calculating economic impact.

Table 5-34 shows how the different alternative combinations affect Grand Coulee power generation and the settlement amount. The maximum settlement reduction (for LV2+HV in comparison to LS1+HS) was calculated to be $52,549, or about a third of a percent of the annual payment of about $15,000,000. The reduction in the settlement for alternative combination LVB+HV would be somewhat less than this amount. The reduction in the settlement for alternative combination LSB+HS would be somewhat less than the $22,521 for LS2+HS.

Summary

The VARQ FC alternative combinations would result in somewhat less hydropower benefits than Standard FC alternative combinations. Alternative combinations with Libby fish flows (LS1+HS, LV1+HV, LS2+HS, LV2+HV, LSB+HS, LVB+HV) would result in less benefit than benchmark combination LS+HS or benchmark combination LV+HV.

Table 5-31. Summary of system annual hydropower benefits by alternative and benchmark combination ($1,000). Alternative combination LVB+HV would be within the range of values between LV1+HV and LV2+HV. Alternative combination LSB+HS would be within the range of values between LS1+HS and LS2+HS.

Load Hours	Alternative Combinations				Benchmark Combinations	
	LS1+HS	LV1+HV	LS2+HS	LV2+HV	LS+HS	LV+HV
Heavy	3,651,591	3,640,198	3,650,256	3,639,196	3,666,703	3,651,570
Light	1,294,401	1,291,864	1,294,035	1,291,597	1,299,915	1,296,183
Total	4,945,992	4,932,063	4,944,291	4,930,793	4,966,618	4,947,753

Table 5-32. Summary of Federal annual hydropower benefits by alternative and benchmark combination ($1,000). Alternative combination LVB+HV would be within the range of values between LV1+HV and LV2+HV. Alternative combination LSB+HS would be within the range of values between LS1+HS and LS2+HS.

Load Hours	Alternative Combinations				Benchmark Combinations	
	LS1+HS	LV1+HV	LS2+HS	LV2+HV	LS+HS	LV+HV
Heavy	1,857,339	1,850,621	1,856,398	1,849,813	1,869,454	1,859,315
Light	659,092	657,908	658,833	657,692	663,382	661,134
Total	2,516,431	2,508,529	2,515,230	2,507,505	2,532,836	2,520,449

Table 5-33. Summary of annual non-Federal hydropower benefits by alternative and benchmark combination ($1,000). Alternative combination LVB+HV would be within the range of values between LV1+HV and LV2+HV. Alternative combination LSB+HS would be within the range of values between LS1+HS and LS2+HS.

Load Hours	Alternative Combination				Benchmark Combination	
	LS1+HS	LV1+HV	LS2+HS	LV2+HV	LS+HS	LV+HV
Heavy	894,667	887,650	896,100	887,603	896,100	888,536
Light	316,160	314,477	316,124	314,457	316,570	314,780
Total	1,210,827	1,202,127	1,212,224	1,202,060	1,212,670	1,203,316

Table 5-34. Grand Coulee Generation and Benefits

Comparison between Alternative and benchmark combinations	GC generation difference between combinations (aMW)	Settlement difference between combinations
LV_1+HV vs. LS_1+HS	-5	-$37,535
LS_2+HS vs. LS_1+HS	-3	-$22,521
LV_2+HV vs. LS_1+HS	-7	-$52,549
LV_2+HV vs. LS_2+HS	-4	-$30,028
LV_2+HV vs. LV_1+HV	-2	-$15,014
LV+HV vs. LS+HS	-4	-$30,028
LS +HS vs. LS_1+HS	-3	-$22,521
LV+HV vs. LS_1+HS	-2	-$15,014

Note: Differences in the settlement amount are based on an average value of $7,507 for each megawatt difference in annual generation.

Employment and Income

The potential for employment and income effects of hydropower impacts is discussed below. No additional impacts were identified from the implementation of the different alternative combinations along the mainstem Columbia River that would be expected to affect regional employment and/or income.

Some alternative combinations result in a loss of generating capacity for the system. When compared to no action alternative combination LS1+HS, Columbia River system hydropower generation would be expected to decrease by approximately 72 GWh with LV1+HV (-0.05 percent), and increase by 282 GWh (+0.21 percent) and 169 GWh (+0.13 percent) with LS2+HS and LV2+HV, respectively. The change in expected system generation from LS1+HS to either benchmark combination was less than 0.1 percent. With the exception of alternative combination LS2+HS, all alternative combinations showed a 0.5 percent or less decrease in generation at non-Federal dams downstream from Libby and Hungry Horse Dams of when compared to LS1+HS. Alternative combination LS2+HS showed a very slight increase in generation of 0.01 percent compared to LS1+HS. Alternative combination LVB+HV would be similar in effect to LV1+HV and LV2+HV. Alternative combination LSB+HS would fall within the range of LS1+HS and LS2+HS.

The overall change in generation varies depending on alternative combinations from a slight decrease to slight increase. These changes are very small relative to the entire system generation and will likely have no discernible impact on power rates.

5.3.14 Municipal Water and Wastewater Treatment

None of the alternatives are likely to affect municipal water sources or wastewater treatment or disposal.

5.3.15 Transportation and Navigation

Alternative Combinations LS1+HS, LS2+HS, and LSB+HS

Under LS1+HS (no action combination), LS2+HS, and LSB+HS, the Keller Ferry would continue normal operations within the current range (1290 to 1208 feet) of reservoir levels. Lake Roosevelt end-of-April elevation would be less than 1248 feet approximately 60 percent of all years. The normal minimum reservoir operating level anticipated is 1208 feet. The Inchelium Ferry also would continue normal operations within the current range of reservoir levels. Benchmark combination LS+HS would have similar effects.

Alternative Combinations LV1+HV, LV2+HV, and LVB+HV

Under LV1+HV and LS2+HS, as well as LVB+HV (preferred alternative combination), the Keller Ferry would continue normal operations within the current range (1290 to 1208 feet) of reservoir levels. However, the Lake Roosevelt end-of-April elevation would be less than 1248 feet approximately 70 percent of all years, which means that the ferry's alternative north landing would have to be used more frequently. The anticipated normal minimum reservoir operating level is 1208 feet. The Inchelium Ferry would also continue normal operations within the current range of reservoir levels. During 1 in 52 years, the additional draft with VARQ FC alternative combinations would lower the reservoir surface elevation to about 1226.3. Benchmark combination LV+HV would be similar to alternative combinations LV1+HV, LV2+HV, and LVB+HV.

Downstream from Grand Coulee Dam, no effects to transportation are expected under any of the alternative or benchmark combinations. This includes navigation and lockages, as well as land-based infrastructure (bridges, roads).

5.4 Cumulative Impacts

Cumulative effects are those effects on the environment resulting from the incremental consequences of the proposed action when added to other past, present and reasonable foreseeable future actions, regardless of who undertakes these actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. Minor and nonsignificant effects or significant localized effects may contribute to cumulative effects.

For the mainstem Columbia River, such actions may include:

Manipulation of River Flows Timing and Magnitude

- Libby Dam operation
- Hungry Horse Dam operation
- IJC Order of 1938
- Columbia River Treaty
- Kootenay Lake operations
- Grand Coulee Dam operation
- Operation of other mainstem Columbia River and tributary dams
- Flood control requirements

Physical Modification of Riparian and Floodplain Areas

- Grand Coulee Dam construction
- Construction of other mainstem Columbia River and tributary dams
- Levee construction and maintenance
- Agricultural activities
- Floodplain development
- Sediment contamination and cleanup

Ecosystem and Species Recovery

- Federal, tribal, state, and local habitat restoration actions
- USFWS FCRPS Biological Opinion
- NOAA Fisheries FCRPS Biological Opinion and Updated Proposed Action
- Biological opinions relating to Columbia River tributaries
- Habitat conservation planning
- Recovery planning
- State TMDL plans

Columbia River Initiative

5.4.1 Hydrology and Flood Control

System Flood Control

System flood control would continue to be managed and maintained for all alternative combinations as it has been. System flood control would be maintained with control points at Birchbank, British Columbia; The Dalles, Oregon, and Vancouver, Washington. Regional growth will likely lead to further development in floodplains, which may affect the future operational considerations for system flood control. Since system flood control under all alternative combinations is essentially equivalent, cumulative impacts under all the alternative combinations would also be comparable.

Columbia River Hydrology

Alternative combinations with fish flows and with VARQ FC would assist in efforts to provide more normative hydrographs in the mainstem Columbia River. Normative conditions in the mainstem river mean that river flows would increase and decrease with timing (but not necessarily flow magnitude) similar to natural conditions. Together with the various other ecosystem and species recovery activities, restoring more normative conditions would likely provide a cumulative benefit to overall ecosystem health. Such normative flow conditions would likely need to be adaptively managed to determine the most effective multi-purpose operation given the changes in river character due to the existence of the mainstem Columbia River dams. And while more normative conditions would likely benefit ecosystem health, such flow patterns likely would not maximize other uses of the system (such as hydropower generation and its economic benefits). It is possible, through the Columbia River Basin Water Resource Management legislation passed in February 2006 in the State of Washington, that new storage for irrigation and Columbia River water quality would be developed. Short and long-term proposals might affect storage along the mid-Columbia, but specific operational information is presently unavailable.

5.4.2 System Power

The system power analysis considered a wide variety of multi-purpose system operations and, accordingly, accounts for much of the potential cumulative effects on system power generation. Alternative combinations that result in lower annual or monthly generation may result in more power generation from sources such as fossil-fuel powered generators that can quickly meet demand. Changes in flow patterns resulting from climate changes may force additional changes in system operations to better balance power generation with ecosystem recovery objectives. Any reduction in flows from drought or climate shifts may lead to lower power generation capacity, lower ecosystem recovery capability, or both. No cumulative impacts on the electrical transmission system are anticipated.

5.4.3 Water Quality

Water quality would continue to be maintained within state standards for total dissolved gas (i.e., maximum TDG saturation of 110 percent with exceptions provided for spill to pass salmon smolts) whenever possible. If meteorological conditions force more spill, either in terms of frequency or of magnitude, then instances of TDG levels exceeding maximum standards could increase. Involuntary spills would continue to occur occasionally due to uncontrolled runoff and would result in temporary exceedances of TDG standards. Actions now being undertaken, such as flow deflector construction at Chief Joseph Dam, expansion of Brilliant Dam, and the generation and spill switch between Grand Coulee and Chief Joseph dams, would enhance the ability of the system to manage spill and TDG generation. Further population growth in the region might cause development of greater power generating and transmission capacity, but the utility of that to ameliorate TDG issues would depend on the ability of the system to incorporate it in a manner that would offset spill.

5.4.4 Aquatic Life

The provision of more normative flows for fish and aquatic organisms presents opportunities for successful maintenance and restoration of habitat conditions they need. VARQ FC and fish flows help in this regard. At the same time, growth and development of the region continue, and various interests compete for water and other resources. Energy requirements would increase, and for the foreseeable future, hydropower is a critical factor in the region. Demands for water, and impacts to watersheds would continue to be a factor in determining the health of aquatic species. It is conceivable that aquatic species would continue to be adversely affected in the long run as development and mitigation balance against each other, but that cannot be predicted with any certainty. Increased knowledge and incorporation of more sustainable technologies could offset that decline.

All alternative combinations being considered for implementation help provide more normative flows, a key habitat component for aquatic species. The Confederated Tribes of the Colville Reservation desire anadromous fish passage to be instituted at Chief Joseph and Grand Coulee dams. If that should happen, then reservoir management under all alternative combinations might need to be adjusted for smolt migration.

5.4.5 Sensitive, Threatened and Endangered Species

There is a large suite of human activities which may affect recovery of listed species of fish and aquatic invertebrates, as well as the general viability of other aquatic species. A large number of actions are occurring which are intended to benefit ESA listed stocks of salmon and steelhead in the Columbia River. ESA biological opinions for anadromous fish address hydropower, hatchery, habitat, and harvest impacts. Recovery actions include studies, estuary habitat restoration, and operational and capital improvements at dams. At the same time, growth and development of the region continue, and various interests compete for water and other resources. Energy requirements are likely to increase, and for the foreseeable future, hydropower is a critical part of that in the region. Likewise, use of dams for flood control is likely to continue. Climate change is also a potential factor in the long-term health of aquatic resources, as are decadal-scale oscillations in weather patterns, which affect the ability of the ocean to support anadromous salmon. In general, cumulative impacts on sensitive, threatened, and endangered species would be similar to those discussed for aquatic life and wildlife. Details on potential unique or notable cumulative impacts to specific species are discussed below.

By providing flows for salmon and steelhead from both Libby and Hungry Horse dams, these alternative combinations help provide at least one component required to increase salmon and steelhead juvenile outmigration capacity from the Columbia River. The ability to meet flow objectives at Priest Rapids and McNary Dams is slightly improved under these alternative combinations. There are some possible impacts from TDG under this alternative. The sum of the potential improvements and detriments to anadromous fish recovery makes the cumulative outcome of this alternative combination difficult to predict. Compared to the benchmark combinations, the fish flow augmentation provided by alternative combinations would provide more options to achieve recovery of the listed fish stocks over the long term.

5.4.6 Recreation

None of the alternative combinations is expected to have a measurable effect on recreation above and below Grand Coulee Dam. They are intended to maintain or enhance aquatic resources, but gauging that effect can be done only indirectly. Alternative combinations which support natural resources and water quality in the long term would do better at ensuring recreational needs are met, but the net impact is difficult to predict when also accounting for regional population growth.

5.4.7 Environmental Health

The EPA is conducting a remedial investigation as part of the Comprehensive Environmental Response and Liability Act (CERCLA or “Superfund”). As part of the remedial investigation, the EPA will be using an Ecological and Human Health Risk Assessment to determine the overall impact of the bed sediment contaminants on the environment and human health. The Remedial Investigation is expected to last 3-5 years. These remediation efforts and other environmental damage prevention may have positive impacts in the long run.

5.4.8 Cultural Resources

All known historic properties at Lake Roosevelt have undergone impacts from the operation of Lake Roosevelt over the past 70 years, including loss of site integrity and of individual items. Forty-three percent of known archaeological sites could receive varying degrees of additional impact under alternative combinations LV1+HV and LV2+HV, as well as alternative combination LVB+HV, through increased exposure (between two and nine percent probability) in late April. Effects include increased weathering to organic materials, artifact movement or damage from human and animal use of the shoreline, and loss from illegal collecting activities. Reclamation has identified specific sites located at elevations with potential for changes in exposure, and has shared that listing with all interested parties.

The effect on cultural resources below Grand Coulee Dam is expected to be the same among the alternative combinations. There is potential for erosion at specific locations which might be subject to wave action, and which might be affected by dam outflows, especially from Grand Coulee, as a function of reservoir surface elevation, such as in Lake Rufus Woods (Chief Joseph Dam reservoir). Recreational activities, agriculture and other development, if permitted, could all add to possible cumulative impacts in the long run.

5.4.9 Other Affected Tribal Interests

None of the alternative combinations are expected to appreciably affect tribal interests, including fishing, hunting, and gathering locations. Addressing ongoing missions for flood control, power production, irrigation, navigation and other purposes will include appropriate government-to-government consultation with tribes.

5.4.10 Transportation and Navigation

Navigation (i.e., transportation of barges and other commercial shipping) would continue in the foreseeable future above Bonneville Dam with no differences among alternative combinations as long as lower Columbia dams and navigation locks are maintained. Demand for such services may increase if inland Oregon, Washington and Idaho production of wheat and other crops increases in the long run. Development of other industries with heavy transportation needs is possible to the extent the inland economy seeks to diversify.

5.5 Mitigation

Mitigation for impacts of a proposed action takes the following forms in NEPA analysis (Council on Environmental Quality 1978):

1. Avoiding the impact altogether by not taking a certain action or parts of an action.

2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

5. Compensating for the impact by replacing or providing substitute resources or environments.

All alternatives in this EIS are formulated with the primary intent of avoiding or minimizing impacts. Some impacts cannot be avoided while meeting the purpose and need of the proposed action.

The mitigation measures discussed below cover the range of impacts of the alternatives, including, where it is feasible to do so, impacts that by themselves would not be considered "significant." Potential mitigation measures are identified, even if they are outside the jurisdiction of the Corps or Reclamation. Some of the identified measures may be undertaken by other entities or individuals. No commitments are made in this EIS to any mitigation action beyond avoidance and minimization, particularly those that are not currently authorized, programmed, and funded. The records of decision that support selection and implementation of operational actions at Libby Dam and Hungry Horse dams will document any mitigation actions that will be pursued by the Corps or Reclamation as part of the implementation of the selected alternative.

Water Quality

Changes in flows due to alternative combinations would be managed to avoid or minimize exceedance of TDG standards. Flow deflectors are being constructed at Chief Joseph Dam starting in 2005, to reduce levels of total dissolved gas (TDG) from involuntary spill in the Columbia River. In addition, an operational shift is being undertaken whereby, when involuntary spill is necessary for Chief Joseph and Grand Coulee Dam, power generation would shift from Chief Joseph to Grand Coulee, and spill would shift from Grand Coulee to Chief Joseph. This combination of structural and operational actions would reduce TDG levels in the Columbia River from Grand Coulee to Priest Rapids Dam. So although the frequency of involuntary spill events would not change appreciably, the severity of their effects would be reduced. Voluntary spill for smolt passage would continue to be managed to stay within prescribed TDG levels.

Sensitive, Threatened and Endangered Species

VARQ FC and fish flows would be implemented to reduce the effects of the FCRPS operation on listed species. As discussed above, mitigation for TDG effects from Grand Coulee and Chief Joseph dams will benefit threatened and endangered populations of fish.

Cultural Resources

Mitigation could include appropriate additional management actions for historic properties affected by implementation of VARQ FC including erosion monitoring targeted to affected sites, completion of the evaluation process for affected sites to determine appropriate mitigation efforts, and public outreach/education. Documentation of named places and other ethnographically known areas would be completed in phases, and named places would be evaluated for TCP status. Protective patrols are already in place during the April drawdown, and Reclamation would work with patrolling agencies and tribes to make any needed adjustments in spatial focus. No change in patrols would be needed during the summer key recreation season because VARQ implementation would not affect pool levels during those times of year.

Discovery of new sites or site components, or impacts to known sites, would be managed through the current cultural resources program at Lake Roosevelt. The Lake Roosevelt Cooperating Group (a planning forum that includes Reclamation, BPA, and Section 106 interested parties) could coordinate in their February meeting each year to discuss the forecast, and adjust plans accordingly.

No specific mitigation is needed or planned for cultural resources impacts below Grand Coulee Dam. Safeguards by Tribal authorities and historic preservation offices should help offset such impacts to the extent that management and enforcement capabilities, and specific site knowledge, allow.

Socioeconomics

Reduction in hydropower generation in Canada and consequent compensation issues are matters appropriately addressed through established Columbia River Treaty processes. Members of the staff of the U.S. Entity have begun technical discussions of VARQ FC with members of the staff of the Canadian Entity at Columbia River Treaty Operating Committee meetings and additional discussions are planned. It is expected that Libby VARQ FC will also be the subject of consultations between the U.S. Entity and the Canadian Entity under the terms of the Libby Coordination Agreement and the provisions of the Columbia River Treaty.

5.6 Unavoidable Adverse Impacts

Unavoidable Adverse Impacts to System and Mainstem Columbia River

There are some impact areas that would be adversely affected. They are discussed in individual sections, but are summarized here in the same order as sections appear.

Hydrology and Flood Control

FCRPS storage dams such as Libby, Hungry Horse and Grand Coulee can never prevent all flooding under any alternative combination. However, system flood control capability is maintained for all combinations.

System Power

There are likely to be impacts to system power generation under the VARQ alternative combinations in winter, a high-demand and high-value time of year, because those alternative combinations result in more storage of water in winter than do the Standard FC alternative combinations.

Water Quality

While voluntary spill for fish passage is managed to stay within Washington and Oregon's variance levels whenever possible, average TDG occasionally would exceed 120 percent saturation under all alternative combinations at Cabinet Gorge, Priest Rapids, Wanapum, Rock Island, and Rocky Reach. Incidences above 120 percent are greater for combinations with fish flows than for those without for Priest Rapids as well. Note that daily peaks cannot be captured using the monthly information available to make these estimates. Also some of the spill is voluntary for juvenile salmon outmigration at dams below Chief Joseph Dam (Wells, Rocky Reach, Rock Island, Wanapum, Priest Rapids, McNary, John Day, The Dalles, and Bonneville).

Aquatic Life

Common to all alternative combinations, there are months where average TDG saturation exceeds 120 percent due to uncontrolled high runoff. This could result in unavoidable adverse effects to aquatic life, due to prolonged levels of high saturation. This could impact fish and aquatic insects by gas bubble disease injury or displacement from preferred habitat.

Sensitive, Threatened and Endangered Species

The TDG generation common to all alternative combinations may periodically affect several threatened or endangered salmon and steelhead ESUs, and Columbia Basin DPS of bull trout. Alternative combinations do not differ in terms of numbers of months in the period of record when such exceedances are believed likely. At some dams, there is a slightly higher incidence of exceedance of spill caps with VARQ FC alternative combinations vs. Standard FC alternative combinations. There is also a slight difference in some cases between alternative combinations and benchmark combinations, which would be due to Libby fish flows.

Environmental Health

None of the alternative combinations is expected to adversely affect environmental health along the Columbia River below Grand Coulee Dam.

Cultural Resources

As with Standard FC, some vandalism, erosion, and looting arising from VARQ implementation to archaeological sites and other historic properties along the Lake Roosevelt shoreline are unavoidable because of the static nature of historic properties. Ongoing patrols and coordination are intended to minimize these impacts.

Socioeconomics

As stated under Hydrology and Flood Control, there is always some chance of flooding under any alternative combination. However, system flood control requirements will continue to be met. There would be some US Federal and non-Federal hydropower revenue losses, as well as potential Canadian losses, associated with VARQ FC in wintertime, when hydropower is most valuable.

5.7 Irreversible and Irretrievable Commitments of Resources

The purpose of this section is to examine the irreversible and irretrievable commitments of resources associated with implementation of the proposed action. Water management involves water storage, water release, and timing of these operations and would be necessary under all the alternative combinations. Once a decision is made for an operational approach, it would affect the ability to release water at a different time or in a different manner. Operations can be tailored within specified ranges through adaptive management. From this perspective, the proposed action would not involve irreversible and irretrievable commitments of resources.

5.8 Relationship between Short-term Uses and Long-term Productivity

This analysis examines the relationship between short-term uses of environmental resources and the maintenance and enhancement of long-term productivity. To a large extent, the timing and magnitude of short-term impacts are weather dependent since the size of the difference between the alternative combinations is dependent on seasonal water supply. For example, a series of very dry or very wet years in the immediate future would result in minimal differences between alternative combinations in the short-term.

Implementation of VARQ flood control with fish flows is intended to provide long-term benefits to listed fish species, including white sturgeon, bull trout, and salmon and steelhead in the Columbia River. Over the long-term, as evaluated based on the historical period of record, the alternative combinations would vary in terms of effects on water quality, aquatic life, power generation and benefits, recreation, environmental health, and cultural resources. As described in the effects analysis for each of these resources, direct, indirect, and cumulative adverse impacts to the resources associated with the mainstem Columbia River are expected to be relatively minor on both a short- and long-term basis. Adaptive management of the Columbia River system would further decrease long-term differences between alternative combinations, and would likely result in minimal differences in long-term productivity in areas that are potentially affected by system operations.

5.9 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, dated February 11, 1994, requires agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities as well as the equity of the distribution of the benefits and risks of their decisions. Environmental justice addresses the fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that no group of people should bear a disproportionate share of negative impacts from an environmental action.

In the area potentially affected by the project above and below Grand Coulee Dam, minority populations include Native American Tribes and Hispanics. Tribes in Washington include the Confederated Tribes of the Colville Reservation at Nespelem, the Yakama Nation at Toppenish, and the Cowlitz Tribe at Longview. In Oregon, they include the Confederated Tribe of the Umatilla Indian Reservation at Pendleton, and the Warm Springs Tribe at Warm Springs.

No disproportionate adverse impacts are expected to result from any of the alternative combinations evaluated in this EIS; there may be benefits to anadromous fish, which would be a positive result for Native American Tribes.

Chapter 6 Coordination, Consultation, and Public Involvement

This chapter provides a summary of the public scoping and the tribal consultation processes followed throughout development of this EIS, and a summary of other laws and regulations which may apply to Federal projects. The agency coordination and consultation process is documented in chapter 1.

6.1 Scoping

The Corps announced their intent to prepare a joint EIS with Reclamation for the Upper Columbia Basin Alternative Flood Control and Fish Operations at Libby Dam, Montana; Hungry Horse Dam, Montana; and Grand Coulee Dam, Washington (60 FR 49943). The Notice of Intent was published in the Federal Register on October 1, 2001.

Letters inviting public comment on the scope and conduct of investigations leading to the preparation of the draft EIS were mailed to more than 2,000 interested parties in the Columbia Basin. These letters announced a series of seven scoping meetings in: Grand Coulee, Washington (October 29, 2001); Newport, Washington (October 30, 2001); Bonners Ferry, Idaho (November 1, 2001); Portland, Oregon (November 8, 2001); Libby, Montana (November 13, 2001); Kalispell, Montana (November 14, 2001); and Eureka, Montana (November 15, 2001).

Approximately 280 people attended the meetings with attendance ranging from fewer than 10 people in Portland, Oregon, to about 90 people in Newport, Washington. Each meeting was conducted similarly, beginning with a one-hour open house followed by a one and one-half hour workshop. An information packet was made available to meeting attendees. The workshop portion of each meeting included an overview of the EIS objectives and NEPA process, a facilitated question and answer session, and breakout sessions where participants could make comments and recommendations. In Portland, the public scoping meeting was preceded by a meeting for local government representatives. In addition, a meeting was held with representatives of the Canadian government agencies and other officials on January 24, 2002, in Creston, British Columbia. A public meeting was also held that same day in Creston.

A formal comment period for receipt of written scoping comments extended through November 30, 2001. The formal scoping process was established to encourage the majority of the scoping comments to be made at the beginning of the study when they could be most beneficial to preparation of the EIS. The final scoping document for the EIS was issued in April 2002.

6.2 Tribal Consultation

Federal agencies have a responsibility to consult and coordinate with American Indian Tribes and traditional communities about actions that affect tribal interests. Over time, treaties, Federal statutes, executive orders, national policies, and case law have collectively defined how these relationships are exercised. In the government to government consultation process, the Corps and Reclamation seek to provide meaningful and timely opportunities for Tribes to comment on agency policies that may have significant or unique effects on tribal interests. This process has been initiated through the development and completion of the EIS and will continue through implementation of the action.

Coordination was conducted with the Confederated Salish-Kootenai Tribes of the Flathead Reservation, the Kootenai Tribe of Idaho, the Confederated Tribes of the Colville Reservation, the Spokane Tribe of Indians, the Kalispel Tribe, and the Coeur d'Alene Tribe. The Corps and Reclamation will participate in government-to-government consultation regarding this EIS and related operations at Libby and Hungry Horse dams and have sent letters to that effect to the regional tribes in the Columbia Basin, including the CRITFC member tribes. The Corps recognizes its trust responsibilities and works to ensure that tribal rights are given their full effect.

Reclamation consulted with staff from the CSKT Tribal Preservation Office in Pablo, Montana, on November 13, 2002. Rates of erosion, underwater sites, and monitoring were discussed. At a meeting in December 2002, staff from the Flathead National Forest (FNF), who manage cultural resources along the Hungry Horse Reservoir shoreline, committed to coordinate with Reclamation to monitor and mitigate potential effects associated with VARQ flood control. In a separate consultation meeting, the Montana SHPO expressed concern that effects of reservoir operations were not being addressed systematically; Reclamation and the Corps, along with the Bonneville Power Administration, are addressing that concern through the development of a Programmatic Agreement at the level of the Federal Columbia River Power System.

Reclamation met with representatives from the CSKT and the FNF in July 2004 to discuss erosion monitoring and artifact movement. In a phone meeting in August 2004, the Montana SHPO agreed with Reclamation that VARQ operations may cumulatively cause lower impacts to resources through less erosion and less visitor impact to sites in the summer months, but will shorten the window of management access because site monitoring will likely not be possible before mid-May.

Reclamation initiated consultation with the Confederated Tribes of the Colville Reservation (CCT) and the Spokane Tribe of Indians (STI) during the analysis of the interim 2002 Environmental Assessment for VARQ FC. Please see the Upper Columbia Alternative Flood Control and Fish Operations Implementation Environmental

Assessment (Corps and Reclamation, 2002) for the results of the 2002 consultation meetings with the CCT and the STI.

Corps representatives have met with the Confederated Salish-Kootenai Tribes and with Upper Columbia United Tribes representatives, and fisheries staff members. In addition, the Corps has had regular and frequent meetings with staff and council membership of the Kootenai Tribe of Idaho during the course of developing the EIS.

Discussions were held with the Washington SHPO on the Area of Potential Effect at Lake Roosevelt. Reclamation's Power Office archaeologist met with the CCT Tribal Historic Preservation Officer and staff via teleconference on October 19, 2004 to discuss the consultation schedule for VARQ FC.

6.3 Other Laws and Regulations

Several Federal statutes, executive orders, and executive memoranda apply to the development of Federal projects. These laws and regulations, and their applicability to this EIS are described in the sections below.

6.3.1 Federal Statutes

American Indian Religious Freedom Act

The American Indian Religious Freedom Act of 1978 (AIRFA) (42 U.S.C. 1996) establishes protection and preservation of Native Americans' rights of freedom of belief, expression, and exercise of traditional religions. Courts have interpreted AIRFA to mean that public officials must consider Native Americans' religious interests before undertaking actions that might harm those interests. The Corps and Reclamation will continue to coordinate with affected Native American Tribes on this study and future implementation plans.

No alternative or alternative combination would have any effect upon Native Americans' rights of freedom of belief, expression, and exercise of traditional religions.

Archaeological Resources Protection Act

The Archaeological Resources Protection Act (ARPA) (16 U.S.C. 470aa et seq.) provides for the protection of archaeological resources located on public and Indian lands, establishes permit requirements for the excavation or removal of archaeological resources from public or Indian lands, and establishes civil and criminal penalties for violations of the law.

For Reclamation's reservoirs, Reclamation and Federal land management agencies (NPS at Lake Roosevelt and USFS at Hungry Horse) are currently implementing the requirements of ARPA for all operations of the reservoir collectively, including VARQ FC. At Lake Roosevelt and Hungry Horse Reservoir, Reclamation is meeting the requirements under ARPA.

At Lake Koocanusa, the USFS has the primary responsibility for ARPA enforcement. Below Libby Dam, the Corps is working with the USFS to protect cultural resources sites on Corps lands. Seasonal high water conditions prevailing under VARQ FC would likely reduce impacts to archaeological sites at Lake Koocanusa. Between Libby, Montana, and Bonners Ferry, Idaho, there are few Federal or Indian lands, such as at Kootenai Falls, so the permit and excavation provisions of ARPA do not apply.

Clean Air Act

The Clean Air Act (CAA) (42 U.S.C. 7401 et seq.), amended in 1977 and 1990, was established "to protect and enhance the quality of the nation's air resources so as to promote public health and welfare and the productive capacity of its population." The CAA authorizes the EPA to establish the National Ambient Air Quality Standards to protect public health and the environment. The CAA establishes emission standards for stationary sources, volatile organic compound emissions, hazardous air pollutants, and vehicles and other mobile sources. The CAA also requires the states to develop implementation plans applicable to particular industrial sources.

This EIS analyzes effects on air quality from the various alternatives and alternative combinations, with reference to published standards, and effects are anticipated only at Lake Koocanusa and Lake Roosevelt. Those effects concern mobilization of lake bed sediments by wind under certain conditions, when the reservoirs are drawn down.

Endangered Species Act

The ESA (16 U.S.C. 1531 et seq.), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat upon which they depend. Section 7(a) of the ESA requires that Federal agencies consult with the USFWS and NOAA Fisheries, as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their critical habitats.

The Corps and Reclamation continue to consult with USFWS and NOAA Fisheries concerning listed species that may be affected by the operation of the FCRPS. The actions addressed in this EIS are in direct response to RPAs contained in the 2000 USFWS FCRPS Biological Opinion, the 2006 USFWS Biological Opinion regarding The Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout and Kootenai Sturgeon Critical Habitat, and in the 2004 UPA and the 2004 NOAA Fisheries

FCRPS Biological Opinion. The Action Agencies are implementing VARQ FC as an interim measure per the 2004 UPA.

Farmland Protection Policy Act

The Farmland Protection Policy Act (7 U.S.C. 4201 et seq.) requires Federal agencies to identify and take into account the adverse effects of their programs on the preservation of farmlands.

There are no land use actions among the alternatives that would involve conversion of farmlands for other purposes.

Federal Water Pollution Control Act

The Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.) is more commonly referred to as the Clean Water Act (CWA). This act is the primary legislative vehicle for Federal water pollution control programs and the basic structure for regulating discharges of pollutants into waters of the United States. The CWA was established to “restore and maintain the chemical, physical, and biological integrity of the nation’s waters.” The CWA sets goals to eliminate discharges of pollutants into navigable waters, protect fish and wildlife, and prohibit the discharge of toxic pollutants in quantities that could adversely affect the environment.

This EIS evaluates possible impacts to water quality, primarily with respect to TDG, but also with regard to temperature and mobilization of contaminants. No temperature effects are anticipated from any alternative or alternative combination. Contaminant issues are possible for Lake Roosevelt. Total dissolved gas effects are possible for the Kootenai River Basin, Pend Oreille River Basin, and the mainstem Columbia River. The Corps along with the USFWS and BPA are working with the State of Montana to resolve TDG and water quality issues prior to implementation of voluntary spill at Libby Dam for sturgeon flow augmentation (Alternative LVB).

Federal Water Project Recreation Act

In the planning of any Federal navigation, flood control, reclamation, or water resources project, the Federal Water Project Recreation Act, as amended (16 U.S.C. 4612 et seq.) requires that full consideration be given to the opportunities that the project affords for outdoor recreation and fish and wildlife enhancement. The Act requires planning with respect to development of recreation potential. Projects must be constructed, maintained, and operated in such a manner if recreational opportunities are consistent with the purpose of the project.

This EIS assesses impacts of alternative actions on recreation; however, no construction is planned as part of any alternative. The EIS also addresses effects on fish and wildlife, and the preferred alternative is intended to benefit threatened and endangered fish species as well as other fish species.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act of 1980 (FWCA) (16 U.S.C. 661 et seq.) requires Federal agencies to coordinate with USFWS and state wildlife agencies when planning new projects or when modification of an existing project occurs. The USFWS and state agencies charged with administering wildlife resources conduct surveys and investigations to determine the potential damage to wildlife. The USFWS incorporates the concerns and findings of the state and Federal agencies, including NOAA Fisheries, into a report that addresses fish and wildlife factors and provides recommendations for mitigating or enhancing impacts to fish and wildlife affected by a Federal project.

The FWCA does not require the Corps and Reclamation to coordinate with the USFWS for continuing operation of existing water resource projects; however, the Corps and Reclamation routinely coordinate with the USFWS on their operations. While there is no Coordination Act Report for this EIS, the proposed alternatives are in response to the 2000 USFWS FCRPS Biological Opinion, 2006 USFWS Libby Dam Biological Opinion, and the 2004 NOAA Fisheries Biological Opinion.

Fishery Conservation and Management Act of 1976

The Fishery Conservation and Management Act of 1976 (16 U.S.C. 1801 et seq.), also known as the Magnuson-Stevens Fishery Conservation and Management Act requires Federal action agencies to consult with the Secretary of Commerce (*i.e.*, NOAA Fisheries) regarding any action or proposed action authorized, funded, or undertaken by the agency that may adversely affect Essential Fish Habitat (EFH) identified under the Act. Species likely to be affected by the actions under this EIS are coho and Chinook salmon in the Columbia River and tributaries.

Consultation on EFH for the FCRPS operation has been addressed through consultation under the ESA (NOAA Fisheries 2004).

Land and Water Conservation Fund Act

The Land and Water Conservation Fund Act (LWCFA) (16 U.S.C. 4601 et seq.) assists in preserving, developing, and ensuring accessibility of outdoor recreation resources. The LWCFA establishes specific Federal funding for acquisition, development, and preservation of lands, water, or other interests authorized under the ESA and National Wildlife Refuge Areas Act. Funds appropriated under the Act are allocated to Federal agencies or as grants to states and localities.

There are no actions in this EIS involving funds under the LWCFA.

Migratory Bird Conservation Act

The Migratory Bird Conservation Act (MBCA) (16 U.S.C. 715 et seq.) requires that lands, waters, or interests acquired or reserved for purposes established under the Act be administered under regulations promulgated by the Secretary of the Interior. The MBCA addresses conservation and protection of migratory birds in accordance with treaties entered into between the United States and Mexico, Canada, Japan, and the former Union of Soviet Socialist Republic. It protects other wildlife, including threatened and endangered species, and restores or develops adequate wildlife habitat. The migratory birds protected under the MBCA are specified in the respective treaties. The Secretary of the Interior is authorized to manage timber, range, agricultural crops, and other species of animals, and to enter into agreements with public and private entities.

The alternatives under this EIS are evaluated with regard to effect on bird habitat in wetlands and riparian areas, but do not affect acquisition of lands under the MBCA.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703 et seq.) establishes a Federal prohibition, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, ... or in any manner, any migratory bird, included in the terms of this Convention . . . for the protection of migratory birds . . . or any part, nest, or egg of any such bird." This prohibition applies to birds included in the respective international conventions between the United States and Great Britain, the United States and Mexico, the United States and Japan, and the United States and the former Union of Soviet Socialist Republic.

The alternatives considered in this EIS are evaluated with regard to effects on birds and their habitat in wetlands and riparian areas. None of the alternatives would result in harm to migratory birds beyond the current range of natural variability. To the extent that certain alternatives aid development of riparian and wetland vegetation and habitat, migratory birds would be expected to benefit from the proposed actions.

National Environmental Policy Act

NEPA (42 U.S.C. 4321 et seq.) provides a commitment that Federal agencies will consider the environmental effects of major federal actions. It also requires that an EIS be included in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The EIS must provide detailed information regarding the proposed action and alternatives, the environmental impacts of the alternatives, appropriate mitigation measures, and any adverse environmental impacts that cannot be avoided if the proposal is implemented. Agencies are required to demonstrate that these factors have been considered by decisionmakers prior to undertaking actions. This and preceding documents (Corps

2001; Corps and Reclamation 2002; Reclamation 2002; BPA *et al.* 1995) have been undertaken specifically in pursuit of NEPA.

Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001 et seq.) addresses processes and requirements for federal agencies regarding the discovery, identification, treatment, and repatriation of Native American and Native Hawaiian human remains and cultural items (associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony). Consistent with procedures set forth in applicable Federal laws, regulations, and policies, the Corps proactively works to establish NAGPRA protocols and procedures.

For Reclamation's reservoirs (Lake Roosevelt and Hungry Horse), Reclamation and the National Park Service are currently implementing the requirements of NAGPRA for all operations of the reservoir collectively, including VARQ FC. Therefore, no additional consultations or other actions are required for VARQ FC. At Lake Koocanusa, the Corps and Forest Service are implementing requirements of NAGPRA for all operations of the reservoir, including VARQ FC. No additional actions are required for VARQ FC.

National Historic Preservation Act

Section 106 of the NHPA (16 U.S.C. 470 et seq.) requires that Federal agencies evaluate the effects of Federal undertakings on eligible historical properties, archeological, and cultural resources and afford the Advisory Council on Historic Preservation or State Historic Preservation Officer (SHPO) and other consulting parties opportunities to comment on the proposed undertaking. The lead agency must examine whether feasible alternatives exist that would avoid eligible cultural resources. If an effect cannot reasonably be avoided, measures must be taken to minimize or mitigate potential adverse effects.

Reclamation determined that VARQ FC has potential to cause impacts to historic properties at Lake Roosevelt and Hungry Horse that are different from Standard FC operations. For Reclamation reservoirs, Reclamation initiated Section 106 consultation under the NHPA with Tribes and other interested parties in 2002, and state SHPOs, during the EA phase of this project. Consultation has been ongoing since that time and the results are documented more fully in the environmental consequences portion of this EIS. Section 106 NHPA compliance for operation of Libby Dam and Lake Koocanusa is based on the 1991 Interior Development and Use Programmatic Agreement with BPA. An Historic Properties Management Plan has been in place at Lake Koocanusa to address impacts to sites since 1987. The Corps' consultation with affected Indian Tribes and SHPOs is ongoing. Effects of operations throughout the FCRPS are being considered in a system-wide programmatic agreement which is presently in draft form.

Pacific Northwest Electric Power Planning and Conservation Act

The Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act) was passed by Congress on December 5, 1980 (16 U.S.C. 829d-1). This law created the eight-member NPCC, whose members are appointed by the Idaho, Montana, Oregon, and Washington governors. The NPCC was entrusted with adopting a fish and wildlife program for the Columbia River Basin by November 1982, and preparing a 20-year regional electric power and conservation plan by April 1983. These plans are periodically updated and amended.

The NPCC's Fish and Wildlife Program established a number of goals for restoring and protecting fish and wildlife populations in the basin. These goals led to changes in the operation of the Coordinated Columbia River System during the mid-1980s.

As Federal agencies responsible for managing and operating Federal hydroelectric facilities, the Corps and Reclamation must take into account the Northwest Power and Conservation Council's Fish and Wildlife Program and Mainstem Amendments in the decision-making process. The Mainstem Amendment recommendations for summer operations at Libby and Hungry Horse dams, consisting of stable or flat flows that extend into September with a 10 foot draft limit in most years, differ from the operations analyzed the 2004 NOAA Fisheries' Biological Opinion (2004 BiOp). However, the operation of the FCRPS, including the summer flow augmentation operations from the Libby and Hungry Horse projects, is being discussed in the collaborative remand process ordered by Judge Redden, U.S. District of Oregon. The summer operations recommended in the Mainstem Amendments for Libby and Hungry Horse dams are within the normal range of operations and within the range of impacts previously analyzed in this EIS or other NEPA documents; therefore, no further NEPA analysis would be needed if these recommendations are adopted at a later date

The NPCC's Fish and Wildlife Program and amendments recommend adoption of a VARQ FC operation.

Pollution Control at Federal Facilities

To the extent applicable to an alternative presented in this EIS, compliance with the standards contained in the following legislation pertaining to control of contaminants was included in this evaluation:

- The Safe Drinking Water Act, as amended (42 U.S.C. 300F et seq.).
- The Solid Waste Disposal Act (42 U.S.C. 6901 et seq.).
- Oil Pollution Act (33 U.S.C. 2701 et seq.).

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended (42 U.S.C. 9601 [9615] et seq.).
- The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.).
- The Resource Conservation and Recovery Act (RCRA) of 1976, as amended (42 U.S.C. 6901 et seq.).
- Toxic Substances Control Act (TSCA), as amended; Title 40 CFR Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions" (15 U.S.C. et seq.)
- The Noise Control Act of 1972, as amended (42 U.S.C. 4901 et seq.).
- Occupational Health and Safety Act (29 U.S.C. 651 et seq.).

The alternatives in this EIS are evaluated for possible effects concerning mobilization of contaminated sediments in Lake Roosevelt, Washington.

Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) (5 U.S.C. 601 et seq.) requires Federal agencies to semiannually publish in the Federal Register a description and summary of any rule they intend to promulgate which is likely to have a significant economic impact on a substantial number of small entities. Agencies are also required to submit this information to the Chief Counsel for Advocacy of the Small Business Administration for comment. The RFA also requires periodic listing and review of rules for continued need and possible amendment.

A request was made during scoping that the Corps and Reclamation provide documentation under the RFA as part of this EIS effort. There is no rulemaking being proposed, so the RFA is not considered applicable, but analysis is performed in this EIS concerning effects of alternatives on employment, income, and other economic factors.

Rivers and Harbor Act of 1899

The Rivers and Harbor Act of 1899 regulates structures or work in or affecting navigable waters of the United States including discharges of dredged or fill material into waters of the United States. Structures include without limitation, any pier, boat dock, weir, revetment, artificial islands, piling, aid to navigation or any other obstacle or obstruction. No such structures, dredging or filling are planned as part of any alternative evaluated in this EIS.

Water Resources Development Act of 1990

The Water Resources Development Act of 1990 (WRDA) has several purposes. It establishes a goal of no overall net loss of the nation's remaining wetland base and increasing the quality and quantity of the wetlands. The Act also directs the Secretary of the Army to include environmental protection as one of the primary missions of the Corps.

The NEPA process satisfies the requirements of section 310(b) of WRDA, which requires public participation in developing or revising changes to reservoir operation criteria.

Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act (16 U.S.C. 1278 et seq.) designates qualifying free-flowing river segments as wild, scenic, or recreational. The Act establishes requirements applicable to water resource projects affecting wild, scenic, or recreational rivers within the National Wild and Scenic Rivers system, as well as rivers designated on the National Rivers Inventory. Discharges into streams, impoundments, diversions, channel alterations, and other measures can alter the stream discharge, velocity, and channel dimensions. These hydraulic changes may cause modifications to the free-flowing character of the stream, resulting in loss or diminution of its environmental values. The Act requires consideration of the impacts and consultation with the responsible agency prior to implementation of a project.

This EIS evaluates aesthetics and flow characteristics among the impacts of the alternatives it contains. No action is proposed that is anticipated to detract from those values for any Wild and Scenic River reach.

Wilderness Act

The Wilderness Act of 1964 (16 U.S.C. 1131 et seq.) established the National Wilderness Preservation System. Areas designated as wilderness under the original Act, and subsequent wilderness legislation, are to be administered for the use and enjoyment of the public in such a manner as to leave them unimpaired as wilderness. Development activities are generally prohibited within wilderness areas, and Federal agencies proposing actions must consider whether the effects of those actions would impair wilderness values. The alternatives affect lowland areas that are not within any designated wilderness areas. Additionally, none of the alternatives have the potential to affect any designated wilderness areas since such areas in the vicinity all occur at high elevations and/or well away from the mainstem river corridors.

6.3.2 Executive Orders

Executive Order 11593, Protection and Enhancement of the Cultural Environment

Executive Order 11593, dated May 13, 1971, outlines the responsibilities of Federal agencies to consider effects to historic properties in consultation with the Advisory Council on Historic Preservation where a Federal undertaking may adversely affect a property. Agencies are also to preserve, rehabilitate, and restore listed historic properties on the National Register. Agencies are encouraged to avoid, or at least mitigate, an adverse effect on listed properties. The executive order furthers the purpose and policies associated with the NEPA; the NHPA; the Historic Sites Act of 1935; and, the Antiquities Act of 1906.

Reclamation is meeting the requirements of this executive order for Lake Roosevelt and Hungry Horse Reservoir through implementation of the Section 106 of the NHPA. For operation of Libby Dam and Lake Koocanusa, requirements of Executive Order 11593 are also being met by the Corps through implementation of Section 106 of the NHPA.

Executive Order 11988, Floodplain Management Guidelines

Executive Order 11988, dated May 24, 1977, outlines the responsibilities of Federal agencies in the role of floodplain management. Each agency shall evaluate the potential effects of actions on floodplains and should avoid undertaking actions that directly or indirectly induce growth in the floodplain or adversely affect natural floodplain values.

This EIS evaluates effects of alternative water operations on flooding and floodplains. No development in any floodplain is anticipated as a result of the alternatives considered.

Executive Order 11990, Protection of Wetlands

Executive Order 11990 encourages Federal agencies to take actions to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands when undertaking Federal activities and programs. Minor, short-term, indirect impacts to wetlands adjacent to the levees or roadways could occur during construction of improvements.

This EIS assesses effects on wetlands and riparian areas; the preferred alternative is intended to benefit natural processes that include riparian function.

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

Executive Order 12898, dated February 11, 1994, requires Federal agencies to consider and address environmental justice by identifying and assessing whether agency actions may have disproportionately high and adverse human health or environmental effects on minority or low-income populations. Disproportionately high and adverse effects are those effects that are predominantly borne by minority and/or low-income populations and are appreciably more severe or greater in magnitude than the effects on non-minority or non-low income populations.

This EIS addresses environmental justice effects of the alternatives it evaluates.

Executive Order 13007, Native American Sacred Sites

Executive Order 13007, dated May 24, 1996, directs Federal agencies to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners. Agencies are to avoid adversely affecting the physical integrity of such sacred sites and to maintain the confidentiality of sacred sites when appropriate. The act encourages government-to-government consultation with tribes concerning sacred sites. Some sacred sites may qualify as historic properties under the NHPA.

For Reclamation's reservoirs (Lake Roosevelt and Hungry Horse), Reclamation is currently implementing the requirements of Executive Order 13007, wherever possible, for all operations of the reservoir. This includes VARQ or any other future actions that cause water levels to fluctuate. No additional actions under this executive order are required for VARQ. The Corps takes into consideration Executive Order 13007 in the Historic Properties Management Plan (now under revision) and Operations Management Plan for Libby Dam and Lake Koocanusa. This Executive Order does not apply to non-Federally owned lands downstream of Libby Dam to Bonners Ferry, Idaho, but may apply to Forest Service lands at Kootenai Falls.

Executive Order 13084, Consultation and Coordination with Indian Tribal Governments

This order requires Federal agencies to be guided by Tribal sovereignty and rights when making policy affecting Tribal governments, and to have a process for Tribal representatives to have meaningful and timely input on regulatory policies significantly or uniquely affecting their communities.

The Corps and Reclamation seek to provide meaningful and timely opportunities, via government-to-government consultation and other coordination, for Tribes to comment on agency policies that may have significant or unique effects on tribal interests. A list of those tribes involved in the EIS process can be found in Section 6.3.1. This process has been initiated and will continue through the development and completion of the EIS process.

6.3.3 Executive Memoranda

Council on Environmental Quality Memorandum, August 11, 1990, Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA

This Council on Environmental Quality Memorandum establishes criteria to identify and consider the adverse effects of Federal programs on the preservation of prime and unique farmland, to consider alternative actions, as appropriate, that could lessen adverse effects, and to ensure Federal programs are consistent with all state and local programs for the protection of farmland.

This EIS evaluates effects on any farmland within the influence of proposed actions. Much of the valley bottomland along the rivers in the project area is designated as prime or unique farmland. Effects on all agriculture, including effects on designated prime or unique farmland, are discussed in the socioeconomic sections in Chapters 3, 4, and 5.

6.3.4 Columbia River Treaty

The Corps, a member of the United States Entity along with BPA and others, coordinate the planning and operation of the FCRPS with Canada through a variety of arrangements. Examples include development of assured operating plans and detailed operating plans under the CRT, and arrangements with Canada for mutually beneficial nonpower uses agreements. To the extent possible, the Corps utilizes these mechanisms to coordinate operations.

Modeling frameworks used for analyses of alternatives and alternative combinations in this EIS were constructed and applied in accordance with provisions of the CRT. Members of the staff of the U.S. Entity have begun technical discussions of VARQ with members of the staff of the Canadian Entity at Columbia River Treaty Operating Committee meetings and additional discussions are planned. It is expected that Libby VARQ will also be the subject of consultations between the U.S. Entity and the Canadian Entity under the terms of the Libby Coordination Agreement and the provisions of the Columbia River Treaty.

List of Preparers and Distribution List follows.

DISTRIBUTION LIST

The individuals and organizations listed below and 67 individuals not affiliated with groups listed below will receive either a printed copy, compact disc, or an Executive Summary of the draft EIS document. In addition, all other entities on the VARQ scoping mailing list will receive notification by mail of the draft EIS availability. Copies of the printed or electronic versions of the draft EIS may be obtained by contacting Evan Lewis at:

evan.r.lewis@usace.army.mil
PH 206-764-6922
Seattle District, US Army Corps of Engineers
P.O. Box 3755
Seattle, WA 98124-3755

Indian Tribes and First Nations

Blackfeet Tribe
Coeur d'Alene Indian Tribe
Columbia River Inter-Tribal Fish Commission
Confederated Salish and Kootenai Tribes
Confederated Tribes and Bands of the Yakama Indian Nation
Confederated Tribes of the Colville Reservation
Confederated Tribes of the Umatilla Reservation
Confederated Tribes of the Warm Springs
Lower Kootenay Band
Kalispel Tribe of Indians
Kootenai Tribe of Idaho
Spokane Tribe of Indians
Tobacco Plains First Nation
Upper Columbia United Tribes

Federal Government Officials and Agencies

Advisory Council on Historic Preservation
Bonneville Power Administration
Bureau of Indian Affairs
Bureau of Land Management
Department of Agriculture
Department of Commerce
Department of Energy

Department of Health and Human Services
Department of the Interior
Department of Interior, Office of Environmental Policy & Compliance
Environmental Protection Agency, Office of Federal Activities
Federal Emergency Management Administration
Federal Railroad Administration
Geological Survey
National Oceanic and Atmospheric Administration Fisheries (also called National Marine Fisheries Service)
National Park Service, Lake Roosevelt National Recreation Area
US Fish and Wildlife Service
US Forest Service
The Honorable Brian Baird, US House of Representatives
The Honorable Earl Blumenauer, US House of Representatives
The Honorable Doc Hastings, US House of Representatives
The Honorable Cathy McMorris, US House of Representatives
The Honorable Butch Otter, US House of Representatives
The Honorable Dennis Rehberg, US House of Representatives
The Honorable Mike Simpson, US House of Representatives
The Honorable David Wu, US House of Representatives
The Honorable Max Baucus, United States Senate
The Honorable Conrad Burns, United States Senate
The Honorable Maria Cantwell, United States Senate
The Honorable Larry Craig, United States Senate
The Honorable Michael Crapo, United States Senate
The Honorable Patty Murray, United States Senate
The Honorable Gordon Smith, United States Senate
The Honorable Greg Walden, US House of Representatives
The Honorable Ron Wyden, United States Senate

Canadian Agencies

BC Ministry of Water, Land and Air Protection
BC Ministry of Transportation & Highways, Manager, Planning & Design
Environment Canada
Fisheries and Oceans Canada
Indian and Inuit Affairs Canada
Water Survey of Canada

Montana State Government Officials and Agencies

The Honorable Brian Schweitzer, Governor, State of Montana
Montana Department of Environmental Quality
Montana Department of Fish, Wildlife and Parks

Montana State Historic Preservation Office
Montana Department of Natural Resources and Conservation
Montana Department of Transportation
Montana State University
Dee Brown, Montana State Representative
Paul Clark, Montana State Representative
Tim Dowell, Montana State Representative
George Everett, Montana State Representative
Ralph Heinert, Montana State Representative
Gordon Hendrick, Montana State Representative
Joey Jane, Montana State Representative
William Jones, Montana State Representative
Mike Jopek, Montana State Representative
Rick Maedje, Montana State Representative
Bernie Olson, Montana State Representative
Jon Sonju, Montana State Representative
Janna Taylor, Montana State Representative
Jeanne Windhame, Montana State Representative
Gregory Barkus, Montana State Senator
John Brueggeman, Montana State Senator
Aubyn Curtiss, Montana State Senator
Jim Elliott, Montana State Senator
Bob Keenan, Montana State Senator
Glenn Roush, Montana State Senator
Dan Weinberg, Montana State Senator

Idaho State Government Officials and Agencies

The Honorable Dirk Kempthorne, Governor, State of Idaho
Idaho Department of Environmental Quality
Idaho Department of Fish and Game
Idaho Department of Transportation
Idaho Historic Preservation Office
Idaho Office of Species Conservation
Idaho State Archeologist
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George Eskridge, Idaho State Representative
R.J. "Dick" Harwood, Idaho State Representative
Mary Lou Shepherd, Idaho State Representative
Shawn Keough, Idaho State Senator
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Washington Department of Ecology
Washington Department of Fish and Wildlife
Washington Department of Health
Washington Department of Natural Resources
Washington Department of Transportation
Washington Historic Preservation Office
Washington State Archeologist
Eastern Washington University
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Mike Armstrong, Washington State Representative
David Buri, Washington State Representative
Brian Blake, Washington State Representative
Bruce Chandler, Washington State Representative
Cary Condotta, Washington State Representative
Don Cox, Washington State Representative
Richard Curtis, Washington State Representative
Jim Dunn, Washington State Representative
Bill Fromhold, Washington State Representative
Bill Hinkle, Washington State Representative
Bill Grant, Washington State Representative
Larry Haler, Washington State Representative
Shirley Hankins, Washington State Representative
Janea Holmquist, Washington State Representative
Joel Kretz, Washington State Representative
Jim Moeller, Washington State Representative
Dan Newhouse, Washington State Representative
Ed Orcutt, Washington State Representative
Timm Ormsby, Washington State Representative
John Serben, Washington State Representative
Bob Sump, Washington State Representative
Dean Takko, Washington State Representative
Deb Wallace, Washington State Representative
Maureen Walsh, Washington State Representative
Alex Wood, Washington State Representative
Brad Benson, Washington State Senator
Don Benton, Washington State Senator
Lisa Brown, Washington State Senator
Jerome Delvin, Washington State Senator
Mark Doumit, Washington State Senator
Linda Evans Parlette, Washington State Senator

Jim Honeyford, Washington State Senator
Joyce Mulliken, Washington State Senator
Bob Morton, Washington State Senator
Craig Pridemore, Washington State Senator
Mark Schoesler, Washington State Senator
Joseph Zarelli, Washington State Senator

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Oregon Department of Environmental Quality
Oregon Department of Fish & Wildlife
Oregon Department of Transportation
Oregon Water Resources Department
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Scott Bruun, Oregon State Representative
John H Dallum, Oregon State Representative
Jackie Dingfelder, Oregon State Representative
Linda Flores, Oregon State Representative
Larry Galizio, Oregon State Representative
Mitch Greenlick, Oregon State Representative
Gary Hansen, Oregon State Representative
Mark Hass, Oregon State Representative
Dave Hunt, Oregon State Representative
Derrick Kitts, Oregon State Representative
Jerry Krummel, Oregon State Representative
John Lim, Oregon State Representative
Greg Macpherson, Oregon State Representative
Steve March, Oregon State Representative
Jeff Merkley, Oregon State Representative
Karen Minnis, Oregon State Representative
Mary Nolan, Oregon State Representative
Chuck Riley, Oregon State Representative
Diane Rosembaum, Oregon State Representative
Wayne Scott, Oregon State Representative
Mike Shaufler, Oregon State Representative
Chip Shields, Oregon State Representative
Patti Smith, Oregon State Representative
Carolyn Tomei, Oregon State Representative
Brad Witt, Oregon State Representative
Kate Brown, Oregon State Senator

Ginny Burdick, Oregon State Senator
Margaret Carter, Oregon State Senator
Ryan Deckert, Oregon State Senator
Richard Devlin, Oregon State Senator
Ted Ferrioli, Oregon State Senator
Avel Gordly, Oregon State Senator
Betsy Johnson, Oregon State Senator
Rick Metsger, Oregon State Senator
Laurie Monnes Anderseon, Oregon State Senator
Charlie Ringo, Oregon State Senator
Kurt Schrader, Oregon State Senator
Frank Shields, Oregon State Senator
Bruce Starr, Oregon State Senator

Environmental Groups

American Wildlands
Center for Biological Diversity
Columbia Basin Trust
The Ecology Center
Flathead Lakers
Idaho Conservation League
Idaho Rivers United
Kootenai Valley Trout Club
National Organization to Save Flathead Lake
The Nature Conservancy
North Central Washington Audubon
Northern Idaho Audubon Society
Save our Wild Salmon
Sierra Club
Trout Unlimited
Washington Environmental Council
Western Resource Advocates
The Wilderness Society

Other Agencies/Organizations

Aquila Corporation
Avista Corporation
American Fisheries Society
BC Hydro
Columbia Power Corporation
Elk Mountain Farms, Anheuser-Busch Companies
Lake Roosevelt Forum

Northwest Power and Conservation Council
Pend Oreille Public Utility District
PPL Montana
Puget Sound Energy
Seattle City Light
Spokane Walleye Club
BioAnalysts, Inc.
FM Global
Hydro YES
Lake Roosevelt High School
Lake Roosevelt Vacations, Inc.
RLK Hydro, Inc.
Corbett Draw Farms, GP
Mirror Lake Campground
Piper Farms Ltd
Big Bend Economic Development Council
Idaho Women in Timber
Lakeshore Ranch
Nelson Rod and Gun
Pointer Scenic Cruises
Selkirk Association of Realtors
Other Utilities within the project area, as appropriate
Irrigation Districts, as appropriate
County and City Offices, as appropriate

Libraries

Boise Public Library
Boundary County Public Library
Bozeman Public Library
Castlegar and District Public Library
Clark Fork Library
Coeur d'Alene Public Library
Colville Public Library
Coulee City Public Library
Cranbrook Public Library
Creston Public Library
East Bonner Public Library
Eureka Branch Library
Flathead County Library (Kalispell & Columbia Falls branches)
Idaho State Government Library
Inchelium Tribal Resources Center
Ione Public Library

Lincoln County Public Library
Missoula Public Library
Nelson Municipal Library
Newport Public Library
Northport Library Station
Pend Oreille County Library District
Calispel Valley Library 107
Polson City Library
Portland Public Library, Main Branch
Salish Kootenai Public Library
Spokane Tribal College Library
Trail and District Public Library
Troy Branch Library
Washington State Library
Rosalia Branch
West Bonner Library District

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Individuals responsible for preparing this EIS are listed in three tables: Corps, Reclamation, and Consultants. Because of the number of people involved in coordinating this study, the information presented in these tables is limited to the names, education/years of experience, experience and expertise, and general roles these individuals had in developing the EIS.

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GLOSSARY

Acre-foot: The volume of water that will cover an area of 1 acre to a depth of 1 foot (equal to 43,650 cubic feet, or 325,804 gallons). Used as a measure for water storage volume in reservoirs.

Age Class: All individuals of a fish population which are of the same age—for example, age-2 fish. See also Year Class.

Agronomy: A branch of agricultural science dealing with field crop production and soil management.

Ambient air: Ambient air is the air surrounding a particular spot such as a reservoir or reach of river.

Anadromous fish: Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Annual operating plan: A yearly plan for operating reservoirs on the Columbia River. Such a plan is specifically required by the Columbia River Treaty and by the Pacific Northwest Coordination Agreement.

Aquifer: Any geological formation containing water, especially one that supplies water to wells, springs, etc.

Artifact: An object of any type made by human hands. Tools, weapons, pottery, and sculptured and engraved objects are artifacts.

Augmenting: Increasing: In this application. Increasing river flows above levels that would occur under normal operation, by releasing more water from storage reservoirs.

Average megawatts (aMW): The average amount of energy (number of megawatts) supplied or demanded over a specified time.

Baseload: In a demand sense, an electrical power load that varies only slightly over a specified time period. In a supply sense, a plant that operates most efficiently at a relatively constant level of generation.

B.C. Hydro: The British Columbia Hydro and Power Authority. This Crown Corporation was formed in 1962 following the merger of an expropriated private utility and the B.C. Power Commission.

Best Available Science: A term used to define guidelines for the use of scientific and technical information in a variety of natural resource related fields. Generally, the term relates to whether the information at question follows a valid scientific process (peer review, methods, logical conclusions and reasonable inferences, quantitative analysis, appropriate context, and references) that produces reliable information.

Biological Opinion: Also known as a BiOp. A document prepared by the US Fish and Wildlife Service or National Marine Fisheries Service under Section 7 of the Endangered Species Act. It is a product of consultation between one of those agencies and any federal agency proposing an action that may affect a species listed as threatened or endangered under the Endangered Species Act, or their designated critical habitat. It includes actions necessary to avoid harm or jeopardy to those listed species.

Biological rule curve: A reservoir operation guideline indicating monthly elevation targets, intended to provide improved conditions for resident fish. Biological rule curve operations have been simulated in the SOR for the Hungry Horse and Libby storage projects in Montana. BRCs have been revised and renamed as Integrated Rule Curves.

Bypass system: Structure in a dam that provides a route for fish to move through or around the dam without going through the turbines.

Canadian Entitlement: The Canadian Entitlement is Canada's 50-percent share of the downstream power benefits resulting from the operation of BC Hydro's three large storage dams, Duncan, Keenleyside, and Mica. These dams were built as part of the Columbia River Treaty.

Capacity: The maximum sustainable amount of power that can be produced by a generator or carried by a transmission facility.

Capacity/energy exchange: A transaction in which one utility provides another with capacity service in exchange for additional amounts of firm energy (exchange energy) or money, under specified conditions, usually during off-peak hours.

Columbia River Treaty: A treaty signed by the United States and Canada on September 16, 1964, for joint development of the Columbia River. The treaty is a U.S.-Canadian agreement for bilateral development and management of the Columbia River to achieve flood control and increased power production. Under the Treaty, Canada built three large storage dams: Keenleyside, and Mica on the upper reaches of the Columbia River and Duncan Dam on the Duncan River, a tributary to Kootenay Lake. Libby Dam, on the Kootenai River in Montana is the lone U.S.-built treaty project.

Computer Modeling: The use of mathematical simulations of complex systems, like dam operations in the Columbia basin.

Critical period: The portion of the 50-year streamflow record that would produce the least amount of energy with all reservoirs drafted from full to empty.

Cubic feet per second: A measure of water flow past any given point in a river or through a dam. One cubic foot of water is about 7 ½ gallons.

Cultural resources: The nonrenewable evidence of human occupation or activity seen in any district, site, building, structure, artifact, ruin, object, work of art, architecture, or natural feature that was important in human history at the national, state, or local level.

Damage center: A geographic location on the river system that has historically been subject to damage from flooding.

Demand: The rate at which electric energy is used, whether at a given instant or averaged over any designated period of time.

Depletions: Withdrawals of water from a stream, thereby reducing the volume of instream flow.

Direct-service industries (DSIs): Industrial customers, primarily aluminum smelters, that buy power directly from BPA, rather than from utilities, at relatively high voltages.

Displacement: The substitution of less-expensive energy generation for more-expensive energy generation (usually hydroelectric energy transmitted from the Pacific Northwest or Canada substituted for more expensive coal and oil-fired generation in California). Such displacement usually means that a thermal plant can reduce or shut down its production, saving money and often reducing air pollution.

Dissolved gas concentrations: The amount of chemicals normally occurring as gases, such as nitrogen and oxygen, which are held in solution in water, expressed in units such as milligrams of the gas per liter of liquid, or percent saturation.

Draft: Release of water from a storage reservoir, expressed in terms of reservoir surface elevation.

Drawdown: Same as draft.

Endangered species: As defined under the federal Endangered Species Act, a plant or animal species which is in danger of extinction throughout all or a significant portion of its range because its habitat is threatened with destruction, drastic modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors. Species listed as endangered are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Entrainment: The drawing of fish and other aquatic organisms into tubes or tunnels carrying water for cooling purposes into thermal electric power plants, or for power generating purposes into the turbine intakes of hydroelectric plants. Entrainment May also occur over spillways or through sluiceways of dams.

Environmental Assessment (EA): A concise public document prepared by a Federal agency to provide an evaluation of impacts of a proposed Federal action when impacts are not believed significant, or can be mitigated to nonsignificance (results in a Finding of No Significant Impact, or FONSI), or to document a decision to prepare an EIS for actions believed to have significant impacts.

Environmental Impact Statement (EIS): A public document prepared by a Federal agency that provides an evaluation of impacts of a proposed Federal action when impacts are determined to be significant as documented in an EA. An EIS contains an analysis and discussion of significant environmental impacts of a proposed action, and informs the public of reasonable alternatives.

Escapement: Number of fish that escape harvest or other mortality and spawn.

Exotic species: Introduced species not native to the place where they are found.

Firm Energy: The amount of energy that can be generated given the region’s worst historical water conditions. It is energy produced on a guaranteed basis.

Firm Energy Load Carrying Capacity (FELCC): The amount of energy the region's generating system, or an individual utility or project, can be called on to produce on a firm basis during actual operations under the region’s driest historical water conditions. FELCC is made up of both hydro and non-hydro resources, including power purchases.

First Nation: Refers to an individual or organization (such as a band or tribal organization) that self-identifies as being descended form aboriginal Indian people in Canada. It is not a term of legal status. “Status Indian” is the Canadian legal term for those peoples.

Fish Guidance Efficiency (FGE): The efficiency of juvenile fish passage facilities at diverting downstream juvenile migrants from the turbine intakes, measured as the percentage fish approaching the powerhouse that are routed through the collection and bypass facilities.

Fish hatchery: A facility in which fish eggs are incubated and hatched and juvenile fish are reared, typically for release to rivers or lakes.

Fish ladders: A series of ascending pools constructed to enable salmon or other fish to swim upstream, around or over a dam or other barrier to upstream fish migration.

Fish passage facilities: Features of a dam that enable fish to move either upstream or downstream, around, through, or over without harm.

Spill deflectors or flow deflectors: structural modifications made to the spillways of some Columbia-Snake River projects to deflect flows across the downstream (tailwater) water surface, and reduce the deep plunging flows that create high dissolved gas levels.

Flood control rule curve: A curve, or a family of curves, indicating the upper limit of reservoir surface elevation over time, required to maintain reservoir storage space to prevent or control flooding downstream of a dam. (Also called Mandatory Rule Curve or Upper Rule Curve.) The rule curve elevation for a given point in time may be exceeded only temporarily in order to store high runoff to prevent downstream flooding.

Flow: The volume of water passing a given point per unit of time.

Flow Augmentation: The release of water from storage reservoirs to meet specific seasonal life stage needs for fish downstream, above what would normally be released for human needs.

Forebay: The portion of the reservoir at a hydroelectric plant which is immediately upstream of the generating station.

Freshet: A rapid temporary rise in streamflow caused by heavy rains or rapid snowmelt.

Full pool: The maximum level of a reservoir under its established normal operating range.

Gas bubble disease: A condition in fish resulting from prolonged exposure to supersaturated gas levels in water. In this condition, dissolved gas comes out of solution as bubbles in the circulatory systems, eyes, and other tissues of fish. The condition is similar to decompression sickness, or “the bends” in human divers. It may be fatal to fish in some circumstances.

Gas supersaturation: Concentrations of dissolved gas in water that are above the saturation (100 percent capacity) level of the water.

Generation: The act or process of producing electric energy from other forms of energy. Also refers to the amount of electric energy so produced.

Housepit villages: Archeological sites where prehistoric peoples constructed villages of semi-subterranean pit houses.

Hydraulic head: The vertical distance between the surface of a reservoir and the water surface of the river immediately downstream from the turbine and dam.

Hydroelectric: Referring to the production of electric power through use of the gravitational force of falling water.

Hydrology: The science of dealing with the continuous cycle of evapotranspiration, precipitation, and runoff.

Hydrometeorological observations: Data on snowpack measurements and climatic conditions.

Independent power producers: Non-utility producers of electricity who operate generation plants under the 1978 Public Utilities Regulatory Policy Act of 1978 (PURPA). Many dependent power producers are cogenerators who produce power as well as steam or heat for their own use and sell the extra power to their local utilities.

Inflow: Water that flows into a waterbody.

Intake: The entrance to a conduit that passes through a dam or water facility.

Integrated Rule Curve: See Biological Rule Curve

Interchange energy: Electric energy received by one utility system usually in exchange for energy to be delivered to another system at another time or place. Interchange energy is different from direct purchase or sale, although accumulated energy balances are sometimes settled in cash.

Interruptible power: A supply of power which, by agreement, can be shut off on relatively short notice (from minutes to a few days).

Intertie: A transmission line or system of lines permitting a flow of energy between major power systems. BPA has several interties, both AC and DC, connecting the Pacific Northwest to the Southwest.

Juvenile: Early life stage of an animal, having some resemblance to an adult of its kind.

Kuehl-Moffit: A forecasting tool used in predicting runoff volume in the Columbia basin.

Larva (singular; plural larvae): The early life stage of a fish between the time of hatching and transformation to a juvenile stage that more closely resembles an adult.

Levee: A raised embankment constructed to prevent a river from flooding adjacent areas. Known as a dyke in Canada.

Littoral zone: The shallower waters near the shore of a reservoir, lake, or ocean.

Load: The amount of electric power or energy delivered or required at any specified point or points on a system. Load originates primarily at the energy-consuming equipment of customers.

Load following: The adjustment of energy storage releases so that generation and load are continuously in balance. This may mean peak flow releases in daylight hours when demand is high, and reduced releases at night, or it may mean higher flows on weekdays and lower flows on weekends.

Load shaping: See load following.

Local flood control: Flood protection for nearby downstream areas provided by a flood control project or dam.

Lock: A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

Low pool: At or near the minimum level of a reservoir under its established normal operating range.

Macrophytes: Aquatic plants that are macroscopic, or large enough to be seen with the naked eye.

Mainstem: The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.

Megawatt (MW): One million watts, or 1,000 kilowatts, a measure of electrical power.

Megawatt-hour (MWh): A unit of electrical energy equal to one megawatt being supplied or used over one hour.

mg/l: Milligrams per liter.

National Environmental Policy Act (NEPA): The Federal law under which environmental impact evaluations are performed for proposed Federal (or Federally permitted) actions, and written as an environmental impact statement (EIS) or environmental assessment (EA).

Nitrogen supersaturation: a condition in which the concentration of dissolved nitrogen in water exceeds the saturation level. Though this condition is unstable over the long term, it can persist for some time in a given mass of water, for instance river flow leaving a dam and moving downriver. Excess nitrogen can harm fish (see gas bubble disease).

Nonfirm energy: Energy available when water conditions are better than the worst historical pattern; generally such energy is sold on an interruptible (non-guaranteed) basis. Sometimes called secondary energy.

Nonpower operating requirements: Operating requirements at hydroelectric projects that pertain to navigation, flood control, recreation, irrigation, and other nonpower uses of the river.

Offpeak hours: Period of relatively low demand for electrical energy, as specified by the supplier (such as the middle of the night).

Operating limits: Limits or requirements that must be factored into the planning process for operating reservoirs and generating projects. (Also see operating requirements, below.)

Operating requirements: Guidelines and limits that must be followed in the operation of a reservoir or generating project. These requirements may originate in authorizing legislation, physical plant limitations, or other sources.

Operating rule curve: A curve, or family of curves, indicating how a reservoir is to be operated under specific conditions and for specific purposes.

Operating year: The 12-month period from August 1st through July 31st, used for hydropower analyses and operations.

Outage: Periods, both planned and unexpected, during which the transmission of power stops or a particular power-producing facility ceases to provide generation.

Outflow: The volume of water per unit of time discharged at a dam.

Particulates: Substances that consist of minute separate particles, such as dust or soot.

Peak load: The maximum electrical demand in a stated period of time. The peak load may be the maximum instantaneous load or the maximum average load within a designated period of time.

Phytoplankton: The plant portion of floating or weakly swimming organisms, often microscopic in size, in a body of water.

Plankton: Small plants (phytoplankton) and animals (zooplankton) that are suspended in the water and either drift with the currents or swim weakly.

Power peaking: See load following.

Ramping: The act of reducing outflow from a dam. Ramping rates are set to prevent damage to fish and riverbanks downstream.

Record of Decision: A document detailing a decision taken, as in the case of finalizing the action on an Environmental Impact Statement, together with the reasons for making that decision. Records of Decision may be published in the Federal Register.

Recruitment: Survival of young fish to a given age or life stage; often refers to attainment of a size that makes them catchable by fishing gear. The Recovery Plan for Kootenai River white sturgeon defines recruitment as "survival of juveniles until they become a member of the spawning population."

Refill: The point at which a hydropower system is considered "full" from the seasonal snowmelt runoff. Also refers to the annual process of filling a reservoir.

Reliability: For a power system, a measure of the degree of certainty that the system will continue to meet load for a specified period of time.

Re-regulation: Storing variable discharges of water from an upstream hydroelectric plant and releasing them more uniformly over time from a downstream storage plant. This process is used to mitigate for impacts from load following, for instance.

Reservoir draft rate: The rate at which the release of water from storage behind a dam reduces the elevation of the reservoir. Outflow must exceed inflow for this to occur.

Reservoir elevations: The levels of the water stored behind dams.

Reservoir storage: The volume of water in a reservoir at a given time.

Resident fish: Fish species that reside in fresh water throughout their lives.

Residuals: A condition in which migrating juvenile salmonid smolts lose their urge to migrate, physiologically revert to their freshwater life form, and remain in fresh water rather than migrate to sea.

Riprap: Broken rock, cobbles, or boulders placed on the bank of a stream or river for protection against the erosive action of water.

River mile: Distance as measured from the river mouth at river mile 0.

Rule curve: Prescribed water levels, represented graphically as curves that guide reservoir operations.

Run-of-river dams: Hydroelectric generating plants that operate based only on available streamflow and some short-term storage (hourly, daily, or weekly).

Run-of-river reservoirs: The pools or impoundments formed behind run-of-river dams.

Salmonids: Fish of the family Salmonidae, such as salmon, trout (including steelhead), char, and whitefish.

Scoping: The process of defining the extent of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental analysis and documentation in conjunction with a public NEPA process.

Secondary energy: Hydroelectric energy in excess of firm energy, often used to displace thermal resources. Sometimes called non-firm energy.

Sedimentation: The settling of material (such as dust, suspended solids, or particulates) into water and eventual deposition on the bottoms of streams and rivers.

Shaping: The scheduling and operating of generating resources to meet changing load levels. Load shaping on a hydro system usually involves the adjustment of reservoir releases so that generation and load are continuously in balance.

Shifting: In planning, moving surplus or deficit firm energy load carrying capacity (FELCC) from one year of the critical period to another to increase the FELCC's value.

Simulation: The representation of an actual system by analogous characteristics of a device that is easier to construct, modify, or understand; or by mathematical equations. Computer models are simulations, and for example, are used to represent operation of a hydropower system.

Smolt: A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.

Spawning: The releasing and fertilizing of eggs by fish.

Spill: Water passed over a spillway or through sluiceways without going through turbines to produce electricity. Spill can be forced, when there is no storage capability and flows exceed turbine capacity, or planned, for example, when water is spilled to enhance juvenile fish passage.

Spillway: Overflow structure of a dam

Stochastic: Involving chance or probability.

Storage Reservation Diagram: A graphic representation of how much storage space, in terms of water volume, needs to be reserved each month for flood control in a storage reservoir such as Libby or Hungry Horse. The storage reservation for each month is based on that month's seasonal inflow forecast.

Storage reservoirs: Reservoirs that have space for retaining water from springtime snowmelts. Retained water is released as necessary for multiple uses that include flood control, power production, fish passage, irrigation, and navigation.

Streamflow: The rate at which water passes a given point in a stream, usually expressed in cubic feet per second (cfs).

Subyearlings: Juvenile fish less than 1 year old.

Surplus energy: Energy generated that is beyond the immediate needs of the producing system. This energy may be sold on an interruptible basis or as firm power.

Synergy: Addition or multiplication of effects of multiple actions taken together.

System flood control: Flood protection for the Portland, Oregon/Vancouver, Washington metropolitan area that is coordinated among all of the storage reservoirs in the Columbia River System.

Tailrace: The canal or channel that carries water away from a dam.

Tailwater: The water surface immediately downstream from a dam or hydroelectric power plant or excess surface water or runoff immediately below an irrigated field or pasture.

Threatened: Legal status under the federal Endangered Species Act afforded to plant or animal species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Tules: The name commonly applied to fall Chinook salmon originating on the lower Columbia River.

Turbidity: A measure of the optical clarity of water, which depends on the light scattering and absorption characteristics of suspended and dissolved material in the water.

Turbine: Machinery that converts kinetic energy of a moving fluid, such as falling water, to mechanical or electrical power.

Upper rule curve (URC): Defines the maximum allowable elevation of the surface of a storage reservoir, described over the course of a water year (Oct-Sep), for flood control purposes.

Upriver Brights: The name commonly applied to fall Chinook salmon originating on the middle Columbia River. Primarily in the area below Priest Rapids Dam.

Usable storage: Water occupying active storage capacity of a reservoir

Usable storage capacity: The portion of the reservoir storage capacity in which water normally is stored or from which water is withdrawn for beneficial uses, in compliance with operating agreements.

VARQ: Abbreviation for Variable Flow (Q represents engineering shorthand for flow or discharge), an alternative flood control operation whereby a storage reservoir is lowered less in winter during years with a low or medium runoff forecast.

Velocity: Speed; the rate of linear motion in a given direction.

Water conditions: The overall supply of water to operate the Pacific Northwest hydroelectric generating system at any given time, taking into account reservoir levels, snowpack, needs to provide water or retain water to meet various operating constraints (such as the Water Budget, flood control, flow constraints, etc.), weather conditions, and other factors.

Water particle travel time: The theoretical time that a water particle would take to travel through a given reservoir or river reach. It is calculated by dividing the flow (volume of water per unit time) by the average cross-sectional area of the channel.

Water retention time: The length of time that a particle of water is resident in a lake or reservoir, based on rates of inflow, outflow, and circulation within the water body.

Water rights: Priority claims to water. In western states, water rights are based on the principle “first in time, first in right,” meaning older claims take precedence over newer ones.

Water Supply Forecast: Estimates of the volume of water that will runoff from a specific watershed over a specific period of time.

Wortman-Morrow: Forecasting tool developed in the 1980’s using estimated or projected future weather conditions to forecast runoff volumes for the Kootenai basin.

Xerophytic: Plants that are structurally adapted for life and growth with a limited water supply.

Year Class: All individuals of a fish population spawned and hatched in a given year. See also Age Class.

Yearlings: One-year-old juvenile animals, such as fish.

Zooplankton: Free-swimming or floating animal plankton that may be microscopic or difficult to see with the unaided eye.

REFERENCES

Parenthetical Reference	Bibliographic Information
Alden 1953	Alden, W. C. 1953. The physiography and glacial geology of western Montana and adjacent areas. USGS professional paper 231. 200 pp.
Allaboutrivers.com 2004	Allaboutrivers.com, 2004. Website posting detailing kayaking along Buffalo Rapids on Lower Flathead River. http://www.allaboutrivers.com/guides/outputdescrun.cfm?rivername=Flathead%20River&runname=Buffalow%20Rapids%20Run
Anders 1993	Anders, P. J. 1993. Kootenai River fisheries studies. Report C, Kootenai River tributary kokanee spawning ground survey, annual report of research FY 1993. Bonneville Power Administration, Project No. 88-64, Contract No. DE-BI79-88BP93743. www.efw.bpa.gov/environment/ew/ewp/docs/reports/resident/R93743-1.pdf
Anglin *et al.* 2005	Anglin, D.R., S.L. Haeseker, J.J. Skalicky, H. Schaller, K.F. Tiffan, J.R. Hatten, D.W. Rondorf, P. Hoffarth, J. Nugent, D. Benner, and M. Yoshinaka. 2005. Effects of hydropower operations on spawning habitat, rearing habitat, and stranding/entrapment mortality of fall Chinook salmon in the Hanford Reach of the Columbia River. Final draft report. USFWS. Columbia River Fisheries Program Office. Vancouver, Washington.
Ashley and Thompson 1993	Ashley, K. and L. Thompson. 1993. Kootenay Lake fertilization experiment, year one (1992/1993) report. Fisheries Branch, Ministry of Environment, Lands and Parks, and Univ. of British Columbia. Fisheries Project Report No. RD 32.
Barton *et al.* 2005	Barton, G.J., R.R. McDonald, J.M. Nelson, and R.L. Dinehart. 2005. Simulation of flow and sediment mobility using a multidimensional flow model for the white sturgeon critical-habitat reach, Kootenai River near Bonners Ferry, Idaho. U.S. Geological Survey Scientific Investigations Report 2005-5230.
BC Adventure 2004	BC Adventure. 2004. Website posting regarding fishing opportunities on BC fishing. http://www.bcadventure.com/adventure/explore/rockies/cranbrook/koocanusa.htm
BC Hydro 2002	BC Hydro. 2002. Kootenay Canal Generating Station Website. Online at http://www.bchydro.com/recreation/southern/southern1203.html
BC Hydro *et al.* 2004	BC Hydro, Columbia Basin Trust, Environment Canada, Lower Kootenay Band, and Ministry of Water Land and Air Protection. 2004. A Stakeholders Summary of Preferred and Potential Negative Reservoir Levels and River stages on the Kootenay River System in Canada. Final Draft.
BC Hydro 2005	BC Hydro. 2005. Kootenay Lake West Arm: stage-damage relationship development. Memo from Andrea Estergaard to Harry Brownlow dated 28 November 2005.

Parenthetical Reference	Bibliographic Information
BC Ministry of Agriculture, Food & Fisheries 2004	BC Ministry of Agriculture, Food & Fisheries. 2004. Online at http://www.agf.gov.bc.ca
BC Ministry of Management Services 2004	BC Ministry of Management Services. 2004. BC Stats. Queries on regional district industries, agriculture, history, employment, and demographics. Online at http://www.regionalindex.gov.bc.ca/
BCFN 2005	British Columbia First Nation. 2005. BCFN Band Profiles. Online at http://www.bcfn.org. Accessed 19 May 2005.
BCMELP and Environment Canada 2000	British Columbia Ministry of Environment, Lands and Parks, and Environment Canada. 2000. Water Quality Trends in Selected British Columbia Waterbodies. Kootenay Region Summary. Vancouver, BC. Online at http://wlapwww.gov.bc.ca/wat/wq/trendsWQS/regions.html
BCMWLAP 2005	British Columbia Ministry of Water, Land and Air Protection. 2005. Northern leopard frog. Online at: http://wlapwww.gov.bc.ca/wld/identified/documents/Amphibians/a_northernleopardfrog.pdf. Accessed 15 June 2005.
Beaucher 2005	Beaucher, M.A. 2005. Personal Communication; Phone Conversation on March 23, 2005. In-coming Wildlife Area Manager; Creston Valley Wildlife Management Area. Creston, British Columbia.
Behnke 1992	Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6. Bethesda, Maryland.
Bennett and Liter 1991	Bennett, D.H. and M. Liter. 1991. Water quality, fish and wildlife characteristics of Box Canyon Reservoir, Washington. Completion Report 1989-1990. Section 3: Fish. Department of Fish and Wildlife Resources, College of Forestry, Wildlife and Range Sciences, University of Idaho. Moscow. 94 pp.
Berkas *et al.* 2004	Berkas, W. R., M. K. White, P. B. Ladd, F. A. Bailey, and K. A. Dodge. 2004. Water resources data, Montana, water year 2003. Water Data Report MT-03-2. U.S. Geological Survey, Helena MT.
Bigcrane 2004	Bigcrane, L. 2004. Personal communication. Confederated Salish and Kootenai Tribes, November 2004.
Bond 2003	Bond, G. 2003. Personal communication regarding Albeni Falls authorization for navigation and current status of log-chute. U.S. Army Corps of Engineers, Albeni Falls Dam, Oldtown, ID.
Bonde 1987	Bonde, T.J. 1987. Libby Dam-Lake Koocanusa project: a narrative reviewing actions taken to mitigate the effects of dam construction and operation on fish resources. Prepared for U.S. Army Corps of Engineers. Shapiro and Associates, Inc. Seattle WA.
Bonners Ferry Chamber of Commerce 2004	Bonners Ferry Chamber of Commerce. 2004. Online at http://www.bonnersferrychamber.com/pages/history.html

Parenthetical Reference	Bibliographic Information
Bordon 1956	Borden, C.E. 1956. Results of two archaeological surveys in the East Kootenay Region of British Columbia. Research Studies, State College of Washington 24:73-111. Pullman.
Boundary County 2004	Boundary County. 2004. Online at http://www.boundary.bc.ca/economy/index.htm
BPA 1993	Bonneville Power Administration. 1993. BPA Definitions. DOE/BP-2279.
BPA *et al.* 1991	Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation. 1991. The Columbia River system: the inside story. Portland, OR. 82 pp.
BPA et al 1993	Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation. 1993. Biological assessment on 1994-1998 Federal Columbia River Power Operations, December 1993. Submitted to National Marine Fisheries Service. Portland, OR.
BPA et al 1994	Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation. 1994. Supplemental biological assessment on 1994-1998 Federal Columbia River Power Operations, December 1994. Submitted to National Marine Fisheries Service and U.S. Fish and Wildlife Service. Portland, OR.
BPA et al 1995	Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation. 1995. Columbia River System Operation Review: Final Environmental Impact Statement. DOE/EIS-0170. November 1995. Portland, OR. (available online at http://www.nww.usace.army.mil/planning/er/reports.htm#EIS)
BPA et al 1999	Bonneville Power Administration, U.S. Army Corps of Engineers, and Bureau of Reclamation. 1999. Biological assessment for effects of FCRPS operations on Columbia Basin bull trout and Kootenai River white sturgeon. June 1999. Portland, OR.
BPA 2005	Bonneville Power Administration. 2005. Kootenai River Ecosystem Project, Final Environmental Assessment. June 2005. Portland, OR.
Bryant 1978	Bryant, R. L. 1978. Cultural resource investigation: Grand Coulee third power plant extension. Vol. 1. Eugene OR: Pro-Lysts, Inc.
BSF 2004	Big Sky Fishing. 2004. online at http://www.bigskyfishing.com/River-Fishing/NW-MT-Rivers/Kootenai-River/Kootenai-River-FloatingInformation.htm
Burren 2004	Burren, B. 2004. U.S. Forest Service, Flathead National Forest. Hungry Horse MT.
Carlson 1996	Borden, C.E. 1956. Results of two archaeological surveys in the East Kootenay Region of British Columbia. Research Studies, State College of Washington 24:73-111. Pullman.

Parenthetical Reference	Bibliographic Information
Chance 1995	Chance, D.H. 1995. The Fur Trade of the Upper Columbia River, 1792-1871. Contract report submitted to Bonneville Power Administration and National Park Service.
Chisholm *et al.* 1989	Chisholm, I., M.E. Hensler, B. Hansen and D. Skaar. 1989. Quantification of Libby Reservoir levels needed to maintain or enhance reservoir fisheries. Methods and data summary, 1983-1987. Report to Bonneville Power Administration by Montana Fish, Wildlife & Parks, Kalispell, MT.
Choquette 1971	Choquette, W. 1971. Archaeological salvage operations within the Libby Dam pondage, 1976. Report submitted to the Archaeological Sites Advisory Board of British Columbia. Victoria.
Choquette 1973	Choquette, W. 1973. Canadian Libby Reservoir area archaeological salvage project, Interim Report. National Museum of Man, Mercury Series, Archaeological Survey of Canada, Paper No. 26, pp. 42-45. Ottawa.
Coastal and Hydraulics Laboratory 2003	Coastal and Hydraulics Laboratory. 2003. Total dissolved gas exchange at Libby Dam, Montana, June-July 2002. Prepared for Seattle District, U.S. Army Corps of Engineers. U.S. Army Engineer Research and Development Center. Vicksburg MS.
Columbia River Channel Coalition 2003	Columbia River Channel Coalition. 2003. Online at
Colville Confederated Tribes 2004	Colville Confederated Tribes. 2004. Online at http://www.colvilletribes.com/ctec.htm
Corps 1952	U.S. Army Corps of Engineers. 1952. Hungry Horse Dam Reservoir Control Manual. Seattle District. Seattle WA. December.
Corps 1972	U.S. Army Corps of Engineers. 1972. Columbia River treaty flood control operating plan. North Pacific Division. Portland OR. October.
Corps 1984	U.S. Army Corps of Engineers. 1984. Libby Dam and Lake Koocanusa; Kootenai River, Montana; Water Control Manual. Seattle District.
Corps 1991	U.S. Army Corps of Engineers. 1991. Review of Flood Control, Columbia River Basin, Columbia River and Tributaries Study, CRT-63. June 1991. North Pacific Division, Portland, Oregon.
Corps 1993	U.S. Army Corps of Engineers. 1993. Final Supplemental EIS—Interim Columbia and Snake River Flow Improvement Measures for Salmon. March 1993. Walla Walla, WA.
Corps 1999a	U.S. Army Corps of Engineers. 1999a. Revised Flood Control Operating Plan.. Northwestern Division, Portland, Oregon.
Corps 2000a	U.S. Army Corps of Engineers. 2000a. Chief Joseph Dam Dissolved Gas Abatement Project: Final Environmental Assessment and Finding of No Significant Impact. June. Seattle District, Seattle, WA. 138 pp. Online at http://www.nwd-wc.usace.army.mil/nws/hh/gas/pdfs/Abatement_EA.v3.1.pdf

Parenthetical Reference	Bibliographic Information
Corps 2000b	U.S. Army Corps of Engineers. 2000b. Water control manual, Albeni Falls Dam, Pend Oreille River, Idaho. Seattle District, Seattle, WA.
Corps 2002a	U.S. Army Corps of Engineers. 2002a. Final Environmental Assessment, Upper Columbia alternative flood control and fish operations interim implementation. Seattle District..
Corps 2002b	U.S. Army Corps of Engineers. 2002b. Non-Federal Flood Control Works Inspection Reports., Emergency Management Branch, Seattle District.
Corps 2002c	U.S. Army Corps of Engineers. 2002c. Letter from Michael White (Corps) to Anne Badgley (USFWS) confirming staff agreement of 25 and 26 March 2002 concerning Kootenai River white sturgeon flow volume tiers. August 23, 2002.
Corps 2003a	U.S. Army Corps of Engineers. 2003a. Columbia River Treaty Flood Control Operating Plan. Northwestern Division, North Pacific Region, Portland, OR.
Corps 2003b	U.S. Army Corps of Engineers. 2003b. Water Control Manual, Hungry Horse Dam and Reservoir, South Fork Flathead River, Montana - Draft. Seattle District, Seattle, Washington.
Corps 2003c	U.S. Army Corps of Engineers. 2003c. 2004 total dissolved gas management plan, water management plan–final. Online at http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/2004/final/app4.pdf. Accessed 06/28/04.
Corps 2003d	U.S. Army Corps of Engineers. 2003d. Water quality plan for total dissolved gas and water temperature in the mainstem Columbia and Snake Rivers. Portland OR.
Corps 2004a	U. S. Army Corps of Engineers. 2004a. Albeni Falls Dam, recreation areas. Online at http://www.nws.usace.army.mil/.
Corps 2004b	U.S. Army Corps of Engineers. 2004b. Kootenai River Habitat and Ecosystem Restoration Strategies, Draft Report.
Corps 2004c	U.S. Army Corps of Engineers. 2004c. Lake Koocanusa Summary Hydrograph. Online at http://www.nwd-wc.usace.army.mil/nws/hh/basins/libsh.html. Accessed 05/21/2004.
Corps 2005	U.S. Army Corps of Engineers. 2005. Hungry Horse Dam and Reservoir, South Fork Flathead River, Montana. Water Control Manual (Bureau of Reclamation Project). Draft status until completion of the VARQ FC EIS. Seattle District. Seattle WA.
Corps *et al.* 1992	U.S. Army Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation. 1992. Columbia River Salmon Flow Measures Options Analysis Environmental Impact Statement. January 1992. Walla Walla, WA.

Parenthetical Reference	Bibliographic Information
COSEWIC 2003	Committee on the Status of Endangered Wildlife in Canada. 2003. COSEWIC assessment and update status report on the white sturgeon Acipenser transmontanus in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii = 51 pp. (www.sararegistry.gc.ca/status/status_e.cfm).
CRN 2004	Canadian Rockies Net, 2004. Online at http://www.canadianrockies.net/maps/knp.htm http://www.canadianrockies.net/maps/bnp.htm http://www.canadianrockies.net/maps/ynp.htm
Crook 1993	Crook, A.G. 1993. Irrigation Depletion Estimate. Cited in BPA et al, 1995.
CSKT 2001	Confederated Salish and Kootenai Tribes. 2001. Hungry Horse Reservoir traditional cultural use study FY 2000 annual report. Preservation Department. Pablo MT.
CSKT 2003	Confederated Salish and Kootenai Tribes. 2003. Kootenai Indian Place Names. Contract report submitted to Seattle District, US Army Corps of Engineers.
CSKT 2004	Confederated Salish and Kootenai Tribes. 2004. Online at http://www.cskt.org/business/businesses.html
CSSR 2003	Coalition for Smart Salmon Recovery. 2003. Internet web-page on value of Columbia River Basin Value. Online at http://www.smartsalmonrecovery.org/Value/Transport.htm
Council on Environmental Quality 1978	Council on Environmental Quality. 1978. National Environmental Policy Act—Regulations. 40 CFR 1500-1508. Federal Register 43(230):55978-56007.
Dalbey and Marotz 1997	Dalbey, S. and B. Marotz. 1997. Fisheries mitigation and implementation plan for losses attributable to the construction and operation of Libby Dam. Prepared for Montana Department of Fish, Wildlife, and Parks.
Dalbey *et al.* 1998	Dalbey, S., J. DeShazer, L. Garrow, T. Hoffman, and T. Ostrowski. 1998. Quantification of Libby Reservoir water levels needed to maintain or enhance reservoir fisheries. Project No. 1983-46700, BPA Report DOE/BP-12660-7.
Daley et al 1981	Daley, R.J., E.C. Karmach, C.B.J. Gray, C.H. Pharo, S. Jasper, and R.C. Weigand. 1981. The effects of upstream impoundments on the limnology of Kootenay Lake, B.C. Scientific Service No. 117. National Water Research Institute, Inland Waters Directorate. Vancouver, British Columbia. 96 pp.
David Evans and Associates 1996	David Evans and Associates. 1996. Lake Koocanusa, Montana fugitive dust study. Final report. Prepared by Enviroanalysis for U.S. Army Corps of Engineers, Seattle District. Seattle WA.
Desautel 2004	Desautel, K. 2004. Personal communication, Colville Tribes. November, 2004.

Parenthetical Reference	Bibliographic Information
Duke et al .1999	Duke, S., P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, L. Lockard, B. Marotz, V.L. Paragamian, and S. Bettin. 1999. Recovery plan for the white sturgeon (Acipenser transmontanus) Kootenai River population. U.S. Fish and Wildlife Service, Region 1. Portland, OR.
Dunnigan *et al.* 2003	Dunnigan, J., B. Marotz, J. DeShazer, L. Garrow, and T. Ostrowski. 2003. Mitigation for the construction and operation of Libby Dam, Annual Report 2001-2002. Prepared for Bonneville Power Administration, Project No. 1995-00400 (BPA Report DOE/BP-00006294-3).
Easthouse 2004	Easthouse, K.B. 2004. Assessment of increased river flows on ground water quality in wells adjacent to the Kootenai River, Montana. Seattle District, U.S. Army Corps of Engineers. Seattle WA.
Ellis 2005	Ellis, D. 2005. Personal Communication; Phone Conversation on March 23, 2005. Refuge Manager; U.S. Fish & Wildlife Service, Kootenai National Wildlife Refuge.
Emerson 1994a	Emerson, S. 1994a. Effects of cross-cultural contact. In A design for management of cultural resources in the Lake Roosevelt basin of northeastern Washington. Pp. 6.1-6.42 in J. Galm, ed. Eastern Washington Univ. reports in archaeology and history 100-83. Eastern Washington Univ., Cheney.
Energy Laboratories 2003	Energy Laboratories, Inc. 2003. 2002 annual drinking water quality report, city of Libby, MT. PWSID #00274. Online at http://www.libbymontana.com/water%20treatment.html.
Enviroanalysis 1996	Enviroanalysis. 1996. Lake Koocanusa, Montana fugitive dust study final report. Prepared for U.S. Army Corps of Engineers, Seattle District.
Environment Canada 2004	Environment Canada. 2004. Species at risk. Online at http://www.speciesatrisk.gc.ca/default_e.cfm.
EPA 1993	Environmental Protection Agency. 1993. Clark Fork-Pend Oreille basin water quality study. EPA report 910/R-93-006. Seattle WA.
EPA 2002	Environmental Protection Agency. 2002. PM2.5 data analysis (7/17/2002). Online at http://www.epa.gov/airtrends/data/pm25publicall_new.pdf.
EPA 2003	Environmental Protection Agency. 2003. National air quality and emissions trends report 2003. Office of Air Quality Planning and Standards, EPA 454/R-03-005. Online at http://www.epa.gov/oar/oaqps/greenbk/.
Faler *et al.* 1988.	Faler, M.P. , L.M. Miller, and K.I. Welke. 1988. Effects of variation in flow on distribution of northern squawfish in the Columbia River below McNary Dam. North American Journal of Fisheries Management, 8:30-35.
FERC 2000	Federal Energy Regulatory Commission. 2000. Final environmental impact statement. Cabinet Gorge and Noxon Rapids hydroelectric projects Idaho and Montana. Washington, D.C.

Parenthetical Reference	Bibliographic Information
Fickeisen and Montgomery undated	Fickeisen, D.H. and J.C. Montgomery. undated-1976? Dissolved gas supersaturation: bioassays of Kootenai River organisms. Final report to U.S. Army Corps of Engineers. Battelle Pacific NW Laboratories, Richland WA.
Foundation for Water & Energy Education 2004	Foundation for Water & Energy Education. 2004. Online at http://www.fwee.org/c-basin.html
Frizell 1996	Frizell, K. H. 1996. Dissolved gas supersaturation study for Grand Coulee Dam. Bureau of Reclamation, Technical Services Center. Denver CO.
Frizell 1998	Frizell, K. H. 1998. Operational alternatives for total dissolved gas management at Grand Coulee Dam. Bureau of Reclamation, Technical Services Center. Denver CO.
Frizell and Cohen 1998	Frizell, K. H. and E. Cohen. 1998. Structural alternatives for TDG abatement at Grand Coulee Dam conceptual design report. Bureau of Reclamation, Technical Services Center. Denver CO.
Frizell and Cohen 2000	Frizell, K. H. and E. Cohen. 2000. Structural alternatives for TDG abatement at Grand Coulee Dam feasibility design report. Bureau of Reclamation, Technical Services Center. Denver CO.
Fulcrum Environmental Consulting, Inc. 2004	Fulcrum Environmental Consulting, Inc. 2004. Colville Indian Reservation Boundary Waters Shoreline Development Assessment. Prepared for the Confederated Tribes of the Colville Reservation.
Galm and Lyman 1988	Galm, J. and R.L. Lyman. 1988. Archaeological investigations at river mile 590: the excavations at 45DO189. Eastern Washington Univ. Reports in archaeology and history 100-61. : EWU Archaeological and Historical Services, Cheney WA.
Galm and Nials 1994	Galm, J., and F. Nials. 1994. Modeling prehistoric land use in the Lake Roosevelt basin. Pp. 4.1-4.73 in A design for management of cultural resources in the Lake Roosevelt basin of northeastern Washington. J. Galm, ed. Eastern Washington Univ. Reports in archaeology and history 100-83. Eastern Washington Univ., Cheney.
Gardner 2005	Gardner. B. 2005. Westslope cutthroat trout. online at www.fisheries.org/AFSMontana/SSCpages/westslope_cutthroat_trout.htm (accessed 1/5/06).
GEI Consultants, Inc. 2004a	GEI Consultants, Inc. 2004a. Intermountain province subbasin plan. Pend Oreille subbasin assessment. A report prepared for the Northwest Power and Conservation Council. NPPC Review Draft. Portland OR.
GEI Consultants, Inc. 2004b	GEI Consultants, Inc. 2004b. Intermountain province subbasin plan. Upper Columbia subbasin assessment. A report prepared for the Northwest Power and Conservation Council. NPPC Review Draft. Portland OR.
Geist *et al.* 2004	Geist, D.R. Brown. R.S., Scholz, A.T. B. None. 2004. Movement and survival of radio-tagged bull trout near Albeni Falls Dam. Prepared for the Dept of Arm, Seattle District, COE, Seattle. WA under Contract DACW68-02-D-0001, Task Order EC01, Project Number 44477.

Parenthetical Reference	Bibliographic Information
Goetz 1989	Goetz, F. 1989. Biology of the bull trout Salvelinus confluentus: A literature review. US Forest Service. Willamette National Forest. Eugene, OR.
Hamilton 2000	Hamilton, J. T. 2000. Hungry Horse archaeological project investigation management summary review period 1994-1998 phase I. U.S. Forest Service, Flathead National Forest. Kalispell MT.
Hamlet *et al.* 2005	Hamlet, A.F., P.W. Mote, M.P. Clark, and D.P. Lettenmaier. 2005. Effects of temperature and precipitation variability on snowpack trends in the western United States. Journal of Climate 18(21): 4545.-4561.
Hamlet 2001	Hamlet, A.F. Effects of climate change on water resources in the Pacific Northwest: impacts and policy implications. Preparatory white paper for Climate and Water Policy Meeting, Skamania, WA, July 16-17, 2001.
Hauer and Stanford 1997	Hauer, F. R. and J.A. Stanford. 1997. Long-term influence of Libby Dam operation on the ecology of macrozoobenthos of the Kootenai River, Montana and Idaho. Prepared for Montana Department of Fish, Wildlife, and Parks. Helena MT. 68 pp.
HDR Engineering, Inc. 2003	HDR Engineering, Inc. 2003. Kootenai Flats seepage analysis, Bonners Ferry, Idaho. Prepared for the Seattle District, U.S. Army Corps of Engineers.
Hensler *et al.* 1996	Hensler, M.E., J.E. Huston, and G.K. Sage. 1996. A genetic survey of lakes in the Cabinet Wilderness Area and proposed inland rainbow trout recovery. Montana Fish, Wildlife and Parks. Kalispell, MT.
Hirst 1991	Hirst, S.M. 1991. Impacts of the Operation of Existing Hydroelectric Developments on Fishery Resources in British Columbia, Volume II - Inland Fisheries; Canadian Manuscript Report of Fisheries and Aquatic Sciences 2093. Prepared for Recreational Fisheries Branch, Ministry of Environment and B.C. Hydro.
Hoffman *et al.* 2002	Hoffman, G., B. Marotz, J. DeShazer, T. Ostrowski, and J Dunnigan. 2002. Mitigation for the construction and operation of Libby Dam. Project No. 1995-00400, 163 electronic pages, (BPA Report DOE/BP-00006294-1)
Holderman and Hardy 2004	Holderman, C.E. and R. Hardy (eds.). 2004. Kootenai River ecosystem project: an ecosystem approach to evaluate and rehabilitate a degraded, large riverine ecosystem. Kootenai Tribe of Indians. Bonners Ferry, Idaho.
IBIS 2005	IBIS. 2005. Interactive Biodiversity Information System. Website: http://www.nwhi.org/ibis/home/ibis.asp
Idaho DEQ 2001	Idaho DEQ. 2001.
ISAB 2004	Independent Scientific Advisory Board. 2004. ISAB findings from the reservoir operations/flow survival symposium. Prepared for the Northwest Power and Conservation Council. Portland, OR.

Parenthetical Reference	Bibliographic Information
Ingersoll *et al.* 2000	Ingersoll, C.G., D.D. MacDonald, N. Wang, J.L. Crane, L.J. Field, P.S. Haverland, N.E. Kemble, R.A. Lindskoog, C. Severn, and D.E. Smorong. 2000. Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines. United States Geological Survey for U.S. EPA, Great Lakes National Program Office.
Jamieson and Braatne 2001	Jamieson, B., and J. Braatne. 2001. The impact of flow regulation on cottonwood forests along the Kootenai River in Idaho, Montana and British Columbia. BioQuest International Consulting Ltd. Bonneville Power Administration, Portland, OR.
Johnson 2000	Johnson, A. 2000. Reconnaissance survey on metals, semivolatiles, and PCBs in sediment deposits behind Upriver Dam, Spokane River. Washington Department of Ecology Pub. No. 00-03-021.
Kalispel Tribe 2004	Kalispel Tribe. 2004. Online at http://www.kalispeltribe.com/index2.html
Kimbrough *et al.* 2003	Kimbrough, R.A., R.R. Smith, G.P. Ruppert, and W.D. Wiggins. 2003. Water resources data, Washington, Water Year 2003. USGS-WDR-WA-03-1. Tacoma WA.
Kinne and Anders 1996	Kinne, P. and P. Anders. 1996. Kootenai River water and sediment quality investigation, May 1994-1995–draft. Kootenai Tribe of Idaho
Kootenai River Network 2004	Kootenai River Network. 2004. Online at http://www.kootenairivernetwork.org. Accessed 7/21/2004.
LeCaire 2000	LeCaire, Richard. 2000. Lake Rufus Woods subbasin summary (including the Nespelem River). Prepared for the Northwest Power Planning Council by Confederated Tribes of the Colville Reservation. November. http://www.cbfwa.org/FWProgram/ReviewCycle/fy2001im/workplan/RufusWoods.doc. accessed October 14, 2005.
Lee *et al.* 1997	Lee, D.C., J.R. Sedell, B.E. Reiman, R.F. Thurow, and J.E. Williams. 1997. Broadscale assessment of aquatic species and habitats. In T.M. Quigley and S.J. Arbelbide, eds. An Assessment of Ecosystem Components in the Interior Columbia Basin and portions of the Klamath and Great Basins. U.S. Forest Service General Technical Report PNW-GTR, Portland, OR.
Leeds *et al.* 1980	Leeds, Leon L., J.V. Jermann, and L.A. Leeds. 1980. Cultural resource reconnaissance for the proposed downstream riverbank stabilization program, Grand Coulee Dam, Washington. Reconnaissance Report No. 35. Univ. of Washington Office of Public Archaeology. Seattle, WA.
Libby, Montana 2004	Libby, Montana. 2004. Online at http://www.libbymt.com/community/#employment
Linenberger and Glaser 2002	Linenberger, T.R., and L.S. Glaser. 2002. Dams, dynamos, and development: the Bureau of Reclamation's power program and electrification of the west. Bureau of Reclamation, Washington, D.C..
Lower Kootenay Indian Band 2004	Lower Kootenay Indian Band. 2004. Online at http://www.kktc.bc.ca/lower%20kootenay.htm

Parenthetical Reference	Bibliographic Information
Mackinnon *et al.* 1992	Mackinnon, A., J. Pojar, and R. Coupé (eds.). 1992. Plants of northern British Columbia. B.C. Ministry of Forests and Lone Pine Publishing. Vancouver B.C., Canada.
Marotz *et al.* 1996	Marotz, B.L., C. Althen, D. Gustafson and B. Lonon. 1996. Model development to establish integrated operational rule curves for Hungry Horse and Libby reservoirs – Montana. Final report 1996. Project 83-467 prepared for Bonneville Power Administration. Montana Fish, Wildlife & Parks, Kalispell, MT. 114 pp.
Marotz and Althen 2004	Marotz, B., and C. Althen. 2004. Biological Responses to Alternative Flood Control Strategies at Hungry Horse and Libby Dams, Montana. Natural Solutions, Helena MT.
Marotz 2005	Marotz, B. 2005. Personal Communication; Phone Conversation on March 23, 2005. Biologist; Montana Department of Fish, Wildlife and Parks.
Matheson 2004	Matheson, Q. 2004. Personal communication, Coeur d'Alene Tribe, November, 2004.
McLeod *et al.* 1986	McLeod, C. Milo and D. Melton. 1986. The prehistory of the Lolo and Bitterroot National Forests: an overview. U.S. Forest Service, Lolo National Forest, Missoula MT.
MFWP 2004	Montana Department of Fish, Wildlife, and Parks. 2004. 2004 Montana fishing regulations. Helena MT.
MFWP 2005	Montana Fish, Wildlife and Parks. 2005. Northern leopard frog. Online at http://fwp.state.mt.us/fieldguide/detail_AAABH01170.aspx. Accessed 15 June 2005.
Miller *et al.* 1999	Miller, F. K, R. F. Burmester, D. M. Miller, R. E. Powell, P. D. Derkey. 1999. Digital geologic map of the Sandpoint 1- by 2-degree quadrangle, Washington, Idaho, and Montana. U.S. Geological Survey, Open File Report 99-144.
Montana DEQ 2001a	Montana Department of Environmental Quality. 2001a. Town of Eureka public water system, PWSID #MT0000210, source water delineation and assessment report. Eureka MT.
Montana DEQ 2001b	Montana DEQ. 2001b. Nutrient management plan: TMDL for Flathead Lake, MT. December.
Montana DEQ 2004	Montana Department of Environmental Quality. 2004. Montana numeric water quality standards. Circular WQB-7. Helena MT.
Montana DEQ 2005	Montana Dept. of Environmental Quality. 2005. Air quality information. Available online: http://deq.state.mt.us/AirQuality/Aqinfo.asp. Accessed 15 Apr 2005.

Parenthetical Reference	Bibliographic Information
Moser *et al.* 2003	Moser, M.L., R.W. Zabel, B.J. Burke, L.C. Stuehrenberg, and T.C. Bjornn. 2003. Factors affecting adult Pacific lamprey passage rates at hydropower dams: using “time to event” analysis of radiotelemetry data. pp. 61-70 *in* Spedicato, M.T., G. Lembo, and G. Marmulla, eds. Aquatic telemetry: advances and applications. Proceedings of the Fifth Conference on Fish Telemetry Held in Europe. Ustica, Italy, 9-13 June 2003.
MT AFS 2005	American Fisheries Society, Montana Chapter. 2005. Online at http://www.fisheries.org/AFSmontana/SSCpages/westslope_cutthroat_trout.htm.
Muhlfeld 1999	Muhlfeld, C.C. 1999. Seasonal habitat use by redband trout (Oncorhynchus mykiss gairdneri) in the Kootenai River drainage, Montana. Master’s thesis. University of Idaho, Moscow, Idaho.
Muhlfeld 2005	Muhlfeld, C.C. 2005. Status of redband trout *Oncorhynchus mykiss gairdneri* in Montana. online at www.fisheries.org/AFSMontana/SSCpages/redban%20status2.htm (accessed 1/5/2006).
Munsell and Salo 1979	Munsell, D.A. and L.V. Salo. 1979. Libby Additional Units and Reregulating Dam, Comprehensive Management Plan, Cultural Resources. Seattle District, US Army Corps of Engineers.
Murphy 2000	Murphy, M. 2000. Bald eagle nest production, Lake Roosevelt, Washington, 1987-2000. Final Report, Grant No. 1425-7-FG-10-03000, Bureau of Reclamation, USDI, Boise, ID.
NASS 2002	National Agricultural Statistical Service. 2002. 2002 Census of Agriculture – County Data. Online at http://www.usda.gov/nass/
NHC 1999	Northwest Hydraulic Consultants. 1999. Kootenay River erosion study, final report. Prepared for the Association of Kootenay Valley Drainage Districts. Creston, BC.
Nilsson and Svedmark 2002	Nilsson, C., and M. Svedmark. 2002. Basic Principles and Ecological Consequences of Changing Water Regimes; Riparian Plant Communities. Environmental Management 30(4):468-480.
NMFS 2000	National Marine Fisheries Service. 2000. Endangered Species Act section 7 biological opinion on the reinitiation of consultation on operation of the Federal Columbia River power system, including the juvenile fish transportation program, and 19 Bureau of Reclamation projects in the Columbia Basin. Seattle WA.
NMFS 2004	National Marine Fisheries Service. 2004. Endangered Species Act section 7 biological opinion, consultation on remand for operation of the Columbia River power system and 19 Bureau of Reclamation projects in the Columbia Basin. Log No. F/NWR/2004/00727. Seattle, WA.

Parenthetical Reference	Bibliographic Information
NOAA 2005	NOAA Fisheries Service. 2005. Endangered Species Act status reviews and listing information. Office of Protected Resources, Northwest Region. Online at http://www.nwr.noaa.gov/1salmon/salmesa/index.htm. Accessed 5 July 2005.
NPPC 2004	NPPC (Northwest Power Planning Council). 2004. Final Review Draft Kootenai River subbasin assessment. Online at http://www.nwcouncil.org/fw/subbasinplanning/kootenai/plan/
NPPC 2001a	NPPC (Northwest Power Planning Council). 2001a. Draft Flathead River subbasin summary. Online at http://www.cbfwa.org/cfsite/ReviewCycle.cfm?ReviewCycleURL=FY%202002%20Mountain%20Columbia#reports
NPPC 2001b	Northwest Power Planning Council. 2001b. Draft Pend Oreille River subbasin summary. Online at http://www.cbfwa.org/cfsite/ReviewCycle.cfm?ReviewCycleURL=FY%202002%20Mountain%20Columbia#reports
NPCC 2003	Northwest Power and Conservation Council. 2003. Mainstem amendments to the Columbia River Basin fish and wildlife program. Council Document 2003-11. http://www.nwcouncil.org/library/2003/2003-11.pdf accessed September 02, 2005.
NPS 1997	National Park Service. 1997. Lake Roosevelt national recreation area: resources management plan. Natural Resources Program. City?
NPS 2000	NPS (National Park Service). 2000. General management plan Lake Roosevelt National Recreation Area, Washington. City?
NPS 2002	(NPS) National Park Service. 2002. Fiscal year 2003 annual performance plan for Lake Roosevelt National Recreation Area. City?
Paragamian 1994	Paragamian, V. L. 1994. Kootenai River fisheries investigation: stock status of burbot and rainbow trout and fisheries inventory–annual report 1993. Project No. 1988-06500 (BPA Report DOE/BP-93497-5). Online at http://www.efw.bpa.gov/environment/ew/ewp/docs/reports/resident/R93497-5.pdf
Paragamian *et al.* 2000	Paragamian, V.L., V. Whitman, J Hammond, and H. Andrusak. 2000. Collapse of burbot fisheries in the Kootenai River, Idaho, USA, and Kootenay Lake, British Columbia, Canada. pp. 155-164 in Paragamian, V.L., and D.W. Willis, editors. Burbot: biology, ecology and management. American Fisheries Society, Fisheries Management Sec., Pub. 1. Spokane, WA. 170 pp.
Paragamian *et al.* 2002a	Paragamian, V.L., V. Whitman, V. Wakkinen. 2002a. Kootenai River white sturgeon spawning and recruitment evaluation, annual progress report January 1, 2000-March 31, 2001. IDFG Report No. 02-15. Prepared for Bonneville Power Administration, Project No. 1988-065-00, Contract No. 00000148-00001.

Parenthetical Reference	Bibliographic Information
Paragamian *et al.* 2002b	Paragamian, V.L., V.D. Wakkinen, and G. Kruse. 2002b. Spawning location and movement of Kootenai River white sturgeon. Journal of Applied Ichthyology, 18: 608-616.
Paragamian *et al.* 2005	Paragamian, V. L., R.C.P. Beamesderfer, and S.C. Ireland. 2005. Status, population dynamics, and future prospects of an endangered Kootenai River sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society 134(2):518-532.
Partridge 1983	Partridge, F. 1983. Kootenai River fisheries investigations. Idaho Department of Fish and Game. Job Completion Report. Project F-73-R-5, Subproject IV, Study IV. Boise ID.
Perkinson 1993	Perkinson, R.D. 1993. Presentation to the American Fisheries Society, Montana Chapter,17 February, 1993.
Perry 2004	Perry, P. 2004. Personal communication, Kootenai Tribe of Idaho, October, 2004.
Perry and Huston 1983	Perry, S. A. and J. E. Huston. 1983. Aquatic insect study: October 1979 through June 1982. In: Kootenai River fisheries investigations. Final completion report 1983. U.S. Army Corps of Engineers.
PFMC 1999	Pacific Fishery Management Council . 1999. Identification and Description of Essential Fish Habitat, Adverse Impacts, and Recommended Conservation Measures For Salmon. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A. Portland, OR.
Pickett 2004	Pickett, P. J. 2004. Quality assurance project plan: Pend Oreille River total dissolved gas total maximum daily load technical study. Washington State Department of Ecology. Publication No. 04-03-107. Olympia WA.
Pickett *et al.* 2004	Pickett, P. J., H. Rueda, and M. Herold. 2004. Total maximum daily load for total dissolved gas in the mid-Columbia River and Lake Roosevelt submittal report. Washington State Department of Ecology. Publication No. 04-03-002. Olympia WA.
Pocket Water 1999	Pocket Water, Inc. 1999. Kootenai River water quality summary 1997/1998. Prepared for Kootenai Tribe of Idaho. Pocket Water, Inc. Boise ID.
Quigley and Arbelbide 1997	Quigley, T. M. and S. J. Arbelbide (eds.). 1997. An assessment of ecosystem components in the interior Columbia Basin. U.S. Forest Service, Pacific Northwest Research Station. Portland OR.
Reclamation 1981	Bureau of Reclamation. 1981. Water and power resources service project data. Engineering and Research Center, Denver Service Center. Denver CO.
Reclamation 2000	Bureau of Reclamation. 2000. Framework plan for coordinating activities of the Columbia River transboundary gas group phase 1. Columbia River Transboundary Gas Group, Washington and British Columbia.

Parenthetical Reference	Bibliographic Information
Reclamation 2001	Bureau of Reclamation and U.S. Army Corps of Engineers. 2001. Grand Coulee Dam and Chief Joseph Dam joint operation–gas abatement analysis. GCL/CHJ Joint Operation Subcommittee. Prepared for System Configuration Team, Portland, OR.
Reclamation 2002	Bureau of Reclamation. 2002. Hydrologic analysis of the VARQ flood control plan at Hungry Horse Dam. Pacific Northwest Regional Office. Boise ID.
Reclamation 2002b	Bureau of Reclamation. 2002b. Voluntary environmental assessment, FONSI02-02, interim operation of the VARQ flood control plan at Hungry Horse Dam, MT. Pacific Northwest Regional Office, Boise, ID.
Reclamation 2003	Bureau of Reclamation. 2003. Initial review of three strategies to manage water temperature at Grand Coulee Dam-draft. Boise ID.
Regional District of Kootenay Boundary 2003	Regional District of Kootenay Boundary. 2003. Online at http://www.rdkb.com/siteengine/ActivePage.asp?PageID=14
Richards 1997	Richards, D. 1997. Kootenai River biological baseline status report. Prepared for Bonneville Power Administration, Project No. 94-49, Contract No. 95BI40364.
RL&L Environmental Services Ltd. 2002	RL&L Environmental Services Ltd. 2002. Fisheries resource information and TGP risk assessment for the Canadian portion of the lower Columbia River basin. Prepared for Columbia River integrated environmental monitoring program. RL&L Report No. 856D.
Roulette *et al.* 2001	Roulette, B. R., A. A. Finley, P. S. Solimano, J. J. Wilt, and C. Hodges. 2001. Results of a cultural resources inventory survey of Lake Roosevelt between elevations 1289 and 1310 feet above mean sea level and the tailrace terrace. Portland: Applied Archaeological Research.
SAIC 1996	Science Applications International Corporation. 1996. Lake Roosevelt Bald Eagle Study. Final Report under contract no.125-3-CS-10-12990 to Bureau of Reclamation, Pacific Northwest Region, Boise, ID.
Scholz *et al.* 2005	Scholz, A.T., H.J. McLellan, D.R. Geist, R.S. Brown. 2005. Investigations of migratory bull trout (Salvelinus confluentus) in relation to fish passage at Albeni Falls Dam. Prepared for USACE, Seattle District Corp of Engineers. Seattle WA. Contract DACW68-02-D-0001. Task Order EC01.
Schwab *et al.* 2000	Schwab, D., T. Ryan, G. Beaverhead, F. Auld, C. Sanchez, and S. Sanchez. 2000. Hungry Horse Reservoir Traditional Cultural Use Study FY98 & FY99 Annual Report Contract #98BI 03000, Confederated Salish and Kootenai Tribal Preservation Department, Pablo, Montana.
Scott and Crossman 1972	Scott, W.B., and E.J. Crossman. 1972. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bulletin 184. Ottawa, Ontario.
Shapiro 1985	Shapiro and Associates, Inc., 1985. Recreational Facilities and Use on Lake Koocanusa.

Parenthetical Reference	Bibliographic Information
Skaar *et al.* 1996	Skaar, D., J. DeShazer, L. Garrow, T. Ostrowski, and B. Thornburg. 1996. Investigations of fish entrainment through Libby Dam, 1990-1994. Montana Dept. of Fish, Wildlife, and Parks, Prepared for Bonneville Power Administration, Project Number 83-467, Portland, Oregon.
Smith 1984a	Smith, Alan H. 1984a. Kootenai Indian subsistence and settlement patterns, northwest Montana. Project Report No. 2 (v 2), Center for Northwest Anthropology, Washington State Univ. Pullman WA.
Smith 1984b	Smith, A.H. 1984b. Kutenai Indian subsistence and settlement patterns, northwest Montana. Technical Report, U.S. Army Corps of Engineers, Seattle.
Soults 2005	Soults, S. 2005. Personal Communication; Phone Conversation on March 23, 2005. Biologist; Kootenai Tribe of Idaho.
Stushnoff 2002	Stushnoff, B. 2002. Personal Communication; Email Response dated December 4, 2002. Wildlife Area Manager; Creston Valley Wildlife Management Area. Creston, British Columbia.
Stushnoff 2005	Stushnoff, B. 2005. Personal Communication; Phone Conversation on March 23, 2005. Wildlife Area Manager; Creston Valley Wildlife Management Area. Creston, British Columbia.
Sullivan *et al.* 2002	Sullivan, R. D., D. E. Weitkamp, T. Swant, and J. DosSantos. 2002. Controlling total dissolved gas, lower Clark Fork River dams. Parametrix. Kirkland WA and Noxon MT.
TekCominco 2001	TekCominco, 2001. Executive summary: Problem formulation for the ecological risk assessment (ERA) for Cominco operations at Trail, BC. Trail, BC.
Tetra Tech 2004	Tetra Tech, Inc. 2004. Kootenai River geomorphic assessment, Bonners Ferry, Idaho. Final report. Prepared for the Seattle District, U.S. Army Corps of Engineers.
Thoms 1984	Thoms, A. V. (ed.). 1984. Environment, archaeology, and land use patterns in the Kootenai River valley, vol. I, Washington State Univ., Center for Northwest Archaeology, Project Report No. 2. Pullman WA.
Tobacco Plains. 2004	Tobacco Plains. 2004. Online at http://www.kktc.bc.ca/tobacco%20plains.htm
Trail Economic Development Council 2004	Trail Economic Development Council. 2004. Online at http://www.trailedc.ca/outlook.html
Tri State Water Quality Council 1998	Tri State Water Quality Council. 1998. Clark Fork River voluntary nutrient reduction program. Sandpoint ID. Online at http://www.tristatecouncil.org/pages/pubs.html.
Tri-State Council 2002	Tri-State Council. 2002. Clark Fork-Pend Oreille watershed monitoring 2002 report summary.

Parenthetical Reference	Bibliographic Information
Tri-State Water Quality Council 2001	Tri-State Water Quality Council. 2001. Clark Fork River voluntary nutrient reduction program. Clark Fork River voluntary nutrient reduction program (VNRP) three-year evaluation report. VNRP Subcommittee of the Tri-State Water Quality Council. Sandpoint ID. Online at http://www.tristatecouncil.org/pages/pubs.html.
Tri-State Water Quality Council 2003	Tri-State Water Quality Council. 2003. Clark Fork-Pend Oreille watershed monitoring 2003 report summary. Listed online at http://www.tristatecouncil.org/pages/pubs.html.
Turney-High 1941	Turney-High, Henry H. 1941. Ethnography of the Kootenai. Memoirs of the American Anthropological Association 56. Menasha.
Underwood 2000	Underwood, K. 2000. Draft Lake Roosevelt Subbasin Summary, Prepared for the Northwest Power Planning Council. Columbia Basin Fish and Wildlife Authority, Portland OR. Online at http://www.cbfwf.org/files/province/intermtn/subsum/Roosevelt.PDF
University of Idaho 2005	University of Idaho. 2005. Water body comments. Available online: http://inside3.uidaho.edu/WebMapping/IDEQ/index.htm. Accessed 14 Apr 2005.
US Bureau of Economic Analysis 2004	U.S. Bureau of Economic Analysis. 2004. Online at http://www.bea.doc.gov/bea/regional/
US Census Bureau 2000	U.S. Census Bureau. 2005. Census 2000. 2003 Population Estimates; and 1995 to 2025 Population Projections. Online at http://www.factfinder.census.gov
US Census Bureau 2005	U.S. Census Bureau. 2005. Table SUB-EST2002-10-30 Montana incorporated place population estimates, sorted within county: April 1, 2000 to July 1, 2002.
USFS 1994	U.S. Forest Service. 1994. A Synthesis of Monitoring for the Middle Kootenai River Archaeological District, Montana, 1985-1993. Kootenai National Forest.
USFS 1996	U.S. Forest Service. 1996. Interior Columbia Basin ecosystem management project, status of the interior Columbia Basin: summary of scientific findings. Pacific Northwest Research Station, General Technical Report PNW-GTR-385. Portland OR.
USFS 2001	U.S. Forest Service. 2001. Monitoring of the Middle Kootenai River Archaeological District 1997-2001. Kootenai National Forest.
USFS 2002	U.S. Forest Service. 2002. Upper Kootenai Subbasin Review. Kootenai National Forest. Libby, Montana. U.S. Forest Service. 2004. Bitterroot, Flathead and Lolo National Forests forest plan revision proposed action. January. Online at http://www.fs.fed.us/rl/wmpz/.
USFS 2003	U.S. Forest Service, 2003. National Visitor Use Monitoring Results, USDA Forest Service Region 1, Kootenai National Forest.

Parenthetical Reference	Bibliographic Information
USFWS 1975	U.S. Fish and Wildlife Service. 1975. Endangered and threatened wildlife and plants: amendment listing the grizzly bear of the conterminous states as a threatened species. Federal Register 40:31734-31736. July 28.
USFWS 1983	U.S. Fish and Wildlife Service. 1983. Endangered and threatened wildlife and plants: determination of endangered status for the population of woodland caribou found in Washington, Idaho, and southeastern British Columbia. Federal Register 48:49245-49249. October 25.
USFWS 1986	U.S. Fish and Wildlife Service. 1986. Pacific bald eagle recovery plan. Portland OR. 160pp.
USFWS 1986	USFWS 1986 Recovery plan for the Pacific bald eagle. Portland, Oregon.
USFWS 1987	U.S. Fish and Wildlife Service. 1987. Northern Rocky Mountain wolf recovery plan. Denver CO. 102 pp.
USFWS 1993	U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants: finding on petitions to change the status of grizzly bear populations in the Cabinet-Yaak Area of Montana and the Selkirk Mountains of Idaho and Washington from threatened to endangered. Federal Register 58:8250-8251. February 12.
USFWS 1994	U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; determination of endangered status for the Kootenai River population of the white sturgeon. Final rule. Federal Register 59:45989-46561. September 6.
USFWS 1995	U.S. Fish and Wildlife Service. 1995. Endangered and threatened species, bald eagle reclassification, final rule. Federal Register 60:36000-36010. July 12.
USFWS 1999	U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and plants: proposed rule to remove the bald eagle in the lower 48 states from the list of endangered and threatened wildlife. Federal Register 64:36454-36464. July 6.
USFWS 2000	U.S. Fish and Wildlife Service. 2000. Biological opinion; effects to listed species from operations of the Federal Columbia River power system. Portland OR. 97 pp. plus appendices.
USFWS 2001	U.S. Fish and Wildlife Service. 2001. Endangered and threatened wildlife and plants: Final designation of critical habitat for the Kootenai River population of the white sturgeon. U.S. Fish and Wildlife Service. Federal Register Vol. 66:46548-46561. September 6, 2001.
USFWS 2002	U.S. Fish and Wildlife Service. 2002. Clark Fork River recovery unit, Montana, Idaho, and Washington, Chapter 3. Bull trout (Salvelinus confluentus) draft recovery plan. Portland OR.

Parenthetical Reference	Bibliographic Information
USFWS 2003a	U.S. Fish and Wildlife Service. 2003a. Endangered and threatened wildlife and plants: final rule to reclassify and remove the gray wolf from the list of threatened or endangered wildlife in portions of the conterminous United States; establishment of special regulations for threatened gray wolves. Federal Register 68:15804-15875. April 1.
USFWS 2003b	U.S. Fish and Wildlife Service. 2003b. Endangered and threatened wildlife and plants: 12-month finding for a petition to list the lower Kootenai River burbot (Lota lota) as threatened or endangered. Federal Register 68:11574-11579. March 11.
USFWS 2006a	U.S. Fish and Wildlife Service. 2006a. Endangered and threatened wildlife and plants; critical habitat designation for the Kootenai River population of the white sturgeon. Federal Register 71(26):6383-6396.
USFWS 2006b	U.S. Fish and Wildlife Service. 2006b. Fish and Wildlife Service Biological Opinion regarding the effects of Libby Dam operations on the Kootenai River white sturgeon bull trout and Kootenai sturgeon critical habitat (1-9-01-F-0279R). Pacific Region, Portland, Oregon. Feb 18, 2006.
USGS 2000	U.S. Geological Survey. 2000. Water Use Data for the United States. Online at http://water.usgs.gov/watuse/
USGS 2002	U.S. Geological Survey. 2002. Columbia River Basin, Washington. Online at http://vulcan.wr.usgs.gov/Volcanoes/Washington/ColumbiaRiver/description_columbia_river.html
USGS 2003a	U.S. Geological Survey. 2003a. Summary of surface water quality data collected for the northern Rockies Intermountane basins national water quality assessment program in Clark Fork-Pend Oreille and Spokane River basins, Montana, Idaho, and Washington, water years 1999-2001. Open File Report 02-472. Boise ID.
USGS 2003b	Pers. comm., 12/17/03 (from env. health)
USGS 2004a	U.S. Geological Survey. 2004a. Online at http://water.usgs.gov/gis/huc_name.txt. Accessed 7/12/04.
USGS 2004b	USGS. 2004b. Briefing on Lake Roosevelt for DOI and USGS by Gary Turney and Doug Buffington. September 8.
USGS 2005	USGS. 2005. NWIS Web Data for the Nation. http://waterdata.usgs.gov.awis.
UW 2006	University of Washington. 2006. DART (Data Access in Real Time) Adult Passage Graphics. Columbia Basin Research, School of Aquatic and Fishery Sciences, Seattle. Online at http://www.cbr.washington.edu/dart/adultpass.html (accessed 20 Jan 2005).
Watson 1985	Watson, V. 1985. A synthesis of water quality problems in the Clark Fork River basin. Univ. of Montana. Missoula MT. Online at http://ibscore.dbs.umt.edu/clarkfork/Past_Proceedings/1985_proceedings/1985indexpage.htm.

Parenthetical Reference	Bibliographic Information
Wernham 2005	Wernham, R. 2005. Personal communication, U.S. Army Corps of Engineers, Libby Dam, Libby, MT.
Wetlands International 2002	Wetlands International. 2002. Ramsar Sites Directory and Overview. Wageningen, The Netherlands. www.wetlands.org
Williams *et al.* 1989	Williams, J.E., J.E Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M Avarro-Mendoza, D.E. McAllister, and J.E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern: 1989. Fisheries 14(6):2-20.
Wipperman *et al.* 1996	Wipperman, B., G. B. Holms, L. W. Pommen. 1996. State of water quality of the Pend d'Oreille River at Waneta 1980-1994, Canada-British Columbia Water Quality Monitoring Agreement. Online at http://wlapwww.gov.bc.ca/wat/wq/quality/waneta/index.htm. Accessed 6/15/2004.
Woessner *et al.* 2004	Woessner, W. W. *et al.* 2004. Flathead River basin hydrologic observatory, northern Rocky Mountains. Proposal. University of Montana. Online at http://www.cuahsi.org/HO/Prospectuses/HO%20final%20flathhead%20Basin%20Woessner.pdf. Accessed 12/08/2004.
WRCC 2004	Western Regional Climate Center. 2006. Western U.S. climate historical summaries. Online at: http://www.wrcc.dri.edu/climsum.html. Accessed 03/08/2006.
Wright *et al.* 2002	Wright, M.E., K.I. Ashley, R. Lindsay, R. J. Hammond, F.R. Pick, L.M. Ley, P.B. Hamilton, D.C. Lasenby, L.J. McEachern, M. Duffy, J.D. Whall, L.C. Thompson, D. Miller, L. Vidmanic, D. Sebastian, G. Scholten, and M. Young. 2002. Kootenay Lake fertilization experiment Year 7 (1998/1999) report. British Columbia Ministry of Water, Land and Air Protection. Fisheries Project Report No. RD 98.