

# Columbia River System Operation Review Final Environmental Impact Statement

## Main Report



US Army Corps  
of Engineers  
North Pacific Division



## PUBLIC INVOLVEMENT IN THE SOR PROCESS

The Bureau of Reclamation, Corps of Engineers, and Bonneville Power Administration wish to thank those who reviewed the Columbia River System Operation Review (SOR) Draft EIS and appendices for their comments. Your comments have provided valuable public, agency, and tribal input to the SOR NEPA process. Throughout the SOR, we have made a continuing effort to keep the public informed and involved.

Fourteen public scoping meetings were held in 1990. A series of public roundtables was conducted in November 1991 to provide an update on the status of SOR studies. The lead agencies went back to most of the 14 communities in 1992 with 10 initial system operating strategies developed from the screening process. From those meetings and other consultations, seven SOS alternatives (with options) were developed and subjected to full-scale analysis. The analysis results were presented in the Draft EIS released in July 1994. The lead agencies also developed alternatives for the other proposed SOR actions, including a Columbia River Regional Forum for assisting in the determination of future SOSs, Pacific Northwest Coordination Agreement alternatives for power coordination, and Canadian Entitlement Allocation Agreements alternatives. A series of nine public meetings was held in September and October 1994 to present the Draft EIS and appendices and solicit public input on the SOR. The lead agencies received 282 formal written comments. Your comments have been used to revise and shape the alternatives presented in the Final EIS.

Regular newsletters on the progress of the SOR have been issued. Since 1990, 20 issues of *Streamline* have been sent to individuals, agencies, organizations, and tribes in the region on a mailing list of over 5,000. Several special publications explaining various aspects of the study have also been prepared and mailed to those on the mailing list. Those include:

- The Columbia River: A System Under Stress
- The Columbia River System: The Inside Story
- Screening Analysis: A Summary
- Screening Analysis: Volumes 1 and 2
- Power System Coordination: A Guide to the Pacific Northwest Coordination Agreement
- Modeling the System: How Computers are Used in Columbia River Planning
- Daily/Hourly Hydrosystem Operation: How the Columbia River System Responds to Short-Term Needs

Copies of these documents, the Final EIS, and other appendices can be obtained from any of the lead agencies, or from libraries in your area.

Your questions and comments on these documents should be addressed to:

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**Columbia River  
System Operation Review  
Final Environmental Impact Statement (FEIS)**

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**Abstract:**

The System Operation Review (SOR) Final EIS addresses four actions: (a) the need to develop a coordinated strategy for managing the multiple uses of the Federal Columbia River system (System Operating Strategy [SOS]); (b) the need to provide interested parties other than the management agencies with a long-term role in system planning (Forum); (c) the need to renew or change current Canadian Entitlement Allocation Agreements (CEAA); and (d) the need to renegotiate and renew the Pacific Northwest Coordination Agreement (PNCA). **SOS alternatives** analyzed are: (1) operation prior to Endangered Species Act listings of salmon stocks; (2) current operations (no action); (3) stable storage project operation; (4) natural river operation; (5) fixed drawdown; (6) operating strategies proposed by the U.S. Fish and Wildlife Service, National Marine Fisheries Service, the State fisheries agencies, Native American tribes, and Federal operating agencies; and (7) the Preferred Alternative. The seven **Forum alternatives** analyzed are: (1) decisionmaking by the SOR lead agencies (the preferred alternative); (2) decisionmaking by SOR lead agencies and recommendations by an existing regional entity; (3) decisionmaking by SOR lead agencies and recommendations by a new regional entity; (4) decisionmaking by a Federal consultation forum; (5) decisionmaking by a new entity; (6) decisionmaking by one Federal operating agency; and (7) decisionmaking by a Federal agency other than an operating agency. **PNCA alternatives** analyzed are: (1) no replacement contract; (2) contract to maximize regional power benefits; (3) roll over existing PNCA; (4) current PNCA with modified operating procedures (the preferred alternative); and (5) current PNCA with nonpower modifications. **CEAA alternatives** include: (1) no action (no replacement of current allocation agreements); (2) entitlement allocation: 55 percent Federal; 45 percent non-Federal; (3) entitlement allocation: 70 percent Federal, 30 percent non-Federal (the preferred alternative); and (4) no agreement.

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# **Reader's Guide to the System Operation Review Environmental Impact Statement**

The goal in preparing this environmental impact statement (EIS) was to produce an EIS that is clear and understandable not only for agency officials, but also for the general public. The vastness of the river system, the wealth of data used to analyze environmental impacts to river resources, and the complexity of the relationships among river uses made this a challenge.

Twenty technical appendices accompany this document and formed the basis for the EIS Main Report. These appendices provide extensive detail on existing conditions and effects of alternatives. To repeat this information in the main EIS would make the document far too detailed and voluminous for practicality. The EIS format is designed to provide summary-level information that is supported by the more comprehensive technical appendices. The chapters are organized to highlight selected subjects and to separate different types of information, where appropriate. The System Operation Review (SOR) addresses four separate decisions relating to the Columbia River system. Therefore, the EIS content describing alternatives and their consequences is organized into a separate chapter for each decision.

The EIS is presented as follows:

## **Chapter 1. Introduction: Setting the Stage for the System Operation Review**

This is the traditional "Purpose and Need" chapter.

## **Chapter 2. The Columbia River Basin**

This chapter is the "Affected Environment" chapter. It provides a general overview of each resource, leaving the detail to the technical appendices. It stops short of addressing how the operation of the existing Columbia River system affects resources because this is discussed in the next chapter.

## **Chapter 3. The Columbia River System**

A description of the programs and facilities of the existing coordinated system is pulled out here as a separate segment of the Affected Environment. This was done with the view that the system description is an intact subject that should stand alone.

## **Chapter 4. System Operating Strategies**

Chapter 4 addresses the first SOR decision, which is the development of a long-term system operating strategy (SOS). This chapter describes why and how the SOS alternatives (including the preferred alternative) were identified, presents their expected impacts for each river use or resource, and compares the SOS alternatives based on their impacts. For the SOSs, this chapter combines material that would normally be found in Chapters 2 and 4 of a traditional EIS. The summary of impacts presented in this chapter is drawn from the corresponding impact analysis chapters of the technical appendices.

## **Chapter 5. Columbia River Regional Forum**

This chapter discusses development of a process to involve regional interests in the periodic review and update of the SOS. This second SOR decision involves only an

administrative action, and therefore does not require environmental review under the National Environmental Policy Act (NEPA). Chapter 5 describes alternatives for such a process, and their merits, so that readers will better understand how system operation decisions will be made in the future.

#### **Chapter 6. Pacific Northwest Coordination Agreement**

In parallel to Chapter 5 for the Forum, Chapter 6 describes and evaluates alternatives for renewal or replacement of the Pacific Northwest Coordination Agreement (PNCA). The PNCA is a contract by which agencies and utilities coordinate their power generation activities.

#### **Chapter 7. Canadian Entitlement Allocation Agreements**

The Canadian Entitlement Allocation Agreements (CEAA) address the sharing of downstream power benefits from upriver storage built under the terms of the Columbia River Treaty between the United States and Canada. Chapter 7 discusses alternatives for replacing expiring Federal agreements with three non-Federal utilities owning dams on the mid-Columbia River.

#### **Chapter 8. Making the SOR Decisions**

This chapter describes the decision process and evaluation factors that the SOR agencies have used to identify a preferred alternative for each of the four SOR actions (the SOS, Forum, PNCA, and CEAA decisions). Chapter 8 explains the results of this process, and how the agencies will make final decisions on the SOR actions.

#### **Chapters 9 through 15.**

These are the traditional back chapters of an EIS: Coordination and Public Involvement; Environmental Consultation, Review, and Permit Requirements; Distribution of EIS; EIS Preparers; Glossary; References; and Index. There is also a special chapter (10) that describes numerous other regional studies that relate to the Columbia River system.

#### **Technical Appendices**

The Table of Contents lists 20 appendices. Each of the first 18 appendices was prepared with a common format, similar to that of the EIS, for consistency and to facilitate cross-referencing. These appendices are organized as follows:

- Chapter 1—Introduction: Scope and Process**
- Chapter 2—[Resource] in the Columbia River Basin Today**
- Chapter 3—Study Methods**
- Chapter 4—Alternatives and Their Impacts**
- Chapter 5—Comparison of Alternatives**

Appendix S, the Fish and Wildlife Coordination Act Report, addresses the requirements of the Fish and Wildlife Coordination Act rather than NEPA, and follows a different format. The final appendix, Appendix T, documents public review comments on the Draft EIS and the SOR agencies' responses to those comments. This appendix has an introductory section that summarizes the review input, followed by reproduction of the actual comments and the responses.

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3	Spokane Tribe of Indians, Comments on SOR Process
4	Confederated Tribes of the Umatilla Indian Reservation, Draft Consultation Plan
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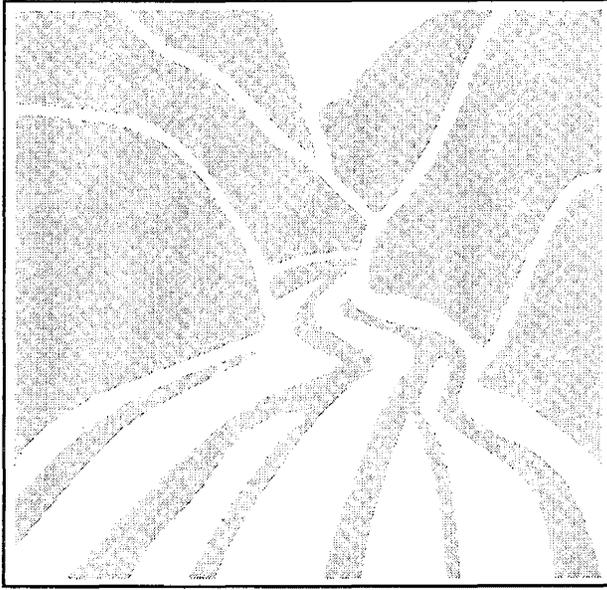
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**Introduction:  
Setting the Stage for the System Operation Review**



## 1.0 INTRODUCTION: SETTING THE STAGE FOR THE SYSTEM OPERATION REVIEW

### 1.1 SOR BACKGROUND, NEED, AND PURPOSE

The Columbia River is one of the greatest natural resources in the western United States. The river and its tributaries touch the lives of nearly every resident of the Northwest—from providing the world-famous Pacific salmon to supplying hydroelectric energy for over 75 percent of the region's demand.

Since early in the century, public and private agencies have worked to harness this dynamic river for the benefit of the region. Federal agencies have built 30 major dams on the river and its tributaries since the 1930s. Multiple uses of the system, ranging from natural resource management to industrial and commercial purposes, have evolved largely from this dam development. Today, these river uses are increasingly competing for limited water resources in the Columbia River Basin. Often, they conflict with each other. To date, meeting these demands has been guided somewhat independently by those sharing responsibility for the management of the Columbia River system.

The Federal agencies responsible for river management decided to use the pending expiration of several long-term agreements involving power production as an opportunity to review future operations of the Columbia River system and river use issues. Through this process, they hoped to achieve a coordinated river system operation that better meets the needs of all river users. Renewal of the agreements and the need to determine impacts on river uses from changing river operations provided the impetus for the System Operation Review (SOR).

The SOR is a joint project of the Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (Corps), and Bonneville Power Administration (BPA). The review is the environmental analysis required by the National

Environmental Policy Act (NEPA) to consider changes in Columbia River system operations and the effect of those changes on users of the system and the environment.

Plans to conduct the SOR were taking shape in 1990 when the first petition was filed seeking protection of Columbia River Basin salmon under the Endangered Species Act (ESA). ESA petitions of multiple species created political pressure for the region to solve its salmon problem. One activity was the 1990-1991 "Salmon Summit," which led to short-term river operating measures to benefit fish and the study of longer-term actions. The National Marine Fisheries Service (NMFS) declared the Snake River sockeye an endangered species in November 1991, and in April 1992 ruled that the spring/summer and fall runs of Snake River chinook were threatened. In an emergency action in August 1994, NMFS reclassified the Snake River chinook stocks as endangered. These rulings required the Federal operating agencies to consult with NMFS on annual river operating plans and resulted in a number of interim operations changes.

The ESA listings and associated events have had a significant effect on the SOR. While one of the primary goals of the SOR is to decide on a coordinated operating strategy to balance conflicting demands on the system, the reality is that the need to help conserve endangered salmon, specifically, and all salmon generally, has taken precedence over other considerations. Much of the trading off that will be done in deciding on a system operating strategy will hinge on what can be gained for endangered salmon at what cost to other uses. In short, the single most immediate and salient issue in the SOR is the recovery of endangered runs of wild salmon on the Snake River. While the Northwest contemplates the extent to which commercial fishing, hatchery practices, and habitat destruction are affecting salmon populations, the system operating strategy will

represent the role that Federal dam operations will play in that recovery. (See Chapter 10 for a discussion of other concurrent studies that are related to salmon and river system issues.

Management of Columbia River system operations is very much an evolving, ongoing process. River operations from 1992 through 1994 were managed under Biological Opinions issued by NMFS addressing the effects of the respective annual operating plans on the listed salmon species.

On March 16, 1994, NMFS released a Biological Opinion on a longer-term operating plan covering Federal Columbia River Power System (FCRPS) operations from 1994 through 1998. The opinion said that the proposed operations would present no jeopardy to salmon listed as threatened or endangered under the ESA.

Shortly thereafter, on March 28, U.S. District Court Judge Malcolm Marsh made a decision in a legal case involving NMFS' 1993 Biological Opinion on river operations, which affected status of the 1994-98 Biological Opinion. Marsh ruled that NMFS acted in an arbitrary and capricious manner in issuing its 1993 Biological Opinion, and that the 1993 opinion was flawed because it did not do enough to help threatened and endangered salmon. The judge ordered parties in the region to begin meeting to agree on ways to remedy the weaknesses in the 1993 Biological Opinion. Marsh agreed that it would be more productive for the parties to address the 1994-98 opinion in light of his objections to the 1993 opinion rather than spend time discussing operations that have already occurred.

Participants in the talks included: NMFS, the Corps, Reclamation, BPA, the U.S. Fish and Wildlife Service (USFWS), the Department of Justice, the Bureau of Indian Affairs (BIA), five tribes with treaty rights to Columbia River fish, and the states of Oregon, Washington, Alaska, Montana, and Idaho. The meetings continued through November 1994. Eventually, as a result of the input and analysis provided by the

participants, NMFS developed a jeopardy standard and a set of "reasonable and prudent" 1994-98 operating actions. NMFS presented these measures in a new and improved Biological Opinion for operations in 1995 and future years, which was issued in March 1995.

Concurrently, the U.S. Fish and Wildlife Service (USFWS) issued a Biological Opinion addressing the effects of system operations on Kootenai River white sturgeon, which were listed under ESA in June 1994. The USFWS Biological Opinion primarily affects operations at Libby Dam in Montana, as it prescribes flows in the Kootenai River downstream from Libby.

The new long-term river operating strategy represented by the combined recommendations of the NMFS and USFWS Biological Opinions requires environmental impact analysis under the requirements of the National Environmental Policy Act (NEPA). Because the System Operation Review has extensively analyzed the environmental and economic impacts of a range of different operating strategies, those results can be called upon to help NMFS, USFWS, and the region reach final decisions that can be put into effect in a timely fashion. The SOR is intended to be an ongoing management process, and therefore should provide a suitable means for monitoring conditions and adapting to changing management needs.

#### 1.1.1 Need

The underlying need to which the three agencies are responding is a review of the multipurpose management of the Columbia River system. To meet this need, four actions are being considered in the comprehensive review of Columbia River operations encompassed by the SOR. These actions are: (1) developing and implementing a coordinated system operating strategy for managing the multiple uses of the Columbia River system into the 21st century; (2) providing interested parties with a continuing long-term role in system planning and operations through a Columbia River Regional Forum (Forum); (3) renegotiating and renewing the Pacific Northwest Coordination Agreement

(PNCA); and (4) renewing current agreements or developing new Canadian Entitlement Allocation Agreements (CEAA). Each is discussed briefly below, and each is addressed separately in more detail in Chapters 4 through 7.

#### **SOR Actions Analyzed**

- System Operating Strategy
- SOS Periodic Review and Update (Forum)
- Renew/Renegotiate Pacific Northwest Coordination Agreement
- Renew/Renegotiate Canadian Entitlement Allocation Agreements

### **System Operating Strategy**

Balancing the needs of system users as their demands for a finite resource have increased has been a constant challenge for river managers. The priority placed on different needs has shifted over the decades, requiring continual fine-tuning of the river's operation. An objective of the SOR is to establish a System Operating Strategy (SOS) for the Columbia River system that considers competing uses of the river. The SOSs (described later in this document) prescribe operations for the Columbia River system in a way that takes into account the multiple-use nature of the river.

### **System Operating Strategy Periodic Review and Update (Columbia River Regional Forum)**

The SOR agencies view operational planning as a changing, rather than a static process. To keep the SOS tuned to the dynamic nature of the system and its users, another objective is to provide a process whereby users and regional interests are involved in its periodic re-evaluation and update. The SOR agencies are referring to this process as the Columbia River Regional Forum, or the Forum for short. It is not possible to conduct a review such as the

SOR every year, or to develop a new SOS annually. Therefore, the SOR assessed ways to provide regional interests such as environmental groups, tribes, utilities and other electricity consumers, and state and Federal fish and wildlife agencies a continuing, long-term role in system planning and operations through such a Forum. The Forum will allow regional interests to participate in updating and revising river management. It may also provide a means to consolidate a number of committees and joint processes that are concurrently used to coordinate a variety of single-purpose activities, such as fishery operations.

### **Pacific Northwest Coordination Agreement**

In 1961, the United States and Canada signed the Columbia River Treaty, which provided for building four storage dams: three in Canada (Mica, Keenleyside, and Duncan) and one in the United States (Libby). The reservoirs built and operated under the Treaty represent almost half the water storage capacity on the Columbia River system.

A direct outgrowth of the Columbia River Treaty, the PNCA is a complex contract for coordination of electric power production on the Columbia River. The PNCA calls for annual planning, which must be consistent with all authorized uses of Columbia River hydro projects. All PNCA parties coordinate operation of their respective projects to meet system requirements. Parties to the Coordination Agreement are the United States, as represented by the Corps, BPA, and Reclamation; the United States Entity (a feature of the Treaty), as represented by the Corps and BPA; and 15 public and private utilities based in Montana, Oregon, and Washington that own and operate dams in the Columbia River system. The PNCA was signed in 1964 and is scheduled to expire in 2003. A Federal decision to renew or revise the Coordination Agreement requires environmental evaluation under NEPA, so the PNCA has been included as a separate part of the SOR.

## Canadian Entitlement Allocation Agreements

The Columbia River Treaty required Canada to construct and operate 15.5 million acre-feet (MAF [19 billion cubic meters or m<sup>3</sup>]) of storage on the Columbia River system in Canada for optimum power generation and flood control downstream in Canada and the United States. The increase in usable electricity in the United States is referred to as the "downstream power benefits." The Treaty specifies that the downstream power benefits be shared equally between the two countries. Canada's portion of the downstream power benefits is known as the Canadian Entitlement. The Canadian Entitlement was initially sold to the Columbia Storage Power Exchange (CSPE), a nonprofit corporation representing a group of 41 Pacific Northwest utilities in the United States, for 30 years from the completion of each dam. These 30-year periods expire in 1998, 1999, and 2003. The CSPE receives power generated from water from Canadian storage by Federal projects and three mid-Columbia public utility districts (PUDs) with projects on the mainstem Columbia River.

The CEAA are contracts that established how the Canadian Entitlement was to be attributed collectively to the six Federal and to each of the five non-Federal projects downstream of the three Canadian storage projects. There are five allocation agreements between the United States Entity and the PUDs. One agreement applies to each of the five PUD-owned dams on the mid-Columbia—Wells, owned by Douglas County PUD; Rocky Reach and Rock Island, owned by Chelan County PUD; and Wanapum and Priest Rapids, owned by Grant County PUD. The current agreements expire April 1, 2003; however, obligations under a replacement CEAA to deliver the Canadian Entitlement to Canada will begin April 1, 1988 and will exist, at a minimum, until 2024. New CEAs between the United States Entity and the non-Federal project owners will be required to establish obligations to produce the Canadian share of the Treaty Entitlement. NEPA environmental review is required before the BPA administrator, acting on

behalf of the United States Entity, can sign new agreements.

The CEAA currently in effect between the United States Entity and the PUDs define and allocate the Canadian Entitlement. The Canadian Entitlement is computed on the basis that the Pacific Northwest hydroelectric system is operated in a coordinated manner, as if it were a single-owner system. Non-Federal utilities committed to provide a portion of the Canadian Entitlement in return for agreement by the United States Government to participate in a coordinated manner in order to realize the benefits envisioned by the Treaty. Accordingly, the CEAA and the PNCA are linked to the Treaty. Because of this link, parties to both agreements chose to negotiate these future contracts simultaneously. The environmental impacts of alternative forms of both the PNCA and CEAA are analyzed as separate parts of this SOR environmental review.

Both the Columbia River Treaty and the Coordination Agreement require planning into future years. Annual planning under the Coordination Agreement prepares parties for operations 4 years into the future. The planning period that began in 1994 extends through 1998. This is also the first year that the CEAA begin to expire. Because all these agreements interrelate, utilities needed to consider what their obligations under the CEAA would likely be in 1998 when they conducted Coordination Agreement planning in 1994. Rights and obligations for providing power to the coordinated system under the Coordination Agreement could have an impact on a utility's cost or ability to deliver its share of the Canadian Entitlement power.

### 1.1.2 Purpose

In evaluating the four actions, the agencies will consider the following purposes in providing an appropriate balance among uses. These purposes can be divided into three categories: (1) resources, (2) institutional, and (3) legal/regulatory. They reflect the obligations of the SOR lead agencies and the cooperating agencies,

as identified in authorizing legislation, agency policies, and relevant management plans. The purposes also represent the concerns of regional users, either as expressed during the scoping process at the beginning of the SOR, supported through participation during the analysis, or communication through review of the Draft EIS.

### Resource Purposes

Comments of regional interests expressed during scoping were summarized as resource purposes to:

- Provide an economic, reliable, and environmentally sound power system
- Provide an adequate supply of irrigation, municipal, and industrial water
- Provide an economic and dependable flood damage reduction and public safety system
- Provide waterborne transportation capability
- Provide equitable treatment of fish and wildlife
- Protect and preserve threatened, endangered, and sensitive species
- Provide opportunities for recreation on lakes and reservoirs
- Protect and preserve cultural resources
- Protect and enhance socioeconomic well-being
- Protect and enhance environmental quality.

### Institutional Purposes

Purposes set for systemwide operational planning and efficiency are to:

- Provide direct public access to the ongoing decision process and operating strategy governing the Columbia River system
- Create and maintain a technical database for operating decisions.

### Legal/Regulatory Purposes

Agencies must comply with certain legal and regulatory requirements in making river management decisions. Within the context of these requirements, SOR purposes are to:

- Implement recommended near-term actions within existing authority
- Identify areas where new authority is required to implement recommended long-term actions
- Satisfy existing contracts
- Comply with environmental laws and regulations.
- Satisfy Native American treaty rights and obligations regarding natural and cultural resources.

## 1.2 THE SYSTEM OPERATION REVIEW INTERAGENCY TEAM

A Federal interagency team is conducting the SOR. The team includes three lead agencies and three cooperating agencies.

### 1.2.1 Lead Agencies

The lead agencies—the Corps, Reclamation, and BPA—share responsibility and legal authority for management of the Federal elements of the Columbia River system. These three lead agencies are jointly conducting the SOR.

**U.S. Department of the Army, Corps of Engineers:** The Corps operates and maintains 12 of the 14 projects under study in the SOR. Nine of these projects control the lower Snake and Columbia Rivers, and three provide storage in the upper reaches of both rivers. The Corps has a major role in coordinating multiple uses of the system. It is responsible for managing flood control storage at all major reservoirs in the Columbia River Basin; maintaining navigation locks and channels to accommodate river transportation; and operating fish passage facilities.

**U.S. Department of the Interior, Bureau of Reclamation:** Reclamation operates Grand Coulee and Hungry Horse Dams, two of the storage projects included in the SOR study area. Because of its size (5.19 MAF [6.4 billion m<sup>3</sup>] of storage in Lake Roosevelt) and key location, Grand Coulee Dam plays a prominent role in the coordinated operation of the Columbia River

system. Storage at Hungry Horse is also very valuable because of its headwaters location; water released from Hungry Horse passes through many downstream powerplants.

**U.S. Department of Energy, Bonneville Power Administration:** BPA markets and distributes power generated at Federal dams on the Columbia River and its tributaries. The agency sells power from the dams and other generating plants to public and private utilities and large industries, and it builds and operates transmission lines that deliver the electricity. Federal law requires that BPA, when providing electricity produced at the Federal dams, give preference to publicly owned utilities and to entities in the Northwest.

The Corps and Reclamation develop operating requirements for their projects. These are the limits within which a reservoir or dam must be operated. Some requirements are established by Congress when a project is authorized; others evolve with operating experience. Within these operating limits, BPA schedules and dispatches power. This process requires continuous communication and coordination among the three agencies.

### 1.2.2 Cooperating Agencies

The NMFS, USFWS, and National Park Service (NPS) are cooperating agencies for the SOR. The U.S. Department of Agriculture, Forest Service (USFS) was initially a cooperating agency, but subsequently withdrew from that role. Each has jurisdiction and special expertise with regard to some aspects of the SOR. As cooperating agencies, they have agreed to contribute their analytical expertise to produce information for the SOR studies.

**U.S. Department of Commerce, National Marine Fisheries Service:** NMFS provides management and research services for the protection, conservation, and use of marine resources and their habitats, and protects endangered marine species. In the latter role, NMFS is responsible for developing a recovery plan for Snake River salmon stocks listed as

threatened or endangered species. NMFS is a cooperating agency because of its fisheries expertise and its ESA jurisdiction.

**U.S. Department of the Interior, Fish and Wildlife Service:** Among many other responsibilities, the USFWS is charged with maintenance of fish and wildlife at a level and in a condition that will ensure their survival and, where possible, provide for a net national gain of fish and wildlife resources. The agency brings to the SOR particular expertise with regard to fish and wildlife in the system, and has responsibilities similar to NMFS' for threatened and endangered nonmarine species.

**U.S. Department of the Interior, National Park Service:** The NPS manages sizable parcels of land adjoining the Columbia River system. Its jurisdiction extends to management of national parks, monuments, historic sites, and recreation areas. The NPS is providing information on recreation and cultural resources.

## 1.3 SCOPE AND PROCESS

The Columbia River SOR provides river managers, users, and the general public an opportunity to examine river system operations in detail, to investigate how each use of the river affects other uses, and to consider the consequences of changing the way the system currently operates. The first chapter of this environmental impact statement (EIS) lays the groundwork for later chapters and describes how the SOR has gotten to this point in the review. Subsequent chapters describe the existing Columbia River system, detail the SOR alternatives developed through this EIS process, discuss the effects of changing how the system functions, and explain the tradeoffs among uses that the various alternatives would precipitate.

The first step in the process was to establish the scope of the study. The three lead agencies held public meetings in 14 cities around the region in August 1990 and consulted with numerous local, state, and Federal agencies on river uses to better define the issues, concerns, and opportunities that would drive the SOR. As

a result of this process, the agencies were able to better define the geographic scope of the study, what studies should be undertaken, what schedule might govern the entire process, and what role the public would play in the review.

### 1.3.1 Geographic Scope

In general, the geographic area of interest for the study is the Columbia River Basin, including the portion that lies in Canada (Figure 1-1). The Columbia River originates at Columbia Lake on the west slope of the Rocky Mountain Range in British Columbia. The river flows from Canada into the United States, travels through Washington State, and eventually forms part of the border between Oregon and Washington. Extending a total of 1,214 miles (1,953 kilometers [km]), the Columbia River flows into the Pacific Ocean near Astoria, Oregon. Three major tributaries in the United States are the Kootenai, the Clark Fork-Pend Oreille, and the Snake.

The specific scope of the SOR encompasses 14 Federal dams on the Columbia and lower Snake Rivers (shown on Figure 1-1) that have major influence on multiple-purpose system operation, and for which power production is coordinated under the PNCA. These include five storage dams: Hungry Horse, Libby, Albeni Falls, Grand Coulee, and Dworshak; and nine downstream run-of-river projects: Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The SOR includes evaluation of the potential influence of system operating strategies on the lower Columbia River below Bonneville Dam. The review does not evaluate potential impacts at other Federal projects, such as the projects in the Willamette Valley, the Yakima Valley, and on the Snake River above Brownlee Dam, because the operational influence of these projects on the mainstem Columbia River portion of the system is small. Further, in some cases these projects are already being studied under separate authorities. None of the projects on the Snake River above Brownlee is subject to the PNCA or CEAA.

The SOR also evaluated the effects that changing operation of the Federal projects would have on several non-Federal projects, specifically, the five mid-Columbia River dams owned by three PUDs (Chelan, Douglas, and Grant), and Brownlee Dam owned by Idaho Power Company (IPC). Impacts at other non-Federal projects in the system were included to the extent these projects would be significantly affected by any of the alternatives analyzed in the study.

The SOR did not evaluate operation of the Federal projects above Brownlee Dam on the Snake River. These projects meet multiple purpose requirements that leave no flexibility for power coordination under the PNCA, so they were considered outside the SOR scope. Nevertheless, the SOR examined the potential effects on the system if additional water were to become available from the Snake River. It treated the Snake River Basin above Brownlee Reservoir as a "hypothetical" reservoir that could supply varying amounts of river flow at different times of the year. Potential water supplies from the Snake River would be based on voluntary sales that could be accommodated within existing authorities and institutional constraints.

The SOR did not consider changes to operations at the Canadian projects in the Columbia River Basin that would require modifications to the Columbia River Treaty. While consideration of changes to the International Joint Commission (IJC) order on Kootenay Lake was also excluded from the scope of the SOR, changes at U.S. projects that would affect operations at Canadian projects were included. Adjustment to Canadian project operations was proposed as part of some of the SOSs, but such adjustments were within the provisions of the Treaty. The SOR strove to eliminate or minimize changes in inflow patterns at Canadian projects.

### 1.3.2 System Operation Review Process

The vastness and complexity of the Columbia River system presented a challenge to the lead agencies in devising a study process. Not only

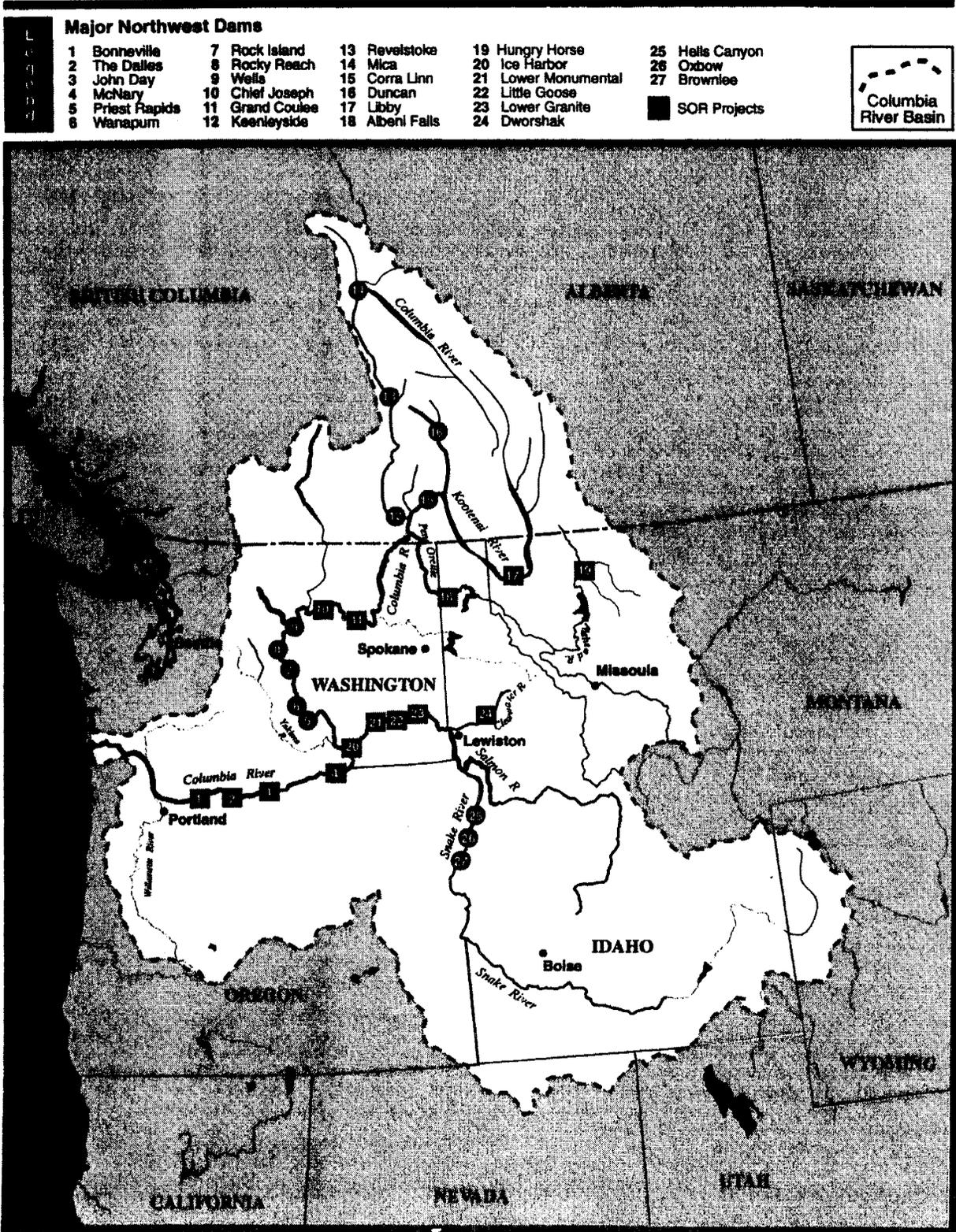


Figure 1-1. Columbia River Basin

did the study have to encompass the many uses of the system, it also had to address those uses from the perspective of three management agencies, four cooperating agencies, and the general public.

The SOR is an extensive, multifaceted study that began in July 1990, when the scoping process was initiated. The SOR Scoping Document, presenting the scope of the study and the methods to be used to analyze alternatives in this EIS, was issued in May 1991. Pilot studies of four river uses were conducted simultaneously with development of the Scoping Document. From July 1991 to August 1992, work groups representing 10 key river uses (identified below) developed and screened 90 initial system operating alternatives. From the initial screening, 10 candidate strategies were formulated for public review in September 1992. Following public comment, seven strategies were identified and developed for full-scale analysis in the EIS. Full-scale analysis of SOS alternatives took place from September 1992 to January 1994. The SOR agencies issued a Draft EIS in July 1994 with a public review period extending into December 1994. Following consideration of the public review comments, the agencies prepared and issued this Final EIS.

During this time, the lead agencies developed and analyzed different approaches to periodically update future SOSs and to give all interested parties opportunities to participate in ongoing and future decisionmaking that affects river uses (the Forum). The agencies also examined alternative ways to meet regional power coordination requirements under the PNCA and allocate the Canadian share of power under the CEAA. All of these efforts culminated in this Final EIS.

The SOR agencies developed a multi-phase study process to accomplish the review in a systematic manner. The following sections summarize the key elements of this process.

## Notice of Intent

The SOR was officially announced to the public on July 18, 1990. On that date, Reclamation, the Corps, and BPA sent a joint press release to newspapers in the Northwest announcing the schedule for public scoping meetings. The following day, July 19, 1990, a notice appeared in the *Federal Register* regarding the three Federal agencies' intent to prepare an EIS. The notice said the EIS would enable the agencies to make decisions on future PNCA and CEAA through an examination of various overall strategies for operating the system.

## Scoping

On July 26, 1990, the three agencies sent information on the scoping meetings to approximately 11,000 groups and individuals. The mailing invited the public to submit written comments on management of the river system and the scoping process. It also included a post-paid card to be returned by those who wished to continue receiving information on the SOR.

Prior to each meeting, the three agencies placed an advertisement in a local general circulation newspaper. The advertisements included a coupon that could be returned to get on the SOR mailing list. When the scoping process closed on September 20, 1990, approximately 600 coupons had been returned.

The scoping meetings, which began on August 6, 1990 in Seattle, were held both in population centers and near project sites. The last meeting was in Idaho Falls on August 23, 1990. In the intervening weeks, meetings were held in Grand Coulee, Spokane, and Kennewick, Washington; Sandpoint, Boise, and Orofino, Idaho; Libby, Eureka, Missoula, and Kalispell, Montana; and Pendleton and Portland, Oregon.

Each meeting began with a brief slide-tape presentation outlining the purpose and need for the review, followed by a question and answer session. Attendees were then invited to discuss their concerns in small group sessions; each group then reported back to the entire audience.

Individuals were also given time to present formal testimony.

Approximately 800 people attended the 14 meetings, and 220 comment letters were sent to the agencies. Hundreds of comments were collected from the scoping meeting records and compiled into a comment matrix. These comments were further compiled into summaries made available to the public in January 1991. The lead agencies analyzed the scope and issues addressed in the comments and used this analysis to prepare a *Scoping Document* released in May 1991.

Following the public meetings and coordination with local, state, and Federal agencies and Indian Tribes, the lead agencies established the geographic and jurisdictional scope of the study and defined the issues that would drive the EIS. Section 1.3.1 described

the scope for the study; Section 1.4 summarizes the issues.

**Project Organization**

The lead agencies established a project organizational structure (Figure 1-2) to analyze the broad range of system operating alternatives. Ten interagency work groups were assigned one river use or resource to consider. These work groups provided a forum for experts and other interested parties throughout the region to work together on analysis for a particular river use. Key objectives were to share ideas and information, bring the best available science to the table, and, ideally, reach consensus on issues.

Overseeing these work groups is an interagency coordination group—the Analysis Management Group (AMG)—which has served

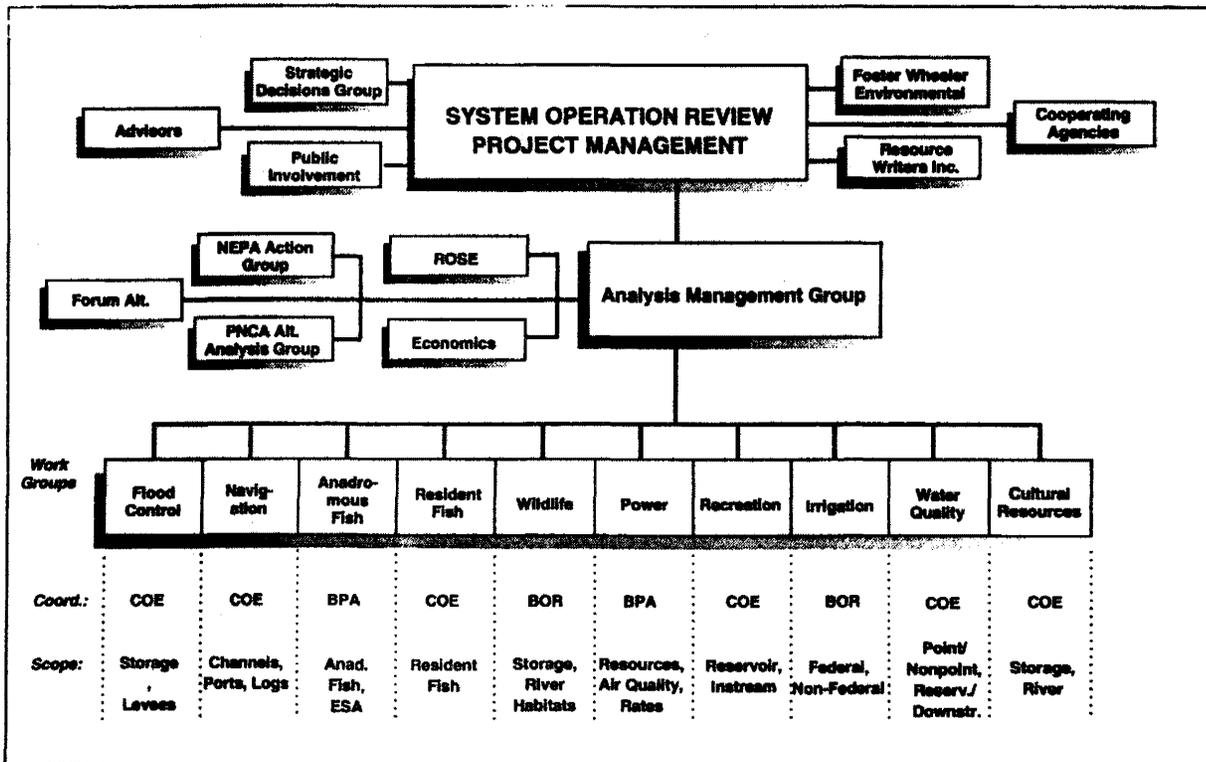


Figure 1-2. Columbia River System Operation Review organization chart

as the hub of the structure through which all processes, findings, and problems are channeled to the decisionmakers. This group, which consists of the SOR project managers from the three lead agencies, the coordinators for the 10 resource work groups, and representatives of each of the three cooperating agencies, provided guidance to the work groups throughout the analysis. Other groups that reported to the AMG included:

- Economic Analysis Group—Conducted analysis of costs and socioeconomic implications of alternatives.
- River Operation Simulation Experts (ROSE)—Developed detailed specifications for system operation to be used as inputs to computer programs known as hydroregulation models, and ran the models to simulate system operations. These models calculate reservoir elevations and flow volumes at various points along the river for a particular operating scenario.
- PNCA Alternatives Analysis Group—Considered different forms of the Coordination Agreement and how they could better meet system needs.
- SOR NEPA Action Group—Provided guidance to work groups on NEPA and other environmental compliance requirements.
- Public Involvement Group—Planned and coordinated logistics for all public involvement activities, including public meetings, newsletters, and other SOR publications.
- Forum Alternatives Work Group—Developed and evaluated alternatives for revising and updating the system operating strategy.
- Contractors—Assisted work groups with study analysis, decision processes, EIS preparation, and public involvement.

### **System Operating Strategy Decision Process**

After analyzing information from scoping, the SOR followed a three-phase decision process for developing a system operating strategy. The first phase was a pilot or test analysis. Then, the agencies invited public participation in the

work groups and began the screening phase. Initial SOS alternatives were identified, and the work groups screened these alternatives to develop candidate strategies for detailed evaluation. The last phase consisted of full-scale analysis of the candidate strategies.

### **Pilot Analysis**

While the scoping document was being developed, the SOR agencies did a "pilot analysis." Its purpose was to become familiar with the decision analysis process and to test the proposed analytical method from start to finish using three operating alternatives. The Anadromous Fish, Resident Fish and Wildlife (later split into two groups), Recreation, and Power Work Groups were created at this point to conduct the test. Work group members at this point only included staff from the three lead agencies.

During this phase, these work groups proceeded through all of the steps of the decision analysis process. They developed a simplified screening model, identified alternatives, evaluated sensitivity, determined key variables, assigned ranges of uncertainty and probabilities, calculated results, and developed conclusions. This phase was accomplished in a 6-month period from November 1990 to April 1991. Each work group documented its results in separate Pilot Analysis Reports.

### **Screening**

#### **Initial System Operating Strategy**

**Alternatives**—The remaining work groups were formed after the pilot analysis confirmed that the study approach was workable. The SOR managers asked the work groups to develop: (1) an alternative that would provide the greatest benefit to their river-use area, and (2) one or more alternatives that, while not ideal, would provide an acceptable environment for their river use. Other alternatives were offered for analysis; some came from the scoping meetings, others were suggested by activities and events taking place in the region that affected river operations, such as the Salmon Summit, the

Corps' 1992 Options Analysis/Environmental Impact Statement (OA/EIS), and the Northwest Power Planning Council's (NPPC's) Fish and Wildlife Program amendments. Overall, 90 alternatives were proposed for the screening analysis.

**Screening Analysis**—The work groups were asked to develop a screening model and use it to evaluate alternatives based on their impacts on key value measures associated with their river use. For example, the Anadromous Fish Work Group not only attempted to define ideal operating conditions for salmon and steelhead, but also evaluated the impact of different operations proposed by other work groups on conditions for those fish populations. To screen alternatives, the work groups established "value measures" or yardsticks by which they could quantify changes to their river use resulting from the various river operating scenarios represented by the alternatives.

Screening was very systematic and carefully planned. Each alternative was reviewed by ROSE and refined by the work groups until it could be simulated using the hydroregulation model. The agencies ran simulations for all 90 alternatives to determine how physical river conditions would respond to each one. Printouts of each model run showed the average monthly streamflows, end-of-month reservoir elevations, power generation, and other outcomes from the proposed operating scenario. ROSE prepared an operating "base case" that each group used to evaluate the results. The base case, which was the 1990-91 annual operating plan for the river system, represented how the system operated prior to changes made for the 1992 operating year. The work groups compared the impacts of a particular alternative on their river use to this baseline operation. In the end, the 10 work groups ranked each alternative according to its impact on their river use.

The screening process not only revealed the effects of alternatives on river uses, it showed the region new things about the river system and helped to clarify relationships that exist among river uses. It provided a perspective on current

operations and how they serve the various river uses. It also showed that there were many other opportunities or methods for meeting particular river-use needs. Yet, as certain needs are more fully satisfied, others are affected. One inescapable conclusion of screening was that many of the uses directly competed with each other.

The work groups spent from July 1991 to August 1992 developing and analyzing the 90 alternatives. When the work group results were examined, patterns began to emerge. The SOR managers, work groups, and other representatives of the lead and cooperating agencies placed the alternatives in five groups, based on operating characteristics:

- Base Case—2 alternatives that represent 1991 operations.
- Flow Augmentation—48 alternatives that would modify flow requirements to benefit anadromous fish.
- Drawdown—16 alternatives that would draw down lower Snake River and John Day reservoirs to benefit anadromous fish.
- Stable Pools—20 alternatives that would stabilize reservoir elevations to benefit primarily resident fish, wildlife, and recreation.
- Power—4 alternatives that would change system planning and operation to benefit power generation.

The results of screening were documented in a two-volume *Screening Analysis* report that was published in June 1992 and widely distributed. Using these results, the alternatives were further sorted and categorized according to their effects on river uses. Some were very similar in effect; some would benefit some river uses, but have large negative impacts on others. The SOR team concluded that each of these categories of effects represented a single operating strategy.

**Full-Scale Analysis/Draft EIS**—By blending the numerical screening data, the categories of effects, and qualitative factors, the SOR agencies initially developed 10 candidate system operating strategies for consideration by the public and

agencies in September 1992. This review was accomplished through a series of 14 mid-point public meetings, held in essentially the same locations as the scoping meetings, and through review of the screening documents. Following public review of the candidate strategies, in late 1992, the lead agencies refined these candidates into seven alternative strategies for full-scale analysis.

Chapter 4 of the Draft EIS described the original seven SOSs and evaluated these operating strategies. The work groups conducted full-scale analysis in a manner similar to screening. ROSE developed hydroregulation model specifications for each of the SOSs (which, with their respective options, numbered 21 in total), and provided the resulting model output to the work groups. The work groups applied their own impact analysis models and procedures to the hydroregulation results, assessed changes in key value measures for their respective resources, and formulated impact conclusions. The July 1994 Draft EIS documented the results of the full-scale analysis.

**Final EIS**—Based on the public and agency review of the Draft EIS, and the outcome of related, concurrent regional processes, the SOR agencies revised the original set of SOS alternatives. A number of the original 21 SOS options were eliminated from further detailed consideration, generally because they were very similar to other options or would not sufficiently address the objectives of the SOR. Several new alternatives that reflected operating strategies developed through the Marsh settlement proceedings were added to the set of SOSs. The work groups re-evaluated, modified, and updated their original analyses for a resulting set of 7 strategies with 13 total options, essentially repeating the process described above for full-scale analysis. The results of this process are reported in the Final EIS.

#### **Forum Process**

Planning for river system operations is a continuing effort, and the SOR is the vehicle for the Federal agencies to develop a way to

periodically re-evaluate and update the preferred SOSs. At issue is how to provide other interests, such as environmental and citizen groups, tribes, state and Federal fish and wildlife agencies, and industry representatives, a way to help shape future operating decisions on the Columbia River system. The agencies named this new collaborative approach "the Columbia River Regional Forum." Seven alternatives, analyzed in this document, aim to improve opportunities for other interests to debate system operation issues before decisions are made and to resolve conflicting recommendations in a way that considers all river uses. The Forum Alternatives Work Group developed and evaluated the alternatives. This group coordinated with a variety of regional interests in identifying and assessing Forum alternatives. Two workshops open to all interested parties were held in 1993. The SOR agencies received further input on the Forum alternatives through the review of the Draft EIS.

#### **Pacific Northwest Coordination Agreement Process**

As described above, the PNCA is a contract for coordinating power generation among Federal parties and 15 other generating utilities. Coordination means major hydro generating facilities are operated as though they belong to a single owner. This results in more efficient power production from the available water. In 1992, the SOR managers established a PNCA Alternatives Analysis Group to consider different forms of the PNCA and how to meet power coordination needs through the year 2024. That group recommended the five alternatives analyzed in this EIS, and conducted a qualitative assessment of the environmental, power generation, and financial implications of the PNCA alternatives.

#### **Canadian Entitlement Allocation Agreement Process**

The CEAA expire in 2003, although obligations to return Canadian Entitlement power to Canada begin in 1998. These agreements established how the Canadian Entitlement was

attributed collectively to the six Federal and to each of the five non-Federal projects located downstream of Canadian Treaty storage. Since the obligation to return the Canadian Entitlement to Canada exists, at a minimum, until 2024, new agreements between the U.S. Entity and the non-Federal project owners will be required to establish obligations to produce the Canadian Entitlement. Environmental review must take place before BPA, acting on behalf of the U.S. Entity, can sign the new agreements. The SOR analyzes alternative ways of allocating the obligation among Federal and non-Federal parties. The alternatives represent the range of possible outcomes for negotiating new agreements. Lead agency staff who were familiar with the power system and the Canadian Entitlement described these alternatives, characterized their consequences, and documented the result in a technical appendix on the CEAA.

### EIS and Technical Appendices

SOR analyses culminated with preparation of the Final EIS and accompanying technical appendices. Each work group prepared a technical appendix to present its analysis, from scoping through full-scale analysis. Each appendix contains an introduction and discussion of major issues, a characterization of the affected environment, a discussion of methods, a detailed analysis of the impacts of each of the seven SOS alternatives on the respective river use, a comparison of alternatives, and a discussion of mitigation measures where applicable (see Appendices B through O). These technical appendices provided the basis for developing and analyzing alternative system operating strategies in this EIS. The EIS Main Report summarizes a wealth of information gathered over 5 years of study and analysis. It presents the very technical information from the appendices in a simplified and summarized form.

The lead agencies followed a similar but condensed process to develop alternatives for the other three SOR actions (see Appendices P, Q, and R). Three sets of multiple alternatives were identified for reviewing and updating the SOS,

renewing or revising the PNCA, and establishing CEAA obligations. These sets of alternatives are presented as independent from each other and from the SOS alternatives.

### 1.3.3 Public Involvement

The SOR provided extensive opportunities for individuals and organizations representing all interests to express their concerns and make recommendations for system operation. In addition to the activities mentioned earlier in the description of the study process, the SOR public involvement staff conducted the following activities as part of the SOR:

- Developed and continually updated a large project mailing list.
- Mailed coordination letters to over 50 government agencies in the summer of 1991 to encourage their participation and solicit their views.
- Held six roundtable discussions in the fall of 1991 to bring the public up-to-date on the SOR.
- Invited members of the public to join the work groups.
- Issued numerous publications describing various aspects of the Columbia River system and the SOR. These include:
  - The Columbia River: A System Under Stress*
  - The Columbia River System: The Inside Story*
  - Screening Analysis: A Summary*
  - Screening Analysis, Volumes 1 and 2*
  - Power System Coordination: A Guide to the Pacific Northwest Coordination Agreement*
  - Modeling the System: How Computers are Used in Columbia River Planning*
  - Daily/Hourly Hydrosystem Operation: How the Columbia River System Responds to Short-Term Needs.*
- Published and mailed 20 editions of the SOR newsletter *Streamline*.
- Held nine public meetings at locations throughout the region in the fall of 1994, to facilitate review of the Draft EIS and receive public comment.

- Set up a toll-free telephone number that has been functioning since the beginning of the SOR (1-800-622-4519).

Newsletters kept the public informed on a regular basis throughout the SOR. Public involvement opportunities also continued throughout the process. After the public comment period on the Draft EIS, comments were analyzed and addressed in this Final EIS. Decision documents on the PNCA, CEAA, and the SOS will be issued following release of the Final EIS, which also indicates agency plans for implementing the Forum process. These actions will complete the SOR analysis, although periodic re-evaluation of system operations will continue through the Forum.

#### 1.3.4 Tribal Coordination

The SOR lead agencies made an ongoing effort to coordinate with the 14 Federally recognized Indian tribes in the Northwest that could be affected by the SOR. Coordination activities have included formal letters, informal telephone contacts, briefings, meetings, distribution of information materials, and development of contracts for selected work products. The SOR team sent formal letters with information on the status of the SOR, suggestions for several ways for tribes to participate in the SOR, and offers to meet with the tribes in June 1991, August 1992, and July 1993. The lead agencies held a general coordination meeting with representatives of eight of the tribes in September 1993. Since that time, the SOR agencies have carried out several additional coordination meetings with tribes, have visited a number of the reservations, and have generally worked to facilitate participation of the tribes in the SOR process.

Tribal representatives participated in the Wildlife, Resident Fish, and Cultural Resources Work Groups to varying degrees during the SOR. Moreover, the SOR agencies contracted with 12 Indian tribes or tribal organizations to evaluate the effects of the dam operations on Native American cultural resources interests. The tribal organizations with SOR contracts

include the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, the Burns Paiute Tribe, the Confederated Tribes of the Warm Springs Reservation, the Shoshone-Bannock Tribes, the Colville Confederated Tribes, the Spokane Tribe, the Kalispel Indian Community, the Coeur d'Alene Tribe, the Kootenai Tribe of Idaho, and the mid-Columbia River Council. Section 9.2 and Appendix D contain additional information on tribal coordination.

Tribal coordination has resulted in input on a variety of issues. Individual tribal representatives have expressed particular concerns related to Federal trust responsibilities to the tribes; the unique relationship between the tribes and the Federal government; and the SOR scope, alternatives and impact analyses. Some of the documentation submitted by the tribes listed above on the effects of dam operations on these issues are included as Exhibits 1 through 10 to the Main Report. Contributions from the tribes that are focused on cultural resources, their evaluation and preservation are printed as exhibits to Appendix D, Cultural Resources.

#### 1.4 KEY ISSUES AND CONCERNS

The Columbia River was dubbed "A System Under Stress" in 1990, when the SOR began. Growth in the Northwest has put steadily increasing pressure on the river system, and there is no longer enough water to fully satisfy all of the demands. The results of the EIS analysis bore this out. In scoping and throughout the SOR, much of the discussion of issues focused on the specific needs of an individual river use or resource as discussed in Section 1.4.2. The study demonstrated, however, that all of the individual resource issues must be considered within the context of two overriding issues that relate to constraints on the system and its operation—how decisions are made and salmon recovery.

### 1.4.1 Key Issues

It became clear during the study that for every action there is a reaction. Operating the system to maximize conditions for one use may worsen conditions for some other use. Relieving the stress in one part of the system may cause it to build in another. The SOR revealed no perfect balance. Rather, it did make clear that one key issue being addressed in this EIS is how to better resolve the conflicts among resources.

A major aspect of this issue is not so much what decisions will be made to resolve conflicts among resources, but how those decisions will be made. A major issue identified in scoping was the perception by fish and wildlife agencies and the Indian tribes that they were excluded from meaningful decisions about system planning and operations. These parties felt that key decisions about the system were dominated by the Federal managing agencies and the region's utilities in closed processes that did not equitably account for environmental values. This feeling of "lacking a seat at the table" demonstrated much of the need for the Forum and helped lead the SOR agencies to encourage broad participation on the SOR work groups.

Another dominant issue that affects all resources in the same way is the status of salmon stocks that use the Columbia River system. The formal listings of the Snake River sockeye salmon as endangered and the spring/summer and fall chinook salmon as endangered under the ESA have significant implications for



*Snake River Sockeye  
Endangered (1991)*



*Spring/Summer & Fall Chinook  
Endangered (1994)*

the future operation of the Columbia River system. The ESA prohibits any Federal action that is likely to jeopardize the continued existence of a threatened or endangered species or destroy or adversely modify its critical habitat, and it requires the development of plans to help threatened and endangered species recover. The listings triggered preparation of a NMFS recovery plan and Federal agency consultation on the effects of actions, including operation of the Columbia River system, on listed salmon. In April 1994, the Snake River Salmon Recovery Team, appointed by the NMFS, issued draft recommendations for salmon restoration and recovery. Following public and peer review, the Recovery Team issued final recommendations in October 1994. They addressed measures ranging from construction to research in type, and from ocean to headwaters in scope. NMFS used these recommendations and other input in developing a draft recovery plan that was released in March 1995. The portions of the draft recovery plan addressing Columbia River operations are the same as the measures recommended by NMFS in its Biological Opinion for operation of the system in 1995 and future years, and are incorporated in the preferred SOS alternative identified in the Final EIS. The ESA makes survival and restoration of the three salmon stocks an overriding issue in operation of the Columbia River system, and places significant constraints on system operations.

### 1.4.2 Resource Concerns

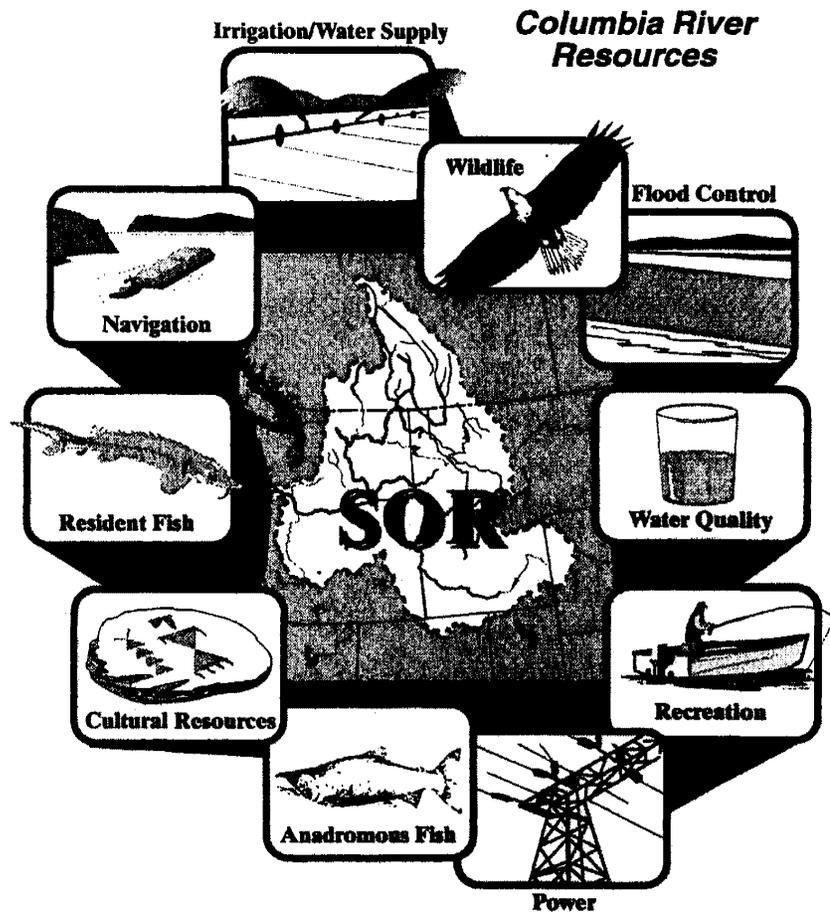
It is clear that not all interested parties agree on the way the river system is currently managed or the way it should be managed in the future. For example, recreational boaters are pressing for full, stable reservoirs for longer periods; power producers want to use the water stored in the system on their preferred schedule, to maximize power generation; and fisheries advocates want operations that will restore habitat and improve migratory conditions. The following is a short description of each major river resource and a summary of concerns about each expressed during the SOR.

**Navigation:** People who operate or have an economic tie with ships, boats, barges, and port facilities on the Columbia/Snake River waterways are the key navigation interests on the Columbia River system. These navigation interests emphasize the importance of waterborne commerce as an element of the regional economy and the need to maintain adequate channel depths for navigation.

**Flood Control:** People who have homes, farms, or businesses in flood-prone areas are the flood control interests of the Pacific Northwest. Maintaining existing levels of flood control was accorded high priority, along with the need to fine-tune planning and flood forecasting for more efficient reservoir storage and water releases.

**Irrigation Water Supply:** The primary irrigation customers of the Columbia River system are farmers who divert or pump water from the rivers to irrigate crops. These customers emphasize the economic benefits of agriculture to the region. Their key concerns are maintaining adequate reservoir elevations to accommodate irrigation pumps, and the availability of stored water for irrigation.

**Power Generation:** Every electricity user in the Northwest is a direct or indirect beneficiary of hydropower produced on the Columbia River system. Further, a large quantity of surplus Columbia River power is sold throughout the western United States and Canada. Many users stressed how vital hydropower is to the regional economy. Some expressed concern that "clean" hydropower might be traded for what they



consider to be expensive, unproven, and more ecologically damaging sources of energy in an effort to save fish. Other power-related concerns spoke to the need for energy conservation, increased generating efficiency, and keeping electric rates low.

**Anadromous Fish Survival:** Anadromous fish interests range from commercial, Native American, and sports fishing groups to state and Federal fisheries management agencies. The opinion of the majority of these interests is captured in the statement: "Federal agencies should accept stewardship responsibilities for fisheries resources and thereby meet the public trust." For some areas of the region,

anadromous fish resources were lost with the construction of the dams.

**Resident Fish and Resident Fish Habitat:** The primary interests related to this resource are anglers, businesses that serve them, some of the region's tribes, and state and Federal fisheries management agencies. These interests say resident fish should be considered to be just as important as anadromous fish in system operations. In fact, for some tribes resident fish have substituted for anadromous fish that were formerly present. They generally would like to see storage reservoirs operated to benefit resident fish, or to limit the effects of storage operations on resident fish.

**Wildlife and Wildlife Habitat:** Resource managers, hunters, and sightseers constitute important interest groups for this resource. They seek more emphasis on wildlife in system operations, including preservation and restoration of habitat and wetlands, improving water quality, and changing river flows to benefit wildlife.

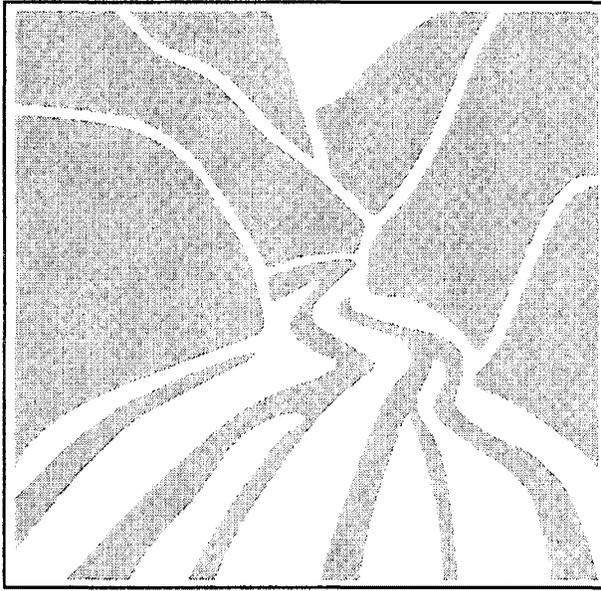
**Recreation:** The recreational facilities and activities made possible by Federal projects on the Columbia River system provide a livelihood for many people. Boaters and marina owners represent these interests, as do local, state, and regional agencies that provide recreational or related services. These interests emphasize the economic and social impacts reservoir operations have on regions and communities dependent on recreation and tourism.

**Cultural Resources:** Humans have lived along the Columbia River for over 10,000 years, and the prehistoric and historic artifacts and sites located along the river banks constitute an important and finite record of this activity. Traditional cultural properties valued by Native Americans are also cultural resources. These properties include Indian treaty fishing sites at usual and accustomed places, and places and natural resources important to the contemporary way of life of tribal groups. Native Americans, professional and amateur archaeologists and historians, and state and Federal agencies are

particularly interested in protecting the region's cultural resources, and Native Americans want to be involved as co-managers of the resources. These interests would like to minimize damage to artifacts and sites that result from reservoir fluctuations, wave and wind action, and inundation. They also are concerned about losses due to vandalism and looting.

**Water Quality Conditions:** Virtually everyone in the Northwest has a stake in water quality. The primary water quality issues related to reservoir operations are dissolved gas supersaturation, water temperature, and sediment. Federal, state, and local agencies and environmental groups represent water quality interests.

**Economic and Social Conditions:** Everyone in the Northwest has an economic stake in the Columbia River system. The relatively cheap hydropower the river provides is an important element in the region's economic life. Throughout the study, commenters expressed concern about the economic effects of any sweeping changes in-river operations, and the social implications of potential economic disruption.



## Chapter 2

# The Columbia River Basin

## 2.0 THE COLUMBIA RIVER BASIN

This chapter describes the existing environment and resources of the Columbia River Basin. The description includes physical and biological conditions, as well as the human environment that has grown up around the natural resources. The affected environment of the Columbia River Basin can be described in voluminous detail. The purpose of this chapter is, however, to identify, as concisely as possible, the resources affected by river system operations and to supply a context for evaluating the impacts of SOR alternatives on those resources. The technical appendices provide extensive supporting details.

The reader can use Chapter 2 in conjunction with Chapter 3 for a complete perspective on affected resources. Chapter 2 addresses the Columbia River Basin as a whole, with emphasis on the river corridor within the SOR geographic scope. Chapter 3 focuses on the facilities, resources, and programs that make up the Columbia River system. Much of the information for these chapters was taken from the SOR technical appendices; *The Columbia River System: The Inside Story*, published by the SOR in 1991; the *Columbia River Salmon Flow Measures Options Analysis/Environmental Impact Statement* (Corps et al., 1992); and the *Interim Columbia and Snake River Flow Improvements for Salmon Supplemental Environmental Impact Statement* (Corps et al., 1993). The latter three documents are incorporated by reference in this EIS.

AFFECTED ENVIRONMENT
<p><b>Chapter 2—Columbia River Basin Resources</b> (e.g., water quality, anadromous fish, recreation, etc.)</p> <p><b>Chapter 3—Columbia River System Facilities and Programs</b> (e.g., dams, fish facilities, resource-based operations, etc.)</p> <p><b>Chapter 2 + Chapter 3 = Affected Environment for NEPA</b></p>

### 2.1 THE NATURAL ENVIRONMENT

The Columbia River is the fourth largest river in North America. It originates at Columbia Lake in the Rocky Mountains of British Columbia, Canada and flows 1,214 miles (1,953 km) to the Pacific Ocean. From its source, the river flows northwest for approximately 200 miles (322 km), then reverses course and travels south for nearly 300 miles (483 km) through mountainous terrain in southeastern British Columbia. The Columbia crosses into the United States near the northeastern corner of Washington State and continues south through highlands before bending westward. After looping again to the east, the river turns westward and flows for over 300 miles (483 km) between Washington and Oregon to the sea.

Three large tributaries of the Columbia River are of primary interest to the SOR: the Kootenai and Pend Oreille Rivers, which join the Columbia River near the U.S.-Canada border, and the Snake River, which joins the Columbia River about 330 miles (531 km) upriver from the mouth. The Columbia River Basin drains over 259,000 square miles (670,810 square km). It produces an average annual runoff at The Dalles of about 173 MAF (213 billion m<sup>3</sup>) (enough water to cover 173 million acres [70 million hectares or ha] to a depth of 1 foot [0.3 m]). The drainage area comprises most of Washington, Oregon, and Idaho; the western quarter of Montana; the southeastern corner of British Columbia; and small portions of Wyoming, Utah, and Nevada.

The following sections describe the natural environment of the Columbia River Basin, including the earth resources (geology, landforms, and soils), air and water resources, and aquatic and terrestrial life that could be affected by river operations.

### 2.1.1 Earth Resources

Although the geology of the Columbia River Basin is not affected by system operations, geologic factors such as soil erodibility and slope stability must be considered by the SOR. Some knowledge of regional geology, landforms, and soils is helpful in understanding the physical effects of system operations (see Appendix L). In addition, biological and human resource patterns are strongly influenced by the physical processes and resources present.

#### Landforms

Landforms include mountains, highlands, valleys, plateaus, and plains. The landforms present in an area are determined by the underlying geology, present and past climates, and geomorphic processes, which include erosion and sedimentation. Geologic and geomorphic similarities allow broad regions to be grouped as physiographic provinces. The Columbia River Basin includes portions of eight distinct physiographic provinces (Figure 2-1), as summarized below.

#### *Northern Rocky Mountains*

Central, northern, and eastern Idaho, western Montana, western Wyoming, and southern British Columbia are covered with numerous ranges that make up the Northern Rocky Mountains. Elevations rise from 2,000 feet (610 m) in the lowest valleys to more than 10,000 feet (3,048 m) on many of the peaks. The Snake River and its two principal tributaries, the Salmon and Clearwater Rivers, drain the southern part of this province; the Columbia River in Canada and its tributaries, the Kootenai and Pend Oreille Rivers, drain the northern end of the range. The Spokane River lies between the Kootenai and Pend Oreille Rivers and drains a large area of northern Idaho. The Libby, Hungry Horse, and Dworshak projects are located within the Northern Rockies province.

#### *Columbia Mountains/Okanogan Highlands*

This province is a complex of high, glaciated mountains to the north, and lower, semi-arid mountains and narrow plateaus to the south. The Okanogan Highlands are an area of relatively low, semi-arid mountains located between the Northern Rockies and the Cascade Mountains. This province includes south-central British Columbia, northeastern Washington, and the very northwestern corner of Idaho. Elevations range from about 1,000 feet (305 m) at the lowest point on the Columbia River to nearly 8,000 feet (2,438 m) at some peaks in British Columbia. Several Canadian dams on the Columbia and Kootenay Rivers are within the Okanogan-Selkirk Highlands, while the Grand Coulee and Albeni Falls projects are situated along the southern edge of the province.

#### *Cascade Mountains*

The crest of the Cascade Mountains defines most of the western edge of the basin. Elevations along the crest are generally about 5,000 feet (1,524 m), but several volcanic peaks of this range rise above 10,000 feet (3,048 m). Mount Rainier is over 14,000 feet (4,267 m); Mount Adams is over 12,000 feet (3,658 m); and Mount Baker, Mount Hood, Mount Jefferson, and the Three Sisters are all over 10,000 feet (3,048 m). Except for a narrow gorge where the Columbia River has cut a path to the ocean, the Cascade Mountains separate the coast from the interior of the region and strongly influence the climate. Bonneville is the only SOR project located in this province.

#### *Columbia Plateau/Columbia Basalt Plain*

This plateau extends from north-central Washington to just below the border with Oregon. It slopes from elevations of nearly 4,000 feet (1,219 m) around the margins to about 500 feet (152 m) along the gorges of the Columbia and the lower Snake Rivers. Many small rivers drain the area, which extends south from the Canadian border to the Blue Mountains, west to the foothills of the Cascades, and east above the Snake River to the Rocky

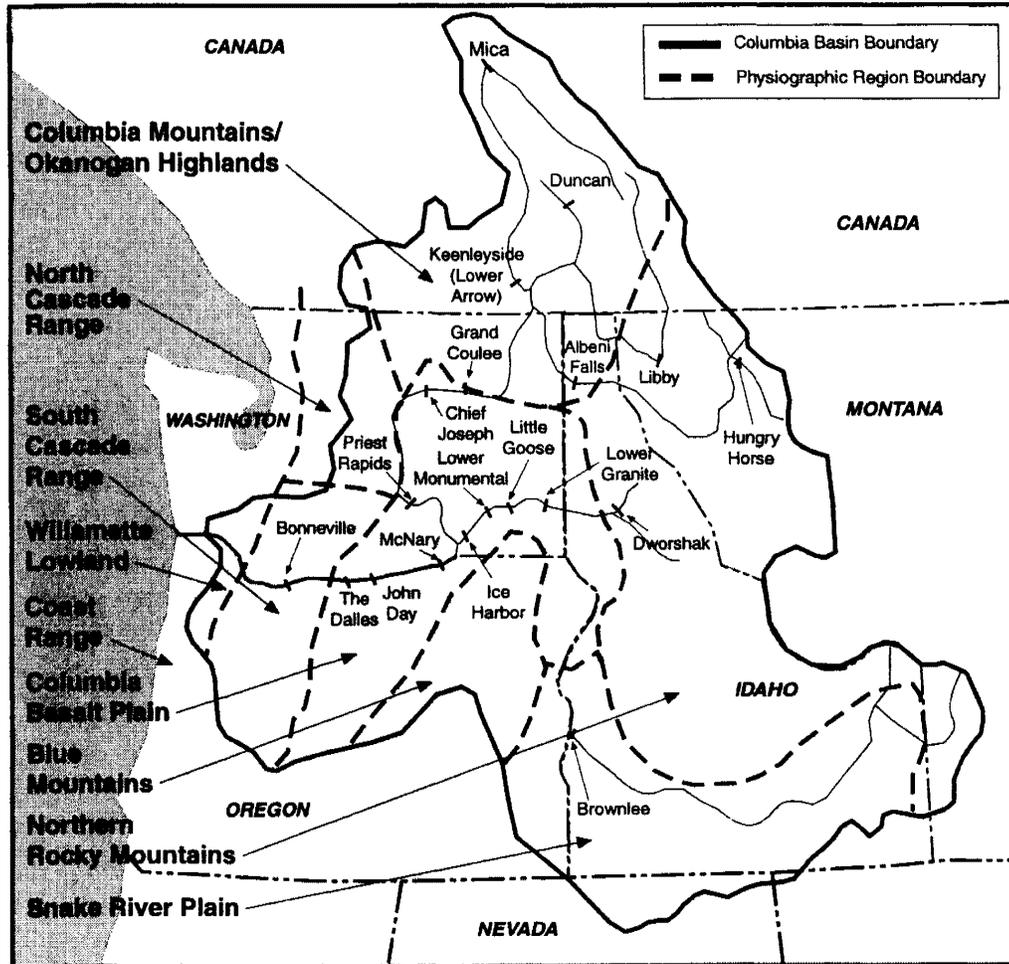


Figure 2-1. Physiographic provinces

Mountains in eastern Idaho. Nine of the 14 Federal projects in the SOR are located within or along the edge of this province. These projects include all four lower Snake River projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor); McNary, John Day, and The Dalles on the lower Columbia; and Grand Coulee and Chief Joseph. In addition, five non-Federal dams on the middle Columbia River are within the Columbia Plateau.

**Snake River Plain**

The Snake River Plain extends from southeastern Oregon across southern Idaho and

includes parts of northern Nevada and Utah. Elevations range from 3,000 feet (914 m) along the Snake River to more than 10,000 feet (3,048 m) at peaks along the basin's fringes. None of the projects specifically addressed by the SOR is within this physiographic province.

**Blue Mountains**

The Blue Mountains lie to the southeast of the Columbia Plateau and extend from southeastern Washington to central Oregon. Peaks in the Blue Mountains and associated ranges rise from 7,000 to 9,000 feet (2,134 to 2,743 m), while peaks in the Wallowa Range on the east rise to more than 10,000 feet (3,048 m).

This area is drained by the John Day and Crooked Rivers, flowing west and north; the Umatilla and Walla Walla Rivers, flowing west to the Columbia; and the Grande Ronde, Malheur, and other smaller tributary streams, draining east to the Snake River. The Blue Mountains province takes in the middle Snake River reach, including the Hells Canyon Complex of IPC projects (see Section 3.1.2).

### **Willamette Lowland**

This area is mostly below 1,000 feet (305 m) in elevation and is largely made of alluvial materials carried by ancient glaciers and streams. The trough is between 30 to 50 miles (48 to 80 km) wide and about 350 miles (563 km) long. The Willamette River in Oregon drains the area south of the Columbia River. In Washington, the Lewis and Cowlitz Rivers are key tributaries to the Columbia River. No projects within the SOR scope are located in this province.

### **Coast Range**

A small portion of the Coast Range drains to the Columbia River. Elevations in this portion of the basin range from zero to about 4,000 feet (1,219 m). All of the SOR projects are upstream of this province.

### **Geology**

The Columbia River Basin is geologically diverse. Bedrock in the northern and eastern basin is generally sedimentary and metamorphic rocks of the Northern Rocky Mountains and Okanogan-Selkirk Highlands; igneous rocks of the Cascade Mountains and the Columbia Plateau form the bedrock in the western, southern, and central basin.

The Northern Rocky Mountains were formed by extensive folding and thrust-faulting of a series of metamorphic and sedimentary rocks. Glacial action profoundly altered the valleys of the northern and eastern sections of the basin, and extensive glacial deposits remain in certain areas. The Okanogan-Selkirk Highlands consist

primarily of granitic, metamorphic, and sedimentary rock.

The Columbia Plateau, or Columbia Basalt Plain, was formed by a series of lava flows extending from the Rocky Mountains to the Cascades and from the Okanogan Mountains to south of the basin. Over millions of years, lava poured out of the earth and formed layers that are called the Columbia River Basalt Group (Galster and Sager, 1989). These basalts blocked rivers and formed lakes; several areas have sedimentary rocks, associated with these rivers and lakes, inlaid between the layers of basalt.

The South Cascade Range consists of a series of Quaternary volcanoes over older volcanic and granitic rocks. The North Cascades are composed of a series of metamorphic terrains and igneous intrusions, and differ from the South Cascades in the relative absence of tertiary volcanics. The Blue Mountains have a core of volcanic and sedimentary rocks with younger sequences of volcanics occurring in the southern and western parts of the province.

### **Soils**

Erosion and sedimentation are important physical processes within the Columbia River system. In broad terms, these geologic processes involve movement of surficial geologic materials, or soils. The susceptibility of surface materials to erosion depends upon a variety of structural characteristics.

Soils west of the Cascade Range are generally deep residual or glacial deposits, interspersed with rich, alluvial stream bottoms. River valleys such as the Cowlitz and Willamette typically have a thin layer of recent floodplain alluvium over sandy- and clay-loam soils developed from older deposits (Pacific Northwest River Basins Commission [PNRBC], 1970).

East of the Cascades the river valleys and lower terraces are predominantly young alluvial soils. Uplands throughout a large area of the

Columbia River Plateau in south-central and eastern Washington, central Idaho, and north-central Oregon have a covering of loessal (fine, wind-blown) soils. These soils are typically deep and fertile, but are easily eroded. Columbia Plateau uplands also have areas of glacial outwash materials and silts from former lakebeds.

Several types of soils are found in the Rocky Mountain portion of the basin. Valley floors typically have surface deposits of glacial drift, outwash, and alluvium. Some soils developed on these materials are coarse and non-organic, while others are dry and fertile. Upland soils are typically derived from metamorphic or granitic rocks, and tend to be relatively coarse and permeable.

### 2.1.2 Water and Air Resources

The Columbia River Basin is climatically diverse, with conditions ranging from mild and rainy to semi-arid. The climate largely determines hydrologic patterns, which are critical to system operations. The climate also strongly influences air and water quality.

#### Climate

The climate in the Columbia River Basin ranges from mild maritime conditions near the river's mouth to near desert in some inland valleys. The Cascade Mountains separate the coast from the interior of the basin and divide Washington and Oregon into two distinct climatic regions. The coastal climate is mild and wet, with only occasional extremes of temperature. East of the Cascades, the interior climate has far greater extremes. Here most of the precipitation is in the form of snow, and summers are hot and dry. The Columbia and Snake River Plateaus are generally semi-arid with little or no rain during the summer growing season and only small amounts of snow during the winter. Relatively large amounts of precipitation occur in the mountains, and many of the higher Cascade and Rocky Mountain peaks retain glaciers.

Annual precipitation varies from approximately 180 inches (4,572 millimeters [mm]) over small areas in the Cascade Range to less than 6 inches (152 mm) over portions of the plains of southern Idaho and eastern Washington. A large part of the basin receives less than 20 inches (508 mm) of precipitation annually. Over about three-quarters of the Columbia River Basin, maximum precipitation occurs during the winter. Deep snow accumulates over most of the mountainous areas, and the water is held in natural storage until the spring runoff. In the mountains in the eastern part of the basin, where the effect of the Continental Divide is greater than that of the ocean, most precipitation occurs in May and June. Low-pressure areas from the hot southerly interiors extend north and cause heavy showers and occasional cloudbursts during the spring and summer.

Drought conditions (periods of relatively low precipitation) in the basin directly affect water users, and indirectly affect others whose businesses or enterprises depend on Columbia River resources. Because most of the basin is a dryland climate with limited precipitation, the extent and frequency of droughts are of paramount importance. Since 1980, the basin has had 7 years of below-normal precipitation (Clearing Up, 1993). Precipitation was approximately 15 percent below normal in 1987, 1988, and 1992, and 8 percent below normal in 1985.

#### Hydrology

Runoff patterns in the basin generally fall into two categories: (1) snowmelt east of the Cascade Mountains, and (2) rainfall west of the Cascade Mountains. But the Columbia River Basin is primarily a snow-fed system. Snow accumulates in the mountains from November to March, then it melts and produces runoff during the spring and summer. Runoff and streamflows normally peak in early June. In late summer and fall, rivers recede. In the Columbia River, water levels are lowest during October and increase very little until April.

East of the Cascades, the major runoff occurs when the snow is melting in the mountains, predominantly from May through June. Streamflows gradually rise over a period of a month, peaking in early June (Figure 2-2). Streamflows fluctuate because variations in air temperatures and the intensity of the sun's rays affect the rate of snowmelt. Occasionally rainfall significantly increases the runoff. Flows can decline very sharply, or they can be prolonged by snowmelt, drainage from natural basin storage, and groundwater outflow. During the winter, occasional rain and snowmelt in lower parts of the basin cause streamflows to increase for periods of several days. The increased streamflows can cause significant flooding along the lower Columbia and tributary rivers.

West of the Cascades, there is more rain in the winter than snow. Tributary streams respond quickly to these rains, and streamflows might peak within a couple of days after a storm. Most of the rain and the resulting runoff occurs from October to March. Moderate streamflows continue through the spring, fed by late snowmelt from high elevations and groundwater outflows.

### Water Quality

The physical, chemical, or biological condition of water is referred to as water quality. The quality of water in the Columbia River Basin is important for several reasons: fish and aquatic plants require relatively clean water to live; treatment costs for drinking and industrial supplies are higher if water is polluted; people want clean, attractive water for recreation; farmers need clean water to irrigate crops; and wildlife depend on rivers for clean, safe drinking water. The following summary of water quality conditions is based on the Assessment of Water Quality Problems and Needs for the

Columbia River Basin (Corps, 1984a), except where otherwise noted. Appendix M, Water Quality, discusses these subjects in more detail.

Water quality in the Columbia River is generally good. The river carries a large volume of relatively unpolluted surface water. Compared to many other rivers in the United States, there are fewer sources of industrial and municipal wastes. Waste disposal and treatment laws and voluntary efforts have changed discharge practices over the past 20 years. But several types of water quality issues remain in the basin today, including: (1) nonpoint source additions; (2) water withdrawal for irrigation; (3) impoundments; and (4) point source effluents.

### Nonpoint Sources

Nonpoint source pollution comes from a wide variety of sources, including irrigation return flows, forestry practices, malfunctioning septic systems, urban runoff, and mining leaches. Irrigation is the dominant nonpoint source of pollutants in the Columbia River Basin. Its effects are most noticeable along the Yakima River and in the mainstem Columbia River from just upstream of Wanapum Dam to its confluence with the Snake River. Currently, 7.3 million acres (3.0 million ha) of land in the Columbia River Basin are irrigated. Irrigation

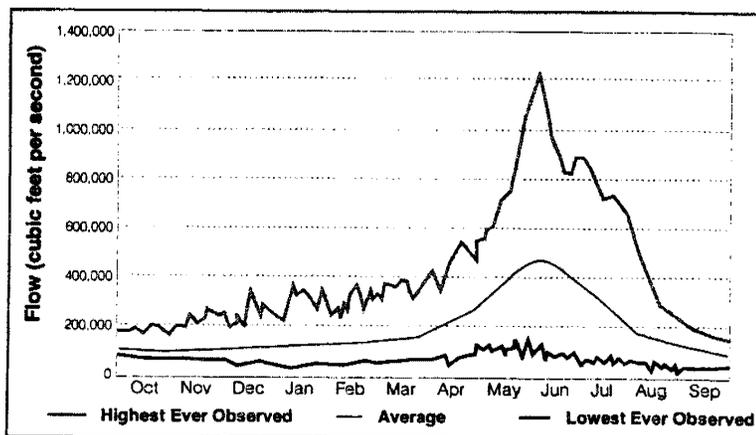


Figure 2-2. Columbia River streamflows as measured at The Dalles

affects water quality through withdrawal and subsequent flow reduction, and through return flows that carry nutrients, pesticides, herbicides, suspended sediments, and salts. Because farmers irrigate from April to October, flow reduction effects occur during the summer, when natural flows are low and water temperatures are warmer. Low water compounded by irrigation withdrawals intensifies the effects of nonpoint source and point source contaminants.

Septic tank effluents and urban runoff carry contaminants (e.g., toxic elements, nutrients, and bacteria) to the river through surface and groundwater systems. Generally, urban runoff is the highest during storms or natural peak discharge periods. Septic tank effluents are a continuing problem. Forestry practices can increase erosion from the watershed, resulting in high levels of suspended sediments and high turbidity in streams. Removing streamside vegetation also causes water temperatures to rise. Historical and current mining operations are the sources of mining leachate. Some mining operations divert water from streams for various purposes; return flows can be polluted with toxins and heavy metals. Separation of minerals sometimes requires the use of chemicals and metals harmful to aquatic systems. Mines that have been closed for years can continue to affect streams when precipitation passes through mine tailings or cavities, leaching out heavy metals and acid discharges.

### ***Water Withdrawal***

Diversions from rivers and lakes for irrigation and municipal and industrial supply have depleted instream flows in the basin. While not large, the effect is measurable (see Section 3.3.8 and related discussions), particularly in selected locations or in low-runoff years. With less water, secondary problems affect water quality more because there is less dilution and higher concentrations of pollutants. Applications for water rights are expected to increase as the region grows. This raises concerns about whether there will be enough water in the river for humans or aquatic organisms and has led to increased interest in

programs to establish minimum instream flow levels.

### ***Impoundments***

Impoundments (reservoirs) have interrupted the free-flowing river system and altered the seasonal variations in water discharge patterns. Some water quality conditions that can be affected by dams and reservoirs include water temperature, gas supersaturation, dissolved oxygen, nutrient availability, dispersion of hazardous chemicals, turbidity, and sanitary quality.

Water temperatures can increase or decrease downstream of a dam depending on the ambient conditions and the method of water release from the reservoir. Compared to free-flowing rivers, reservoirs have increased water surface area, retention time, and stratification of the water column. All of these conditions can change temperatures in the reservoirs. Increased surface area and retention time lead to higher temperatures, while stratification results in warm water near the surface and cold water in the deeper levels of a reservoir. In addition, reservoirs alter the seasonal variations in stream temperature. Compared to natural inflows, large reservoirs typically release cooler water in the spring and summer, and warmer water in the fall and winter.

Gas supersaturation is seasonal; it occurs primarily during the spring runoff. When discharge from a reservoir is more than the powerhouse hydraulic capacity, the project is forced to spill water. The spilling water carries nitrogen from the air into the plunge pool. In the plunge pool, increased hydrostatic pressure deep in the water dissolves the nitrogen and supersaturates the water with nitrogen gas.

In addition to altering the physical characteristics of the flowing water, dams provide excellent growing conditions for algae. Algal blooms occur where water velocity is low, and nutrients, light intensity, and temperature are relatively high. Irrigation returns, industrial effluents, municipal wastes, and runoff from

both urban and rural areas carry nutrients. When they are discharged into the water, they encourage the growth of algae.

Algal blooms and organic matter affect the water quality in reservoirs. Bacteria use the organic matter in algae and the nutrient inputs to grow and reproduce. A number of stream reaches in the basin have low dissolved oxygen concentrations because, when organisms decay or break down the wastes, they use the oxygen supply. This depletes the dissolved oxygen levels available for other aquatic species. Additionally, oxygen replacement decreases the longer the water stays in a reservoir. This effect is even more pronounced in reservoirs that are stratified. The deeper water might experience long periods of little or no exchange with the surface water, which is aerated by the atmosphere.

In reservoirs, turbid storm waters are held and released at a slower rate into calm, clear water. This prolongs downstream turbidity. On the other hand, because of sedimentation and increased retention, the turbidity peaks are often reduced. Sedimentation might also result in the accumulation of toxic compounds, which have an affinity for sediments. As the velocity of water decreases, the sedimentation increases. Storms or deep water withdrawals can release sediments and contaminants into the water column. When released, the sediments or contaminants can be accumulated by aquatic organisms and taken into the food chain, which can eventually pose a hazard to humans.

### **Point Sources**

Waste effluents from municipal and industrial plants can constitute a continuous source of water pollution. Municipal sewage treatment plant effluents primarily affect water bodies in urban areas, while mining wastes can seriously affect aquatic communities in rural areas. Significant industrial discharges can occur in either urban or rural areas. The Columbia River in general is not highly urbanized, although there are some significant population centers along the mainstem and some of the tributaries. Major

contributors to point source pollution of the Columbia River include pulp and paper industries at Wallula, Washington, Lewiston, Idaho, and Castlegar, British Columbia; metal products industries at Trail, British Columbia; food processing industries on the upper Snake River; and numerous aluminum smelters on the Columbia River. These discharges are regulated under National Pollutant Discharge Elimination System (NPDES) permits.

### **Air Quality**

The air quality of the Columbia River Basin varies widely because it is influenced by local air pollution sources, meteorology, and topography (see Appendix B). In general, air pollution sources can be divided into three categories: (1) urban sources, such as carbon monoxide-producing city traffic and pollutants from industrial plants; (2) major single-point emitters, which include coal-fired powerplants that produce sulfur dioxide and can be found both in cities and rural areas; and (3) large areas of exposed soil, including agricultural lands and unpaved roads, which emit particulates in the form of dust. Most of the air pollution comes from urban areas; however, rural areas can also have pollution problems, especially with suspended particulates (fine solid particles) from blowing dust, wood smoke, or field burning.

In general, the region is relatively dry in the summer and early fall, so surface silt and sand can become suspended by the action of the wind. Even though some rural areas might experience high levels of dust, the air quality in the Columbia River Basin, for the most part, meets government standards. The air pollution agencies, however, are concerned about some areas in the basin that do not meet these standards. These "nonattainment areas" have air pollution concentrations that do not fully comply with the Federal, state, and local Ambient Air Quality Standards (AAQS). While several urban areas in the region have nonattainment status for carbon monoxide, the most common types of entries on the nonattainment area list involve small particulate matter (PM<sub>10</sub>). There are also several total suspended particulate (TSP)

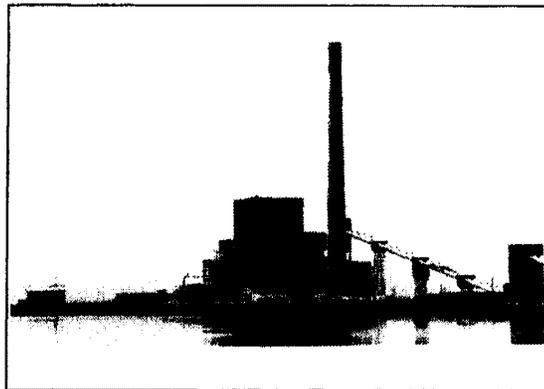
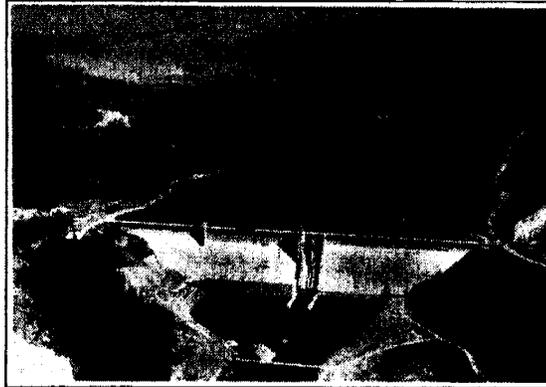
nonattainment areas. Most of the SOR reservoirs are located away from the nonattainment areas. Sandpoint, located on Lake Pend Oreille, is a PM<sub>10</sub> nonattainment area. Clarkston and Lewiston, located on Lower Granite Reservoir, are TSP nonattainment areas.

The Columbia River system produces enormous amounts of electric energy, and generating patterns at the dams are indirectly related to air quality. Hydropower and energy from thermal projects (which use heat to produce electricity) are interchangeable. When hydropower generation is insufficient to meet regional needs, the shortfall is typically met with power from nuclear plants or from powerplants that burn fossil fuels. Several coal-fired plants, including stations near Centralia, Washington and Boardman, Oregon serve the region. The Pacific Northwest and California also exchange large amounts of energy, so Northwest hydropower resources are in effect supplemented by oil-fired plants in California. When generating conditions cause hydropower to be replaced with thermal power, an indirect consequence is increased air pollution from the thermal plants in the Northwest or California. Sulfur dioxide is a byproduct of coal burning. Emissions of nitrogen oxides are the primary concern of operating combustion turbines fueled by natural gas.

### 2.1.3 Aquatic Life

The aquatic life in the Columbia River Basin ranges from very tiny organisms that live in the

*Libby Dam in northwest Montana.*



*Thermal power facility.*

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***When hydropower generation is insufficient to meet regional needs, the shortfall is typically met with power from thermal facilities.***

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mud to sturgeon that weigh hundreds of pounds. It includes plants that function not only as food items but also as protective cover and resting spots for resident and anadromous fish during various stages in their lives.

### **Anadromous Fish**

The Columbia River Basin supports a large population of anadromous fish (see Appendix C). Anadromous fish hatch in freshwater streams or lakes, migrate downriver to the ocean to mature, then return upstream to spawn. Several species and many separate stocks of anadromous fish inhabit the Columbia River. These fish include spring, summer, and fall chinook salmon; coho, chum, and sockeye salmon; steelhead trout; sea-run cutthroat trout; American shad; white sturgeon; and Pacific lamprey. Many of these stocks are severely

depleted because of changing ocean conditions, excessive harvest practices, the dams on the river system that have interfered with migration, and reduced spawning habitat.

Salmon and steelhead are symbolically important to the Pacific Northwest. They are valued by society at large for their commercial and sport fishery uses, and they also have commercial, subsistence, and ceremonial significance to most tribes in the region. Because salmon are part of the region's identity, people are very concerned about their recovery and continued survival.

### **Life History**

Salmon and steelhead have two major migrations in their life cycle: the hazardous downriver migration to the sea and, years later, the exhausting upriver journey to spawn where their life began. After they have laid and fertilized their eggs, all salmon die. A few steelhead survive to repeat the cycle. The fertilized eggs lie in shallow gravel nests, or redds, for about 50 days. The eggs hatch into alevins—fish that are still attached to and feed on nutrients stored in their embryonic yolk sac. They quickly grow into fry, learning to find food among the organic matter that drifts downstream. Within a few months, they are fingerlings several inches long, and they seek protected areas to build strength for the migration to the ocean. Today, a Columbia River salmon or steelhead is much more likely to start life in a hatchery than in a stream or riverbed.

Most wild Columbia and Snake River salmon and steelhead grow in streams or lakes for 1 to 2 years before they are ready for the downstream journey. This journey is typically triggered in spring by the freshet (the fast current fed by melting snow). It is during this period that fingerlings undergo the process of smoltification, a physiological transformation that enables them to adapt to saltwater. The smolts, as they are now called, are biologically ready and programmed to head for the ocean. After a smolt leaves its native habitat, it must pass up to

nine hydroelectric dams to reach the sea. The smolt's migration time is closely linked to survival in a variety of ways. Delays can directly or indirectly kill smolts or cause them to lose their migratory urge. Because their natural ability to adapt to saltwater lasts only about 30 days, prolonged delays might mean they cannot make the biological transition at the end of their journey. In addition, during migration the smolts are vulnerable to predators, such as squawfish and birds.

The salmon and steelhead that survive the downstream journey live in the ocean 1 year or longer, growing to maturity. They then respond to some signal to start the migration back to the Columbia River. They now have a single purpose—to get back to the place of their birth and spawn. Like the passage downstream, upstream migration is very hazardous. The salmon and steelhead swim against the river's current; they are threatened by commercial fishing, anglers, poachers, predators, and the dams. Once the salmon reach their spawning grounds, the females lay their eggs, the males fertilize them, and the cycle begins again. Of the millions that embark on the outward migration every year, only a few thousand make it back to ensure that the species survives for another cycle.

### **Status**

Before Euro-Americans developed the region, annual runs of salmon and steelhead returning to the Columbia River were estimated to be 8 to 16 million fish. Recent records indicate that the runs now total about 2.5 million salmon and steelhead (including fish harvested in the ocean), of which about 0.5 million are wild fish. Since 1938, the minimum estimate of total salmon and steelhead surviving the ocean and returning to the river has ranged from 1.0 to 3.2 million fish (Figure 2-3). In 1993, a new low of 950,000 salmon and steelhead entered the Columbia River. About 240,000 of these were wild fish (WDFW and ODFW, 1994). While much of the habitat for salmon and steelhead has been lost or altered, many areas still support

runs. Table 2-1 lists the salmon and steelhead races in streams and rivers in the system.

The overall trend for salmon and steelhead originating from the Columbia River system has been a decrease in numbers. Some stocks, including Snake River sockeye salmon and fall, spring, and summer chinook salmon (all wild stocks), have shrunk to such critically low numbers that they have been listed as endangered under the Federal ESA. As a result of these listings, the portions of the Columbia and Snake Rivers used by the listed Snake River salmon species have been designated under the ESA as critical habitat.

**Snake River Spring and Summer Chinook Salmon**—The NPPC estimates that prior to the arrival of Euro-Americans, the Snake River Basin produced about 1.4 million chinook salmon (NPPC, 1986). By the mid-1950s, this number was reduced by 95 percent, and another tenfold decrease has occurred in the last 30 to 40 years (Matthews and Waples, 1991). Redd counts of spring and summer chinook in the Snake River Basin index areas indicate a decline from 13,000 in 1957 to 620 in 1980. Since

1980, the numbers of redds have fluctuated with no discernible trends. Post-1977 estimates of wild and hatchery fish over Lower Granite Dam, including most endangered stocks of spring and summer chinook, showed a high in 1978 of 31,375 wild spring and 11,600 wild summer chinook. Beginning in 1978, wild fish numbers decreased dramatically with subsequent moderate fluctuations. Hatchery fish initially increased, but have recently been decreasing in abundance (Figures 2-4 and 2-5).

**Snake River Fall Chinook Salmon**—Fall chinook in the Snake River, now listed as endangered under the ESA, are assumed to have made up a significant portion of all chinook in the system. Between 1910 and 1967, several hundred miles of spawning area were lost because dams were built upstream from Hells Canyon. Additional spawning area was lost when dams were built on the lower Snake River. Wild fall chinook salmon declined from an estimated average of 72,000 between 1938 and 1949 to 29,000 in the 1950s (Waples et al., 1991) to about 1,000 in the mid-1970s. Wild fish generally decreased through 1990, when 78 fall chinook passed Lower Granite Dam;

however, in the last few years, fall chinook returns have generally increased (Figure 2-6). Hatchery fish have also increased over Lower Granite Dam primarily because of hatchery releases from the Hagerman Hatchery, which increased hatchery adult returns in the mid-1980s. Later increases resulted from Lyons Ferry Hatchery strays, on the lower Snake River, and Umatilla Hatchery strays, not of Snake River origin.

**Snake River Sockeye Salmon**—Historical Snake River sockeye salmon runs might have numbered 150,000 fish (NPPC, 1986). Much of the rearing habitat,

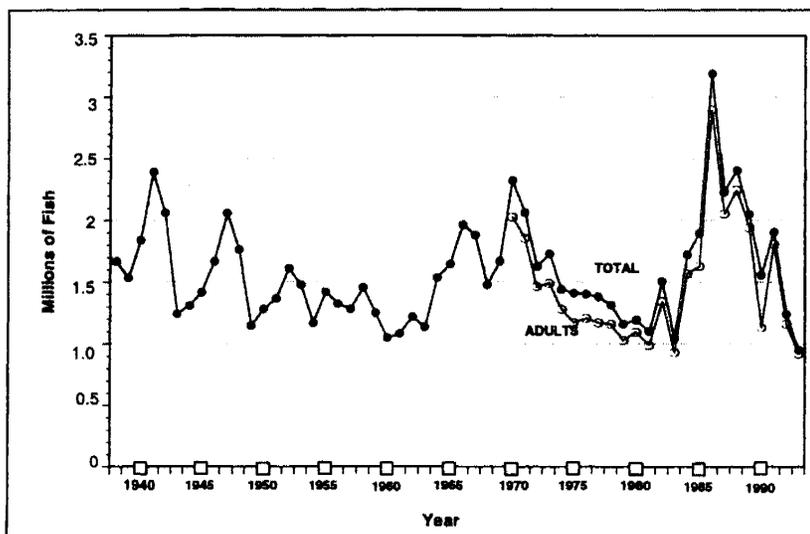


Figure 2-3. Minimum number of salmon and steelhead entering the Columbia River, 1938 to 1993 (Source: WDFW and ODFW, 1994).

Table 2-1. Wild and hatchery races of salmon and steelhead in the Columbia River Basin

	Race							
	Spring Chinook	Summer Chinook	Fall Chinook	Coho	Sockeye	Chum	Winter Steelhead	Summer Steelhead
<b>Lower Columbia River (Below Bonneville Dam)<sup>a/</sup></b>								
Lower Columbia River (Mainstem)			X	X		X	X	X
Grays River			X	X		X	X	
Elochoman River			X	X		X	X	X
Cowlitz River	X		X	X			X	X
Kalama River	X		X	X			X	X
Lewis River	X		X	X		X	X	X
Willamette River	X		X	X			X	X
Sandy River	X		X	X			X	X
Washougal River	X		X	X			X	X
<b>Mid-Columbia (Bonneville Dam to Priest Rapids Dam)<sup>a/</sup></b>								
Mid-Columbia (Mainstem)			X	X				X
Wind River	X		X	X			X	X
Little White Salmon River	X		X	X				
White Salmon River	X		X	X			X	X
Hood River	X		X	X			X	X
Klickitat River	X		X	X			X	X
Fifteen Mile Creek							X	
Deschutes River	X		X		X			X
John Day River	X							X
Umatilla River	X		X	X				X
Walla Walla River	X							X
Mid-Columbia Mainstem (Hanford Reach)			X					X
Yakima River	X	X	X	X	X			X
<b>Snake River</b>								
Snake River (Mainstem)			X					X
Tucannon River	X							X
Clearwater River	X	X	X					X
Grande Ronde River	X		X					X
Imnaha River	X		X					X
Salmon River	X	X	X		X			X
<b>Upper Columbia River (Priest Rapids Dam to Chief Joseph Dam)<sup>a/</sup></b>								
Upper Columbia (Mainstem)			X	X				X
Wenatchee River	X	X			X			X
Entiat River	X							X
Methow River	X	X						X
Okanogan River	X	X			X			X

Source: CBFWA, 1991.

<sup>a/</sup> Definition and terminology for Columbia River reaches are those of the source, and differ somewhat from conventions adopted as standard for the SOR.

primarily lakes, is no longer accessible. The minimum estimate of spawners that the habitat is capable of producing in the Sawtooth Valley lakes of the upper Salmon River is about 6,000 fish (CBFWA, 1991). Only Redfish Lake, in the Sawtooth Valley, is now accessible to sockeye. The peak for Redfish Lake was measured at 4,361 fish in 1955 but declined after 1958 to fewer than 500 fish. The count has been below 100 since 1981 (Chapman et al., 1990) (Figure 2-7). Between zero and eight sockeye salmon have arrived at Redfish Lake each year since 1990. Wild Snake River sockeye were listed as endangered under the ESA in 1991. All returning fish from 1991 through 1994 were retained for a captive breeding program in an attempt to protect this stock from extinction.

**Columbia River Chinook and Sockeye Salmon**—Other anadromous stocks in the Columbia River system have fared better. Upper Columbia River spring and summer chinook numbers were depressed before Grand Coulee Dam was constructed in the 1930s. Summer chinook in the upper Columbia River have been relatively stable over the last 30 years

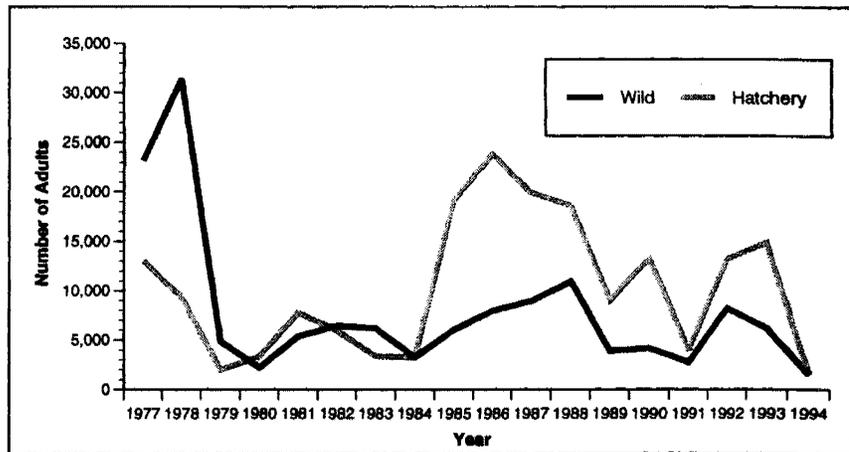


Figure 2-4. Estimated wild and hatchery adult spring chinook salmon passing Lower Granite Dam, 1977-1994 (Source: PSC, 1991; Columbia River Technical Staff, 1993; US v. Oregon Technical Advisory Committee, 1994)

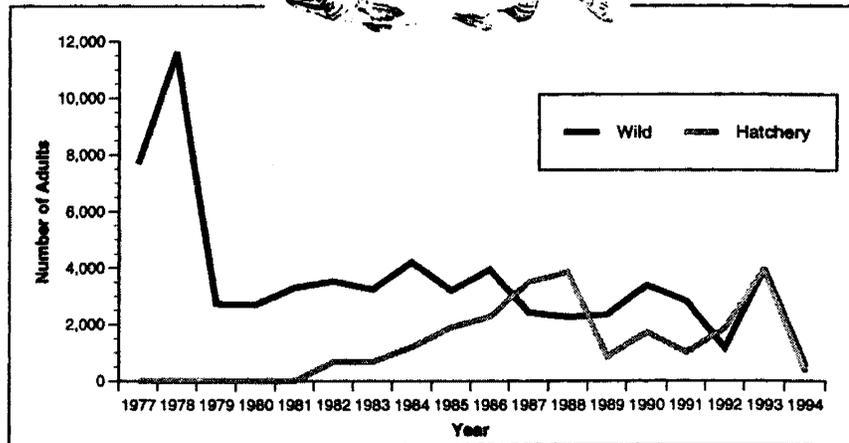


Figure 2-5. Estimated wild and hatchery adult summer chinook salmon passing Lower Granite Dam, 1977-1994 (Source: PSC, 1991; Columbia River Technical Staff, 1993; US v. Oregon Technical Advisory Committee, 1994)

(Figure 2-8). However, this stock was recently petitioned for ESA listing. NMFS issued a determination on September 23, 1994 that this stock did not warrant listing (59 FR 184). Spring chinook redd counts in upper Columbia River tributaries have changed little in recent times. But salmon counts over Priest Rapids Dam have grown from the 1960s to the 1980s, primarily because of increased hatchery production (ODFW, 1991). Upriver bright wild

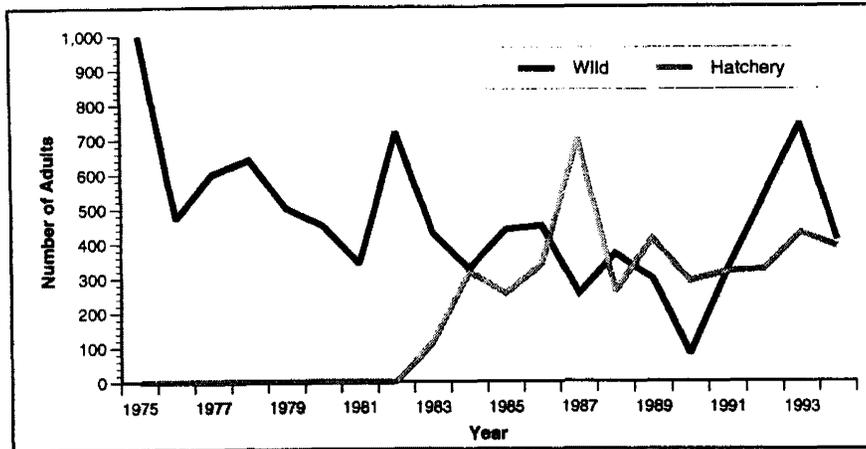


Figure 2-6. Estimated wild and hatchery adult fall chinook salmon arriving at Lower Granite Dam, 1975-1994 (Source: PSC, 1991; Lavoy, 1994, 1995)

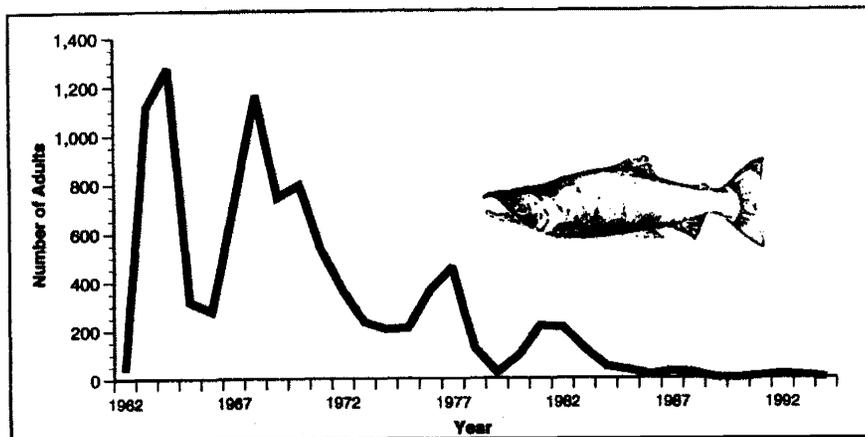


Figure 2-7. Estimated wild spawning Snake River sockeye passing Ice Harbor Dam (1962-1974) and Lower Granite Dam (1975-1994) (Sources: Corps, 1992 and FPC, 1993, 1994)

fall chinook, a late-spawning subspecies, have increased in the last decade. The highest return of 420,600 upriver brights occurred in 1987, but this number fell to 102,900 in 1993 (WDFW and ODFW, 1994). While most of these fish are wild, some are products of hatcheries, and their numbers have followed similar trends.

From 1938 to 1959, total sockeye salmon runs over Bonneville Dam ranged from a low of 10,900 in 1945 to a high of 335,300 in 1947; runs were stable in the 1950s. These figures include runs from the Deschutes, Yakima, Wenatchee, and Okanogan Rivers, in addition to the Snake River sockeye. Since 1960, runs over Priest Rapids Dam have decreased and varied

widely, ranging from 14,900 to 170,100, and averaging about 68,600 fish from 1990 to 1993 (WDFW and ODFW, 1994).

**Steelhead**—The run of 423,000 upper Columbia and Snake River summer steelhead in 1940 was the largest recorded since Bonneville Dam was built. Steelhead numbers remained high until the 1950s; they declined in the late 1970s to between 84,000 and 195,000 fish. By the late 1980s, steelhead numbers increased to between 285,000 to 384,000 fish. This increase appears to reflect primarily hatchery fish since wild summer steelhead counts above Bonneville Dam have not recently improved. Summer steelhead from the lower Columbia River (below Bonneville Dam) originate primarily from hatcheries. These steelhead runs generally

increased in the 1980s compared to the 1970s (CBFWA, 1991). Winter steelhead, mostly located below Bonneville Dam, also originate primarily from hatcheries. Their numbers ranged from 40,000 to 169,000 in the 1953 through 1994 period, with the lowest run occurring in the 1993-94 year (WDFW and ODFW, 1994).

**Coho Salmon**—Nearly all coho salmon in the Columbia River system originate from hatcheries; less than 10 percent are wild. The 1991 return of 1.0 million coho was the second largest return since 1970 (WDFW and ODFW, 1994). But the 1993 run of 118,000 was one of the lower runs since 1960. About 120,000 to

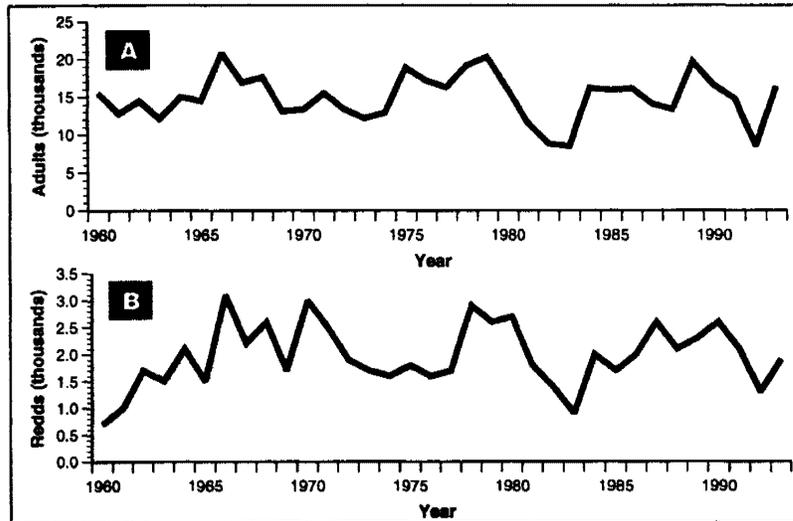


Figure 2-8. Escapement of summer chinook over Priest Rapids Dam (A) and redd indices for summer chinook (B) from Washington tributaries above Priest Rapids Dam, 1960-1993 (Source: WDFW and ODFW, 1994)

166,500 coho were present at one time in the middle and upper Columbia River (Mullan, 1984). The only remaining native upriver coho stock is in the Hood River, a tributary that empties into the reservoir behind Bonneville Dam. The last recorded estimate of the Hood River run was only 100 to 300 fish in 1963 to 1971 (CBFWA, 1991). All Snake River coho stocks were extinct by 1987. As late as 1968, however, up to 6,000 coho returned to the Snake River. Most of these fish originated in the Grande Ronde River, a tributary to the Snake River.

**Other Anadromous Fish**—The numbers of other anadromous stocks on the Columbia River show varying trends. Shad populations have been very high in the last decade. The five highest recorded runs occurred in the last 5 years, with up to 3 million shad passing over Bonneville Dam each year from 1989 through 1993 (WDFW and ODFW, 1994). White sturgeon in the lower Columbia, below Bonneville Dam, are considered to be on the rebound after overharvest in the mid-1980s (WDFW and ODFW, 1994). The relatively non-migratory sturgeon populations in the Columbia River pools are considered depressed

and have suffered relatively low productivity and high mortality from harvest. Pacific lamprey are also considered to be on the decline in the Columbia-Snake River system (Technical Advisory Committee, 1991).

### Resident Fish

Resident fish are freshwater fish that live and migrate within rivers, streams, and lakes (see Appendix K). Resident fish existed in all parts of the Columbia River system before the dams were built. They mixed with anadromous fish in stream

reaches accessible to the latter, and were the only fish present in areas above barriers to anadromous fish passage. A few species of resident fish were originally anadromous, but are now generally prevented from migrating by natural or constructed blockages. These species include landlocked sockeye salmon (kokanee), and sturgeon in some locations. (Some sturgeon are still anadromous, while some kokanee occur naturally alongside anadromous sockeye in the same drainages.)

There are both native and non-native (introduced) resident fish in the Columbia River Basin. The native species are generally adapted to cold or cool flowing water, although some thrive in reservoirs where the water typically is warmer. Many native species, however, have declined in abundance because humans have eliminated or damaged their habitat through dam construction, water pollution, and disruptive land use practices.

Many fish in the Columbia River Basin have been imported from other parts of North America; some of these fish have affected native stocks. Government agencies and anglers introduced most of the non-native species to

improve sport and food fisheries. Many introduced fish species have adapted well to the Columbia River Basin, and have come to dominate the backwater habitats. Non-native salmonids such as brown, brook, and lake trout are abundant in many cold-water rivers, streams, and lakes. Warm- and cool-water species such as bass are especially common in reservoirs. Introduced species can reduce the populations of native fish through predation and competition. For example, walleye and channel catfish use habitats such as backwaters that are important to native species during various life stages.

In the lower Snake and Columbia River reservoirs, dominant native species include northern squawfish, redband shiners, mountain whitefish, chiselmouth, bridgelip sucker, and largescale sucker. The most important common game species (all introduced) include walleye, bluegill, smallmouth bass, largemouth bass, white crappie, black crappie, carp, channel catfish, and yellow perch. Cold-water resident species, such as trout and mountain whitefish, that were once common in the Columbia and Snake Rivers have declined since the construction of the dams. The dams block the fish migrating to their spawning grounds, humans have changed aquatic habitats (Mullan et al., 1986), and the prey base has changed. Warm-water species, most of which have been introduced, have become common. Most of these species have adapted very well to lake or reservoir environments.

There are also several fish species in the upriver storage reservoirs. Lake Koochanusa is noted for its kokanee, westslope cutthroat trout, rainbow trout, bull trout, and burbot (Fraleigh et al., 1989), while the Kootenai River below Libby Dam has an excellent rainbow trout fishery and a sizable whitefish population. Westslope cutthroat trout and bull trout are important sport species in Hungry Horse Reservoir. Key sport fish in Lake Pend Oreille, the natural lake controlled by Albeni Falls Dam, include kokanee, rainbow trout, Kamloops trout (a variety of rainbow), lake trout, lake whitefish, and a variety of warmer-water species. In Lake Roosevelt, walleye is the primary sport fish, but

kokanee, yellow perch, smallmouth bass, rainbow trout, and bull trout also inhabit these waters. Primary sport species in Dworshak include kokanee, rainbow trout, smallmouth bass, and bull trout (Maiolie, 1988). Brownlee primarily supports warm-water species, with smallmouth bass, channel catfish, and black crappie comprising the dominant sport fishery (Rohrer, 1984). Carp and sucker are also very common.

Because of population declines, several Columbia River Basin resident fish stocks are sensitive species and are candidates for legal protection. The USFWS formally listed the Kootenai River white sturgeon as an endangered species under the ESA on September 6, 1994 (59 FR 171). The USFWS determined in 1994 that the bull trout was considered suitable for listing, but was precluded from listing because of the need to focus on other priority species under the ESA (59 FR 111). Other fish species have been designated by the states as of special concern; these include westslope cutthroat trout, redband trout, shorthead sculpin, and torrent sculpin in Montana, and redband trout, sandroller, and burbot in Idaho.

### **Benthic Organisms**

One part of the aquatic community, the benthic community (or benthos), consists of organisms that live on the bottom of lakes or rivers. Benthic plants such as algae and benthic animals such as snails are components of this community. Life in the benthos is largely a sedentary or sluggish existence, where organisms attach to rock, festoon bottoms, crawl over beaches, or perch on other life: plant on plant, animal on plant, and animal on animal (Kruckeberg, 1991). The plant world can range from tiny encrustings of algae on rocks, felty patches on sand and mud, and delicate scums to large algal blooms. Benthic animals are nearly as diverse as plants in form and size. Benthic production is usually minimal in shallow-water areas if the water levels fluctuate and expose the organisms. As a result, benthic organisms will die along shorelines, for example, where water levels fluctuate (Mullen et al., 1986).

Benthic organisms contribute significantly to the diets of many reservoir fish species (Bennett et al., 1983); they are essential elements in the food chain. Two other very important parts of the food chain include phytoplankton and zooplankton. The phytoplankton, or floating plants, are microscopic algae that nourish themselves from the energy of the sun (Kruckeberg, 1991). They are at the base of the food chain. Phytoplankton are usually seen on the surface water when large colonies bloom and form a green film. They provide a food source for bacteria, water molds, and zooplankton. Zooplankton are tiny, floating transparent animals that take on the color of what they have eaten, so they can appear green or brown (Kruckeberg, 1991). Zooplankton are a food source for larger aquatic organisms, such as snails and small fish. Zooplankton are also an important part of the food chain that supports kokanee, walleye, and rainbow trout in Lake Roosevelt (Appendix K).

Several molluscs that are part of the Columbia River Basin benthic community have been identified as in decline. The California floater, shortface lanx, and Columbia pebble-snail are candidates for listing under the ESA. The USFWS is currently evaluating their status.

### **Aquatic Plants**

Macrophytes are the large aquatic plants that grow in the shallow water along the shorelines of lakes or in the slow-moving reaches of rivers. Macrophytes are important elements for study in the SOR because they contribute to the food chain by providing homes for insects, which in turn provide food for fish, and they function as a direct food source for many aquatic organisms. Macrophytes also supply surfaces for fish eggs to incubate and provide protection for fish species during various life stages. These plants are especially important for young fish that hide in the weeds to escape predators. Additionally, macrophytes help stabilize shorelines by reducing erosion and recycling nutrients, an important function in nutrient-poor areas.

### **2.1.4 Terrestrial Life**

This section discusses the vegetation of the Columbia River Basin and then describes the wildlife, including sensitive, threatened, or endangered species, that live in the area. Appendix N, Wildlife, provides more detailed information.

#### **Vegetation**

The Columbia River passes through six major vegetation zones: (1) Douglas-fir/western hemlock; (2) Douglas-fir/Oregon white oak; (3) shrub-steppe (with sagebrush); (4) steppe (lacking sagebrush); (5) Ponderosa pine; and (6) Douglas-fir and grand fir (Franklin and Dyrness, 1973; Payne et al., 1975). The Snake River and associated tributaries (including the Clearwater River) pass through shrub-steppe, ponderosa pine, and Idaho white pine vegetation zones (Franklin and Dyrness, 1973; Daubenmire and Daubenmire, 1984). The following discussions are brief summaries of vegetation types for the respective geographic areas or the basin, with some specific focus on habitat types of particular interest.

#### **Upper Columbia River Tributaries**

The riparian zones along the free-flowing Kootenai and Flathead Rivers can be characterized as deciduous shrub and deciduous tree communities with black cottonwood as the primary tree species (BPA, 1984a, 1984b). Lake Kocanusa and Hungry Horse Reservoir lack well-established riparian zones and backwater areas because of fluctuating water levels. The 36 islands (totaling 324 acres [13 ha]) in Hungry Horse Reservoir support conifer and upland shrub habitats. Vegetation communities adjacent to both reservoirs are dominated by mixed conifer forests composed mostly of Douglas-fir, ponderosa pine, western larch, and spruce. Most of the Pend Oreille River drainage is covered by coniferous forest, with the lower elevations around the lake primarily in the ponderosa pine vegetation zone. There are significant areas of emergent wetlands and largely deciduous riparian vegetation around

Lake Pend Oreille, and a number of islands in the lake itself or in tributary delta areas.

### **Upper and Middle Columbia River**

Lake Roosevelt lacks extensive riparian communities (Payne et al., 1975). The southern portion of Lake Roosevelt is within the shrub-steppe region of eastern Washington (Franklin and Dyrness, 1973) and is subject to periodic drought. Most riparian habitat at the lake is associated with small streams and springs (Payne et al., 1975). Riparian vegetation has established in areas of silt accumulation that are subject to infrequent flooding.

Lake Roosevelt lacks extensive wetland areas. Wetlands dominated by reed canarygrass are limited, but occur primarily in the northern portion of the reservoir where moisture is more abundant (Payne et al., 1975).

From Grand Coulee Dam southward to the Tri-Cities area of Washington, the Columbia River passes through three major vegetation zones: (1) shrub-steppe (with sagebrush); (2) steppe (lacking sagebrush); and 3) Ponderosa pine (Franklin and Dyrness, 1973; Payne et al., 1975).

### **Middle and Lower Snake River**

The Snake River and associated tributaries (including the Clearwater River) in eastern Washington and northern Idaho pass through the xerophytic shrub-steppe, Ponderosa pine, and Idaho white pine vegetation zones (Franklin and Dyrness, 1973; Daubenmire and Daubenmire, 1984). The white pine belt consists of mixed stands of white pine, grand fir, Douglas-fir, Engelmann spruce, and western red cedar.

Fluctuating water levels at Dworshak Reservoir have essentially precluded establishment of riparian vegetation. Some red alder occurs along the reservoir, particularly in draws and tributary deltas. Riparian vegetation along Brownlee Reservoir includes communities dominated by willow, creeping wildrye on islands at the upper end of the reservoir, limited

distribution of cattail, and cottonwood around shallow bays. Almost no wetland vegetation occurs in the vicinity of Dworshak Reservoir; about 40 acres of deciduous forest occur associated with tributaries and springs. Wetland habitat associated with Brownlee Reservoir is limited to shallow bay areas at the upper end of the reservoir and is characterized by sparse amounts of cattails (BPA, 1985). Detailed plant lists are available for each of these reservoirs (Asherin and Orme, 1978; BPA, 1985).

Along the lower Snake River, the project reservoirs are characterized by scrub-shrub, forest scrub, and forest-shrub riparian communities. Several factors have contributed to the lack of extensive riparian areas along the lower Snake River: (1) the steep shorelines associated with the project reservoirs; (2) the inundation of former river bottom riparian areas by the reservoirs; and (3) the presence of railroad embankments, which occupy areas that might otherwise support riparian vegetation. The Corps is implementing a Congressionally authorized mitigation program to create additional habitat along the shorelines to replace the river corridor plant and wildlife communities that were lost through construction of the reservoirs.

Local plant communities have established under normal pool fluctuations and periodic drought. Shallow-water habitat exists primarily along the shoreline and around islands within the lower Snake River project pools. Shallow-water beds support aquatic plants that provide a valuable food source for waterfowl.

Emergent wetlands are also associated with the reservoirs along the lower Snake River. These wetlands generally occur where drainage from adjoining slopes is interrupted by railroad or highway embankments, or agricultural activities. In general, wetland vegetation consists primarily of rushes, sedges, and cattails. Lower Snake River wetlands that have been identified and mapped are limited to approximately 44 acres (18 ha). In addition, numerous small pockets of wetland vegetation

exist in small embayments or impoundments behind roads and railroads.

### **Lower Columbia River**

Physical conditions along portions of the lower Columbia River have led to the creation of extensive shallow-water, wetland, and riparian areas. Backwater areas are most abundant at the John Day project and least abundant at McNary. The lower Columbia River is bordered by approximately 2,097 acres (849 ha) of emergent wetlands. Wetlands are most abundant at the John Day pool, which accounts for 80 percent of the wetland acreage in the reach, and least abundant at Bonneville. The riparian habitat along the lower Columbia River includes shrub, hardwood, and herbaceous types of vegetation. Approximately 3,519 acres (1,424 ha) of riparian vegetation occur in this reach, mainly along the backwaters.

### **Wildlife**

The project reservoirs and adjacent areas on the Columbia-Snake River system provide varying amounts of essential habitat for approximately 42 reptile and amphibian species, 263 bird species, and 81 mammal species (Payne et al., 1975; Tabor, 1976; Lewke and Buss, 1977; Asherin and Orme, 1978). Wildlife that typically use riparian and wetland areas associated with the projects can be divided into 10 main groups: waterfowl, colonial nesting birds, shorebirds, non-game birds, raptors, aquatic furbearers, terrestrial furbearers, big game, reptiles and amphibians, and threatened and endangered species.

### **Waterfowl**

Wintering waterfowl are probably the most abundant wildlife resource in the Columbia River Basin. Common species in this category include mallard, northern pintail, American widgeon, green-winged teal, common merganser, scaup, wood duck, and common goldeneye. Resident, breeding waterfowl are generally limited to Canada geese and selected duck species, which are found throughout the

SOR study area and are numerous in some locations. The common loon is listed as a sensitive species in the Kootenai and Flathead National Forests.

### **Colonial Nesting Birds**

The Columbia River and its major tributaries provide island, bank and tree habitats for a variety of colonial nesting birds. Examples include California gulls, ring-billed gulls, Forsters terns and Caspian terns, which nest on islands in the lower Columbia. Bank swallows nest in holes excavated in the steep banks adjacent to Lake Roosevelt, and feed on insects associated with nearby open water and shoreline habitats. Colonies of cliff swallows are abundant at various dams, where they construct their nests on facility structures. Another widespread colonial nesting bird in the Columbia River System is the great blue heron, which nests in the large cottonwoods or willows that can grow along the river banks, and feeds on invertebrates, snakes and fish that live in shallow water, shoreline, and wetland habitats.

### **Shorebirds**

Killdeer and spotted sandpipers commonly nest on sands and gravel exposed along reservoir and river shorelines. These and other species of shorebirds feed along the shoreline, shallow waters, nearby mudflats and wetlands. Shorebirds typically occur in greatest numbers in the vicinity of mudflats, where invertebrate prey are more abundant.

### **Non-game Birds**

Non-game birds comprise a diverse assemblage of species. Many are insectivorous, such as the redwing blackbird which is a typical resident of cattail marshes. Other insectivores such as the yellow warbler require dense shrub habitat for nesting and feeding; woodpeckers also require shrub or forest habitat. In the Middle and Lower Columbia River System, these habitats are largely restricted to shorelines and embayments of the river and reservoirs. Many non-game birds use the Columbia River as

a migratory flyway, feeding and resting in the mix of habitats present along the shoreline.

### **Raptors**

The osprey, northern harrier, barred owl, and bald eagle are found in and around the riparian or wetland areas of the reservoirs. Cliffs and large trees along river banks support diverse raptor populations, including the golden eagle, prairie falcon (Payne et al., 1975; Asherin and Claar, 1976; Tabor, 1976), Swainson's hawk, red-tailed hawk, great horned owl, and northern pygmy owl (Payne et al., 1975; Asherin and Orme, 1978), American kestrel, common barn-owl, western screech owl, long-eared owl, short-eared owl, and northern saw-whet owl. Barred owls are an indicator species for riparian communities dominated by cottonwood trees on the Kootenai and Flathead National Forests. The Cooper's hawk is also an important raptor of the riparian deciduous tree community. Flammulated and boreal owls, which may use riparian communities, are listed as sensitive species by USFS.

### **Aquatic Furbearers**

Aquatic furbearers in the project reservoirs include muskrat, beaver, river otter, and mink. These species depend on riverine areas, embayments, ponds, tributaries, and riparian forests for den sites and foraging areas.

### **Terrestrial Furbearers**

Representative terrestrial furbearers include striped skunk, raccoon, cottontail, bobcats, coyotes, mice and bats. None of these species is entirely dependent on habitats adjacent to the river or reservoirs, but may be more abundant there because of increased prey or forage. Raccoons, for example, can feed on a variety of aquatic (frogs, crustaceans, etc.) and terrestrial (eggs, immature small mammals, etc.) prey that occur in relatively greater abundance in shallow waters and throughout the riparian zone.

### **Big Game**

Black-tailed and mule deer are the most common big game species inhabiting the SOR study area (Tabor, 1976). Other ungulates (hoofed mammals) include the Columbian white-tailed deer, Idaho white-tailed deer, Roosevelt elk, Rocky Mountain elk, moose, bighorn sheep, and mountain goats. The most notable large carnivores in the basin are the black bear, mountain lion, and grizzly bear.

### **Reptiles and Amphibians**

Reptiles and amphibians that occur in the Columbia River System include gopher snakes, painted turtles, wood frogs, Pacific tree frogs, and spotted frogs. Amphibians are dependent on water habitats for at least part of their life cycle, and particularly sensitive to changes in water level. Permanent ponds tend to increase reptile and amphibian diversity (Tabor, 1976).

### **Threatened and Endangered Species**

Four species of wildlife that may be present near the Columbia River system are Federally listed as threatened or endangered. These species are the bald eagle, peregrine falcon, grizzly bear, and gray wolf. Because the Montana tributaries are close to favorable habitat in Canada, Glacier National Park, and the Bob Marshall Wilderness Area, gray wolves and grizzly bears are found here but generally not in other parts of the basin. Appendix N provides details concerning distribution and habitat requirements of these four species. Other threatened or endangered species, such as Columbian white-tailed deer or woodland caribou, may be present in selected areas of the Columbia River Basin but do not use habitat near the SOR projects. Forty-two species of plants and wildlife are candidates for listing under the ESA. These species include, for example, the northern goshawk, wolverine, western sage grouse, spotted frog, and persistent-sepal yellow-cress. In addition, state agencies in the region have identified a number of species that they consider sensitive.

## 2.2 THE HUMAN ENVIRONMENT

The following section discusses aspects of the human environment of concern in the SOR. The topics addressed include cultural resources (archeology and history); Native American resources and concerns (including Indian trust assets and Federal trust responsibilities to the Indian tribes of the basin); the landscape (land ownership patterns, land use and development, protected resource lands, and scenery); and the people and the economy in the basin. This latter topic is divided into discussions of population, cultural and social groups, economic activities, and economic well-being.

### 2.2.1 Cultural Resource Types and Significance

Cultural resources identified in the SOR study area are representative of the total span of human use and occupation of the area (see Appendix D). Cultural and historic resources can be generally categorized into one of the following three groups: historic sites, including historic architecture, engineering, and archeological sites; Native American archeological sites; and traditional cultural properties. The various parties involved in the SOR have divergent views on the definition and appropriate treatment of cultural resources.

Federal agency cultural resource responsibilities are defined in law. According to Section 301 of the 1992 amendments to the National Historic Preservation Act, a historic property or historic resource is a resource significant in American history, architecture, archeology, engineering, or culture. Historic properties or resources include any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on, the National Register of Historic Places as well as artifacts, records, and material remains related to these properties or resources. Except under rare circumstances, a property must be at least 50 years old to be eligible for National Register nomination.

There is, however, more than one view of what constitutes cultural resources. The academic and legal definitions tend to focus on tangible evidence such as sites and artifacts. Native Americans find these definitions too narrow. They view their entire heritage, including beliefs, traditions, customs, and spiritual relationship to the earth and natural resources, as sacred cultural resources. The SOR agencies have attempted to incorporate the tribes' views in the impact analysis and will continue to consider them while developing mitigation plans.

Most identified cultural resources in the Columbia River Basin are archeological sites. Archeological sites are typically open campsites, housepit villages, rockshelters, rock art (petroglyphs/pictographs), lithic (stone) quarries and workshops, burial grounds and cemeteries, and isolated rock cairns, pits, and alignments.

The significance of archeological sites relates to the quality of the preservation of a site and its contents, location, integrity of setting, association with particular ethnic groups or historically known individuals, or its ability to yield information important in history or prehistory. A particular site's setting and/or contents is essential to scientists in examining research questions about the past. Common research themes include cultural history, cultural process, and human adaptations in response to environmental changes. Archeological sites are also important to the heritage of regional Native American groups, whose primary interest lies with protection rather than investigation. Many archeological sites are also points of recreational or educational interest for the public through interpretation of their historical and scientific significance.

Certain cultural sites are significant because they may represent a specific time period. Examples of sites important for cultural history include Marmes Rockshelter on Lower Monumental Reservoir, Windust Caves on Ice Harbor Reservoir, and Granite Point on Lower Granite Reservoir. These sites are significant because they contain evidence of the earliest



*Marmes rock shelter on Lower Monumental Reservoir, June 1967.*

human occupants in the lower Snake River canyon between 9,800 and 10,200 years ago. They represent what is called the Windust Phase in the cultural historic framework for the lower Snake River region (Leonhardy and Rice, 1970, 1980).

Contemporary Native Americans recognize archeological sites, but they also consider traditional cultural properties—a much broader range of features from the natural environment and the sacred world—to be cultural resources. Traditional cultural properties pertain to cultural sites and natural features and resources important in traditional social and religious practices that tend to preserve cultural identity. Traditional cultural properties encompass such things as distinctive shapes in the natural landscape, named features in local geography, natural habitats for important subsistence or medicinal plants, traditional usual and accustomed fisheries, sacred religious sites, and places of spiritual renewal. Some tribes regard the Columbia River itself as a traditional cultural property. The tribes maintain the vitality of their traditional culture through a strong oral tradition and a variety of spiritual practices overseen by tribal elders.

Some cultural sites are historically significant and of special interest in relation to the period of

Euro-American exploration, the fur trade, military history, mining, navigation, agriculture, and early settlement. The Columbia River system made the first Euro-American exploration, travel, and settlement of the Pacific Northwest possible. Navigation of the river led to exploitation of its resources and establishment of today's settlements. There are many historic sites that are significant because they document this course of development. The Columbia and Snake Rivers served as important arteries

of early day transportation, passing finished goods upstream to inland settlements and agricultural goods and valuable minerals downstream. Examples of transportation developments include the remains of the Cascades Canal and Locks near Bonneville Dam and The Dalles-Celilo Falls Canal and Locks at The Dalles Dam. Railroad development also occurred along the river banks, and rail lines cross the rivers at key points.

Historic sites significant to the study of the fur trade era in the Northwest include the Hudson's Bay Company's Fort Vancouver at Vancouver, Washington; the site of the North West Fur Trading Company's Fort Nez Perce near the mouth of the Walla Walla River; and the Hudson's Bay Company's Fort Colville at Coulee Dam. The historic river crossing at Sineacquoten on the Pend Oreille River at Albeni Falls Dam and the Fort Kootenay sites at Libby Dam were other key sites in the settlement history of the basin. While they are relatively recent developments, some of the Federal projects themselves are significant historic sites. Bonneville and Grand Coulee Dams are listed in the National American Engineering Record as engineering and design achievements. Bonneville Dam is also a

National Historic Landmark. Section 3.3.10 includes a more specific inventory of historic sites at the SOR projects.

Examples of investigated historical sites on Federal dam projects include Hudson's Bay Company Fort Colville in the reservoir of Coulee Dam (Chance and Chance, 1979) and the historical community of Silcott, Washington (Adams, 1976) in Lower Granite Reservoir.

### 2.2.2 Culture History

Culture history describes the known sequence of cultural transformations from the end of the last ice age to the present. The prehistory of the Columbia River Basin, like that of most of North America, spans approximately 11,500 years. There are five temporal periods, summarized below, that are broadly applicable to the Pacific Northwest. Although the Columbia River Basin encompasses a wide variety of ecological and topographic zones, trends in culture history can be generalized across the region. Throughout much of prehistory these trends appear to be consistent with trends simultaneously occurring elsewhere in the western United States.

#### Prehistory

Paleoindian peoples lived more than 10,000 years before the present (B.P.), during the rapidly warming terminal Pleistocene period. Where conditions were favorable, they exploited large mammals such as mammoth, mastodon, camel, and horse, which became extinct during or shortly after this period. Paleoindians also hunted Pleistocene forms of species such as bison, mountain sheep, and deer, which were larger than their modern descendants (Butler, 1986). Paleoindian sites at several rare locations in the region have produced fluted projectile points of the Clovis type, which consistently date between 11,500 and 11,000 B.P. in contexts ranging from Alaska to Central America. (Archeologists have researched a significant buried cache of Clovis artifacts discovered on an old river terrace of the Columbia River near East Wenatchee, Washington in 1987.)

Archeologists identify Early Period (6,000 to 10,000 years B.P.) sites on the Columbia Plateau by the presence of characteristic stone projectile point styles, called Windust and Cascade (Leonhardy and Rice, 1970). Early Period social units (bands) may have inhabited very large territories at low density, traveling within them to exploit seasonally or locally abundant resources, the most important being large ungulates (Ames, 1988). Prehistoric people also exploited very favorable fishing sites, such as The Dalles, Kettle Falls, Priest Rapids, John Day Narrows, Umatilla Rapids, and others only seasonally during this period. Peak salmon runs made salmon harvest at these sites very efficient at certain limited times. Population density was relatively low during this period, and people relied on residential mobility rather than intensive food production and storage to overcome seasonal food scarcity.

The Middle Period (2,000 to 6,000 B.P.) was accompanied by a continental warming and drying trend that peaked sometime between 8,000 and 4,000 years ago (Aikens, 1993) and influenced the distribution of vegetation zones. The modern climatic pattern was established by approximately 4,000 years ago. At or near the beginning of this period, the atlatl, or spear thrower and dart, replaced the thrusting spear as the dominant weapon technology.

The Late Period begins about 2,000 years ago with the introduction of the bow and arrow, as indicated by small, stemmed projectile points (Aikens, 1993). This date indicates an earlier adoption of bow and arrow in the Pacific Northwest than in the adjacent Great Basin, Great Plains, or California culture areas. Population densities continued to grow throughout the Late Period, fostering an intensification of food production that included the historically observed pattern of food storage, particularly of dried salmon, roots, and berries, for winter consumption.

At the beginning of the historic period about 200 years ago, a large number of tribes belonging to several distinct linguistic and cultural groups occupied the Columbia basin.

These included Chinookan peoples, such as the Wasco, along the lower Columbia from the river mouth to The Dalles; Sahaptin speakers, such as the Yakama, Umatilla, Wanapum, Nez Perce, and Palus Tribes of the central Columbia and lower Snake basins; Interior Salish speakers, such as the Colville, Wenatchee, Spokane, Kalispell, and Coeur d'Alene of the upper Columbia and its tributaries; the Kootenai speakers of the Kootenai Basin; and Numic speakers, such as the Shoshone, Bannock, and Burns-Paiute of the Snake River Plain, and the Northern Paiute of the Malheur, upper John Day and Deschutes Basins.

The seasonal economic cycle of the Sahaptin-speaking peoples of the middle Columbia is well known and is somewhat representative of prehistoric subsistence practice throughout the non-mountainous parts of the Columbia Basin in early historic times (Hunn, 1990). Sahaptins lived in winter villages near the Columbia River or on the lower reaches of its major tributaries, subsisting on food stores during the winter, supplemented by hunting and fishing. They inhabited large, multifamily lodges covered with tule mats.

In the early spring, the Sahaptins harvested Indian celeries (lomatiums and other species) and fished spawning runs of suckers in the major rivers. Later, they roamed uplands further from the winter villages to collect bitterroot and lomatiums for long-term storage. In May, the Sahaptins took up posts on the main river at favorable fishing sites, many owned and inherited, for the spring chinook runs. The runs peaked for a few days, then floods in late May made fishing much more difficult in the larger rivers. The Sahaptins then headed for the Cascade Mountains to escape the summer heat, and to harvest and dry large quantities of huckleberries, and hunt deer and other game.

As summer flows in the Columbia made salmon fishing easier, the Sahaptins returned to its banks, harvesting salmon runs that occurred between July and October. The most important of these was the fall chinook run in September, which produced large quantities of stores for

winter food. Up to one-third of the Sahaptin people's annual diet may have consisted of salmon. Edible roots may have supplied an additional 50 percent of the annual Sahaptin caloric intake, with game and huckleberries supplying much of the remaining amount (Hunn, 1990).

The subsistence economies of Indian peoples in other parts of the Columbia Basin varied somewhat from the Sahaptin pattern, depending on the distribution and abundance of local food resources. Tribes of the mountain regions, for example, depended less on anadromous fish and more on large game than the Plateau peoples. Indians of the lower Columbia in the Portland Basin practiced a nearly sedentary lifestyle with a strong emphasis on varied resources near lakes, rivers, and the estuary.

The Columbia River also served as a major trade route in prehistoric times. Chinookan-speaking peoples from the coast and lower Columbia traded coastal goods up the river to The Dalles, which attracted trade representatives from tribes throughout the Columbia Basin and beyond.

### **Precontact Changes and Effects**

Euroamerican influence began during the early 18th century. Horses arrived in the Plateau some time after 1730 and changed Indian mobility, warfare, and subsistence logistics. Old World diseases such as smallpox and measles arrived with the crews of exploring vessels even before trading ships began to arrive on the Pacific coast in the 1790s. These diseases spread rapidly among the native populations and led to dramatic population decline after 1770. By 1830, the Northwest had lost approximately 60 percent of its native population to disease (Boyd, 1990). This trend continued with a major malaria epidemic on the lower Columbia and further outbreaks of measles and smallpox throughout the region. By 1870, the precontact Indian population was reduced by more than 80 percent.

### **Euroamerican Exploration and Trade**

Exploration of the Columbia River drainage began with the efforts of Lewis and Clark in 1805-06 and David Thompson in 1811. Agents for John Jacob Astor founded the fur trading fort Astoria at the mouth of the river in 1810, and overland journeys by Astorians Wilson Price Hunt and Robert Stuart established the transcontinental route that later became the Oregon Trail.

Early relations between Indians and Euroamericans were mostly amicable and governed by mutual interest of the fur trade. Trading posts were established by competing companies during the early 19th century, including Fort Vancouver, Fort Nez Percés, Fort Okanogan, Fort Colville, Kullyspel House and Fort Kootenay. Hudson's Bay Company emerged as the leading trader. During this period metal implements were introduced to Native American material culture, including knives, arrow points, and axes, along with glass trade beads, buttons, and bells. The introduction of firearms brought about major transformations in hunting practices and warfare. More intensive trapping and hunting during the fur trade sharply reduced natural populations of beaver, muskrat, and big game animals.

As Euroamerican settlement intensified in the Northwest, extensive grazing habitat was lost to game animals by horses and domestic livestock. Population pressure from settlers and ranchers, and the discovery of gold and influx of miners brought about conflicts with regional tribes. In spite of treaties with the tribes and good intentions by missionary groups, land encroachments took place and some of these led to Indian wars (1855-58). There were further treaties of cession, and the establishment of today's Indian reservations.

### **Settlement and Development**

Among the earliest Euroamerican settlers in the Northwest were retired Hudson's Bay trappers, many married to Native Americans, who began small farms in the Willamette Valley

beginning in the 1840s. After the question of territorial ownership of the Oregon Country was decided in favor of the United States in 1843, settlers began using the Oregon Trail to emigrate to the Northwest. Emigration increased rapidly after the Indian Wars of the 1850s. With the emergence of a supply center on the lower Columbia at Fort Vancouver in 1825 and Euro-American maritime shipping settlements at Portland and Oregon City by the 1850s, the transportation of labor and supplies up the Columbia River became much easier. With the discovery of gold in Idaho and the Caribou country of British Columbia in the 1860s, commercial transportation became a priority.

### **Transportation**

By the 1860s, steamboat lines were running supplies to the gold fields via river ports such as White Bluffs, Wallula, and Lewiston on the middle Columbia and lower Snake rivers. This also created a market for cattle from Columbia Basin ranches, which flourished during the 1870s and 1880s when there was an open range with abundant bunch grass. After the major gold rush of 1859 to 1860, smaller groups of itinerant Chinese placer miners worked river bars throughout the Columbia Basin into the 1890s before returning to China or moving to coastal Chinatowns in San Francisco, Portland, and Seattle. Railroad construction started in the 1860s and followed portions of the Columbia River drainage, ultimately leading to settlements at Ainsworth (Pasco), Walla Walla and Spokane. Much of this construction was done using Asian and Italian labor. In 1879, rail and steam transportation became consolidated by establishment of the Oregon Railway and Navigation Company to meet the need for shipment of grain and agricultural goods from eastern Columbia Basin communities to market (Meinig, 1968).

### **Commerce and Industry**

By the 1890s, commercial fish wheels went into operation along the lower Columbia River to tap the immense anadromous fish runs. These were banned in the late 1920s because

they were so destructive of the fishery. Fish canneries sprang up on the lower Columbia River in response to great demand for commercial fish products. Seasonal labor during the late 19th century and early 20th century was often supplied by Chinese, Japanese, and Filipino men who formerly worked at railroad construction. At the turn of the 20th century, orcharding became an important economic enterprise in the rich bottom lands of the Columbia Basin. Peaches, apricots, cherries and apples became products of demand along with watermelons and cantelope. In time, potatoes, sugar beets, beans and lentils took their place as important agricultural products of the eastern Great Columbia plain (Meinig, 1968). Private development of electrical energy began with water-driven generators like those at Allard and Priest Rapids in 1908 on the middle Columbia River. Bonneville Dam was the first Federal dam on the Columbia River mainstem (completed in 1938). The mission of the Federal Columbia Basin Project was to supply electrical energy for industry, navigation for commercial barge transportation, and flood control protection for downstream residential and business communities. The last of the Project dams, Lower Granite, was completed in 1975.

### 2.2.3 Native Americans

The river people's way of life has, since time immemorial, related to the river system which provided the foundation of their spirituality, culture, and economy. Apart from sporadic coastal explorations from the 1500s through the 1700s, Euro-American contact with the Indians of the region began in the early 1800s. Subsequent interactions between Native Americans and Euro-Americans represent a major part of the region's history, and helped shape the distribution, characteristics, and values of Native Americans that are now of interest for the SOR.

### Tribes and Reservations

The Lewis and Clark expedition, other early explorers, and the fur traders who came to the Northwest beginning in 1805 originally

encountered well over 100 individual Indian tribes (Ruby and Brown, 1992). Some of these tribes became extinct through population decline, while others officially ceased to exist as a result of government action. Today, there are 14 Federally recognized Native American tribes in the SOR study area, each with its own reservation. In several cases, two or more tribes are located on the same reservation and function within a confederated tribal structure. The 14 tribal organizations include:

- Kootenai Tribe
- Coeur d'Alene Tribe
- Confederated Salish and Kootenai Tribes of the Flathead Reservation
- Confederated Tribes of the Warm Springs Reservation
- Kalispel Tribe of Idaho
- Shoshone-Bannock Tribes
- Spokane Tribe
- Burns-Paiute Tribe
- Colville Confederated Tribes
- Confederated Tribes of the Umatilla Indian Reservation
- Confederated Tribes and Bands of the Yakama Indian Nation
- Nez Perce Tribe
- Shoshone-Paiute Tribes of the Duck Valley Indian Reservation
- Blackfoot Tribe.

The locations of the reservations are shown in Figure 2-9. The combined Indian population living on these reservations is approximately 51,000 people (Appendix O). Many other members of these tribes do not live on the reservations.

### Treaties

The existing tribal and reservation structure is largely the result of treaties between the United States government and the tribes during the period of Euro-American settlement of the West. Isaac Stevens, Washington Territorial Governor, negotiated a series of major treaties with Columbia River Basin (and Puget Sound) Tribes in 1855 (see Table 2-2). Other treaties followed in the 1860s.

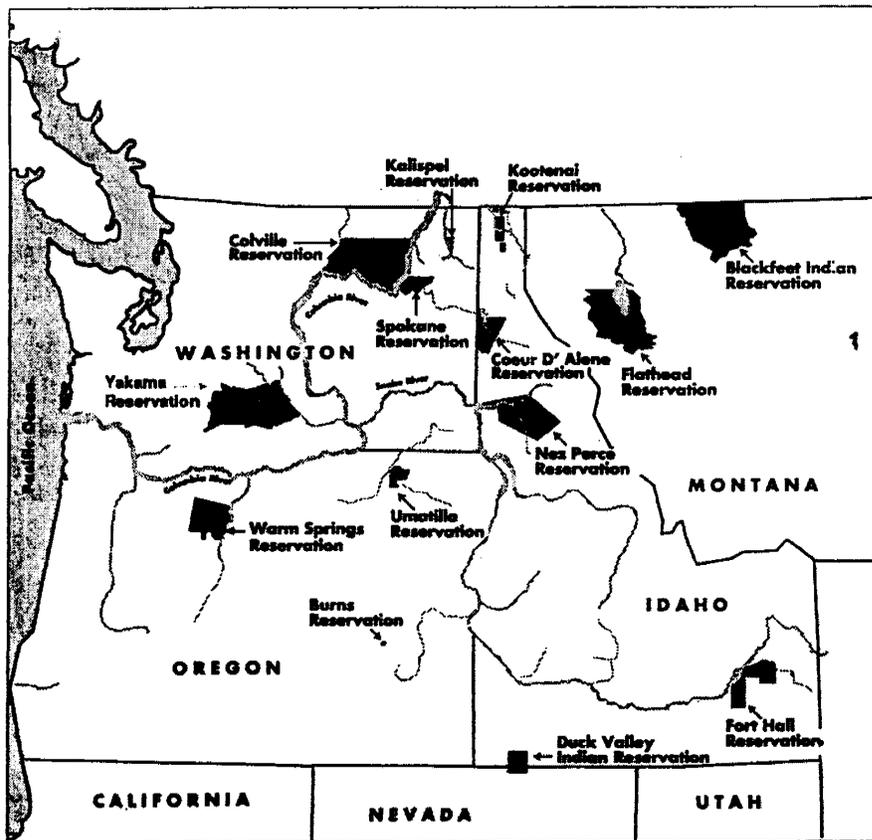


Figure 2-9. Indian reservations within the SOR study area

A treaty is a contract between sovereign nations (Pevar, 1992). Article VI of the U.S. Constitution makes treaties superior to state laws and constitutions, and equal in weight to Federal laws. Treaties can be abrogated (nullified) by Congress, but must be enforced as long as they remain valid. Furthermore, the courts consider treaty rights to be private property that must be compensated if the rights are abrogated. The preservation of treaty rights is the responsibility of the entire Federal government. The SOR agencies consequently have an affirmative legal duty to protect treaty rights.

The Indian treaties generally contain two major features. One is a grant of rights from the signatory tribe(s) to the United States, in the form of land ceded to the government. In return for this land, the government promised to create, maintain, and protect a Federal reservation on

which the Indians could live permanently. (Most reservations were created in this way, but some were established by executive order or act of Congress.) The Supreme Court has decreed that treaty provisions are to be interpreted liberally and to the benefit of the tribes. An important aspect of treaty interpretation is that any rights that Indians do not explicitly give up in the treaty language remain in full force (Pevar, 1992).

The Federal government discontinued formal treaty making with tribes in 1871. Since that time, the

government has formally and legally recognized tribes only by Executive Order, subject to approval by both houses of Congress. Though Executive Order tribes cannot share in off-reservation reserved rights except by specific agreement, their legal status is the same as for treaty tribes. The Indian Reorganization Act of 1934 sought to protect the land base of the tribes and authorized them to adopt constitutions and by-laws for self-government.

### On-Reservation Resources

The total land area within the boundaries of the 14 Indian reservations is approximately 6.5 million acres (2.6 million ha; U.S. Department of Commerce, 1974). Several different types of land status apply to lands within the reservations. Indian lands are defined as: (1) all land

**Table 2-2. Key treaties with Columbia Basin Indian Tribes**

Treaty	Tribe(s)
Hell Gate Treaty of July 16, 1855	Flathead (Salish), Pend d'Oreille (Upper Kalispel), Kutenai
Yakama Treaty of June 9, 1855 <sup>a/</sup>	Yakama, Klickitat, 12 others
Walla Walla Treaty of June 9, 1855 <sup>a/</sup>	Cayuse, Umatilla, Walla Walla (all now Confederated Umatilla Tribes), Nez Perce
Treaty of June 25, 1855	Tenino, Wasco (now Confederated Warm Springs Tribes)
Fort Bridger Treaty of July 3, 1868	Shoshone, Bannock

Source: Ruby and Brown, 1992.

a/ Both negotiated at the Walla Walla Treaty Council.

within the limits of any Indian Reservation under the jurisdiction of the United States government, notwithstanding the issuance of any patent, and including rights-of-way running through the reservation; (2) all dependent Indian communities within the borders of the United States, whether within the original or subsequently acquired territory thereof, and whether within or without the limits of a state; and (3) all allotments, the Indian titles to which have not been extinguished, including rights-of-way running through the same (18 USC 1151). Many reservations also include extensive inholdings of non-Indian private lands. These are generally lands that were declared "surplus" after allotments were made to individual Indians and were opened to homesteading, or allotment lands that were later transferred to non-Indians (Pevar, 1992). In 1991, tribal acreage among the 14 reservations amounted to about 4.5 million acres (1.8 million ha; Appendix O).

Indian trust and tribal lands are managed for a variety of purposes by the BIA or the tribes. Forestry is a primary land use on a number of reservations that have significant timber resources, such as the Colville, Yakama, and Warm Springs Reservations (Ruby and Brown, 1992). Extensive areas of the Flathead, Nez Perce, Coeur d'Alene, Umatilla, and Shoshone-

Bannock Reservations, among others, are used for crops or grazing. (In some cases agricultural lands are leased to other parties, principally non-Indians.) Many of the tribes operate factories or commercial facilities as tribal enterprises. Examples are numerous and include resorts, casinos, marinas, corporate farms, and mining operations.

Fish and wildlife are also important resources on many reservations. Treaties reserve to tribes the right to fish and hunt on their reservations, and tribes generally manage fish and wildlife resources on the reservations. The Colville tribes' trout hatchery on Lake Roosevelt is a notable example of Tribal fish and wildlife enhancement programs.

#### **Off-Reservation Rights and Resources**

As a result of treaties, Federal statutes, and the legal concept of aboriginal rights, Northwest Indians continue to hold and exercise rights to important activities and resources in areas beyond their respective reservation boundaries. These off-reservation rights typically include fishing, hunting, gathering activities, and use of sacred and religious sites.

### **Fishing, Hunting, and Gathering Rights**

Fishing, hunting, and gathering wild plant materials have always been important to Indians in the Northwest and elsewhere. Anadromous fish were, and still are, central to the religion, culture, and subsistence of most Columbia Basin Tribes. Both coastal and interior plateau peoples relied on local game resources as well, and many plateau tribes traveled to the Great Plains to obtain bison (after introduction of the horse). Berries, roots such as camas, and other natural crops were typically important food sources as well, and a variety of plants was gathered for medicinal purposes.

Northwest Indians continue to rely on these resources to varying degrees, and often obtain them in off-reservation areas. The legal and political history of Indian fishing rights is by now well-known throughout the region. Courts have reaffirmed the treaty rights of Indians to share equitably in the harvest of anadromous fish, and to continue to fish in their "usual and accustomed places." Hunting and gathering rights have also received considerable attention, but the primary interest, particularly with respect to the SOR, has been on treaty fishing rights.

The history of treaty fishing rights on the Columbia River is divided into several historical periods. In the 1840s, after creating Oregon Territory, Congress opened up the territory to homesteading. Both white settlers and Native Americans took up land claims along the Columbia River. Then in 1855, a series of nearly identical treaties with several Northwest tribes was negotiated with the goal of acquiring much Indian aboriginal-title land for white settlement. These 1855 treaties specifically allowed the signatory tribes to retain hunting and fishing rights. The fishing rights included the exclusive right of taking fish on streams on or bordering reservations and at "usual and customary" sites along the Columbia River.

Current fishing techniques include dip-netting from platforms fastened to the steep banks of the river, hook and line fishing, and setting gill nets with one end secured to the shoreline or buoy

and the other end projecting into the river. The ceremonial and subsistence fishing season, regulated by Federal-State-Indian conservation agreements, may extend 8 to 9 months for some Native American families.

### **In-lieu Fishing Sites**

The Northwest tribes, through these reserved treaty fishing rights, have access to the river banks to fish during the fishing season. When this right was diminished by the construction of Bonneville Dam, the Federal government made an agreement with the Yakama, Warm Springs, and Umatilla tribes in 1937 that the government would replace the usual and accustomed fishing stations, protected by treaty, that the dam flooded. After the construction of the The Dalles, John Day, and McNary Projects flooded many more of the usual and accustomed fishing sites along the Columbia River mainstem, Congress provided compensation for this loss, both monetary and in the form of "in-lieu" fishing sites in the Bonneville and The Dalles pools.

Under Public Law (PL) 100-581, signed on November 1, 1988, the Corps is directed to provide a wide range of facility improvements, land transfers, and land acquisitions in support of Columbia River treaty fishing activity. Title IV of PL 100-581 specifically identified 23 sites (known as Section 401a sites) along the Columbia River in Oregon and Washington to be transferred to the Department of the Interior, BIA, for use as treaty fishing access sites by members of the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and the Bands of the Yakama Nation. Section 401(b) of PL 100-581 directed the Corps to acquire from willing sellers privately owned lands adjacent to the Bonneville pool for at least six new treaty fishing access sites (at a cost not to exceed \$2 million), and to conduct facility improvements at five existing in-lieu sites.

In August 1989, at public meetings at locations along the Columbia River, the Corps outlined a multi-year Preconstruction Engineering and Design program developed to respond to PL 100-581's diverse requirements. A report on the first phase of the program was submitted in March 1993. It addressed facility construction and land transfer for one Section 401.(a) treaty fishing access site and three Section 401.(b) in-lieu fishing sites. In April 1995 the Corps issued a final phase-two evaluation report (and finding of no significant impact) that recommended development of an additional 19 treaty fishing access sites, two in-lieu fishing sites, and six acquisition sites. The two phases of the program addressed a total of 31 sites. (Additional information may be found in the revised "Phase One Interim Evaluation Report Public Law 100-581, Title IV Columbia River Treaty Fishing Access Site," October 1992, released by the Corps of Engineers, Portland District.)

### **Trust Responsibilities and Indian Trust Assets**

In addition to respecting aboriginal rights and treaty-reserved rights, the Federal government must honor its trust responsibility to Indian tribes. This doctrine can be traced to *Cherokee Nation v. Georgia* (30 US [5 Pct.] 1 [1831]), in which the U.S. Supreme Court stated that Indian tribes were not foreign nations, but constituted "distinct political" communities "that more correctly, perhaps, be denominated domestic...nations" whose "relation to the United States resembles that of a ward to his guardian." This trust responsibility involves a commitment by the Federal government to protect tribal treaty rights, advance tribal interests, and to encourage tribal autonomy and self-governance (Pevar, 1992). Trust responsibility is also a commitment to protect and maintain such rights reserved by or granted to Indian tribes or individuals by treaties, statutes, executive orders, and other agreements. Numerous court decisions have defined and described the trust responsibility as requiring the Federal government to adhere to stringent

fiduciary standards of conduct in matters relating to Indian tribes.

According to the principles of Federal trust responsibility, government agencies must use their authority to scrupulously safeguard Indian trust assets. Indian trust assets are defined as legal interests in property held in trust by the United States for Indian tribes or individuals. Common examples of Indian trust assets include lands, air, minerals, wildlife, fish, plants, cultural sites, and water—essentially everything necessary to preserve or maintain a way of life. From a strict interpretation of the SOR scope, trust assets affected by SOR actions are anadromous and resident fish and wildlife.

Federal policies require agencies to carry out their activities in a manner that protects Indian trust assets and avoids adverse impacts when possible, and mitigate impacts where it cannot avoid them. Federal policies also require explicit discussion and consideration of Indian trust assets in NEPA documentation.

### **Traditional Communities**

Along the Columbia River exist a number of Native American communities that never abandoned their traditional village sites, but were not signatory to treaties. These non-Federally recognized Indian communities continue to rely on fish from the Columbia River to support their subsistence. They include groups living today at Lyle Point, Rock Creek, and Priest Rapids. Many members of these communities are enrolled as members of recognized tribes on one of the nearby reservations. Their subsistence and cultural identity is closely linked to the Columbia River.

### **Cultural Survival**

One of the key issues of Native American groups living along the Columbia River is one of cultural survival. Historically, the impacts of Federal dam construction upon ethnic identity have been adverse. The best documented case studies have been conducted at Colville and Spokane reservations (Ray, 1977). Far beyond

the physical loss of resources like fish and wildlife is the loss of cultural ways of life that have existed for centuries. Relocation of traditional social groups to new residential areas posed serious problems for social-cultural reintegration. With contemporary Indian reservations serving as home base for many traditionally distinct Indian groups, the disruption to social and ceremonial interaction has been great, and threatens survival of distinctive social-cultural traditions and traditional subsistence practices. For example, recent studies in water quality indicate that there is now human health risk for heavy consumption of lower Columbia River fish due to pollution of the river by heavy metals, chemicals and radiation exposure downstream from the Hanford Site. Tribal representatives are also concerned about potential health risks associated with the discharge of smelter slag into the Columbia River at Trail, British Columbia.

#### 2.2.4 The Landscape

The Columbia River Basin is a rich and diverse landscape with scenic beauty that offers a variety of experiences. The basin is characterized by several mountain ranges, plateaus, and large river valleys. Water-related settings range from wilderness mountain lakes and streams (many streams of the basin have attained national significance) to urban waterfront parks. The forests and mountains of the Pacific Northwest have abundant and diverse aquatic, terrestrial, and wildlife resources, and many outstanding natural and scenic wonders. In addition, the basin contains millions of acres of cropland. Land use in the basin is strongly influenced by land ownership patterns, water availability, and the productivity of the land. There are large areas of publicly owned land, particularly in the forested and mountainous portions of the basin. The public lands provide most of the natural, recreational, and scenic resources. Along with privately owned lands, however, they also support a variety of commercial uses.

#### Land Ownership Patterns

About two-thirds of the land in the Columbia River Basin is publicly owned, enabling the development of government land management programs and providing extensive recreational opportunities (see Appendix G). In fact, most of the headwater areas in Montana and Idaho are located in national forests. Within the river corridor itself, however, most of the land is privately owned, particularly as one moves down mainstem and tributary corridors. Virtually all of the river corridor land downstream from Grand Coulee Dam on the Columbia River and below Hells Canyon on the Snake River is privately owned. Exceptions to this pattern include two Federal reservations on the mid-Columbia reach, some Federal and state lands managed for wildlife habitat, national forest lands near the river in the Columbia Gorge, and scattered parcels that are state or local government parks.

While most of the large tracts of public lands in the basin are original public domain lands that were never settled, some lands became public through government acquisition. When the government built the Federal dams, it acquired all the lands within the designated project boundaries. After construction, many lands not needed for project facilities and operations were allocated to public uses, such as recreation and wildlife habitat.

Public lands in the Columbia River Basin are managed by Federal government agencies, state and local governments, and Indian tribes. Federal lands, including Indian reservations under Federal jurisdiction, account for approximately 55 percent of the total land area. Key types of Federally owned lands include national forests, units of the national park system, resource lands managed by the Bureau of Land Management (BLM), national wildlife refuges, and Federal reservations used for military or related purposes. About 0.5 percent of the land is in state ownership and 0.5 percent in county or municipal ownership. Montana, Idaho, Oregon, and Washington all have sizable acreages of state-owned lands, which are

managed largely for income from timber, range, and mineral resources, but also provide wildlife habitat and recreation. The acreage of state lands near the projects in the SOR is not large, but includes a number of wildlife and park units. The remaining lands, nearly 40 percent of the regional total, are privately owned. Appendix G, Land Use and Development, provides more detailed information on land ownership.

### **Federal Protected Lands**

Many areas of public lands in the Columbia River Basin have been set aside with special management designations because of the recreational, scenic, biological, geological, or cultural resource values present on those lands. Most of these lands are Federally owned. The designations include wilderness areas, national parks, national monuments, a national scenic area, national recreation areas, wild and scenic rivers, and national wildlife refuges. Many of these areas are at higher elevations and are not directly connected with the Columbia River system. Key Federal land units with special designations that are within the SOR river corridor are listed in Table 2-3.

### **Land Use and Development**

Indians occupied the Columbia River Basin for thousands of years prior to settlement by Euro-Americans in the 1800s. They typically settled in the river valleys, where they had access to fish and water (Jackson and Kimerling, 1993). The Indian peoples living in the interior of the region reflected the influence of neighboring coastal, desert, and plains Indian cultures. Seasonal migration between high-elevation areas and relatively protected valleys was common.

The first non-indigenous people came to the Pacific Northwest and the Columbia River Basin in the early 1800s. Explorers, trappers, traders, and missionaries came to the "Oregon Country" (as the region was known until Congress granted territorial status in 1848) when the first resource to be exploited was fur. Forts built as centers for this industry were typically located west of

the Cascades, where crops could be planted and livestock raised on the fertile valley soil. The Spalding Mission near Lewiston and the Whitman Mission near Walla Walla, Washington, both established in 1836, were key early settlements in the interior of the basin.

Agriculture assumed an important role in the 1840s and continues to have great economic importance to the region. The attraction of free land through Donation Act land claims and later under the Homestead Act attracted over 300,000 emigrants over the Oregon Trail between 1843 and 1870. While most initially settled in the Willamette Valley, others eventually located in eastern Oregon and Washington to develop dryland farming and livestock operations.

With the discovery of gold near Orofino, Idaho in 1859 and in the Canadian Caribou country soon after that, thousands of miners flocked to the Columbia Basin. Steamboat supply lines provided the materials for mining boom towns. After the major rushes during the 1860s, many miners traversed all of the major river bars along the Columbia River in search for gold. Evidence for early placer mining is common in almost every reach of the Columbia River, often associated with Chinese miners.

Land cover in the U.S. portion of the Columbia River Basin is distributed among four major classes: forest (approximately 50 percent of the total land area), rangeland (33 percent), cropland (13 percent), and other (primarily urban and transportation, less than 4 percent). Land use patterns within the basin reflect the land cover distribution.

Some forest lands are essentially single-use forests used primarily or exclusively for timber production. Large acreages of publicly owned forest lands are managed for multiple uses, including timber for recreation, wildlife habitat, and other purposes. Rangeland generally occurs at intermediate elevations, below the timbered areas and above the larger valleys. Extensive areas of grazing lands are located in southeastern Oregon and southern Idaho.

Table 2-3. Designated Federal protected lands within SOR scope<sup>a/</sup>

River Segment	Designation	Managing Agency
Upper Columbia	Coulee Dam National Recreation Area	National Park Service
Middle Columbia	Saddle Mountain National Wildlife Refuge	U.S. Fish and Wildlife Service
	Hanford Reservation	U.S. Department of Energy
Lower Columbia	Columbia River Gorge National Scenic Area	U.S. Forest Service/Columbia River Gorge Commission
	Umatilla National Wildlife Refuge	U.S. Fish and Wildlife Service
	McNary National Wildlife Refuge	U.S. Fish and Wildlife Service
	Ridgefield National Wildlife Refuge	U.S. Fish and Wildlife Service
	Lewis and Clark National Wildlife Refuge	U.S. Fish and Wildlife Service
	Columbian White-Tailed Deer National Wildlife Refuge	U.S. Fish and Wildlife Service
Middle Snake	Hells Canyon National Recreation Area (includes wilderness area)	U.S. Forest Service
North/Middle Fork Flathead	Wild and Scenic River	National Park Service/ U.S. Forest Service
	Great Bear Wilderness Area	U.S. Forest Service
Middle Snake (in Hells Canyon NRA)	Wild and Scenic River	U.S. Forest Service
Imnaha	Wild and Scenic River	U.S. Forest Service
White Salmon	Wild and Scenic River	U.S. Forest Service
Klickitat	Wild and Scenic River	U.S. Forest Service
Kootenai	Kootenai National Wildlife Refuge	U.S. Fish and Wildlife Service

a/ Wild and scenic river entries are those currently designated and included within or adjacent to projects or river reaches within the SOR scope.

Croplands in the basin support diverse forms of agriculture, including forage, orchards, grain, and a variety of row crops. In general, irrigated croplands are found in the Snake River Plain, Columbia Plateau, and in valleys along tributaries of the interior Columbia River Basin. Dryland farming of grains and other crops in rotation is predominant in the Palouse region of

southeastern Washington and northwestern Idaho, and on other lands in the Columbia Plateau where natural rainfall is sufficient. Farming west of the Cascades is mainly dryland, but in some areas, irrigation water is diverted from the rivers to augment natural water supplies from rainfall in the growing season.

Urbanized land uses include developed communities and transportation systems. While these uses account for a small proportion of the total land area, that proportion is increasing rapidly as a result of conversion of rural land to urban uses. Much of the urbanized land in the basin is concentrated in the Portland-Vancouver, Spokane, Boise, and Eugene-Springfield urban areas. The remainder is distributed among a number of smaller cities and hundreds of other communities. The largest concentrations of urban use along the river system reaches within the SOR scope are Lewiston-Clarkston on the lower Snake River, Wenatchee on the middle Columbia River, the Tri-Cities (Richland, Kennewick, and Pasco) area near the Columbia and Snake River confluence, and the Portland-Vancouver area on the lower Columbia River. Today, a vast system of railroads, transmission lines, and local, state, and Federal highways serves virtually all portions of the Columbia River Basin.

### **Aesthetics**

The diverse landscape of the Columbia River Basin provides a variety of scenic attractions that are key elements of the basin's recreational resources (see Appendix J). Mountain landforms in the Cascades and the Northern Rockies are extensive and include massive volcanic cones, nonvolcanic snowcapped peaks, and forested ridges. The interior of the basin is dominated by dry plateau-type landforms and greener stream valleys. Water features vary within and between these types of terrain. The mountain areas offer numerous lakes, glaciers, high-gradient streams, and waterfalls. Streams and lakes are less numerous in the dry interior, but the water bodies that are present tend to be visually prominent. For example, rivers such as the Yakima and John Day have carved highly scenic canyons.

Most of the projects in the SOR study area are located in arid or semi-arid plateau and mountainous terrain. In this generally dry region, water features attract much attention and are important aesthetic resources. The mid-Columbia projects, Brownlee, the four lower

Snake River projects, and the McNary, John Day, and (most of) The Dalles projects on the lower Columbia share similar Columbia Plateau landscape settings. These river reaches flow through relatively narrow canyons cut into the basalt layers. Valley walls are typically steep but somewhat rounded near the top, and range in height from about 200 to over 2,000 feet (60 to 600 m) above river level. Shrub-steppe vegetation of grasses and sagebrush is characteristic, with pockets of trees and other shrubs along water courses or in relatively cooler, shaded sites.

Landscapes around the Libby, Hungry Horse, Dworshak, and Albeni Falls projects are more typical of mountain settings. The slopes above these reservoirs are heavily forested, primarily with conifers. Nearby peaks and ridges reach up to 5,000 feet (1,500 m) above the valley floors, and often have exposed-rock summits or cliffs. The mountains around Libby and Hungry Horse are more rugged, while Dworshak and Albeni Falls are located near the edge of the Northern Rockies and have less steep terrain.

The extensive visual environment around Lake Roosevelt reflects both the plateau and mountain settings. The northern portion of the lake is situated in the Okanogan Highlands and is bordered by relatively low ridges covered with conifers. Lake Roosevelt's southern part is similar to the mid-Columbia in landforms and vegetation. The Bonneville project also has a varied landscape, as it represents a transition from the moist Willamette Lowland to the dry Columbia Plateau. The prominent gorge through the Cascades is flanked by mountainous terrain, but there are geologic and vegetative similarities with areas to the east.

Except for a portion of the Hells Canyon reach of the Snake River that is designated as wilderness, all of the reservoirs and river reaches in the SOR show evidence of human development. None could be characterized as heavily developed, however, and several projects have extensive areas that are essentially unmodified. This is particularly true in the

upstream reaches of the study area, such as around Hungry Horse. The level of development and landscape modification generally increases toward the downstream areas of the system. Within the river corridor itself, development is most extensive and concentrated in the Lewiston-Clarkston, Tri-Cities, and Portland-Vancouver areas.

Transportation routes provide ready visual access to most of the lower reaches of the river corridor. Highways parallel both sides of the lower Columbia River up to McNary Dam, and one or both sides in some other locations farther upstream. Most of the shorelines of Lake Pend Oreille, Lake Koocanusa (Libby Reservoir), and Hungry Horse Reservoir are accessible by road. In some areas of the system, such as Brownlee, Dworshak, and much of the lower Snake River, easy visual access is limited to selected locations where roads approach or cross the reservoirs.

### 2.2.5 The People and the Economy

The following discussion summarizes key demographic, economic, and social characteristics of the Columbia River Basin. Appendix O, Economic and Social Impacts, presents more detailed information.

#### Population

The combined population of Oregon, Washington, Idaho, and Montana in 1990 was just over 9.5 million. Approximately 5 million of these people, or 53 percent of the four-state total, live in the U.S. portion of the Columbia River Basin. The total basin population also includes approximately 15,000 residents of northwestern Wyoming and very small numbers from parts of northwestern Utah and

northeastern Nevada. Historically, population growth in the basin has centered in urban areas such as the Tri-Cities and Spokane, Washington; Portland, Oregon; Vancouver, Washington; Eugene and Springfield, Oregon; Boise, Nampa, and Caldwell, Idaho; and Missoula and Kalispell, Montana. Outside of the urban areas, the basin is sparsely populated because large tracts of land are devoted to forestry, agriculture, and livestock grazing.

Figure 2-10 shows long-term population growth for the four states. From 1900 to 1990, population in this four-state region increased by 612 percent, or an average compound annual growth rate of about 2.2 percent. While steady growth has been the long-term trend, the rate of growth has varied considerably over time and from state to state. As a region, population almost doubled (88.3 percent) between 1900 and 1910. Growth then slowed through 1940, but increased again after that date. The 1940s and 1950s were periods of relatively rapid population increase, particularly in Oregon and Washington. From 1980 to 1990, the population increased by about 18 percent in Washington, 8 percent in Oregon, 7 percent in Idaho, and 3 percent in western Montana.

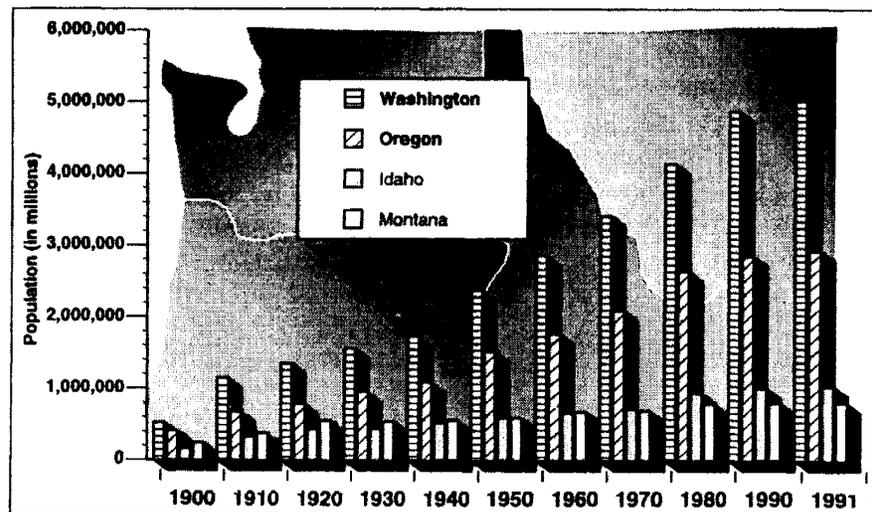


Figure 2-10. Population of Northwest states, 1900 to 1990 (Source: U.S. Census Bureau, 1993, 1988, 1961).

While the Northwest as a whole has been growing at a significant rate, the Columbia River Basin and the counties most directly affected by the SOR have not all kept pace. During the 1980s, none of the Idaho, Oregon, or Washington counties along the river corridor experienced population growth greater than the state-average growth rates. The counties that had declines or slow growth were the smaller, rural areas, while the larger, more urbanized counties showed consistent growth. The populations of Gilliam and Sherman Counties in Oregon, for example, declined from 2,057 to 1,717 and from 2,172 to 1,918, respectively. In comparison, Clackamas County, Oregon grew from 241,911 to 278,850, an increase of over 15 percent. Urban areas within the region generally have been attractive to immigrants because of the variety of employment opportunities.

The population of the Northwest is projected to grow by about 30 percent between 1990 and 2010 (Appendix O). The regional economy is expected to foster increased immigration during the forecast period. Comparatively stronger economic growth and increases in retirees and recreation visitors should put population growth above the nationwide rate.

### **Cultural and Social Groups**

The Columbia River Basin is home to a diverse population representing many different cultures and ethnic backgrounds. To a great extent, the social and cultural characteristics of the population are simply a part of the regional fabric and are independent of the river system. In some cases, however, social and cultural groups relate to the river system in ways that are significant for the SOR.

Native Americans are a diverse cultural group that could be affected by the SOR because of their strong ties to the river system, as discussed in Section 2.2.3. There are also various active citizens groups in the basin, including groups representing timber-based communities, commercial fisheries, sport fisheries, farming communities and irrigators, environmental and civic groups. Many of these

have participated in SOR meetings and have taken an active interest in the SOR. The different views of these groups tend to reflect their economic dependence on river system resources.

### **Economic Activities**

The Columbia-Snake River system provides a variety of resources for public and private use. Major economic activities include transportation, agriculture, electric power generation, and recreation. Section 3.3 provides more detailed information on specific uses of the Columbia River system. The following is a brief summary of these activities from a regional economic perspective.

#### ***Navigation***

The 465-mile (748-km) Columbia-Snake Inland waterway represents a key link to the eastern interior region, providing barge transport from the Pacific Ocean to Lewiston, Idaho, the most inland port (see Appendix H). The transportation system consists of navigation channels and locks, port facilities, and shipping operations. The Corps maintains the channels at authorized dimensions, and locks on the mainstem dams provide hydraulic lifts for barge access. Six barge companies operate approximately 40 towboats and 175 barges on the Columbia-Snake River system. Fifty-four port facilities and associated shipping operations provide transport for the various agricultural and timber products produced in the region. In addition to barging, other types of commercial transportation activities in the system include log rafting on Dworshak Reservoir, ferries on Lake Roosevelt, and passenger and mail boat service on the Snake River upstream of Lewiston.

#### ***Irrigation***

There are approximately 7.3 million acres (3 million ha) of irrigated cropland in the basin, including 193,000 acres (78,000 ha) in British Columbia (see Appendix F). Of this total, 380,000 acres (153,786 ha) are irrigated by pumping from the lower Columbia and Snake

River pools, and approximately 557,000 acres (225,000 ha) are irrigated by the Columbia Basin Project at Grand Coulee. Irrigated lands in the region produce a wide variety of crops. Potato, sugar beet, hop, mint, and fruit production is almost exclusively from irrigated lands. Irrigation also accounts for most corn, vegetable, and hay production in the region. Irrigated crop values can range from \$6,000 per acre (\$2,428 per ha) from high-yielding apple and grape orchards to \$150 per acre (\$60 per ha) for some types of hay production (Appendix F). These and other crops produced through irrigated farming are sold to markets throughout the country and provide substantial revenue to the region.

### **Hydroelectric Power**

The Columbia and Snake Rivers are heavily developed for hydroelectric power generation (see Appendix I). All 14 Federal dams have hydroelectric facilities, which collectively provide an installed capacity of about 18,900 megawatts (MW). This is approximately equivalent to the average energy demand for the Pacific Northwest in 1992 (NPPC, 1993). These power resources serve residential, commercial, agricultural, and industrial loads. Some of the agricultural and industrial users are heavily dependent on economical power for continued operations.

### **Recreation**

The diverse landscape of the Columbia River Basin provides a wide range of recreational opportunities (see Appendix J). The reservoirs and adjacent lands of the Columbia River system are recreational resources. Various agencies have developed hundreds of recreation sites that offer opportunities for boating, swimming, fishing, waterskiing, windsurfing, camping, and picnicking. The projects are heavily used for recreation, with a total annual average of 18 million recreation days reported on the 14 pools in the SOR study area (Appendix J). These activities have significant economic and non-economic value to the users. In addition, recreationists using the projects spend money for

a variety of recreation-related goods and services. The recreation resources of the Columbia River system, and the expenditures that they generate, are important components of the regional tourism industry.

### **Anadromous Fish**

The harvest of Columbia River anadromous fish has been a major human activity throughout history in the Northwest (see Appendix C). All three Columbia River anadromous fisheries, non-native commercial, sport, and Native American, have experienced immense declines in harvest from before the turn of the century. With the variations in run sizes and changing market conditions, the incomes generated by salmon harvest have also varied greatly, but these incomes continue to be strong elements of the local economies of Oregon, Washington, and the treaty tribes. The total gross annual value of the commercial harvest in the Columbia River averaged about \$15,200,000 (1990 dollars) from 1986 to 1990 (Appendix O). Many people in coastal and lower river communities work in the fish harvesting, fish processing, boat services, recreational charter, and other tourist-related industries. The commercial fishery and charter fishing industries tend to be labor intensive, so much of the revenue generated goes directly into households. As a result, consumer-supported businesses, such as retail sales, housing, and restaurants, are indirectly affected if income from fishing declines substantially.

### **Municipal and Industrial Water Supply**

In addition to irrigation of agricultural land, water pumped from the Columbia River system is used for other purposes (see Appendix F). Municipalities draw water from the pools for their water supplies. Industrial plants, such as pulp and paper mills and food processing operations, use water in their production processes. Recreation-related businesses, such as country clubs, use water to irrigate golf courses, and various state and county parks use water for irrigation and water supply. Wildlife management areas also draw water from the system to irrigate vegetation for wildlife. In

various ways, these water uses support local jobs and contribute to the regional economy.

### **Economic Well-Being**

The socioeconomic effects of system operations are felt primarily within the communities along the Columbia River system, in nearby upland areas that draw water from the rivers, and in the commodity production areas that rely on the rivers for transportation. Quantified geographically, the area most likely to feel these socioeconomic effects would be a zone extending up to 30 or 40 miles (48 to 64 km) on either side of the river reaches included within the SOR scope. Employment and income characteristics, which are standard measures of economic well-being, are summarized below.

#### **Employment**

Over the past 10 years, the economy of the Pacific Northwest has evolved from being resource-based to more diverse, with growing trade and service sectors. In 1980, resource-based industries accounted for 30.9 percent of manufacturing employment; by 1990, their share had fallen to 27.2 percent (Appendix O). High technology industries (aerospace, electronics, and scientific instruments) have grown in share over the last decade from 30.3 to 42 percent of total manufacturing. Overall, the manufacturing share of the regional economy was 19.4 percent in 1980 and 17.7 percent by 1990.

The lumber and wood products industry still plays an important role in the region's economy, but this sector has declined from a decade ago. Food processing employment has also decreased in relative terms since 1980. The transportation equipment sector, primarily Boeing, remained at nearly 4 percent of total employment over the last decade, while the electronics and scientific instruments industries have grown. Energy-intensive aluminum production is economically important to the region, but the level of employment in this sector is relatively small (0.7 percent of total employment in 1990).

While the manufacturing share fell over the decade, the non-manufacturing share of total employment rose from 80.6 to 82.3 percent. A rise in wholesale and retail trade and services accounted for most of the gain.

California, with over 29 million people (more than 10 percent of the nation's total population) represents an important market for the Pacific Northwest. The tourism industry, fueled by the scenic coast, Columbia River Gorge, Hells Canyon, and other attractions, provides economic stimulus in less populated regions and helps generate activity in the service and trade sectors. Agriculture is also a substantial industry in the region, although employment declined to about 275,000 in 1990, down from about 285,000 in 1980.

For the forecast period 1990 to 2010, overall growth for major sectors of the regional economy in each state is expected to be moderate. Manufacturing employment is forecasted to be generally stagnant, while non-manufacturing employment is expected to be relatively robust. Growth in the electronics industries is expected to be strong, but the natural resource industries are expected to suffer declining employment levels. Employment in the finance, trade, and service sectors is expected to remain strong as the economy reflects continuing shifts in national demographics and growth in trade and service activity. Increased foreign trade and current management trends also suggest growth in business services. Non-manufacturing employment is projected to grow faster than the national average for the same sector.

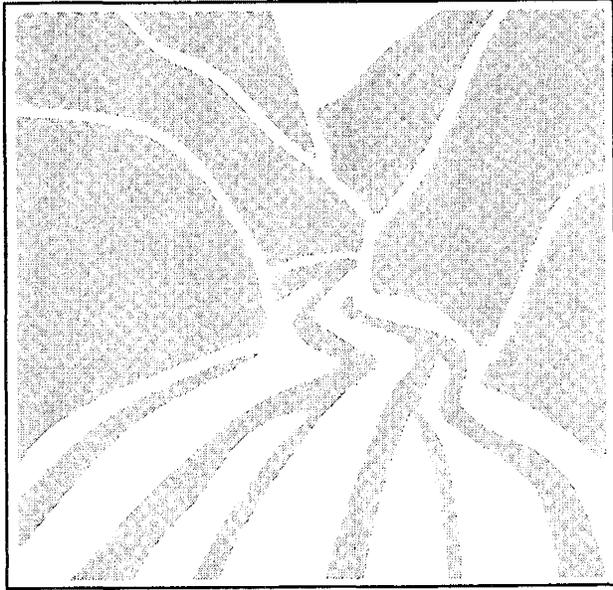
The economies of some parts of the region are thriving, while others are not. Job-producing businesses are moving into or expanding in some areas, while other areas are losing jobs. While it might appear that the Columbia River Basin as a whole is doing well economically, much of the region east of the Cascade Mountains has been lagging. A primary reason for this difference is that employment in extractive industries, such as mining, fishing, logging, and farming, has been

declining, and many of these jobs have not been replaced by growth in other industries.

**Income**

As with employment, the interior areas of the basin tend to lag behind the western Washington and Oregon urban areas in income levels. In 1989, only two Washington counties in the study area (Garfield and Lincoln) exceeded the state per capita personal income (PCPI) of \$17,696. Six counties in Oregon (Gilliam, Morrow, Multnomah, Sherman, Wallowa, and Wasco) and three counties in Idaho (Adams, Lewis, and Nez Perce) exceeded the state PCPI of \$16,003 and \$13,760, respectively. Only Flathead County in Montana exceeded the \$14,520 state PCPI.





# Chapter 3

## The Columbia River System



### 3.0 THE COLUMBIA RIVER SYSTEM

Dam construction in the Columbia River Basin has harnessed the hydroelectric potential of the rivers, provided inland navigation on the lower Columbia-Snake River reaches, supplied water for irrigation, and improved flood control for areas subjected to flooding in the past. Some 255 Federal and non-Federal projects have been constructed in the basin, making it one of the most highly developed in the world.

Operators of Columbia River Basin projects must take into account diverse interests and a broad spectrum of agencies and river users. This fact demands an integrated approach to planning and operations among the projects. Key projects are operated in a coordinated manner that supports multiple uses and increases the benefits to the people of the western United States and Canada. Multiple uses include flood control, navigation, anadromous and resident fish, wildlife, power, recreation, irrigation, and water supply. Additional resources, such as water quality and cultural resources, that are technically not water "uses" must also be considered.

This chapter addresses facilities and resource-based programs of the system that are managed or operated by the three lead agencies. Unlike Chapter 2, which addresses basin resources in general, this chapter focuses on elements that are integral to the operation of the Columbia River system. Programs and facilities managed by other agencies are only addressed if they significantly influence or are affected by system operations.

#### 3.1 THE STRUCTURE OF THE SYSTEM

Dam development in the Columbia River Basin began in the 1800s. Mainstem dam development began with Rock Island Dam (a non-Federal project) on the Columbia River in 1933 and continued through 1975 with the completion of Lower Granite Dam on the Snake River. Most of the dams were constructed from the 1950s through the 1970s. Federal agencies

have built 30 major multipurpose dams with hydropower facilities on the Columbia and its tributaries.

##### 3.1.1 Federal Dams and Reservoirs

The SOR focuses on 14 Federal dams in the Columbia River Basin that are major components of multiple-purpose system operation, and for which power generation is coordinated under the PNCA. These 14 large-scale water projects provide public benefits in many different areas. Project features include dams and reservoirs, navigation channels and locks, hydroelectric powerplants, high-voltage power lines and substations, fish ladders and bypass facilities, irrigation diversions and pumps, parks and recreation facilities, boat launches, lands that are dedicated to the projects, and areas set aside for wildlife habitat.

BPA, the Corps, and Reclamation each have a role in coordinating the Columbia River system. The Corps operates 12 of the 14 projects (all except Grand Coulee and Hungry Horse). The Corps has responsibilities for flood control, recreation, fish and wildlife, navigation, power production, and water quality at these 12 reservoirs (although responsibilities for several resources are shared with other agencies). The Corps also maintains navigation channels and exercises flood control responsibilities throughout the Columbia River Basin. Reclamation has responsibilities for Federally financed water development and irrigation programs, recreation, fish and wildlife, hydropower, and water quality. The agency built and operates Grand Coulee and Hungry Horse Dams. BPA markets and distributes the power generated at the Federal projects in the Columbia River Basin. BPA sells power from the dams and other generating plants, and builds and operates transmission lines that deliver the electricity. The Corps and Reclamation develop multiple purpose operating requirements for their projects and, within these limits, BPA schedules and dispatches power.

The general characteristics of each of these 14 Federal projects are summarized in Table 3-1, which includes information on location, construction date, and the original purposes specifically identified in the legislation authorizing the projects. Additional uses have been authorized subsequently at many of the projects. Figure 1-1 shows the geographic locations of the 14 projects.

### 3.1.2 Non-Federal Dams and Reservoirs

In addition to the 14 Federal projects described above, the SOR considers the effects of operation of the Federal projects on several non-Federal projects. These include five public utility district-owned dams on the middle Columbia River, three middle Snake River dams owned by Idaho Power Company (IPC), and several Canadian dams. Impacts at non-Federal projects were included to the extent these projects would be significantly affected by any of the alternatives analyzed in the study. A brief description of these non-Federal facilities and how they relate to the SOR follows.

#### Canadian Projects

Projects located in the Canadian portion of the Columbia River headwaters play a key role in overall system operation and coordination. Although the lead agencies do not operate these Canadian projects, the Columbia River Treaty provides for coordination of both power production and flood control. Canadian projects relevant to the SOR are located on the Columbia, Duncan, and Kootenay Rivers in British Columbia. Three of the projects—Mica, Duncan, and the Arrow Lakes—are Treaty storage projects and are particularly important to overall system coordination. The Columbia River Treaty, signed in 1961, cleared the way for construction of storage capacity at these three Canadian storage projects and at Libby Dam that more than doubled the storage capacity of the Columbia hydroelectric system. Other dams, including Corra Linn, Brilliant, Waneta, Sevenmile, and Revelstoke, have less impact on system coordination.

#### Mid-Columbia River Dams

After Rock Island Dam was built, four more run-of-river dams were constructed on the middle Columbia River in Washington during the 1950s and 1960s by three different PUDs. These projects are operated under licenses from the Federal Energy Regulatory Commission (FERC). They include:

- Wells, operated by Douglas County PUD
- Rocky Reach, operated by Chelan County PUD
- Rock Island, also operated by Chelan County PUD
- Wanapum, operated by Grant County PUD
- Priest Rapids, also operated by Grant County PUD.

Flow patterns at the mid-Columbia projects are influenced by operations at the Canadian and Federal projects upstream, particularly Grand Coulee. While releases from Grand Coulee are reregulated by Chief Joseph, a Federal project located upstream from Wells Dam, Federal storage project operations still affect the size and timing of flows at the five PUD dams. The SOR strategies do not include any specific actions that would require the mid-Columbia projects to operate outside their normal ranges. The limited SOR evaluation of these projects is intended to check this assumption, and determine whether any shifts in flow patterns would have identifiable consequences.

#### Middle Snake River Dams

The IPC operates three FERC-licensed dams, collectively known as the Hells Canyon Complex, on the middle Snake River between Oregon and Idaho. Hells Canyon, Oxbow, and Brownlee Dams are hydropower facilities that affect flows on the lower Snake River. Brownlee is the most significant of the three for the SOR, as this reservoir has a total storage capacity of 1.4 MAF (1.7 billion m<sup>3</sup>), of which 980,250 acre-feet (1.2 billion m<sup>3</sup>) are used jointly for flood control and power production. The flood control operations at Brownlee help to

Table 3-1. General project characteristics

Project	Operator	Location	Year Completed	Type of Project	Authorized Purposes
Libby	Corps	Kootenai near Libby, MT	1973	Storage	Flood Control, Power
Hungry Horse	Reclamation	S. Fork of the Flathead, near Hungry Horse, MT	1953	Storage	Flood Control, Power, Irrigation
Albeni Falls	Corps	Pend Oreille, near Newport, WA	1955	Storage	Flood Control, Power, Navigation
Grand Coulee	Reclamation	Columbia, at Grand Coulee, WA	1942	Storage	Flood Control, Power, Irrigation
Chief Joseph	Corps	Mid-Columbia, near Bridgeport, WA	1961	Run-of-River	Power
Dworshak	Corps	N. Fork of the Clearwater, near Orofino, ID	1973	Storage	Flood Control, Power, Navigation
Lower Granite	Corps	Lower Snake, near Almota, WA	1975	Run-of-River	Power, Navigation
Little Goose	Corps	Lower Snake, near Starbuck, WA	1970	Run-of-River	Power, Navigation
Lower Monumental	Corps	Lower Snake, near Kahlotus, WA	1970	Run-of-River	Power, Navigation
Ice Harbor	Corps	Lower Snake, near Pasco, WA	1962	Run-of-River	Power, Navigation
McNary	Corps	Lower Columbia, near Umatilla, OR	1957	Run-of-River	Power, Navigation
John Day	Corps	Lower Columbia, near Rufus, OR	1971	Run-of-River <sup>1/</sup>	Flood Control, Power, Navigation
The Dalles	Corps	Lower Columbia, at The Dalles, OR	1960	Run-of-River	Power, Navigation
Bonneville	Corps	Lower Columbia, at Bonneville, OR	1938	Run-of-River	Power, Navigation

Source: Corps, 1989.

1/ John Day has allocated flood control storage, but is operated in a manner that is similar to other mainstem dams that are run-of-river projects.

protect the lower Snake River, especially in the vicinity of Lewiston, Idaho, and contribute with other reservoirs to reducing flooding on the lower Columbia River (Corps, 1984b).

### 3.1.3 Storage and Run-of-River Projects

The 14 Federal projects examined in detail in the SOR fall into two major categories, storage and run-of-river, and it is important to understand the difference between the two. The difference between storage and run-of-river projects, graphically illustrated in Figure 3-1, is explained below. The five Federal storage projects considered in the SOR are Grand Coulee, Albeni Falls, Libby, Hungry Horse, and Dworshak. The nine Federal run-of-river projects considered in the SOR are Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, and Chief Joseph. Table 3-2 lists some of the operating characteristics of these projects, including normal operating ranges and usable storage volumes.

#### Storage Projects

Storage is the key to the operation of the multiple-use river system. The main purpose of the storage reservoirs is to adjust the river's natural flow patterns to conform more closely to water use patterns, storing water from rain and snowmelt until needed. More water is produced during the spring snowmelt than is required at the time for power production, irrigation, and other uses. Reservoirs capture the runoff and store it until the late summer, fall, and winter when it is released.

Storage capacity represents the system's capability to "shape" flows for a variety of purposes. Shaping refers to the operating agencies' ability to control river flow by timing the release of water from the storage reservoirs.

Traditionally, water was held in storage and released to maximize power production. In addition, shaping helped reduce downstream flows during the flooding season. In recent years, however, storage has also been used to increase flows during periods of fish migration. Balancing the various uses of system storage has thus become more challenging as the demands increase; only a finite amount of water and storage space is available in the system to meet competing needs.

The total water storage in the Columbia River system is 55 MAF (67.9 billion m<sup>3</sup>), of which 42 MAF (51.8 billion m<sup>3</sup>) are available for coordinated operations. About half of that storage capacity is in Canada. This is an enormous amount of water, but it is only about 30 percent of an average year's runoff as measured at The Dalles. While there is a large amount of storage on the Columbia River, there is not the degree of control that exists on other large river systems in the United States, such as the Missouri and Colorado River systems.

The combined storage in the reservoirs of the five Federal storage projects considered in the

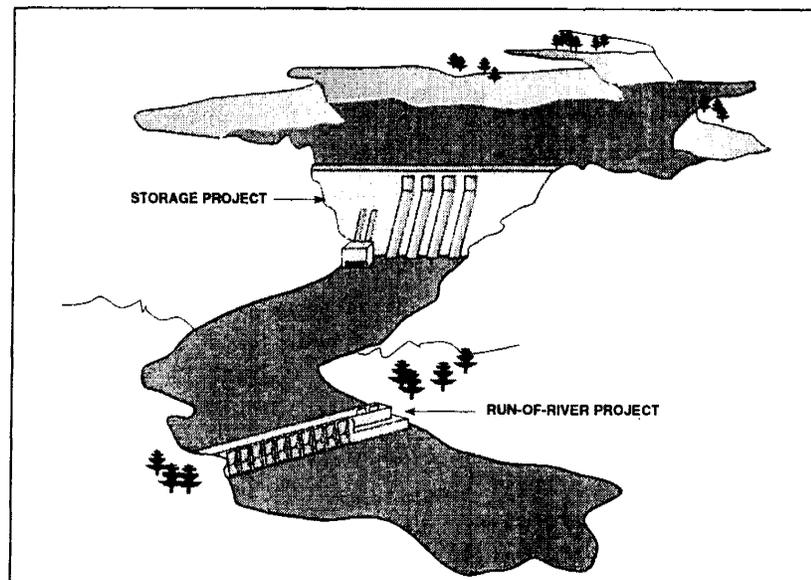


Figure 3-1. Storage and run-of-river projects

Table 3-2. Reservoir operating characteristics

Project	Name of Reservoir	Reservoir Capacity (acre-feet)	Minimum Operating Pool (ft)	Normal Minimum Pool (ft)	Normal full pool (ft)
<b>Storage Projects</b>					
Libby	Lake Koochanusa	4,979,500	2,287 <sup>2/</sup>	NA	2,459
Hungry Horse	Hungry Horse	2,980,000	3,336 <sup>2/</sup>	NA	3,560
Albeni Falls	Lake Pend Oreille	1,155,200	2,049.7 <sup>2/</sup>	2,051 <sup>2/</sup>	2,062.5
Grand Coulee	Lake Roosevelt	5,185,000	1,208 <sup>2/</sup>	NA <sup>2/</sup>	1,290
Dworshak	Dworshak	2,015,800	1,445 <sup>2/</sup>	NA <sup>2/</sup>	1,600
<b>Run-of-River Projects</b>					
Chief Joseph	Lake Rufus Woods	116,000 <sup>1/</sup>	930	930	956
Lower Granite	Lower Granite Lake	49,000 <sup>1/</sup>	733	733	738
Little Goose	Lake Bryan	49,000 <sup>1/</sup>	633	633	638
Lower Monumental	Lake Herbert G. West	20,000 <sup>1/</sup>	537	537	540
Ice Harbor	Lake Sacajawea	25,000 <sup>1/</sup>	437	437	440
McNary	Lake Wallula	185,000 <sup>1/</sup>	335	337	340
John Day	Lake Umatilla	534,000 <sup>1/</sup>	257	Varies	268
The Dalles	Lake Celilo	53,000 <sup>1/</sup>	155	155	160
Bonneville	Lake Bonneville	100,000 <sup>1/</sup>	70	71.5	77

Source: Corps, 1989.

NA = Not applicable

1/ Refers to pondage between minimum and normal full pool.

2/ For the storage reservoirs, entries in this column represent the minimum possible elevation based on location of the project intakes. Actual reservoir levels may only reach these elevations rarely.

SOR is about 16 MAF (19.7 billion m<sup>3</sup>). Active storage capacity of the five storage projects ranges from about 1.2 MAF (1.5 billion m<sup>3</sup>) at Albeni Falls to nearly 5.2 MAF (6.4 billion m<sup>3</sup>) at Grand Coulee. Three Canadian dams—Mica, Duncan, and Keenleyside—add another 20.5 MAF (25.3 billion m<sup>3</sup>) of storage. These eight projects are strategically located in the middle and upper basin to capture runoff for later release.

Reservoir levels at storage projects typically vary greatly during normal operations and with changes in year-to-year water conditions. Hungry Horse operates over a range of 224 feet (68 m); Libby, 172 feet (52 m); Dworshak, 155 feet (47 m); Grand Coulee, 82 feet (25 m); and Albeni Falls, 11.5 feet (3.5 m) (although Albeni Falls operates over relatively small range, it controls a large volume of stored water because of the large surface area of Lake Pend Oreille). Variations between full pools and lowered pools tend to occur seasonally. Just prior to the spring snowmelt, pools are generally kept low to provide enough space for increasing flows and flood control. When possible, operators try to operate pools near full during the summer, when recreation demand is the highest. Figure 3-2 illustrates annual and seasonal elevation patterns for Libby under simulated wet (1955-1956), normal (1948-1949), and dry (1976-1977) conditions.

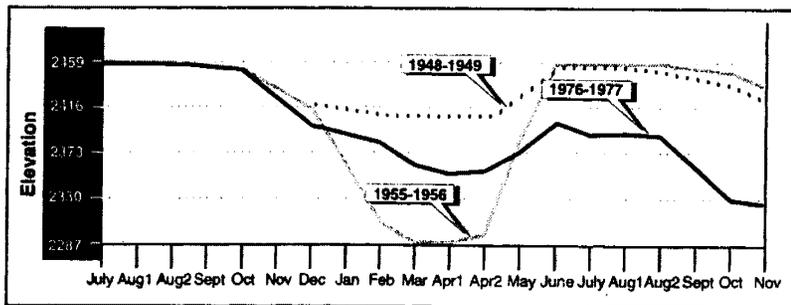


Figure 3-2. Reservoir elevation profile for Libby (Lake Kocanusa) under selected water conditions

### Run-of-River Projects

These projects, which have limited storage capacity, were developed primarily for navigation and hydropower generation. All run-of-river projects provide hydraulic head for power generation. The eight Federal projects on the lower Snake and Columbia Rivers also form enough channel depth to permit barge navigation. Run-of-river projects pass water at the dam at nearly the same rate it enters; the water that backs up behind run-of-river projects is referred to as pondage. The pondage at these projects is sufficient to control flows on only a daily or weekly basis. Use of the pondage causes frequent, small fluctuations in water levels. Reservoir levels behind these projects typically vary only 3 to 5 feet (1 to 1.5 m) in normal operations (see Table 3-2).

While it is physically possible to draft these reservoirs well below the normal minimum pool levels, the projects were not designed to operate at levels below minimum operating pool (MOP). Some of the project facilities at the dams, such as the navigation locks, fish ladders, and juvenile fish bypass facilities, would no longer function at lowered reservoir levels. Irrigation structures and recreation facilities on these reservoirs depend on normal water levels. Also, railroad and highway fills and other embankments would not be protected against increased wave action on the reservoir (Corps et al., 1992).

### 3.2 SYSTEM PLANNING AND OPERATION

Each Federal project within the scope of the SOR was constructed under specific Congressional authorizing legislation identifying the major intended uses (see Table 3-1). All of the projects were specifically authorized for hydropower production, most were authorized for navigation, and some were also authorized for flood control and irrigation. The seasonal abundance of

water and the predictability of its use allows a project to support other uses as well, but only after its authorized purposes are met. General Congressional authorization allows for such uses as water quality, fish and wildlife, recreation, and municipal and industrial water supply.

While the authorizing legislation stipulated intended use, it seldom contained explicit provisions for operating the individual projects or for their coordinated operation within the total system. The Corps and Reclamation are largely responsible for deciding how to operate their projects based on principles of multiple-use operation, their agency charters, operation experience, and public concerns. Overall operation plans are contained in project operation and water control manuals prepared for each project.

Congressional authorization, multiple-use operating principles, project control manuals, and public concern provide overall guidance for system planning and management. Within this overall framework, planning is needed to guide system operations in response to actual hydrologic conditions. As a result, there are several annual planning processes that guide system operations from year to year.

### 3.2.1 Annual Planning

The Columbia River Treaty requires the United States (the Corps and BPA) and Canada (B.C. Hydro) to prepare operating plans each year. These plans are the basis for the operating rule curves for the Treaty projects in Canada. These plans, in turn, are factored into the annual plan developed by parties to the PNCA, because releases of water from the Canadian storage reservoirs are crucial for coordinated system planning in the United States.

Annual planning for coordinated power system operations occurs pursuant to the PNCA. Planning studies are made as if the total coordinated system had a single owner, synchronizing operations to maximize power production.

The annual planning process starts each February, and it incorporates nonpower considerations. Each reservoir owner submits multiple-use operating requirements, such as specified instream flows, that must be accommodated in the resulting plan. Utility parties also submit forecasts of their electricity loads, the output of their non-hydro generating resources, and planned maintenance outages for their resources. Studies are conducted to determine how much power can be produced from the whole system and by each PNCA party. These studies are updated throughout the operating year and guide reservoir operations that produce the planned power capability while meeting numerous other operating requirements.

Annual plans are also developed for purposes other than power. In particular, anadromous fish operations are planned through a Coordinated Plan of Operation (CPO). The SOR lead agencies work with the fisheries agencies and tribes to develop the CPO. Another key plan is the Corps' annual fish passage plan, which specifies operations for juvenile and adult fish passage facilities.

### 3.2.2 Annual and Short-Term Operations

Operation of the Federal system over the year is based on meeting several related but sometimes conflicting objectives. These include: providing adequate flood storage space for controlling spring runoff; providing sufficient water levels for navigation, recreation, and fish and wildlife; maintaining an acceptable probability that reservoirs will refill to provide water for next year's operation; providing adequate water supply for irrigation; providing flows to aid downstream migration of anadromous juvenile fish; and maximizing power generation, within the requirements imposed by other objectives.

Annual operation of the Federal system follows a three-season cycle:

- August through December is the fixed drawdown period, when storage reservoirs are operated according to predetermined rule

curves. Rule curves are monthly reservoir elevation targets that guide reservoir operations. This strategy is necessary because forecasts of the snowpack runoff are not available until January.

- January through March is the variable drawdown period, when operation of the reservoirs is guided by the latest runoff forecasts. Reservoirs are drafted to provide flood control space and to meet power needs. They are also drafted to make nonfirm energy sales. Every effort is made, however, to keep enough water in storage to provide fish flows necessary for spring fish migration and to reasonably ensure reservoir refill by summer.
- From April through July, the reservoirs are refilled with spring runoff. Also during this time, water is released to help juvenile salmon and steelhead migrate to the ocean. Operations for flood control and power sales continue as needed.

The lead agencies have some flexibility to operate the system, attempting to meet the diverse and changing needs of the region based on information that becomes available over the course of the operating year. Many factors cause short-term operational adjustments. For example, sometimes more rain causes higher flows in the fall. This water can be used to produce surplus energy (nonfirm energy), or the water can be left in storage for future use if storage space is available. In a poor snowpack year, it may be necessary to draft reservoirs to levels jeopardizing their refill to get enough power to meet firm energy demand in the region or to meet other obligations. Runoff can be so low that about 25 percent of the time reservoirs in the system fail to fully refill. When this occurs, optional power sales cease and power generation is limited to meeting firm power requirements (Corps et al., 1993).

The actual operations take place in what is described as "real time," that is, decisions must be made in a few hours, days, or at most, a few weeks. Operators regulate the system in an

effort to satisfy all the power and nonpower purposes contained in the annual operating plan. They may need to make decisions to respond to in-stream conditions for fish or navigation, or to take advantage of an opportunity to make a profitable power sale. Boating accidents, generator outages, the weather, and even the timing of recreational events can influence operational decisions.

### 3.3 SYSTEM RESOURCES AND USES

Federal legislation authorizing each project identifies the major intended purposes for that project. Most of the projects covered in the SOR were specifically authorized for flood control, power production, navigation, and/or irrigation. The specifically authorized purposes of a project must be met. If additional water is available, the project can support other uses as well. The following sections address the multiple-use issues associated with operation of the Columbia River system, providing information on project facilities, programs, and institutions that contribute to those uses. Table 3-1 lists the authorized uses of the 14 Federal projects.

Decisions on the four SOR actions will affect, to varying degrees, all river uses and the resources present within the system. The following discussion summarizes how 11 key resource areas are integrated into, or affected by, system operations. More specific information on impacts and operations is provided in Chapter 4.

#### 3.3.1 Flood Control

Because the Columbia River's flow varies so much, the river has been subject to severe floods. Controlling the damaging flood waters was one of the original purposes for many of the dams on the river system. Flood control remains a high priority for system operations, particularly during high-runoff years. With the addition of the Treaty storage reservoirs, a high level of flood control is possible in most years. Damaging floods now occur much less

frequently in the basin. (Appendix E provides more detailed information on flood control operations).

### **Flooding History**

Flood damage has historically occurred along the Flathead River near Kalispell, Montana; the Kootenai River between Bonners Ferry, Idaho, and Kootenay Lake; the Pend Oreille River below Albeni Falls; the Columbia River near Richland-Kennewick-Pasco, Washington; the lower Clearwater River near Lewiston, Idaho; and the Portland/Vancouver area on the lower Columbia River. Although many streams in the basin remain uncontrolled, reservoirs and levees on the major rivers are now able to minimize flood damage in most of these areas.

Early efforts to control floods in the region were organized locally in places subject to frequent damage. Levees and floodwalls were built to protect floodprone areas along the lower Columbia River and elsewhere. After the tragic flood of 1948 that destroyed Vanport, Oregon, the Corps developed a multiple-use reservoir storage plan for the Columbia River Basin, with regional flood control as a major objective. This plan has evolved over the years, with the projects authorized by the Columbia River Treaty bringing the system up to the desired level of protection.

There have been 6 years since 1879 in which daily peak unregulated flows have exceeded 900 kcfs (25,200 cubic meters per second [cms]) at The Dalles (cfs is a unit of measure for the rate at which water flows; kcfs means thousand cubic feet per second). No significant flooding of the Columbia River below Bonneville Dam has occurred since completion of the Federal projects. Flood damage potential, however, is greatest in the lower Columbia from the Portland-Vancouver area to the mouth of the river. This area suffers winter rainfall floods from the Willamette River as well as snowmelt floods from the Columbia. In addition, it is the most developed reach of any of the rivers and tributaries in the study area. Flood control operations now focus on preventing flood

damage in this reach (system flood control) as well as in smaller upstream areas of the basin that are subject to damage (local flood control).

### **Flood Control Operations**

The objective of any flood control operation is to capture enough runoff in reservoirs to keep streamflows from reaching dangerously high levels. The primary flood control season in the Columbia River system is May through July—the snowmelt flood period. The most serious snowmelt floods develop when long periods of warm weather combine with a big snowpack. Some of the worst floods result when heavy rains accompany a heavy snowmelt. In addition to the snowmelt period, rain-induced floods also occur in the winter in the southern and western parts of the drainage.

The volume of the snowmelt runoff can be predicted several months in advance with fairly high accuracy. As a result, flood control storage space in Columbia River system reservoirs is kept only during those months when flood risk exists; the amount of space needed depends on how much runoff is expected. System operators therefore use reservoir space to store water for hydropower, irrigation, recreation, and other purposes during periods when there is no flood risk, and use the space jointly for flood control and the other purposes as appropriate during the flood season. This is the concept of joint-use storage put into practice for the Columbia River system.

Timing is critical during flood control operations. Filling the storage reservoirs must be timed so flows are reduced when runoff is highest. From April through July, reservoirs are allowed to refill gradually, at a rate that maintains downstream flows at safe levels. System operators use a computer model that forecasts runoff and simulates reservoir operation on a daily basis. In years of moderate to high runoff, careful monitoring is required to ensure that damaging flows do not occur. In other years, the potential for flooding is reduced because the snowpack is light or because cool weather and other conditions result in a

prolonged runoff. Other considerations, such as refill requirements, water releases for fish, and power generation opportunities, heavily influence storage reservoir operation in those years.

Currently, up to 37 MAF (45.7 billion m<sup>3</sup>) of storage space can be made available for flood control from the Columbia River system. This represents 16.5 MAF (20.4 billion m<sup>3</sup>) available at the U.S. storage projects (Grand Coulee, Albeni Falls, Libby, Hungry Horse, and Dworshak) and 20.5 MAF (25.3 billion m<sup>3</sup>) at the Canadian Treaty projects. This reservoir storage is supplemented by a system of local levees, floodwalls, and bank protection. Levees have been constructed throughout the basin to supplement flood protection and help protect agricultural, residential, industrial, and other lands. Few of the levee structures are maintained by the SOR agencies; most are owned and maintained by municipalities or local levee districts. Major levee systems in the basin include:

- Approximately 95 miles (152.9 km) of levees on the U.S. portion of the Kootenai River below Libby Dam
- Several miles of levees along both banks of the upper Flathead River in the vicinity of Hungry Horse Dam
- Levees on the Pend Oreille River in the vicinity of Albeni Falls
- The Lewiston levees, which were built as part of the Lower Granite project and are maintained by the Corps
- Levees in the Tri-Cities area that are owned and operated by the Corps as part of the McNary project
- More than 20 levee systems along the lower Columbia River, in the Portland metropolitan area and around downstream communities.

These levee systems offer varying degrees of flood protection. For example, some of the lower Columbia levees are designed to sustain

flows of 800 kcfs (22,565 cms) or more. The McNary project levees also provide the Tri-Cities area with a very high level of flood protection (see Appendix O, Section 4.5.3). Other levee systems on this reach can fail at flows as low as 600 kcfs (16,992 cms), which is considered the "major damage" threshold. In addition to these strategies, many communities have adopted measures such as land use regulation and improved land treatment practices to minimize the potential for flood damage. Participation in the National Flood Insurance Program requires localities to maintain a given level of flood protection, which is typically protection from a 100-year flood.

### Damage Centers

Areas of historical flood damage are located throughout the entire basin. Since completion of the Federal hydroelectric system, many of the areas previously subject to frequent flood damage are now protected by flood control operations, levees, and other measures. Currently, the primary damage centers in the basin are on the upper Columbia River (including tributaries), the Clearwater River, and the lower Columbia River. Consequently, the impact analysis presented in Section 4.2.11 covers these specific areas.

#### *Libby Dam to Kootenay Lake*

The area of potential flood damage along the Kootenai River downstream of Libby Dam occurs in the reach known as Kootenai Flats, extending from Bonners Ferry, Idaho, to Kootenay Lake in Canada. Historically, high water would cover portions of the flood plain every year and more infrequent events would flood the entire valley—more than 60,000 acres (24,282 ha). Levees now protect about 35,000 acres (14,165 ha) of croplands in the United States and about 17,000 acres (6,880 ha) of agricultural land in Canada.

#### *Columbia Falls to Flathead Lake*

The primary area of potential flood damage along the upper Flathead River downstream of

Hungry Horse Dam occurs in the reach between Columbia Falls, Montana and Flathead Lake. Most residential and commercial damages occur in the area adjacent to the city of Kalispell, Montana; agricultural damages are predominantly upstream and downstream of this area. The Flathead River floods the lower portions of this reach about once in every 4 years; higher elevations of the flood plain are flooded less frequently.

#### ***Pend Oreille Lake and Albeni Falls Dam to Cusick***

The lowlands along Lake Pend Oreille and portions of the cities of Sandpoint and Priest River have been flooded three times since construction of Albeni Falls Dam. Downstream of the project, Calispell Flats near Cusick, Washington is the area most subject to flooding. Other areas subject to flooding under natural conditions include about 15,000 acres (6,000 ha) of agricultural land on the west bank of the river and about 2,000 acres (800 ha) of Kalispel Indian Reservation land located opposite of Cusick.

#### ***Dworshak Dam and the Clearwater River***

Floods in the Clearwater River Basin are generally of three types: (1) spring snowmelt with and without spring rainstorms, (2) winter rainstorms accompanied by snowmelt, and (3) ice jams. There is no flood protection provided between Dworshak Dam and the Lewiston levees. The city of Lewiston, at the confluence of the Clearwater and Snake Rivers, is protected by levees up to about river mile (RM) 5 on the Clearwater.

#### ***Lower Columbia River***

The lower Columbia River below Bonneville Dam is estuarial. Predominantly agricultural land use in the upstream portion gives way to increased industrial development as the river approaches the Portland metropolitan area. This area is the largest population concentration in the Columbia River Basin. Most of the land in the 100-year flood plain is leveed to protect

intensive commercial and industrial development. Cities and towns along the lower Columbia River include Woodland, Longview-Kelso, and Cathlamet in Washington; and St. Helens, Rainier, Clatskanie, and Westport in Oregon. Flooding in the area results from runoff of spring snowmelt, sometimes augmented by spring rains; or from intense winter rainstorms augmented by snowmelt. Flood risk areas include agricultural lands; portions of cities and towns; and transportation facilities consisting of railroads, highways, air terminals, and navigation facilities.

#### **3.3.2 Navigation**

Navigation in the Columbia River Basin is both commercial and recreational. Commercial use takes place primarily along the Columbia-Snake River Inland Waterway. Recreational use occurs along this waterway and on the reservoirs and river reaches farther upstream. Appendix H provides detailed information on navigation.

#### **Columbia-Snake River Inland Waterway**

Construction of the Federal dam system helped form the Columbia-Snake River Inland Waterway, which allows navigation for 465 miles (748 km) from the Pacific Ocean to Lewiston, Idaho. The waterway consists of three segments. The first is the 40-foot-deep (12 m), open-river channel for ocean-going vessels that extends 106 miles (170 km) from the ocean to Portland, Oregon and Vancouver, Washington. The second is the Vancouver to The Dalles Navigation Project, which is authorized to 27 feet (8.2 m) but maintained at 17 feet (5.2 m) to Bonneville Dam and at 14 feet (4.3 m) to The Dalles Dam. The third is the shallow-draft barge channel that extends 359 miles (578 km) from Vancouver to Lewiston, Idaho. The channel accommodates shallow-draft tugs, barges, log rafts, and recreational boats. It connects the interior of the basin with deep-water ports on the lower Columbia River, an important benefit particularly for the agricultural industry. Each dam between Bonneville Dam and Lewiston has a system of locks and maintains sufficient water depth at MOP to pass

vessels. Four Federal dams on the mainstem of the Columbia River—Bonneville, The Dalles, John Day, and McNary—have navigation locks that pass boats and barges. Locks at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams accommodate river traffic on the lower Snake River up to Lewiston.

Barges and other river traffic need minimum water depths to navigate successfully. Unlike other river uses, navigation has depth requirements that do not vary with the seasons. Dam operators must regulate water releases and maintain reservoir levels to provide minimum navigation depths all year. Operating requirements for navigation differ among the waterway's three segments. In the first segment, the open-river channel from the ocean, navigation requirements can usually be met by natural river flows, without any special releases. Periodic dredging maintains the channel depth to support navigation even at normal low flows.

In the third segment, the barge channel to Lewiston, maximum and minimum reservoir elevations have been established to maintain an

authorized 14-foot (4.3-m) channel depth. The required channel depth can be maintained physically, by dredging, or operationally by raising pools. For example, the McNary pool needs to be at a minimum of 338 feet (103.0 m) and Priest Rapids Dam discharges need to be stable to facilitate the movement of naval reactor compartment disposal shipments to the Port of Benton by the U.S. Navy. Thus, navigation requirements are fully met within the flexibility provided under normal system operation. Traditionally, locks are taken out of service for approximately 2 weeks each year for maintenance, which generally occurs in the spring.

The presence of the Columbia-Snake River Inland Waterway has led to the development of a sizable river transportation industry in the region. Six barge companies currently operate approximately 40 tow boats and 175 barges. Fifty-four port facilities and shipping operations (Table 3-3) provide transportation for agricultural and timber products (Corps et al., 1992). In 1993, navigation activity generated a cumulative total of 15,991 lockages (operations

Table 3-3. Number of Columbia/Snake River port facilities by pool and use

Pool	Grain	Wood	Mooring Vessels	Petro	Container	Fertilizer	Not used	General	Misc.
Bonneville	2	2	—	—	—	—	—	—	—
The Dalles	5	2	—	—	—	—	—	1	—
John Day	4	2	1	—	—	—	—	1	—
McNary	7	2	2	4	1	3	2	—	4
Ice Harbor	2	—	—	—	—	—	—	—	—
Lower Monumental	1	—	—	—	—	—	—	—	—
Little Goose	4	—	—	—	—	1	—	—	1
Lower Granite	4	7	—	1	3	—	—	1	—

Source: Corps et al., 1992

of a single navigation lock to move vessels upstream or downstream) at the eight lower Columbia and Snake River dams. Commercial traffic accounted for 13,390 of the lockages and recreational boating traffic accounted for the remaining 2,601 lockages.

The Columbia-Snake River Inland Waterway through McNary to the Lower Granite pool handled nearly 6.7 million tons (6.03 million metric tons) of freight in 1990. This included cargo originating in the Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary Reservoirs. Since 1980, cumulative cargo volumes have ranged from 5 to 8 million tons (4.5 to 7.2 million metric tons) per year. At least a portion of the Snake River segment (as measured by the figures for Ice Harbor) was used for transporting an average of 3.8 million tons (3.4 million metric tons) of the cargo each year from 1980 through 1990 (Corps et al., 1992).

Major export items from the Columbia River include wheat, corn, logs, soda ash, wood chips, barley, lumber, sorghum, coke, and beet pulp pellets. Nearly all of these commodities rely on barge transport through the inland system of locks for delivery to export terminals and ultimately to markets worldwide. In 1990, over 26.5 million tons (23.9 million metric tons) of these goods were exported from Columbia River deepwater ports (see Figure 3-3 for a breakdown of these products by tonnage).

While the two segments of the inland navigation channels end at the head of the McNary and Lower Granite pools, river reaches and reservoirs

above these pools are used for various types of navigation. The most common upstream navigation use is recreation.

### Other Navigable Waters

Many types of motorized and non-motorized pleasure craft are used by private boaters on the mid-Columbia reservoirs, the Snake and Clearwater Rivers above Lower Granite, Dworshak Reservoir, and the three reservoirs of the Hells Canyon Complex. Commercial tour guide and transportation services also exist in some locations, particularly on the Hells Canyon reach of the Snake River upstream from Lewiston, Idaho. An open-river channel with a minimum depth of 3 feet (1 m) extends for 90 miles (145 km) on the Snake River above Lewiston.

There are two ferry operations on Lake Roosevelt behind Grand Coulee Dam. The Keller Ferry is part of Washington State Highway 21. It can run throughout the entire

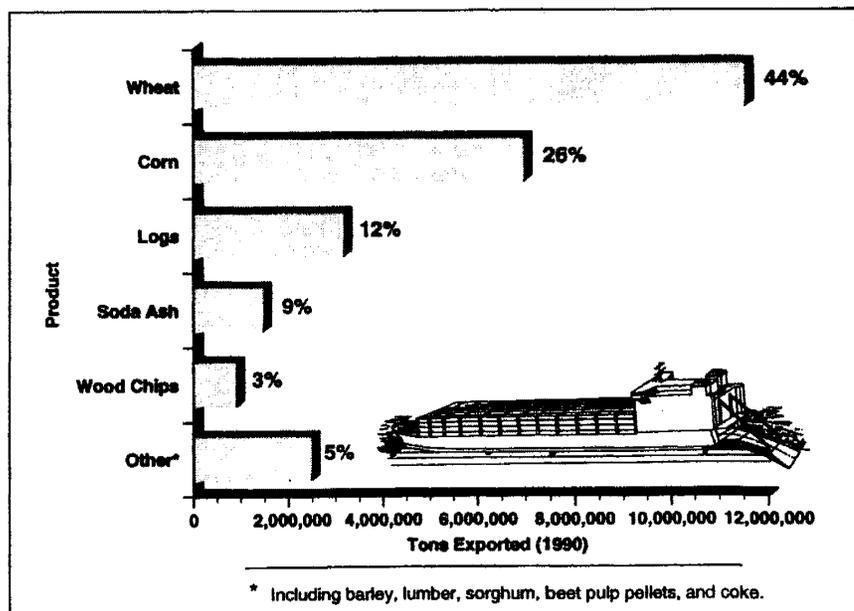


Figure 3-3. Products exported from the Columbia River (Source: Mason, 1991)

operating range of the reservoir, from elevation 1,208 to 1,290 feet (368 to 393 m). The Gifford-Inchelium Ferry provides access to the Colville Indian Reservation from Washington State Highway 25. This ferry cannot operate below elevation 1,220 feet (372 m). Both ferries carry normal highway traffic.

Navigation in other parts of the Columbia River Basin is primarily recreational and is concentrated in the upstream storage reservoirs. Pleasure boaters make use of the large, relatively stable pools at these reservoirs. SOR projects commonly associated with recreation-based navigation include Dworshak, Albeni Falls, Hungry Horse, Libby, and Grand Coulee. The three reservoirs of the Hells Canyon Complex (Brownlee, Oxbow, and Hells Canyon) offer opportunities for recreational boating (Corps et al., 1993), as do the river reaches below Federal projects and below Hells Canyon.

In addition to recreation-based navigation, Dworshak Reservoir is used for a specific commercial purpose—log transportation. Dworshak waters transport approximately 20 million board-feet of logs per year (Corps et al., 1993). Timber is logged from public and private forest lands around the reservoir and brought to loading facilities on the reservoir shoreline. Reservoir levels must be a minimum of between 1,570 and 1,585 feet (479 and 483 m) to accommodate log transportation (one of the four log dumps is operational at 1,570 feet (479 m); all four are operational at 1,585 feet (483 m). Log transportation typically occurs on the reservoir from mid May until early September, with 90 percent taking place in June, July, and August.

### 3.3.3 Anadromous Fish

Historically, salmon migrated nearly 1,200 miles (1,931 km) up the Columbia River to Lake Windermere, Canada, and 600 miles (965 km) up the Snake River to Shoshone Falls near Twin Falls, Idaho (Lavier, 1976). Dam construction blocked anadromous fish access to much of the

upstream portions of the Columbia and Snake Rivers, along with their tributaries. Completion of Grand Coulee Dam in 1941 blocked access to over 500 miles (805 km) of the upper Columbia River, excluding tributaries. Another 52 miles (84 km) of the mainstem were lost with the building of Chief Joseph Dam, the current upstream limit of salmon and steelhead in the Columbia (Lavier, 1976). Over 50 percent of the originally inhabited mainstem of the Snake River is no longer accessible to anadromous fish; Hells Canyon Dam now limits access to the lower 247 miles (397 km) of this river. Dworshak Dam blocked upstream migration on the North Fork of the Clearwater when it was built in the early 1970s.

Government agencies have developed an extensive array of fishery programs and facilities at the downstream projects to accommodate anadromous fish migration in the remaining accessible portions of the basin. Some fish facilities were included in the initial design of the projects; others have been added as the agencies learn more about the needs of the species. Facilities and operations designed to benefit fish include: ladders for adults and diversion screens for juveniles; a transportation program consisting of collection facilities, barges, and trucks for juvenile migration; hatcheries to supplement wild stocks; and in-stream flow management for both juveniles and adults. Research and monitoring programs have been established to guide future actions. These efforts have evolved over time as project operators have sought to meet specific needs.

The Pacific Northwest Electrical Power Planning and Conservation Act of 1980 significantly expanded fish programs in the Columbia River Basin. The Act created the NPPC and led to its Fish and Wildlife Program to protect, mitigate, and enhance fish and wildlife. The sections below discuss relevant facilities and programs that contribute to ongoing regional efforts to improve the status of anadromous fish runs. Appendix C provides additional discussion.

### Adult Passage

Fish ladders, which allow adult fish to migrate upstream, were built during the original construction of all eight Federal run-of-river projects on the lower Columbia and Snake Rivers. (The five PUD dams on the mid-Columbia River also have fish ladders to maintain anadromous fish access to the Wenatchee, Methow, and Okanogan Rivers.) Each of these projects has one to three ladders that operate continuously, except for winter maintenance outages. Storage projects effectively blocked upstream migration of anadromous fish and were not designed with adult passage facilities.

Bonneville Dam has three fish ladders; The Dalles, John Day, McNary, Ice Harbor, and Lower Monumental Dams have two fish ladders each; and Little Goose and Lower Granite Dams each have one fish ladder. Adult fish enter a ladder through collection systems that run along the entire front of a dam's powerhouse, and at other key locations. Specific flow conditions near the ladder entrances are needed to attract adult fish into these systems. The attraction water is provided by pumps, small turbines, or gravity flow from the reservoir behind the dam, depending on the design of the individual system. Once inside a collection system, the fish swim upstream to the base of the fish ladder where they migrate up the ladder and exit into the reservoir above the dam. Each ladder contains a fish-counting station where the fish pass an underwater viewing window, allowing them to be counted and identified by species.

### Juvenile Bypass and Transport

In the early 1950s, the Corps began the Fish Passage Development and Evaluation Program (FPDEP) to develop methods of safe juvenile fish passage at the mainstem dams. Regional fish agencies and other experts have cooperated in the program. These intensive research efforts led to the installation of submersible traveling screens to steer juvenile fish away from turbine intakes. The fish are diverted into special channels for bypass around the dam or collection

for transport downstream by truck and barge (Figure 3-4) (Corps et al., 1993).

Studies indicate that injury and mortality of juvenile fish can occur through all routes of passage at dams, but mortality through turbines is usually high relative to other routes of passage (Snake River Salmon Recovery Team, 1993). Juvenile fish passing directly through the turbine chambers can be killed by the high water pressure or by turbine blades. Juveniles not immediately killed are often stunned as they exit the turbine chambers, which leaves them susceptible to predation. All eight lower Columbia and Snake River dams have therefore been equipped with some type of system to get downstream migrants through the powerhouse without passing through the turbines. Six of the projects have facilities to divert juvenile anadromous fish away from the turbine intakes and through a bypass system to the tailrace, where they are collected for transport or released back into the river. The systems at Lower Granite, Little Goose, and McNary Dams are used to collect fish for the juvenile fish transport program, which is described later in this section. The bypass system at Lower Monumental began full operation for collection and transportation in 1993. The bypass systems at Bonneville and John Day Dams, projects closer to the Pacific Ocean, discharge fish back to the river below the projects. Bypass facilities at Ice Harbor and The Dalles, which in the past have used ice and trash sluiceways to pass fish, are being designed and are scheduled to be operational in 1998 and 1999, respectively.

Before the dams were built in the Columbia River Basin, smolts migrating downstream generally experienced swift river flows from their hatching areas to the Pacific Ocean. Since the construction of the projects, juvenile migration takes longer; smolts must swim through slack water reservoirs as they move downstream. Longer migration times have been linked to higher predation, increased disease, and some fish remaining in the reservoirs instead of completing their migration. To improve survival of juvenile fish through the system of dams and reservoirs, NMFS and the Corps, in

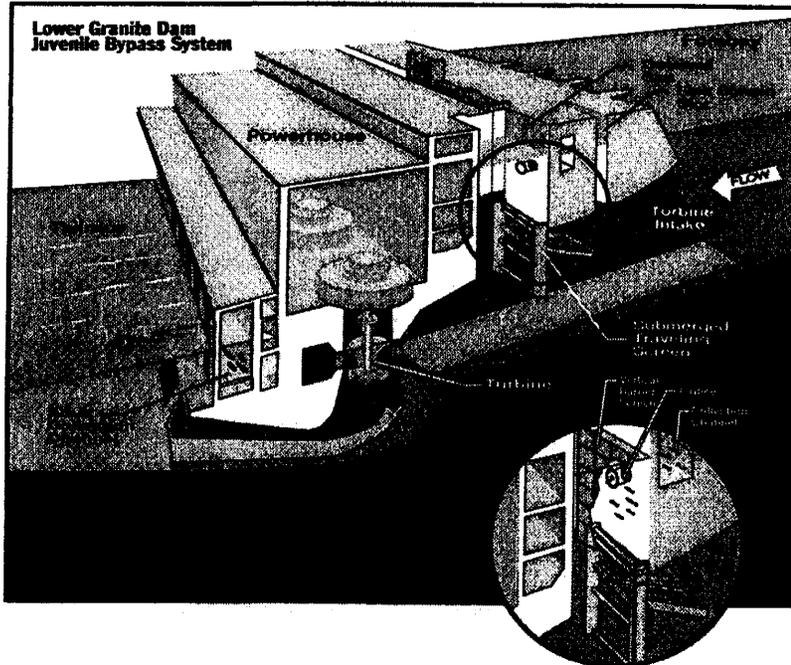
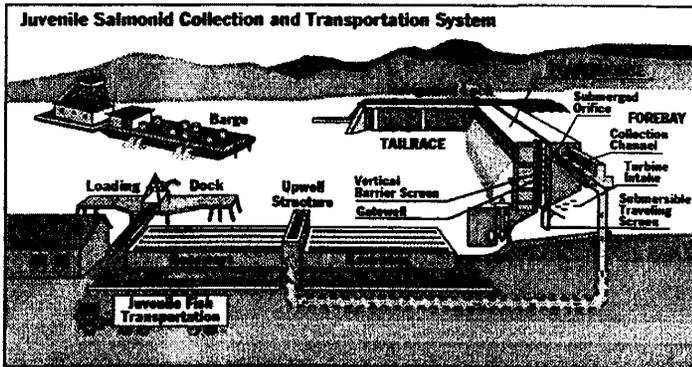


Figure 3-4. Juvenile fish transportation and bypass facilities

cooperation with the fish agencies and tribes, developed a Juvenile Fish Transportation Program that began in the early 1970s, with mass transportation beginning in 1977 (Park and Athearn, 1985). Essentially, the program is a mass-transit system using barges and trucks to move smolts downriver, with the goal of increasing their survival rate by moving fish around the hazards of passing through dams and reservoirs. In 1981, NMFS transferred operation of the transport program to the Corps.

NMFS continues its involvement, along with the state agencies, through the Fish Transportation Oversight Team (Corps et al., 1993).

As described above, screens are used to divert fish into collection systems for transport at four projects—Lower Granite, Little Goose, McNary, and Lower Monumental. After being separated from adult salmonids, larger resident fish, and debris, juvenile fish are routed directly onto a barge for transport, or into raceways and held for later transport by truck or barge. Barges, used during peak migration periods, constantly circulate river water so the smolts can imprint on the chemical composition of the water to help them locate their home stream when they return as adults. Trucks are used to transport the smaller numbers of smolts collected during the early and final stages of the season. The transport program operates from April through October on the lower Snake River and through December on the lower Columbia River (Corps et al., 1993).

As many as 20 million young salmon and steelhead are transported each year from the Columbia and Snake Rivers combined, although this represents only a portion of the outmigrating fish population. NMFS has concluded that transport is beneficial to chinook and steelhead under all flow conditions (Matthews et al., 1992). Nevertheless, within the region there is considerable debate and disagreement over the benefits of transporting fish and the acceptability of the program.

## Hatcheries

Despite historical abundance of wild runs of salmon and steelhead in the Columbia River Basin, nearly 75 percent of current runs in the system are of hatchery stock (ODFW and WDF, 1991). The ratio of wild to hatchery fish varies from species to species. To supplement stocks of wild fish, Federal and state fishery agencies began raising hatchery stocks of steelhead and salmon and releasing them into the river system. Hatchery operations first began in the Columbia River system in 1876; today, over 80 hatcheries producing salmon and steelhead are located on the Columbia River system (Corps, 1992a). A number of these facilities were built specifically as mitigation for effects of the Federal dams on anadromous fish populations.

Releases of hatchery-raised fish vary from year to year, with numbers increasing over the last several years. During the 1993 migration year, over 88 million juvenile salmonids were released from state, Federal, and tribal fish hatcheries into the system above Bonneville. Releases included stocks of chinook, coho, sockeye, and steelhead (see Figure 3-5 for a breakdown by species). Over 21 million of this total were fish released into the Snake River; the remaining 67 million fish originated in the

middle and lower Columbia River (CBFWA, 1993). Like the Juvenile Fish Transportation Program, there is regional debate concerning the benefits of hatchery-raised fish in the system. Fish produced in hatcheries are generally not as strong as wild fish and seem to be more susceptible to disease, predation, and other forms of mortality. Some critics of the hatchery program argue that proliferation of hatchery stocks is likely to influence the gene pool of the wild stocks. It is generally thought, however, that the recovery of anadromous stocks in the Columbia River Basin will rely in part on hatchery fish.

## In-stream Flow Management

### Water Budget

In addition to physical facilities, operating measures have been put into effect to assist anadromous fish migration. One such measure is the Water Budget, in which water is discharged from storage projects to increase spring and summer flows for juvenile fish migration in the Snake and Columbia Rivers. The Water Budget was instituted in 1983, as one of the initial actions in the NPPC's Fish and Wildlife Program. The amount and timing of Water Budget releases are determined annually. Releases from storage reservoirs are made after considering requests from the Fish Passage Center in Portland, which represents the fisheries agencies and tribes. The increased flow is presumed to help flush fish downriver and reduce their exposure to predators and other hazards in reservoirs. Up to 4.64 MAF (5.7 billion m<sup>3</sup>) of water can be released each spring. The total Water Budget volume includes up to 1.19 MAF (1.5 billion m<sup>3</sup>) on the lower Snake River, and up to 3.45

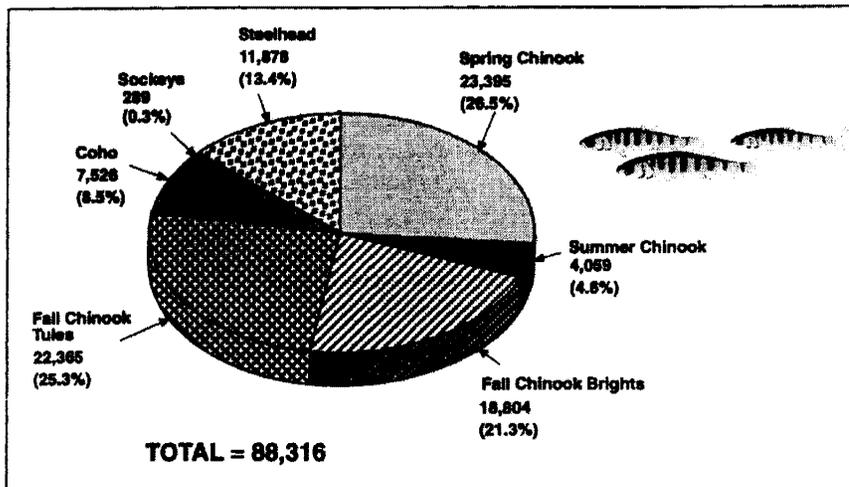


Figure 3-5. Summary of hatchery releases by species for 1992 (numbers in thousands) (Source: CBFWA, 1993)

MAF (4.3 billion m<sup>3</sup>) on the middle and lower Columbia River. On the Columbia River, Water Budget flows come from natural flows and releases from Grand Coulee and other upstream storage projects. There is relatively less storage capacity on the Snake River, and the availability of water for spring flow augmentation depends largely on natural runoff. As a result, high flows cannot be achieved in low runoff years, even with large releases from storage reservoirs such as Dworshak and Brownlee (Corps et al., 1992, 1993).

### **Interim Flow Improvements**

Beginning in 1992, the SOR agencies adopted a number of interim flow improvement measures in response to the ESA listings of Snake River salmon. Compared to 1991 and prior operations, the primary changes initially were provision of an additional 3.0 MAF (3.7 billion m<sup>3</sup>) for flow augmentation on the Columbia River; an additional 300 thousand acre-feet (KAF) (370 million m<sup>3</sup>) in the spring and 470 KAF (580 million m<sup>3</sup>) in the summer from Dworshak for flow augmentation; system flood control shifts from Dworshak and Brownlee to Grand Coulee; operating John Day and the lower Snake River projects somewhat below normal pool levels during the migration period; and up to 427 KAF (0.5 billion m<sup>3</sup>) of additional water from the upper Snake River. As a result of ESA consultation with NMFS for operations in 1993 and subsequent years, flow improvement actions are intended to meet specific monthly flow targets at Lower Granite and McNary. Consistent with the 1995 NMFS and USFWS Biological Opinions, the SOR agencies are meeting these flow targets by operating Federal storage projects to achieve flood control elevations by mid-April, and drafting those projects through the summer to minimum specified elevations.

### **Spill**

In 1989, fisheries agencies, Indian tribes, BPA, and others signed a Long-Term Spill Agreement, which established a plan for spilling water to help juvenile salmon and steelhead

migrating from their spawning grounds to the ocean. The NPPC Fish and Wildlife Program calls for a 90 percent salmon survival rate at each dam on the Columbia River by using spill during most of the spring and summer migration. The spill agreement provides that a specific amount of water be passed over the spillways of four Corps projects—Lower Monumental, Ice Harbor, John Day, and The Dalles—in the spring and summer to protect young fish. When water is spilled, fish are drawn with it, passing them over the spillways instead of through the turbines. The spill agreement was adopted as a temporary measure to improve juvenile fish passage for 10 years or until permanent juvenile fish bypass facilities, such as screens, can be installed at these dams. Although the Corps did not sign this agreement, the agency considers the spill requests each year and has provided spills in each of the last 5 years. At the request of NMFS, the Corps implemented an emergency program of additional spill for a portion of the 1994 juvenile out migration. As a result of the 1995 NMFS Biological Opinion, in 1995, the Corps implemented an expanded spill program.

Flow augmentation and spill are both instream flow measures to help fish, but they are quite different. Flow augmentation moves fish between dams, while spill is used to move fish over dams.

### **Vernita Bar Agreement**

Under an agreement signed in 1988, dam operators provide certain flow levels from fall to early spring to protect salmon spawning and hatching at Vernita Bar below Priest Rapids Dam. This is the last remaining major fall chinook salmon spawning area on the mainstem of the Columbia River. In the past, operators of Federal projects had informally cooperated to ensure lower flows over Vernita Bar during the fall spawning period and higher flows in the winter while eggs are incubating. The Vernita Bar Agreement made formal the efforts by Grant County PUD, BPA, and others to deliver flows needed to encourage and protect salmon spawning at this location.

### **Non-Treaty Storage Fish Agreement**

A portion of the water storage capacity in the reservoir behind Mica Dam in British Columbia is not covered by the Columbia River Treaty. BPA and B.C. Hydro developed a contract called the Non-Treaty Storage Agreement (NTSA) to coordinate use of 4.5 MAF (5.6 billion m<sup>3</sup>) of water storage. The power generating capability represented by the storage is to be shared equally by BPA and B.C. Hydro. In October 1990, BPA signed a related agreement with the Columbia Basin Fish and Wildlife Authority (CBFWA), which represents Northwest fish and wildlife agencies and 13 Indian tribes. The agreement aims to assure, through operating guidelines and regular communication, that use of non-Treaty storage water will pose no significant risks to fish. NTSA water has been used at times in the past few years to meet requests for additional flows to aid fish migration. (See Section 4.1.9 for a more complete NTSA discussion.)

### **Research and Monitoring**

Many agencies and organizations are involved in fishery research and monitoring programs related to Columbia-Snake River salmon and steelhead. These efforts encompass the dams and fish passage facilities, transportation, hatcheries associated with the projects, the reservoirs, and tributary streams.

The Corps monitors juvenile and adult migration at Corps dams, conducts or sponsors ongoing research on anadromous fish, and participates in the research programs of other organizations. The Corps also operates 23 stations along the river system that monitor dissolved gas levels, which can be harmful to fish.

BPA funding is used to implement many of the actions included in the NPPC's Fish and Wildlife Program. In this way, BPA sponsors a wide variety of fish research and enhancement programs related to reservoir mortality, hatcheries, disease, spawning habitat, and numerical modeling of fish survival.

Other Federal agencies, primarily NMFS and USFWS, and state fish and wildlife agencies from Idaho, Oregon, and Washington, and Indian tribes also participate in research efforts (Corps et al., 1993). A key program staffed by these entities is the Fish Passage Center, which monitors each year's juvenile outmigration. It does this primarily through the Smolt Monitoring Program and by receiving system operations, fish passage, and power generation data from the Corps and BPA.

Data from the research and monitoring programs help the lead agencies determine future actions to manage anadromous fish resources throughout the basin.

### **Other Actions**

#### **Squawfish Management**

Many juvenile salmon migrating downstream through reservoirs on the lower Snake and Columbia Rivers are killed by predators. The squawfish is the primary predator of juvenile salmon in the hydrosystem. BPA funds a program to reduce squawfish predation. The squawfish program includes harvest technology research, prey protection measures, basic biological research, and a "bounty" system to encourage people to catch squawfish. The program is based on the premise that a sustained, annual squawfish harvest rate of 10 to 20 percent of the total population will reduce juvenile salmonid predation loss by 50 percent or more within 10 years (Beamesderfer et al., 1990).

#### **Enhanced Law Enforcement**

An enhanced law enforcement program has been put into place to protect adult salmonids from illegal fishing, with special focus on the endangered species stocks. Other benefits of the program include increased protection of all salmonid stocks and resident fish throughout the basin, more public awareness, increased prosecution support, and increased protection of juvenile salmon through enforcement of laws protecting habitat. The program is supported by

BPA, the Columbia River Inter-Tribal Fish Commission, the Oregon State Police, the Washington Departments of Fisheries and Wildlife, and the Idaho Department of Fish and Game. The scope of this project is systemwide; that is, from the mouth of the Columbia River and adjacent nearshore ocean areas, through the mainstem, to the upstream spawning tributaries and nursery lakes (Corps et al., 1993).

### **Turbine Operating Guidelines**

Research has indicated that operating turbines at peak efficiency might increase survival rates of juvenile fish passing through them. Therefore, every effort is made to operate turbines at the eight lower Snake and Columbia River dams within 1 percent of peak efficiency. These guidelines are described in the Corps' annual fish passage plans, NMFS Biological Opinion (May 1993), and BPA's annual system load shaping guidelines.

### **3.3.4 Resident Fish**

Rivers and reservoirs of the Columbia River Basin are also home to fish that do not migrate to the sea. These fish, such as trout, sculpins, and bass, are referred to as resident fish and are also described in Chapter 2. Resident fish in the basin include both native and exotic species. Appendix K provides more detailed information. Traditionally, state and tribal fish and wildlife agencies have managed the resident fisheries in the rivers and reservoirs for the benefit of the public, with little direct involvement by the operating agencies. Traditional state management efforts include stocking of native and exotic species, and establishing regulations for catch, possession, size, and season limits. The lead agencies, however, have recently begun to devote more resources to benefit and preserve resident fish populations. Recent ESA petitions of certain resident fish species (e.g., bull trout and sturgeon) have increased the need for Federal agency involvement. Specific programs in place to benefit resident fish include production facilities, water management, and research, as described in the following sections.

### **Production Facilities**

Historically, resident fish populations throughout the basin have been supplemented by the introduction of hatchery and non-native stocks. Stocking of fish has largely been conducted by state agencies in response to declining stocks or to create and maintain sport fishing opportunities. For example, kokanee were introduced into Flathead Lake in 1916 and by 1933 supported a popular fishery. Unlike the situation with anadromous fish, there are relatively few resident fish production facilities associated with Columbia River system projects. In recent years, stocking programs have received increased scrutiny, largely out of concern for the protection of fish genetics and the desire to avoid the introduction of species that would compete with indigenous fish.

Hatcheries and net pens have been used at Lake Roosevelt to maintain the kokanee and rainbow trout populations. Two new hatcheries have been constructed to replenish the depleted kokanee population. The rainbow trout fishery in Lake Roosevelt is also a supplemented fishery. In addition to the production from the hatchery managed by the Confederated Tribes of the Colville Reservation and other state and Federal hatcheries, rainbow trout naturally reproduce in some of the tributaries to the reservoir. Although not strictly a "put and take" fishery (in which annual stocking and harvest are essentially equal), numerous net pens located throughout the reservoir are used to raise rainbow trout to catchable size; then they are released into the reservoir from May through June (Peone et al., 1990). Most of these fish are caught within 14 months of the time they are released (Peone et al., 1990).

### **Water Management**

The NPPC Fish and Wildlife Program provides for fishery requirements to be directly incorporated into water management. Project operations to benefit resident fish generally involve minimizing flow and reservoir level fluctuations during spawning season; most fish

that spawn in the lower Columbia River reservoirs do so from June to mid-July.

Discharge requirements at most projects are considered a compromise to meet needs for fish, power, flood control, wildlife, and public safety. Some projects have operating limits specifically designed to benefit resident fish. For example, to provide better spawning conditions and protection of redds and juveniles (especially kokanee) in the Flathead River, Hungry Horse releases provide minimum and maximum flows during specific periods of the year. At Albeni Falls, the lake level reached on November 20 is maintained through the end of the year to protect beach-spawning kokanee redds. In addition, the lake is not significantly drafted below that level during the incubation season (January through April). Other projects, such as Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary, include fisheries considerations in decisions to provide discharges when it is possible (Corps, 1989, 1984b).

### **Research Programs**

The SOR agencies are involved in several research programs studying resident fish in system reservoirs. The Corps has conducted a multiyear study of resident fish populations and habitat at Lower Granite. BPA supports other research through funding of the NPPC Fish and Wildlife Program. Similarly, Reclamation has funded research by the Upper Columbia United Tribes (UCUT) on Lake Roosevelt kokanee and trout.

### **NPPC Amendments**

Phase 4 of the NPPC's Columbia River Basin Fish and Wildlife Program amendment process focuses on resident fish and wildlife. One of the goals of the program is to protect, mitigate, and enhance resident fish to the extent these stocks are affected by development and operation at each hydropower facility. Measures that the NPPC adopted in November 1993 include: completing assessments of resident fish losses related to hydropower facility operation;

establishing reservoir levels necessary to maintain or enhance resident fish; supporting natural and artificial propagation; enhancing habitat through comprehensive watershed management; coordinating with appropriate parties, including Reclamation, Montana Power Company, Oregon Department of Fish and Wildlife, the Corps, the FERC, and Washington Water Power Company, to provide minimum flows to benefit key species; and mitigating for fish losses at areas such as the Libby, Hungry Horse, and Dworshak projects. The NPPC further amended the resident fish and wildlife program in September 1995.

### **3.3.5 Wildlife**

While the focus of most mitigation and enhancement actions at Federal projects in the Columbia River system has been on fish, wildlife protection is also an important consideration. The presence of suitable habitat is the key to maintaining healthy wildlife populations, and state and Federal laws require protection of wildlife habitat. Primarily through the NPPC program, the region is considering a variety of actions to acquire, restore, enhance, and/or protect wildlife habitat. These actions will supplement existing river system management efforts to benefit wildlife. (See Appendix N for additional information.)

### **Managed Wildlife Habitat at Projects**

Much of the land within and adjacent to Federal project boundaries is designated and managed as wildlife habitat. Several national wildlife refuges are located on project lands or adjacent to system reservoirs. Other parcels of project lands are operated as habitat management units (HMUs), lands designated to be managed primarily for wildlife habitat. Managed wildlife lands at or near the projects are summarized below; these lands provide much of the best wildlife habitat, such as wetlands and riparian vegetation, that remains in the Columbia River system.

### ***Libby Dam and the Kootenai River***

Lake Koocanusa is virtually surrounded by the Kootenai National Forest, which provides managed wildlife habitat. In addition, the Corps manages 488 acres (197 ha) downstream from the dam as habitat for big game and waterfowl. Farther downstream on the Kootenai River, the Kootenai National Wildlife Refuge near Bonners Ferry, Idaho provides additional managed habitat.

### ***Hungry Horse and the Flathead River***

No project lands at Hungry Horse are dedicated specifically for wildlife habitat management. However, extensive habitat is located in the adjacent Flathead National Forest and nearby Glacier National Park. Downstream, much of the land in the vicinity of Flathead Lake is managed by Federal or Montana state agencies with consideration for wildlife habitat. The project area includes the Lone Pine State Preserve, a National Waterfowl Production Area, and the Stillwater Game Preserve.

### ***Albeni Falls and the Pend Oreille River***

Lake Pend Oreille is mostly surrounded by the Kaniksu National Forest and Farragut State Park. The state park includes the David Thompson State Game Preserve, which is the only designated wildlife area at the Albeni Falls project.

### ***Grand Coulee and Chief Joseph***

Most of the shoreline of Lake Roosevelt lies within the Colville Indian Reservation, the Spokane Indian Reservation, or the Coulee Dam National Recreation Area. While these areas were designated for other primary purposes, their management reflects consideration of wildlife values. The Chief Joseph Dam Wildlife Mitigation Sites provide managed wildlife habitat along Lake Rufus Woods, the reservoir behind Chief Joseph Dam.

### ***Middle Columbia River***

A number of areas have been reserved and managed for wildlife habitat along the mid-Columbia, including the Saddle Mountain and Columbia National Wildlife Refuges, and the Wahluke, Priest Rapids, Crab Creek, Colockum, Quilomene, Schaake, Swakane, Quincy, Entiat, Wells, and Chelan Butte Wildlife Areas.

### ***Middle and Upper Snake River***

This stretch of the Snake River is mostly surrounded by the Wallowa, Nez Perce, and Payette National Forests, all of which are managed with consideration for wildlife habitat. In addition, the area includes the Hells Canyon National Recreation Area (HCNRA), much of which is designated as wilderness.

### ***Dworshak and the Clearwater River***

When Dworshak Dam was completed in 1973, 17,000 acres (6,880 ha) of low-elevation habitat were flooded. As a result of the adverse impact of the Dworshak project upon big game populations in the area, more than 20,000 acres (8,094 ha) at Dworshak have been designated for present and future wildlife management. The Corps manages all of the land immediately surrounding Dworshak Reservoir. The Corps initially developed agreements with the USFWS (as successor to the U.S. Bureau of Sport Fisheries and Wildlife), and the Idaho Department of Fish and Game concerning the management of these lands.

In 1992, the Corps, BPA, the Nez Perce Tribe, and the State of Idaho signed the Dworshak Agreement. This agreement established trust funds for the Idaho Department of Fish and Game and the Nez Perce Tribe to protect, mitigate, and enhance wildlife and additional wildlife habitat within the state of Idaho affected by the development of Dworshak Dam (BPA, 1993b). BPA has prepared an environmental assessment to study the potential effects of implementing the agreement.

### **Lower Snake River**

Approximately 760 acres (308 ha) of irrigated HMUs are associated with the four lower Snake River projects (Sather-Blair et al., 1991); the largest area is located at Ice Harbor Dam. Irrigated HMUs receive surface water from the project reservoirs and depend on high-pressure irrigation systems for continued vegetative growth. These HMUs have been planted extensively with trees and shrubs along reservoir shorelines and with herbaceous plants to establish feeding areas for various wildlife species. They represent an intensive management technique to replace riparian areas lost when the dams were constructed, under the terms of the *Lower Snake River Fish and Wildlife Compensation Plan*.

### **Lower Columbia River**

Three areas have been designated for habitat management along the John Day and The Dalles pools; these are managed by the Oregon Department of Fish and Wildlife. Five additional areas totaling over 4,500 acres (1,821 ha) occur on McNary pool and are managed by the Corps as HMUs (Sather-Blair et al., 1991). These areas provide essential habitat for plants and wildlife of the lower Columbia and have been developed or established naturally under prolonged periods of normal reservoir operating conditions. The Corps manages the 500-acre (202-ha) McNary Wildlife Nature Area, located just downstream of McNary Dam. The 3,600-acre (1,457-ha) McNary National Wildlife Refuge (NWR), managed by the USFWS, is near the confluence of the Snake and Columbia Rivers (Corps et al., 1992). The 22,885-acre (9,265-ha) Umatilla NWR is located along both sides of the John Day pool.

### **Water Management**

Project operations to benefit wildlife generally involve minimizing flow and reservoir level fluctuation at critical times, thereby providing a more stable terrestrial habitat in the vicinity of the project reservoirs and along the

ivers. This practice is especially crucial for waterfowl that nest along the system.

Discharge requirements at some projects (including Albeni Falls and Libby) are considered to reflect needs for wildlife and some projects have operating limits specifically designed to benefit wildlife. For example, to protect geese during their nesting period (March 1 through May 15), the Corps has typically maintained John Day at a minimum elevation of 262 feet (79.9 m); drafting below this level would cause land bridges to form, enabling predators to access island nesting sites (Corps, 1989).

### **Habitat Acquisition**

The NPPC Fish and Wildlife Program provides for formal input of wildlife requirements to be directly incorporated into water management. The lead agencies recognize that development of the hydropower system in the Columbia River Basin has affected many species of wildlife, including the loss of some habitats and the creation of others. For some of the projects, lands adjacent to the projects were turned over to the Federal agencies after project completion. For example, land surrounding Dworshak Reservoir, much of which is crucial wildlife habitat, is managed by the Corps. The Fish and Wildlife Program has proposed additional habitat acquisition, with cooperation by state and Federal agencies and Indian tribes. Major habitat acquisitions are being negotiated at Dworshak and Grand Coulee.

### **3.3.6 Hydroelectric Power**

The Columbia-Snake River system has been heavily developed for hydroelectric power. The integrated system of 30 Federal hydroelectric projects in the Columbia River Basin has a total installed nameplate generating capacity of about 19,600 MW (BPA, 1993c). The 14 Federal projects in the SOR account for 18,900 MW, two-thirds of the region's hydroelectric generating capacity. The remainder of the region's electricity comes from non-Federal hydro projects and from thermal resources,

including nuclear, gas-fired, and coal-fired plants. (See Appendix I for detailed information on power.)

### Power Coordination

Hydroelectric dams on the Columbia and Snake Rivers are the foundation of the Northwest's power supply; falling water is the "fuel" for power-generating turbines at the dams. Power production on the coordinated Columbia River system involves three primary objectives that system managers try to meet, within a variety of system requirements:

- Developing the hydro system's firm energy capability,
- Optimizing future energy production through refill, and
- Maximizing nonfirm energy production to keep regional power rates as low as possible.

A complex coordinated planning process has evolved on the Columbia River system to meet these objectives, based on the possibility that the lowest historical streamflow conditions could recur in the future. Power planners call this worst-case sequence of low water years the "critical period." Critical period planning is essentially a standard that defines how much firm energy should reasonably be expected to be available. It helps planners determine how much non-hydro power is needed to meet expected energy demand in the region.

The coordinated planning process involves two overall steps: first, to factor in all uses of the system to determine how much water will be available for power production, and second, to plan system operation to maximize the amount of power that can be generated with the available water. Coordinated planning is guided by the Columbia River Treaty and the PNCA.

### *The Columbia River Treaty*

The Columbia River Treaty requires the United States and Canada to prepare an Assured Operating Plan and a Detailed Operating Plan each year. The operating plans are prepared by

the Columbia River Treaty Operating Committee, made up of representatives of BPA, the Corps, and B.C. Hydro.

The Assured Operating Plan dictates how Treaty storage will be operated 6 years in advance. It is developed to meet the flood control and power objectives of the Treaty—the only recognized purposes for project operation when the Treaty was signed. The Detailed Operating Plan examines the upcoming 4-year critical period and addresses operations over the next 12 months. These two plans are factored into the annual plan developed by parties to the PNCA, as releases of water from the Canadian storage reservoirs are crucial for coordinated system planning in the United States.

### *The Pacific Northwest Coordination Agreement*

The contractual basis for power coordination among the hydropower facilities in the Columbia Basin in the United States is the PNCA. Coordinating system operations through annual planning provides many advantages. Coordination enables utilities to take advantage of their differences in streamflows, loads, generation, and maintenance schedules to better use their resources. Coordination also lets utilities operate hydro and thermal resources more efficiently. They can produce more power with greater reliability through coordination than they could by operating independently.

An important point to understand about the Coordination Agreement is that the planning studies are made as if the total coordinated system had a single owner. If all projects in the system belonged to a single utility, the owner would synchronize operations to maximize power production. Coordinated planning attempts to duplicate that hypothetical situation. The Coordination Agreement contains a number of provisions to make the single-ownership concept work. Additional discussion of coordination under the PNCA is provided in Chapter 6 of this volume, and in Appendix R, PNCA.

## Generation

Streamflows in the region do not follow the same pattern as electric energy use. Storage reservoirs are the key to matching the region's water supply with electricity use patterns. Energy—in the form of water—is held in reservoirs when natural streamflows exceed power generation requirements. Water is released through turbines when it is needed to produce electricity. The hydraulic capacity at each project is at least two times the average annual streamflow, allowing generating operations to provide additional power during high-flow periods (Corps et al., 1992).

Hydro projects are often operated to follow the peaks in power demand. Output levels generally vary significantly on a daily basis, with generation typically much higher during daylight hours than at night. On a weekly basis, power loads and generation tend to be considerably higher on weekdays than on weekends. The mainstem dams, in particular, often follow these daily and weekly cycles, causing project discharges and reservoir levels to fluctuate frequently within the normal operating range.

Power demand is higher in the winter and lower during spring and summer in most of the Northwest. Output from both storage projects and run-of-river projects, therefore, tends to be highest during the winter. Annual streamflow patterns also influence generation patterns. During years of relatively high runoff, hydro plants are often operated at high levels in the spring to take advantage of the surplus water to generate nonfirm or secondary energy. Power planners try to maximize hydroelectric production during the spring runoff period, keeping thermal plants inactive to avoid spilling water that can be used for power generation.

## System Capacity

Capacity is the maximum amount of power that can be produced by a generating resource at specified times under specified conditions. Capacity is a product of the hydropower system

that affects the cost of producing power and the value of the power produced. There are two measures of capacity: instantaneous and sustained. Instantaneous capacity is the maximum amount of power that can be produced to meet a 1-hour peak load. It is primarily affected by the availability of generators and their maximum capability. In the past, the Northwest hydrosystem's instantaneous capacity has exceeded the peak load forecast by large margins. Currently, these margins are decreasing, and the system may require new resources to meet instantaneous peak loads in the future. Sustained capacity is the ability of the hydrosystem to meet several hourly peak loads within a specific period day after day. For the Northwest hydrosystem, planners define sustained capacity as the ability of the system to deliver energy for 10 hours a day, 5 days a week, under critical water conditions.

## Power Marketing

Hydropower accounts for approximately 75 percent of the Northwest's electricity supply. When there is a surplus, it is an important export product for the region. BPA markets and distributes the power generated by the Corps and Reclamation at the Federal projects in the Columbia River Basin, selling 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. Power lines originate at generators at the dams and extend outward to form key links in the regional transmission grid. BPA owns and operates the transmission system, which consists of 14,787 circuit miles (23,792 km). The Northwest grid is interconnected with Canada to the north, California to the south, and Utah and other states to the east. Power produced at dams in the Northwest serves customers both locally and thousands of miles away.

## Firm Sales

BPA's firm power sales contracts are long-term commitments that contain a guarantee to meet some or all of a customer's load

requirements over a defined period. These contracts are often based on an estimate of the firm energy load-carrying capability (FELCC) of the system. FELCC can be defined as the energy produced by the power system if the critical water years were to recur.

The Northwest's publicly owned utilities have first call on power produced at Federal hydro projects, a principle known as "preference." BPA has long-term firm power sales contracts with over 120 utilities, including municipalities, public utility districts, and rural cooperatives. The agency also sells firm power directly to some Federal agencies and some of the region's largest industries, including aluminum smelters. These industries are called direct service industries, or DSIs.

### **Nonfirm Sales**

Nonfirm generation is power in excess of that needed to meet firm power requirements. In most water years, streamflows are high enough to produce at least some nonfirm generation. This is particularly true after January 1, when initial runoff forecasts make it possible to estimate how much water will be available from the snowpack. In an average year, nonfirm generation may add 25 percent or more to the hydro system's generating output (Corps et al., 1993).

Nonfirm energy is generally sold with no guarantee of continuous availability, and delivery can be terminated on very short notice. The DSIs have first call on BPA's nonfirm energy. The remainder is sold to utilities in the Northwest and elsewhere. Preference applies to nonfirm energy sales as well as firm.

BPA built transmission lines to California to allow power exchanges (including nonfirm sales) with California utilities. Because of the relatively high cost of operating oil and gas-fired generating plants in California and the seasonal differences in the need for power between the Northwest and the Southwest, these nonfirm sales have been mutually advantageous to the two regions. Nonfirm energy sales allow

California utilities to shut down their expensive thermal plants, reducing operating costs and pollution. Nonfirm sales bring in revenues to the Northwest and help keep electricity rates in the region among the lowest in the United States.

### **Direct Service Industries Sales**

BPA has 15 DSI customers, 8 aluminum companies and 7 non-aluminum companies. Their 3,000-MW load is important to the region because it provides some of the reserves required by the Federal power system. Three-fourths of the load is served with firm energy. The remainder is served with either nonfirm energy or firm energy that is "borrowed" from the future. If neither nonfirm nor borrowed energy is available, BPA has the right to interrupt service to one-quarter of the DSI load.

### **3.3.7 Recreation**

The rivers, reservoirs, and adjacent land areas within the scope of the SOR provide opportunities for many water-based recreational activities such as sightseeing, fishing, waterskiing, rafting, boating, windsurfing, and swimming. (See Appendix J for more complete information on recreation.) Land-based activities such as picnicking, camping, and hiking do not require water access, but many users prefer sites that are enhanced by scenic lakes and rivers.

Recreation has become an increasingly important use of the Federal hydroelectric system. Recreation use and development are authorized at all of the projects under Federal legislation, including the Federal Water Project Recreation Act of 1964 and the Flood Control Act of 1944. Under these laws, the Corps and Reclamation are the agencies responsible for providing recreation facilities on the reservoirs. The lead agencies cooperate with Idaho, Montana, Oregon, and Washington state parks departments and a variety of other local entities, such as counties, cities, and port districts, to build and manage a system of water-related recreation facilities. These include boat ramps,

swimming beaches, marinas, campgrounds, picnic areas, and interpretive sites. To accommodate recreation, dam operators try to keep storage reservoirs as full and stable as possible during the summer, without jeopardizing other project uses. Normal power generation and flood control operations are generally compatible with recreation at reservoirs during the high-use summer months.

### Recreation Activities and Use Levels

Sightseeing and driving to enjoy scenery are among the most popular forms of recreation in the basin. Roads and highways paralleling the rivers and reservoirs provide access to majestic vistas of natural features such as forests, mountains, cliffs, rivers and streams, and waterfalls. The engineering features of the projects also attract visitors, and most projects have visitor centers that describe their history, operations, and purposes.

Boating and fishing are very popular recreational activities throughout the basin. Much of the boating is associated with fishing. Waterskiing, cruising, sailing, and windsurfing are other popular forms of boating activity, particularly at the reservoirs. The free-flowing river reaches below some of the dams support kayaking, canoeing, and whitewater rafting. Camping and picnicking are traditional activities that occur at all of the projects. Swimming takes place at both developed and unimproved beaches during warm weather. The importance of individual recreation activities varies from project to project.

Visitor use at recreational facilities varies significantly among areas of the system. Bonneville receives the most visits, with annual use estimated at about 3.3 million recreation days (Appendix J).

The Hells Canyon National Recreation Area receives the least—about 44,000 recreation days per year. Figure 3-6 displays annual visitation by project or river reach.

In addition, visitation varies considerably by season, with use heavily concentrated in the summer. While pool elevations and river flows can have an influence, weather is the most important factor determining the seasonal use and demand for water-related outdoor recreation in the basin. Another factor that must be considered is the availability of other similar recreation resources. The primary recreational activities, including sight-seeing, fishing, boating, and waterskiing, occur year-round at most of the project areas in the basin. However, the peak period of use occurs during the warm, dry summer months.

Annual visitation typically builds slowly, beginning in April and continuing in May. Visitation tends to increase rapidly from the end of May through June and July, and peaks in August. The projects typically receive over 50 percent of average annual visitation during this period. The term "peak recreation season"

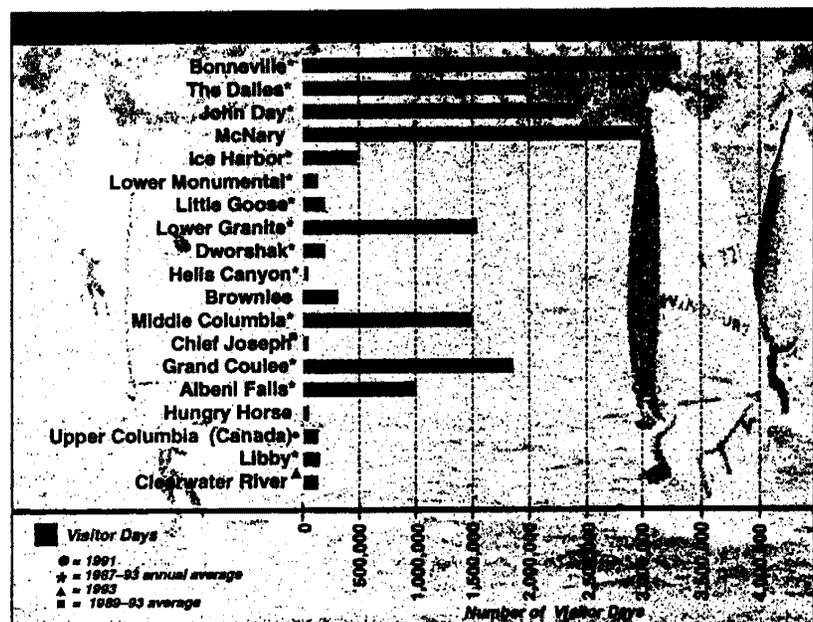


Figure 3-6. Baseline annual recreation use (in visitor days) by project or river reach (Source: Appendix J)

roughly corresponds to the period between Memorial Day and Labor Day weekends. During this period, weather is most amenable for water-dependent and water-related recreation activities throughout the Pacific Northwest. Most students are out of school for the summer, and families take their vacations during this period. During the summer, the storage projects are generally refilled and held as high as possible to promote and support recreation use. Visitation generally begins to decline in September, regardless of reservoir operations.

### **Recreation Facilities**

Recreation sites at the project vary greatly in size, type of facilities, level of development, features, management, use, and accessibility. Larger, more intensively developed sites have facilities to support a variety of activities and most offer boat and swimmer access. Many provide boat ramps, docks, marinas, campgrounds, and day-use areas with developed swimming and picnicking facilities. These sites typically have paved launch lanes and parking areas, restrooms with running water, retail and service concessions, landscaping, and irrigated lawn areas. There are also many smaller sites that are less developed and support one or two uses. In addition, there are many informal sites that have no developed facilities and only provide access to the water or to publicly owned lands. Appendix J, Recreation, provides a detailed inventory of recreation facilities associated with the Federal projects; some of the major facilities are described below.

#### ***Libby/Kootenai River***

Lake Kootenai is an important regional recreation resource on both sides of the U.S./Canada border. There are 23 developed recreational sites on both sides of the border and a number of informal sites. Seventeen sites have boat ramps, 18 have campgrounds (with 755 individual campsites), and 6 have boat moorage with 218 spaces. The USFS manages campgrounds, picnic areas, fishing access points, boat ramps, and swimming beaches. The Corps manages several day use facilities including

viewpoints, a visitor center, observation tower, fishing access site, boat moorage, and day-use area. Lake Kootenai Resort and Marina, located 6 miles (10 km) upstream from Libby Dam, is a privately managed facility operating under a special-use permit from the USFS. The British Columbia Ministry of Environment, Lands and Parks manages Wardner and Kikomun Creek Provincial Parks, located adjacent to the reservoir on the Canadian side.

The Kootenai River below Libby Dam supports an excellent rainbow trout fishery. Anglers float this reach or fish from shore. Several sites with limited facilities provide access to the river.

#### ***Upper Columbia/Canadian Projects***

While the upper Columbia reach in British Columbia possesses a unique set of recreational resources, it is virtually unknown to outdoor enthusiasts from outside the immediate region. Recreation facilities and sites are limited. The nine identified sites along the reach from the international boundary to Keenleyside Dam range from moderately developed overnight campsites and boat ramps to undeveloped and unmanaged recreation areas. Most of these sites are managed by service clubs, municipal and provincial governments or are unmanaged. Fishing, sightseeing, and picnicking are the primary recreational activities in the upper Columbia.

#### ***Hungry Horse/Flathead River***

With the exception of Reclamation's visitor center near the dam, all visitor and recreational facilities at Hungry Horse Reservoir are managed by the USFS. There are 15 developed sites on the reservoir, including 2 island sites. Eleven sites have boat ramps and 8 offer developed camping facilities. The USFS also manages several developed recreation sites along the Middle and South Forks of the Flathead River. These river access sites include boat launches, restrooms, and parking areas. There are no developed sites along the South Fork below Hungry Horse Dam.

### **Albeni Falls/Lake Pend Oreille**

Lake Pend Oreille is a major regional recreation resource for northern Idaho. There are 21 developed recreation sites scattered around the lake. Twenty-four of the sites have boat ramps, 11 provide moorage, and 8 sites have campgrounds (with 320 individual campsites). The Corps operates campgrounds and day-use parks on the reservoir and manages a visitor center at the dam. The USFS also operates campgrounds and day-use sites on the reservoir. Idaho State Parks operates the largest public campground and day-use park on the southern tip of the lake. There are also several informal sites managed by the Idaho Department of Fish and Game, and a number of private marinas and resorts that offer a full range of facilities.

### **Grand Coulee**

Lake Roosevelt, behind Grand Coulee Dam, is one of the most significant recreation resources in the Pacific Northwest. The 150-mile-long (241-km-long) lake reaches almost into Canada and has 31 developed recreational sites, including 28 with campgrounds, 7 with boat ramps, and 12 with picnic and other day-use facilities. The Coulee Dam National Recreation Area, managed by the NPS, encompasses about 55 percent of the project area. The NPS manages most of the developed recreational sites on Lake Roosevelt. The balance of the project area lies within the respective reservations of the Colville Confederated Tribes and the Spokane Tribe, which manage several recreational facilities. Reclamation provides visitor facilities and guided tours at the dam. Lake Roosevelt has become particularly well known for house boating, which is supported by three concession operations on the lake.

### **Middle Columbia River**

The Corps is primarily responsible for providing recreation sites on Lake Rufus Woods behind Chief Joseph Dam; facilities include a

visitor center, viewpoints, and fishing access sites. The Washington State Parks and Recreation Commission operates Bridgeport State Park at Chief Joseph, which includes a campground, day-use park, and golf course. State and local entities cooperate in managing boat ramps, swimming beaches, campgrounds, picnic areas, the golf course, and interpretive signs.

The three mid-Columbia PUDs have supported cooperative development of a system of parks and recreation sites at their projects along this river reach. The PUDs have built or funded baseball and soccer fields, tennis courts, campgrounds, picnic areas, boat ramps, and a nature interpretive area. The most extensive facilities are at the Rock Island and Rocky Reach projects near Wenatchee. The larger developed facilities are operated by the state of Washington as state parks. These include Daroga and Lincoln Rock on Rocky Reach (Lake Entiat), Wenatchee Confluence on Rock Island, and Wanapum on Wanapum Lake. Altogether, there are 14 developed recreational sites that provide 11 boat ramps, 2 boat moorage facilities, 6 campgrounds (with 416 total campsites), and 12 picnic areas.

The Hanford Reach of the Columbia River begins below Priest Rapids Dam and continues downstream approximately 51 miles (82 km) to the upper end of the McNary pool. It is the last free-flowing reach of the Columbia River in the United States above Bonneville Dam. The Hanford Reach is currently being studied by the NPS for Federal designation as a wild and scenic river, and it is also a candidate for designation as a state scenic river. The reach is used year-round for a variety of recreational activities such as fishing, flatwater motor boating, waterfowl hunting, and floating. The Wahluke Wildlife Recreation Area, managed by the Washington Department of Wildlife, is the primary public access resource (NPS, 1992). Primitive boat launches are located at the Vernita Bridge, White Bluffs Ferry Landing, and Ringold Hatchery.

### **Middle Snake River**

The Hells Canyon Complex (Brownlee, Oxbow, and Hells Canyon Dams owned by IPC) and the HCNRA contain most of the recreational resources on the middle Snake River. IPC operates recreational facilities that include parks with day/night-use facilities, boat ramps, and recreation vehicle (RV) hookups on the reservoirs. The USFS, BLM, and Oregon State Parks also manage developed recreational facilities on or near the reservoirs. Within the HCNRA, there are only five developed or semi-developed sites, two of which have boat ramps. Recreational use focuses on floating or jetboating the free-flowing stretch of the Snake River. Overnight camping is limited to small, remote, undeveloped sites. The portion of the Hells Canyon reach outside the HCNRA has 14 developed recreational facilities.

### **Dworshak**

There are no other large, forested lakes within 100 miles (161 km) of Dworshak Reservoir (Corps, 1975). As a result, it is an important regional recreational resource for eastern Washington and northern Idaho. There are 12 developed recreation sites at Dworshak, including campgrounds at Dworshak State Park and 3 other sites. Dworshak is one of the few lakes in the Northwest with boat-accessible campsites. There are 76 sites, called mini-camps, which contain picnic tables, fire grills, tent pads, outhouses, and trash receptacles. There are six boat ramps at Dworshak that are usable to various elevations and a marina at Big Eddy that has a restaurant, store, and marine fuel facility. (The marina facilities at Big Eddy have been closed since early in the 1992 season; only the boat ramp has been operating since then.) In addition, there are picnic areas and developed swimming beaches located adjacent to the lake.

### **Clearwater River**

The Clearwater River is an important local and regional recreational resource. Steelhead fishing, which occurs primarily from November

through February, is the most popular recreational activity and draws anglers from throughout the Northwest. Summer activities such as rafting and swimming are becoming increasingly popular. Between Ahsahka and Lewiston, there are 19 day-use sites that provide access to the river; 10 have boat ramps. Most of the recreational facilities along the Clearwater were developed by the Idaho Department of Fish and Game. The NPS (which operates part of the Nez Perce National Historic Park), Idaho Department of Transportation, and the Corps have also developed recreation sites. In addition to boat ramps and access trails to the river, recreation sites adjacent to the river offer picnic areas, undeveloped beaches, and interpretive signs.

### **Lower Snake River**

There are 40 recreation sites along the four lower Snake River projects. These include 29 boat ramps with 56 launch lanes, 7 moorage and marina facilities, 10 campgrounds with approximately 500 individual campsites, and 23 day-use facilities. Most of the recreation sites are relatively remote from population centers, although there are three parks at the Ice Harbor project that are within 10 to 15 miles (16 to 24 km) of Pasco and Kennewick. The Lower Granite project is the most heavily developed; recreation sites are concentrated in the urban Lewiston-Clarkston area, and include an extensive riverside trail system in addition to the typical water-based facilities. Several of the larger developed facilities in this reach were developed by the Corps and are operated by counties or port districts under lease. Major developed sites on these projects also include Chief Timothy, Central Ferry, and Lyons Ferry State Parks in Washington and Hells Gate State Park in Idaho.

### **Lower Columbia River**

As a group, the four lower Columbia River projects represent the portion of the system that is most intensively developed and visited for recreation. The Columbia River Gorge National Scenic Area includes most of the recreational

opportunities at The Dalles and Bonneville projects, which are within a relatively short drive of the Portland metropolitan area. There are approximately 75 developed recreation facilities at the four projects, including 48 sites with boat ramps, 7 moorage facilities, 26 sites with developed swimming beaches, 13 windsurfing beaches, 20 campgrounds with 936 individual campsites, and 36 picnic areas. The most highly developed project is Bonneville, with 20 formal recreational sites and numerous dispersed sites. Some of the developed sites are Washington and Oregon State Parks.

### **Columbia River Below Bonneville Dam**

The free-flowing section of the Columbia River below Bonneville Dam is popular with recreationists from the Portland metropolitan area and other communities adjacent to the river. Between the dam and the confluence with the Willamette River near Portland, there are at least nine developed recreation sites with boat ramps and five sites with moorage facilities. In addition, there are 3 campgrounds that contain a total of 230 campsites, and 5 picnic areas. Releases from Bonneville, and resulting changes in flow velocity and river elevation influence the use of these recreational facilities.

### **3.3.8 Irrigation**

Irrigation has brought agricultural prosperity to vast arid areas of the Northwest. About 7.3 million acres (3.0 million ha) are irrigated in the Columbia River Basin (see Appendix F). Of this, 7.1 million acres (2.9 million ha) are in the United States, with the remainder in Canada. These figures include irrigated lands in urban use, forest nurseries and seed orchards, recreation sites, and other non-agricultural uses. Growers in eastern Washington, northeastern Oregon, and southern Idaho depend on irrigation to produce wheat, corn, potatoes, peas, alfalfa, apples, grapes, and a vast assortment of other crops.

Water releases for irrigation are scheduled on a local basis, not as a centralized Columbia River system function. Reclamation, local

irrigation districts, and canal companies operate most of the irrigation reservoirs in the basin.

Six percent of the Columbia Basin's water is diverted for agriculture, on average diversions are proportionately greater or less in some months and from year to year. Much of this water eventually finds its way back into the rivers as irrigation return flows. The effect on the overall water supply from individual projects is minor, but the combined impact on the river system is measurable. Storing water in reservoirs to meet irrigation demands alters river flows for other uses. The effects are much larger proportionally on some tributaries, such as the Snake River, than on the mainstem Columbia.

All of these effects are accounted for in the annual studies used to guide the operation of the Columbia River system. Operating requirements for irrigation aim to have the reservoirs capture and hold as much runoff as possible during the fall, winter, and early spring. In the early part of the irrigation season (early April and May), demands for water are often met by diverting natural streamflows. When natural streamflows are no longer adequate, the reservoirs are drafted to supply irrigation water. Releases continue throughout the growing season, which usually ends in mid-October.

Since water conditions vary greatly from year to year, demands for irrigation water also vary, as does the ability to refill the storage space in reservoirs. Sometimes it is necessary to hold water in excess of irrigation demands in a reservoir from one year to the next to ensure meeting demands in subsequent low-runoff years. Holding water over depends on the available storage and competing uses for the storage. For example, in some years, water in storage may need to be evacuated for flood control and so may not be available for irrigation.

When dry conditions persist over several years, there may not be enough water to meet all irrigation demands and supplies to some users may be curtailed. Allocation of water in such

cases depends on the seniority of the users' water rights and storage rights, as determined by state water resource agencies.

### Federal Irrigation Projects

Irrigation is a use at 10 of the 14 Federal projects. Grand Coulee, operated by Reclamation, is the only one of the affected projects where irrigation diversion facilities are integral to the dam and related structures. Irrigation water is withdrawn from the other projects by non-Federal parties via pumping stations on the reservoir shorelines. The major irrigation consideration at these projects is to ensure that pool elevations are high enough to permit the pumps to operate. None of the projects other than Grand Coulee and Hungry Horse has storage allocated to irrigation.

Lake Roosevelt is the irrigation water source for the vast Columbia Basin Project (Figure 3-7). Water is pumped from the reservoir 270 to 360 feet (82 to 110 m) vertically into a feeder canal to Banks Lake, where it is distributed by canal to irrigators. The Columbia Basin Project currently supplies irrigation water to 557,500 acres (225,600 ha). Irrigation requires approximately 2.3 to 2.7 MAF (2.8 to 3.3 billion m<sup>3</sup>) of water annually and in 1992 produced crops valued at over \$550 million. The diversion of 2.3 MAF (2.8 billion m<sup>3</sup>) is slightly over 2 percent of the average total annual flow of the Columbia River at Grand Coulee Dam. The volume diverted could increase by approximately 350 to 500 KAF (432 to 617 million m<sup>3</sup>) in the future, if a proposed 87,000-acre (35,209-ha) expansion is completed (Reclamation, 1993b).

### Non-Federal Irrigation Withdrawals

Non-Federal parties divert water for irrigation at many locations on the Columbia River system. In the SOR study area, extensive areas of irrigated agriculture have developed near the four lower Columbia River pools and Ice Harbor pool on the lower Snake River. Large-scale pumping plants withdraw water from the pools for pumping to fields. Thirteen

irrigators pump water from the Ice Harbor pool to irrigate over 36,000 acres (14,600 ha) (Figure 3-7), and 24 pumpers irrigate nearly 139,000 acres (56,300 ha) from the John Day pool (Figure 3-7). Both are key projects for the SOR evaluation.

### Municipal and Industrial Water Supply

Use of reservoir storage to meet municipal and industrial water supply needs is of relatively minor consequence in the Columbia River system. Some cities and industries divert water from the river system, but these diversions are small and have little measurable impact on overall system operations. Total depletion for municipal and industrial water use is estimated at less than 2 percent of annual flow (A.G. Crook Company, 1993). Municipal and industrial water withdrawals from the river system are concentrated on or near the Lower Granite and McNary pools. Water users withdrawing directly from McNary Pool include the cities of Richland, Kennewick, and Pasco and industrial firms nearby. The City of Lewiston and Potlatch Corporation have water supply intakes on the Clearwater River above Lower Granite.

#### 3.3.9 Water Quality

Water quality within the river system must be adequate to maintain aquatic life and allow for municipal or industrial use and water recreation. Minimum outflow requirements, which generally vary by season, are specified for each project to help maintain desired downstream conditions. The lead agencies recognize Federal and state water quality standards and manage a variety of programs and facilities intended to maintain water quality throughout the basin. The primary water quality factors studied in the SOR are water temperature and dissolved gas levels. (See Appendix M for detailed water quality information.)

#### Temperature

Water temperature is an important consideration in project operation. In winter, stored water can be warmer than natural flows.

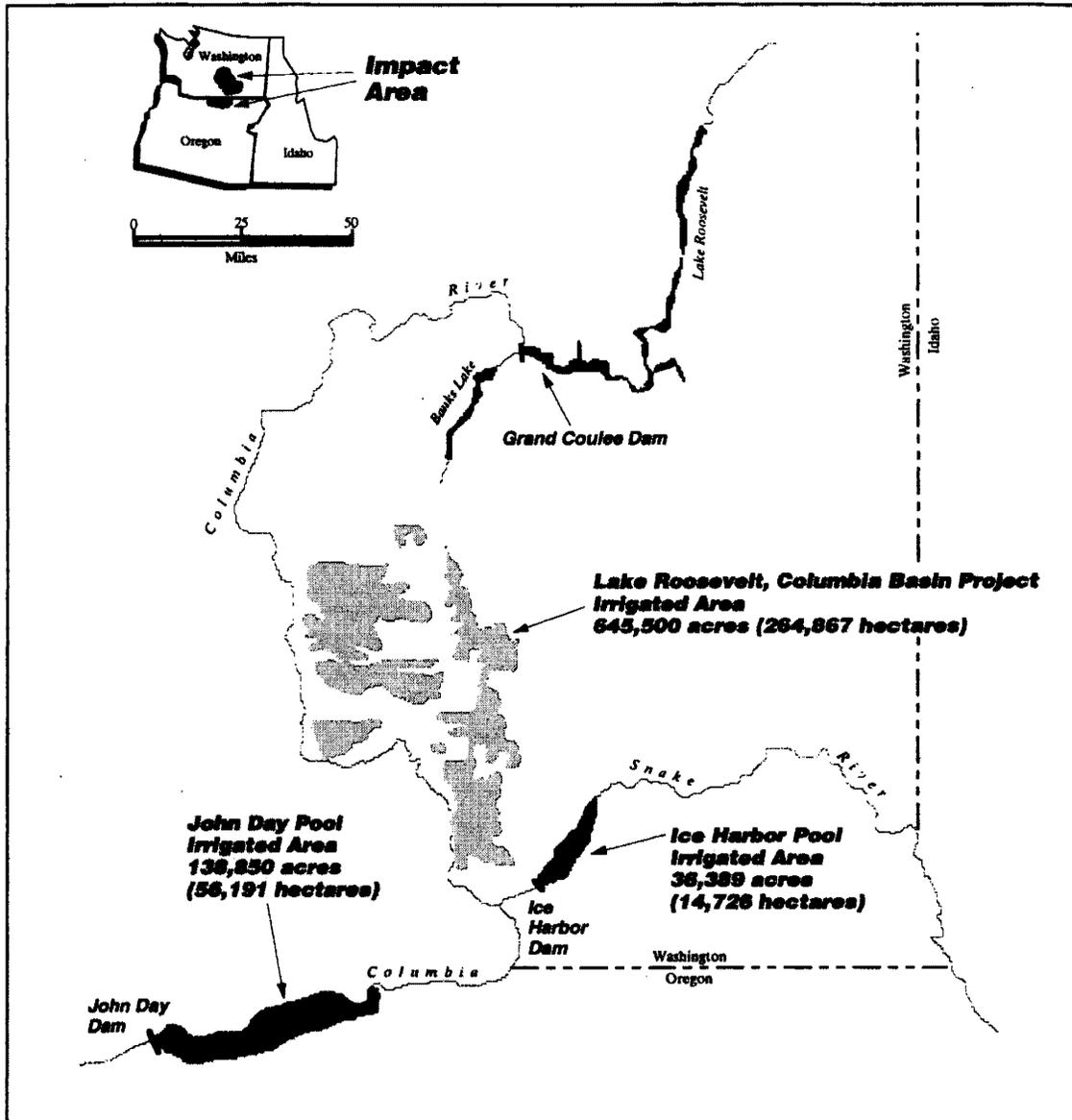


Figure 3-7. Key SOR irrigated areas and acreage (Source: Appendix F)

In summer, the sun heats up surface waters in the reservoirs, while the natural streams remain much cooler. Reservoir regulation (how a reservoir is drafted and filled) plays a significant role in how solar radiation and atmospheric temperature affect water temperature. Thermal characteristics of large storage projects are very different from run-of-river projects. The deep storage projects retain water for several months.

The water is in layers that vary in temperature. The relatively shallow run-of-river reservoirs have short retention times (only a few days), and have more uniform water temperatures from the surface to the bottom.

Dam operators influence downstream river temperatures by regulating outflows and by using multilevel outlets installed at some

projects, including Libby, Hungry Horse, and Dworshak. The outlet gates can be operated to supply water at various temperatures within the reservoir to influence the water temperature downstream.

### **Dissolved Gas**

Water that contains high levels of dissolved gases, such as nitrogen, can be harmful to fish. Dissolved gas saturation in water below Columbia River system dams often exceeds the states' maximum acceptable standard of 110 percent. The Corps has made major efforts to reduce gas levels in the water by regulating flow and installing flip lips at the base of some of the project spillways. Forced spill within the system is rare, as a result of flow regulation; most spill is planned through agreements with fish agencies intended to aid downstream fish passage. Flip lips are designed to reduce the plunge of water into the pools below the dams and consequently dissipate some of the energy that causes supersaturation. Neither flow regulations nor flip lips have been completely effective in reducing dissolved gas to safe levels.

The operating agencies constantly monitor water quality in the system. The Corps implemented a Dissolved Gas Monitoring Program as an integral part; of daily reservoir regulation activities in 1979; there are 15 monitoring sites located throughout the system. Currently, the Corps also constantly monitors water temperature. In addition to temperature and dissolved gas, the agencies monitor pH levels, suspended sediment, turbidity, the presence of toxic substances, groundwater levels, and nutrient levels.

### **3.3.10 Cultural Resources**

Much of the existing information about the specific archeological and historical sites found throughout the Columbia River Basin was gathered when the Federal dams were built. These earlier surveys were done using methods and standards that have changed considerably, so there is still much that is unknown about cultural resources in the reservoir pools. The SOR

agencies routinely work with Indian tribes and others to inventory and manage cultural resources found in the project areas.

Reclamation delegates cultural resources management responsibilities at Grand Coulee and Hungry Horse to other agencies. The Corps directly manages cultural sites on its projects. Corps staff, working directly or through contracts, manage the resources according to facility master plans and historic property management plans.

The following text briefly describes the historic and archeological sites at the projects. This discussion is based on information provided in Appendix D.

#### **Libby/Kootenai River**

Researchers have recorded a total of 250 archeological sites at Lake Kooconusa and an additional 17 sites on Corps' project lands below Libby Dam. These sites, which include camps, structures, dumps, processing sites, rock art, and others, represent prehistoric and historic human occupation of the project area. All of the sites are included within the middle Kootenai River and Libby-Jennings Archeological Districts. The USFS monitors cultural resources at the reservoir (Thoms, 1984; Roll, 1982).

#### **Hungry Horse/Flathead River**

Systematic cultural resources inventory of the Hungry Horse Project began in 1994. The USFS has surveyed much of the area with slopes of less than 30 percent that is above the minimum pool elevation and has recorded 30 archeological sites. Seven additional sites are known to be located in backshore areas above the pool. These sites were recorded during spot check surveys for individual projects such as timber sales.

#### **Albeni Falls/Pend Oreille Lake**

To date, 375 cultural resource sites have been inventoried. About 300 sites relate to prehistoric times and include large open camps, village sites, and petroglyphic rock art. The 40

to 75 historic sites include David Thompson's 1809 fur trading post, a later Hudson's Bay Company village, several ferry landings, railroad construction camps, and forestry and mining related structures.

### **Grand Coulee**

Archaeologists have recorded over 300 prehistoric and historic archeological sites around Lake Roosevelt and an additional 26 sites immediately downstream of Grand Coulee Dam. An additional 177 sites have been reported in ethnographic sources, and historic maps and records indicate the locations of an additional 31 unrecorded historic sites. Segments of the reservoir shoreline have never been systematically surveyed and most likely contain additional unrecorded resources. The recorded prehistoric sites include large villages, camps, activity-specific resource procurement/processing sites, cemeteries, and isolated burials. Small habitation sites are the most common type recorded, many of which appear to have human burial components. Historic sites found near Grand Coulee include homesteads, mines, and towns. Fort Colville and St. Paul's Mission are maintained by the NPS as interpretive sites and are listed on the National Register of Historic Places. Twenty prehistoric sites at Kettle Falls have been listed on the National Register of Historic Places as part of a National Historic District. Most other recorded sites around the reservoir have been insufficiently studied to determine if they are eligible for the National Register of Historic Places. Although numerous sites have been inundated by the reservoir, clearly many scientifically and culturally significant sites remain within the drawdown zone and around its shoreline (Corps et al., 1992).

### **Middle Columbia River**

The Lake Rufus Woods (the reservoir behind Chief Joseph Dam) National Historic District currently includes 347 recorded cultural sites. Most of these sites represent prehistoric camps, village sites, cemeteries, and rock art sites. Several historic homesteads, ferries, and mining

sites are included. Intensive excavations were conducted at 18 prehistoric sites between 1978 and 1980. This archeological project was the largest scientific recovery effort to date within the Columbia River system.

### **Middle Snake River**

No comprehensive cultural resources survey has been made at Brownlee Reservoir. Only 13 prehistoric sites and 7 historic sites have been identified within the reservoir area.

### **Dworshak/Clearwater River**

Dworshak Reservoir has been partially surveyed. Currently, 214 cultural resource sites have been identified. These sites include fishing camps, homesteads, burial sites, rockshelters, and village sites.

### **Lower Snake River**

There are 285 known archeological sites within the project boundaries of the four lower Snake River dams. The number of sites range from 33 at Ice Harbor to 138 at Lower Granite. These sites are both prehistoric and historic and range in age from the earliest period of human occupation to recent times. Two archeological districts (Windust Caves and Palouse Canyon) and three sites (Strawberry Island, Marmes Rockshelter, and Hasotino) are listed on the National Register of Historic Places. Marmes Rockshelter is also a designated National Historic Landmark.

### **Lower Columbia River**

There are 408 known archeological sites within the four reservoirs on the lower Columbia River. John Day has the most sites (223) and Bonneville the fewest (21). There are 14 properties that have been put on the National Register of Historic Places. These include Bonneville Dam, North Bonneville Archaeological District, Columbia River Highway Historic District, and Cascade Locks Marine Park at Bonneville; Five Mile Rapids Archaeological site, Indian Shaker Church and

Gulick Homestead, Wishram Indian Village Site, and Memaloose Island at The Dalles; the Umatilla archaeological site and Telegraph Island Petroglyphs at John Day; and Lower Snake River Archaeological District, Tri-Cities Archaeological District, Strawberry Island Village site, and Box Canyon archaeological site at McNary.