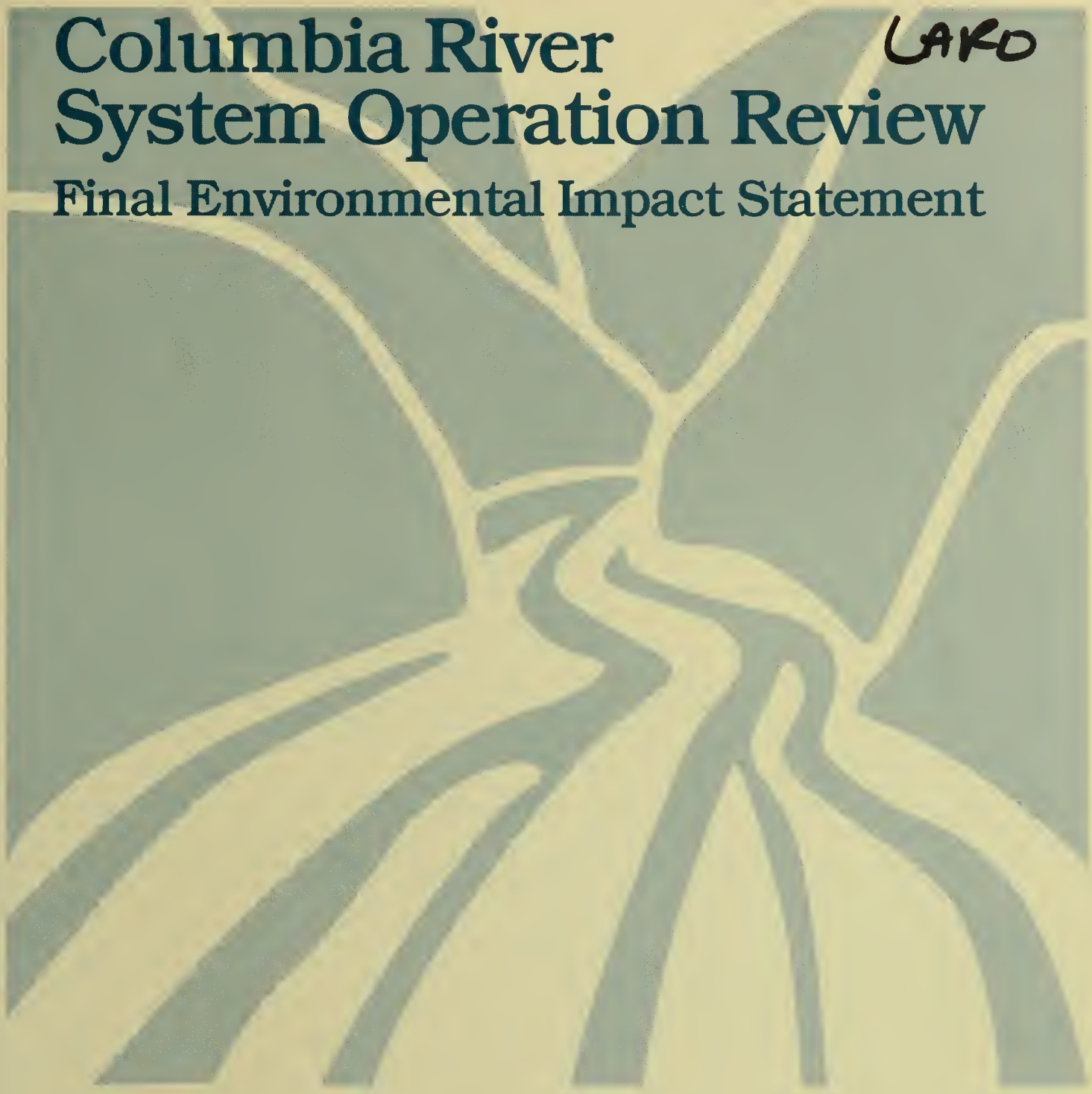
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Columbia River System Operation Review

Final Environmental Impact Statement



Main Report

BONNEVILLE POWER ADMINISTRATION

US Army Corps of Engineers
North Pacific Division

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

DOE/EIS-0170

November 1995

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 ElS, 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.

CONTENTS

1.0 INTRODUCTION: SETTING THE STAGE FOR THE SYSTEM OPERATION REVIEW 1-1
- 1.1 SOR BACKGROUND, NEED, AND PURPOSE 1-1
  - 1.1.1 Need 1-2
  - 1.1.2 Purpose 1-4
- 1.2 THE SYSTEM OPERATION REVIEW INTERAGENCY TEAM 1-5
  - 1.2.1 Lead Agencies 1-5
  - 1.2.2 Cooperating Agencies 1-6
- 1.3 SCOPE AND PROCESS 1-6
  - 1.3.1 Geographic Scope 1-7
  - 1.3.2 System Operation Review Process 1-7
  - 1.3.3 Public Involvement 1-14
  - 1.3.4 Tribal Coordination 1-15
- 1.4 KEY ISSUES AND CONCERNS 1-15
  - 1.4.1 Key Issues 1-16
  - 1.4.2 Resource Concerns 1-16

2.0 THE COLUMBIA RIVER BASIN 2-1
- 2.1 THE NATURAL ENVIRONMENT 2-1
  - 2.1.1 Earth Resources 2-2
  - 2.1.2 Water and Air Resources 2-5
  - 2.1.3 Aquatic Life 2-9
  - 2.1.4 Terrestrial Life 2-17
- 2.2 THE HUMAN ENVIRONMENT 2-21
  - 2.2.1 Cultural Resource Types and Significance 2-21
  - 2.2.2 Culture History 2-23
  - 2.2.3 Native Americans 2-26
  - 2.2.4 The Landscape 2-31
  - 2.2.5 The People and the Economy 2-35

3.0 THE COLUMBIA RIVER SYSTEM 3-1
- 3.1 THE STRUCTURE OF THE SYSTEM 3-1
  - 3.1.1 Federal Dams and Reservoirs 3-1
  - 3.1.2 Non-Federal Dams and Reservoirs 3-2
  - 3.1.3 Storage and Run-of-River Projects 3-4
- 3.2 SYSTEM PLANNING AND OPERATION 3-6
  - 3.2.1 Annual Planning 3-7
  - 3.2.2 Annual and Short-Term Operations 3-7
- 3.3 SYSTEM RESOURCES AND USES 3-8
  - 3.3.1 Flood Control 3-8
  - 3.3.2 Navigation 3-11

CONTENTS (continued)

3.3.3	Anadromous Fish	3-14
3.3.4	Resident Fish	3-20
3.3.5	Wildlife	3-21
3.3.6	Hydroelectric Power	3-23
3.3.7	Recreation	3-26
3.3.8	Irrigation	3-31
3.3.9	Water Quality	3-32
3.3.10	Cultural Resources	3-34
4.0 SYSTEM OPERATING STRATEGIES		4-1
4.1 SOS ALTERNATIVES		4-1
4.1.1	SOS Development	4-1
4.1.2	SOS 1—Pre-ESA Operation	4-5
4.1.3	SOS 2—Current Operations	4-5
4.1.4	SOS 4—Stable Storage Project Operation	4-18
4.1.5	SOS 5—Natural River Operation	4-18
4.1.6	SOS 6—Fixed Drawdown	4-19
4.1.7	SOS 9—Settlement Discussion Alternatives	4-19
4.1.8	SOS PA—Preferred Alternative	4-20
4.1.9	Rationale for Selection of the Final SOSs	4-20
4.1.10	SOS Alternatives Not Studied in Detail	4-23
	Structural Modifications at the Projects	4-24
	Nonproject Alternatives	4-24
	SOS Alternatives Not Carried Forward from Screening	4-25
	Non-Treaty Storage	4-25
	Confederated Tribes of the Umatilla Indian Reservation Alternative	4-27
4.2 IMPACTS OF THE SOS ALTERNATIVES		4-43
4.2.1	Earth Resources	4-44
4.2.2	Water Quality	4-57
4.2.3	Air Quality	4-69
4.2.4	Anadromous Fish	4-75
4.2.5	Resident Fish	4-105
4.2.6	Wildlife	4-124
4.2.7	Cultural Resources	4-134
4.2.8	Native Americans	4-144
4.2.9	Aesthetics	4-147
4.2.10	Recreation	4-150
4.2.11	Flood Control	4-167
4.2.12	Navigation	4-172
4.2.13	Power	4-175
4.2.14	Irrigation	4-181

CONTENTS (continued)

4.2.15 Municipal and Industrial Water Supply 4-184
4.2.16 Economics 4-188
4.2.17 Social Impacts 4-196
4.3 SUMMARY COMPARISON OF SOS ALTERNATIVES 4-199
4.3.1 Summary of Effects by SOS 4-199
4.3.2 Key Relationships Among Resources 4-219
4.3.3 Mitigation for SOS Alternatives 4-221
4.3.4 Cumulative Effects 4-235
4.3.5 Other Specific NEPA Considerations 4-237
Unavoidable Adverse Effects 4-237
Irreversible and Irretrievable Commitments of Resources 4-237
Short-term Uses and Long-term Productivity 4-238
Energy Requirements and Conservation Potential of Alternatives 4-238
Natural or Depletable Resource Requirements and Conservation Potential of Alternatives 4-239
Urban Quality, Historic and Cultural Resources, and the Design of the Built Environment 4-239

5.0 COLUMBIA RIVER REGIONAL FORUM 5-1
5.1 COLUMBIA RIVER REGIONAL FORUM CONCEPT 5-1
5.1.1 Current Decisionmaking Environment 5-1
5.1.2 Alternative Development 5-3
5.1.3 Forum 1 Through 7 5-3
5.1.4 Forum Alternatives Not Studied in Detail 5-7
5.2 EVALUATION OF FORUM ALTERNATIVES 5-7
5.2.1 Basis of Evaluation 5-7
5.2.2 Institutional Characteristics by Alternative 5-7
5.3 PROPOSED ACTION 5-11
5.3.1 Review of Existing Situation 5-11
5.3.2 Proposed Interim Action 5-12
5.3.3 Evaluation 5-12

6.0 PACIFIC NORTHWEST COORDINATION AGREEMENT 6-1
6.1 PNCA ALTERNATIVES 6-1
6.1.1 Alternative Development 6-1
6.1.2 PNCA 1—Existing Contract Terminates, No Replacement Contract (No Action) 6-2
6.1.3 PNCA 2—Contract to Maximize Regional Power Benefits 6-2
6.1.4 PNCA 3—Extension of Existing Contract (Base Case) 6-5
6.1.5 PNCA 4—Modified Contract Supplemented with Operating Procedures 6-5

CONTENTS (continued)

6.1.6 PNCA 5—Power Coordination Agreement to Enhance Nonpower Considerations 6-5
6.1.7 PNCA Alternatives not Studied in Detail 6-5
6.2 IMPACTS OF PNCA ALTERNATIVES 6-6
6.2.1 Environmental Impacts 6-6
6.2.2 Hydropower System Impacts 6-9
6.2.3 Financial Impacts 6-10
6.2.4 Contractual Impacts 6-10
6.3 SUMMARY AND COMPARISON 6-11
6.3.1 Evaluation of Alternatives 6-11
6.3.2 Preferred Alternative 6-13

7.0 CANADIAN ENTITLEMENT ALLOCATION AGREEMENTS 7-1
7.1 CEAA ALTERNATIVES 7-1
7.1.1 Alternative Development 7-1
7.1.2 Alternative CEAA Return Allocations 7-2
7.1.3 CEAA Alternatives not Considered in Detail 7-3
7.2 IMPACTS OF CEAA ALTERNATIVES 7-3
7.2.1 CEAA 1—No Action 7-4
7.2.2 CEAA 2—55 Percent Federal, 45 Percent Non-Federal 7-4
7.2.3 CEAA 3—70 Percent Federal, 30 Percent Non-Federal 7-4
7.2.4 CEAA 4—No Agreement 7-4
7.3 PREFERRED ALTERNATIVE 7-4

8.0 MAKING THE SOR DECISIONS 8-1
8.1 THE NATIONAL ENVIRONMENTAL POLICY ACT PROCESS 8-1
8.2 CRITERIA AND PATH FOR DECISIONS 8-1
8.2.1 Purposes 8-2
8.2.2 Implementability 8-2
8.2.3 Acceptability 8-3
8.3 THE PATH FOR SELECTING PREFERRED ALTERNATIVES 8-3
8.3.1 System Operating Strategy 8-3
8.3.2 The Forum 8-6
8.3.3 PNCA and CEAA 8-6

9.0 COORDINATION AND PUBLIC INVOLVEMENT 9-1
9.1 AGENCY COORDINATION 9-1
9.1.1 Lead and Cooperating Agencies 9-1
9.1.2 Other Agencies 9-2
9.2 COORDINATION WITH TRIBES 9-2

CONTENTS (continued)

9.3 PUBLIC INVOLVEMENT 9-4
9.3.1 Scoping and Other Public Meetings 9-5
9.3.2 Involvement of the Public in Work Groups 9-6
9.3.3 Draft EIS Meetings 9-8
9.3.4 Publications 9-9
9.3.5 Future Public Involvement Efforts 9-10

10.0 RELATED REGIONAL PROCESSES AND STUDIES 10-1
10.1 RELATED REGION-WIDE FISHERIES AND RIVER SYSTEM STUDIES 10-1
10.1.1 National Marine Fisheries Service ESA Listing and Recovery Plan 10-1
10.1.2 U.S. Fish and Wildlife Service ESA Listings 10-3
10.1.3 NPPC Fish and Wildlife Program 10-3
10.1.4 Short-Term System Operations 10-4
10.1.5 System Configuration Study 10-5
10.1.6 Lower Snake River Biological Drawdown Test 10-5
10.1.7 Other Key Fishery Studies 10-6
10.2 BUREAU OF RECLAMATION SNAKE RIVER AUGMENTATION PROGRAMS 10-6
10.2.1 Water Acquisition 10-6
10.2.2 Water Rental Group/Snake River Anadromous Fish Water Management Committee 10-7
10.2.3 Snake River Basin Water Committee 10-7
10.2.4 New Storage Appraisal Study 10-7
10.2.5 Snake River Resource Review 10-8
10.3 OTHER ACTIONS 10-8
10.3.1 Resource Programs EIS 10-9
10.3.2 Canadian Entitlement Return EIS 10-9
10.3.3 Business Plan EIS 10-9
10.3.4 Continued Development of the Columbia Basin Project, Washington 10-9
10.3.5 Hanford Reach Comprehensive River Conservation Study and EIS 10-10

11.0 ENVIRONMENTAL CONSULTATION, REVIEW, AND PERMIT REQUIREMENTS 11-1
11.1 NATIONAL ENVIRONMENTAL POLICY 11-1
11.2 ENDANGERED AND THREATENED SPECIES AND CRITICAL HABITAT 11-1
11.3 FISH AND WILDLIFE CONSERVATION 11-2
11.3.1 Fish and Wildlife Conservation Act 11-2
11.3.2 Fish and Wildlife Coordination Act 11-2
11.3.3 National Wildlife Refuge System Administration Act 11-3
11.3.4 Migratory Waterfowl Act 11-3
11.3.5 Marine Protection, Research, and Sanctuaries Act 11-4
11.3.6 Pacific Northwest Electric Power Planning and Conservation Act 11-4

CONTENTS (continued)

11.4 HERITAGE CONSERVATION 11-4
11.4.1 National Historic Preservation Act 11-4
11.4.2 Existing Programmatic Agreements 11-5
11.4.3 Archeological Resources Protection Act 11-5
11.4.4 Native American Graves Protection and Repatriation Act 11-6
11.4.5 American Indian Religious Freedom Act 11-6
11.5 STATE, AREA-WIDE, AND LOCAL PLAN AND PROGRAM CONSISTENCY 11-6
11.6 COASTAL ZONE MANAGEMENT CONSISTENCY 11-7
11.7 FLOOD PLAIN MANAGEMENT 11-7
11.8 WETLANDS PROTECTION 11-7
11.9 FARMLAND PROTECTION 11-8
11.9.1 Farmland Protection Policy Act 11-8
11.9.2 CEQ Memorandum on Analysis of Impacts on Prime or Unique Agricultural Lands 11-8
11.10 RECREATION RESOURCES 11-8
11.10.1 Wild and Scenic Rivers Act 11-8
11.10.2 Columbia River Gorge National Scenic Area Act 11-9
11.10.3 Wilderness Act 11-9
11.10.4 Water Resources Development Act 11-9
11.10.5 Federal Water Project Recreation Act 11-9
11.10.5 Land and Water Conservation Fund Act 11-10
11.11 GLOBAL WARMING 11-10
11.12 PERMITS FOR STRUCTURES IN NAVIGABLE WATERS 11-10
11.13 PERMITS FOR DISCHARGES INTO WATERS OF THE UNITED STATES 11-11
11.14 PERMITS FOR RIGHTS-OF-WAY ON PUBLIC LAND 11-11
11.15 ENERGY CONSERVATION AT FEDERAL FACILITIES 11-11
11.16 POLLUTION CONTROL AT FEDERAL FACILITIES 11-11
11.16.1 Clean Air Act 11-11
11.16.2 Clean Water Act 11-12
11.16.3 Safe Drinking Water Act 11-12
11.17 INDIAN TREATIES 11-12
11.18 OTHER 11-13
11.18.1 Estuary Protection Act 11-13
11.18.2 Watershed Protection and Flood Protection Act 11-13

12.0 DISTRIBUTION OF THE FINAL EIS 12-1

13.0 EIS PREPARERS 13-1

14.0 GLOSSARY OF TERMS AND ACRONYMS 14-1

CONTENTS (continued)

15.0 REFERENCES 15-1

16.0 INDEX 16-1

EXHIBITS

1 Confederated Tribes of the Colville Reservation, Comments to System Operation Review (SOR), Draft Environmental Statement, May 1995
2 Systems Operations Review of the Columbia River System, Comments of Kootenai Tribe of Idaho, May 10, 1995
3 Spokane Tribe of Indians, Comments on SOR Process
4 Confederated Tribes of the Umatilla Indian Reservation, Draft Consultation Plan
5 Confederated Tribes of the Umatilla Indian Reservation, Identification of Trust Resources System Operation Review
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9 Coeur d' Alene Tribe Review Comments on SOR Preliminary Final EIS
10 Confederated Tribes of the Colville Reservation, Comments on the SOR Preliminary Final EIS

APPENDICES

A River Operation Simulation
B Air Quality
C Anadromous Fish and Juvenile Fish Transportation
D Cultural Resources
E Flood Control
F Irrigation/Municipal and Industrial Water Supply
G Land Use and Development
H Navigation
I Power
J Recreation
K Resident Fish
L Soils, Geology, and Groundwater
M Water Quality
N Wildlife

CONTENTS (continued)

O Economic and Social Impacts
P Canadian Entitlement Allocation Agreements
Q Columbia River Regional Forum
R Pacific Northwest Coordination Agreement
S Fish and Wildlife Coordination Act Report
T Comments and Responses

FIGURES

1-1	Columbia River Basin	1-8
1-2	Columbia River System Operation Review organization chart	1-10
2-1	Physiographic provinces	2-3
2-2	Columbia River streamflows as measured at The Dalles	2-6
2-3	Minimum number of salmon and steelhead entering the Columbia River, 1938 to 1991	2-11
2-4	Estimated wild and hatchery adult spring chinook salmon passing Lower Granite Dam, 1977-1994	2-13
2-5	Estimated wild and hatchery adult summer chinook salmon passing Lower Granite Dam, 1977-1994	2-13
2-6	Estimated wild and hatchery adult fall chinook salmon arriving at Lower Granite Dam, 1975-1994	2-14
2-7	Estimated wild spawning Snake River sockeye passing Ice Harbor Dam (1962-1974) and Lower Granite Dam (1975-1994)	2-14
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	2-15
2-9	Indian reservations within the SOR study area	2-27
2-10	Population of Northwest states, 1900 to 1990	2-35
3-1	Storage and run-of-river projects	3-4
3-2	Reservoir elevation profile for Libby (Lake Koocanusa) under selected water conditions	3-6
3-3	Products exported from the Columbia River	3-13
3-4	Juvenile fish transportation and bypass facilities	3-16
3-5	Summary of hatchery releases by species for 1992 (numbers in thousands)	3-17
3-6	Baseline annual recreation use (in visitor days) by project or river reach	3-27
3-7	Key SOR irrigated areas and acreage	3-33
4-1	Shoreline erosion processes and characteristics that contribute to erosion	4-46
4-2	Total average pool elevation range (P_R) at affected projects for representative SOSs, by alternative	4-48
4-3	Total sediment eroded from lower Snake River reservoirs under average conditions, SOS 5 and 6	4-51
4-4	Simulated total lead exceedance curves for Lower Granite and Ice Harbor	4-68
4-5	Simulated DDT exceedance curves for Lower Granite and Ice Harbor	4-69
4-6	CRiSP1.5 estimated juvenile passage survival assuming average water year for in-river only migration, and with fish transport using varied transport survival models	4-94
4-7	Estimated total harvest and spawner escapement for 30 to 40 years into the future, based on selected transport survival hypotheses, using SLCM analysis	4-101

FIGURES (continued)

4-8	Comparison of index values representing aquatic production at Lake Koocanusa for median water years	4-110
4-9	Percent of years that June average flows equal or exceed specified sturgeon flow levels for May, June, and July at Bonners Ferry	4-111
4-10	Comparison of index values representing aquatic production at Hungry Horse Reservoir for median water years	4-113
4-11	Comparison of 2-year index values for fish species in Lake Pend Oreille	4-114
4-12	Comparison of 2-year index values for kokanee growth and survival in Lake Roosevelt	4-115
4-13	Comparison of 2-year index values for fish species in Brownlee Reservoir under the various alternatives	4-117
4-14	Comparison of 2-year index values for fish species in Dworshak Reservoir	4-119
4-15	Comparison of 2-year index values for fish species in Lower Granite Reservoir	4-120
4-16	Comparison of 2-year index values for fish species at Lake Umatilla (John Day pool) assuming a range of variability in pool elevation	4-122
4-17	Current distribution of water-dependent habitats in principal affected areas of the Columbia River System	4-127
4-18	Quantity of riparian habitat under SOSs at principal affected areas of the Columbia River System	4-129
4-19	Quantity of emergent marsh habitat under SOSs at principal affected areas of the Columbia River System	4-129
4-20	Quantity of drawdown zone projected for stable storage, natural river, and continued current operations at affected projects and reaches: SOSs 2c, 4c, 5b	4-130
4-21	Number of projects or reaches with beneficial or adverse effects on Federally listed wildlife	4-134
4-22	Reservoir impact zones and potential impacts on historic and cultural properties	4-135
4-23	Average days per year that archaeological sites would experience shoreline erosion and site exposure	4-138
4-24	Percent difference from SOS 2c in historic property shoreline erosion and site exposure	4-138
4-25	Estimated systemwide recreational use for representative SOS options (average water conditions)	4-165
4-26	Flood control costs relative to S0S 2c	4-171
4-27	Net navigation costs, relative to SOS 2c	4-175
4-28	Combined incremental irrigation costs	4-186
4-29	Combined incremental municipal and industrial water supply costs relative to SOS 2c	4-190
4-30	Aggregate net system operation costs relative to SOS 2c	4-195
9-1	Locations of SOR public meetings	9-5

TABLES

2-1	Wild and hatchery races of salmon and steelhead in the Columbia River Basin	2-12
2-2	Key treaties with Columbia Basin Indian Tribes	2-28
2-3	Designated Federal protected lands within SOR scope	2-33
3-1	General project characteristics	3-3
3-2	Reservoir operating characteristics	3-5
3-3	Number of Columbia/Snake River port facilities by pool and use	3-12
4-1	System Operating Strategy (SOS) Alternatives	4-6
4-2	Summary of alternatives in the Draft and Final EIS	4-21
4-3	Estimates of Columbia River Basin juvenile salmonid survival to below Bonneville Dam using Crisp 1.5, SOS 2c vs SOS 9d	4-31
4-4	Summary of direct annual economic impacts associated with SOS 9d	4-41
4-5	Temperature model simulation results, number of days exceeding 63°F	4-62
4-6	Total dissolved gas model simulation results, number of days exceeding 110-percent saturation	4-64
4-7	Sediment simulation results	4-66
4-8	CRiSP1.5 fixed (1986) transport survival	4-92
4-9	CRiSP1.5 1986 adjusted transport survival	4-92
4-10	Average in-river juvenile travel time (days) for surviving fish during 50 average water year conditions based on CRiSP1.5 model	4-100
4-11	Relative overall effect of the SOSs on resident fish production in the Columbia River	4-125
4-12	Comparison of archaeological site shoreline erosion, site exposure, and inundation by SOS	4-139
4-13	Average annual vertical shoreline exposure	4-151
4-14	Estimated annual recreation days for an average water year, by project and SOS (in thousands)	4-163
4-15	Columbia River system flood control points and flow or stage above which damage begins to occur	4-169
4-16	Average annual flood damages	4-170
4-17	Average annual hydropower generation by SOS, compared to SOS 2c	4-179
4-18	Annual net system replacement power cost by SOS, compared to SOS 2c ($1,000,000)	4-180
4-19	Change in annual irrigation pumping costs at Grand Coulee	4-183
4-20	Change in annual irrigation pumping costs at Ice Harbor	4-185
4-21	Change in annual irrigation pumping costs at John Day	4-185
4-22	Combined increase in costs to irrigators at Grand Coulee, Ice Harbor, and John Day pools ($000)	4-187
4-23	Increased annual pumping cost—M&I Pumpers	4-189
4-24	Direct economic impacts by alternative compared to SOS 2c, at 3.0 percent discount rate ($1,000)	4-193

TABLES (continued)

4-25	Direct economic impacts by alternative compared to SOS 2c, at 7.75 percent discount rate ($1,000)	4-194
4-26	Summary of regional employment impacts, compared to SOS 2c	4-197
4-27	Environmental comparison of SOS alternatives	4-200
5-1	Forum alternatives	5-4
5-2	Assessment of Forum alternatives	5-8
6-1	PNCA alternatives	6-3
6-2	Assessment of PNCA alternatives	6-7
6-3	Summary of comparative analysis of PNCA alternatives	6-12
7-1	CEAA alternatives	7-2
10-1	Scope of related regional study processes	10-2
10-2	Volumes of flow augmentation water from Reclamation projects in Idaho, 1991-1995	10-8
13-1	List of preparers, Bonneville Power Administration	13-2
13-2	List of preparers, Bureau of Reclamation	13-3
13-3	List of preparers, U.S. Army Corps of Engineers	13-4
13-4	List of preparers, Foster Wheeler Environmental (contractor)	13-5
13-5	List of preparers, other contractors	13-8

Chapter 1

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^3]) 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 CEAAs 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^3] 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

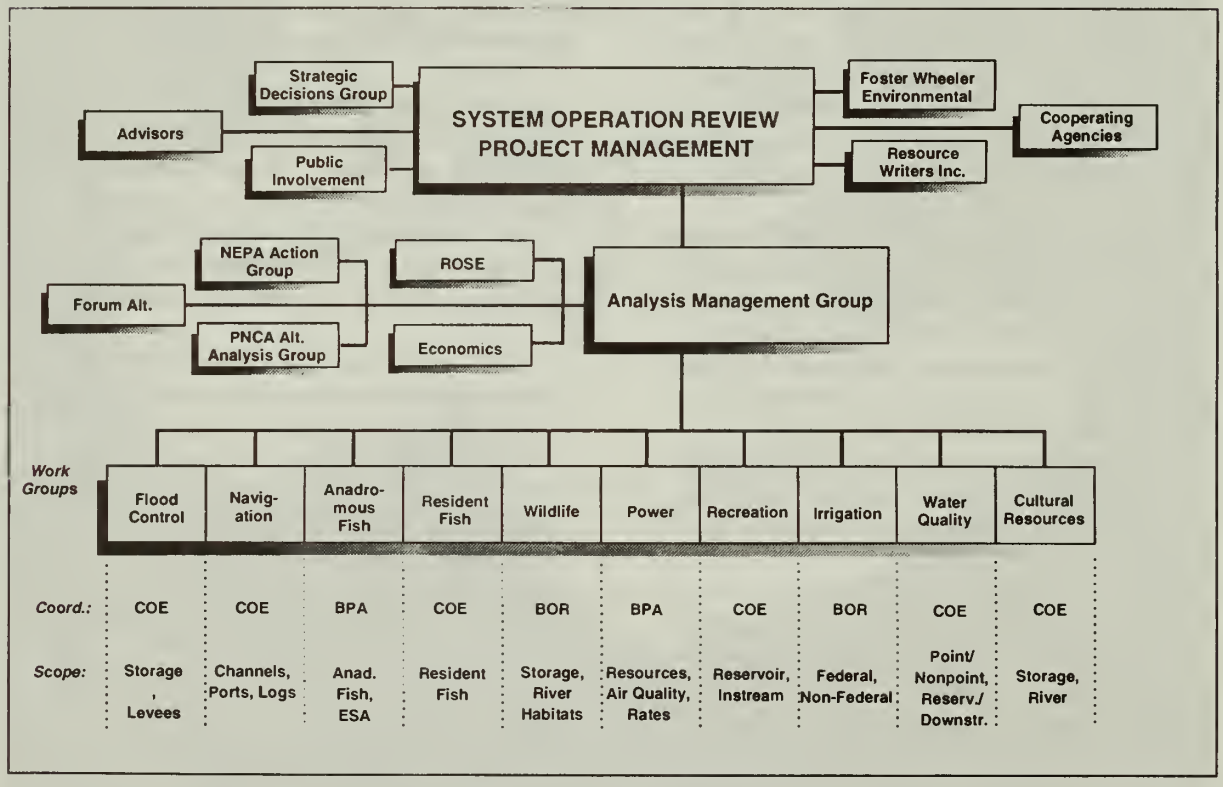


Figure 1-2. Columbia River System Operation Review organization chart

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 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.



Snake River Sockeye
Endangered (1991)



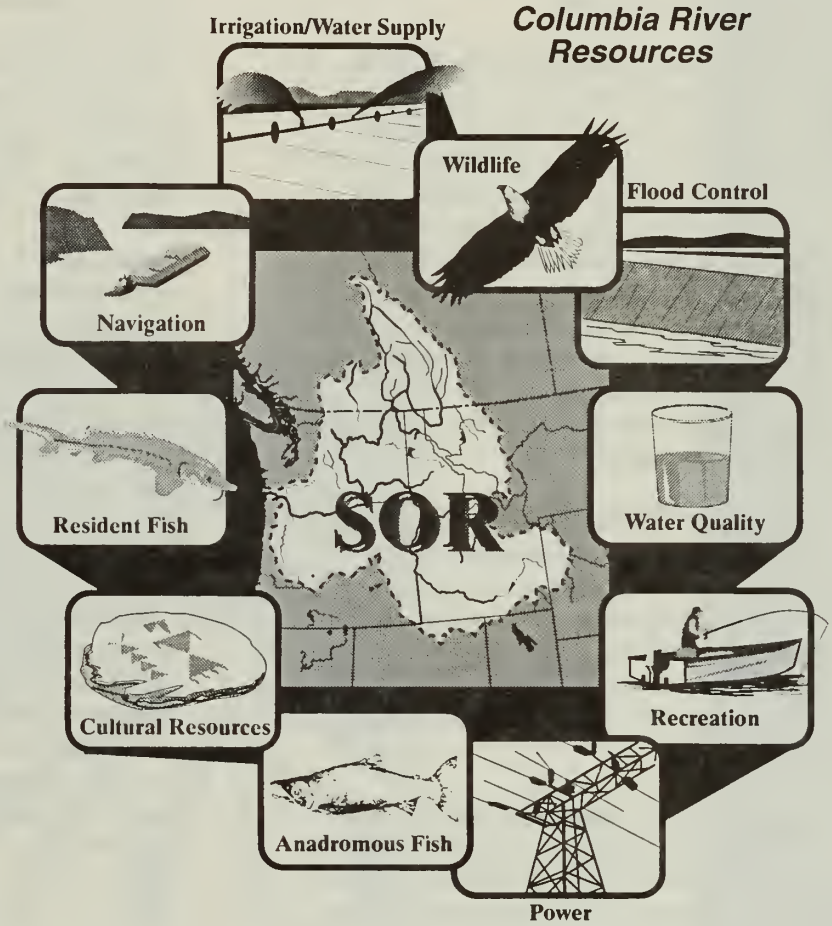
Spring/Summer & Fall Chinook
Endangered (1994)

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

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^3) (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

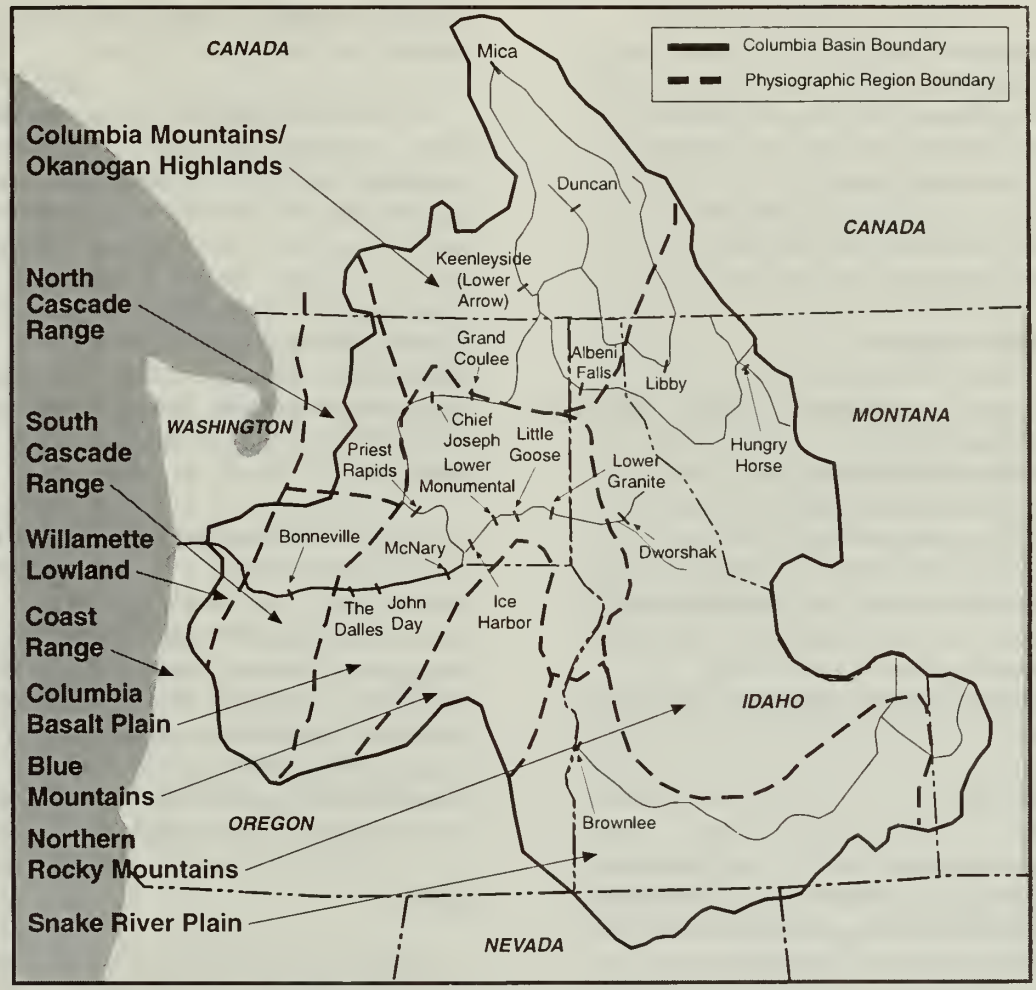


Figure 2-1. Physiographic provinces

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

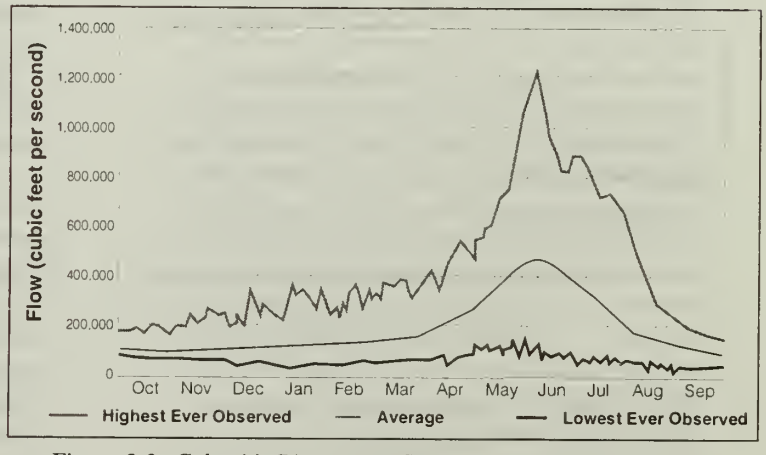


Figure 2-2. Columbia River streamflows as measured at The Dalles

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

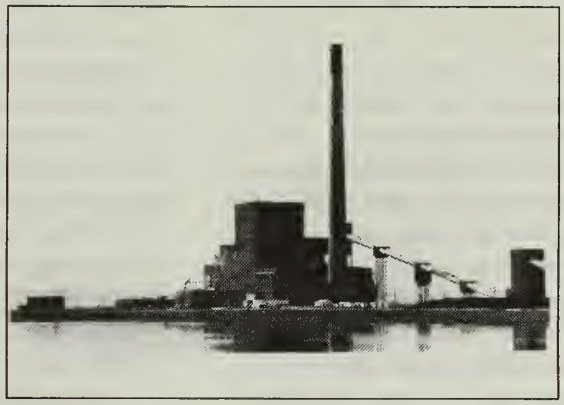
The air quality of the Columbia River Basin varies widely because it is influenced by local air pollution sources, meteorology, and topography (see Appendix B). In general, air pollution sources can be divided into three categories: (1) urban sources, such as carbon monoxide-producing city traffic and pollutants from industrial plants; (2) major single-point emittors, 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_{10}). 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_{10} nonattainment area. Clarkston and Lewiston, located on Lower Granite Reservoir, are TSP nonattainment areas.

Libby Dam in northwest Montana.





Thermal power facility.

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

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 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.

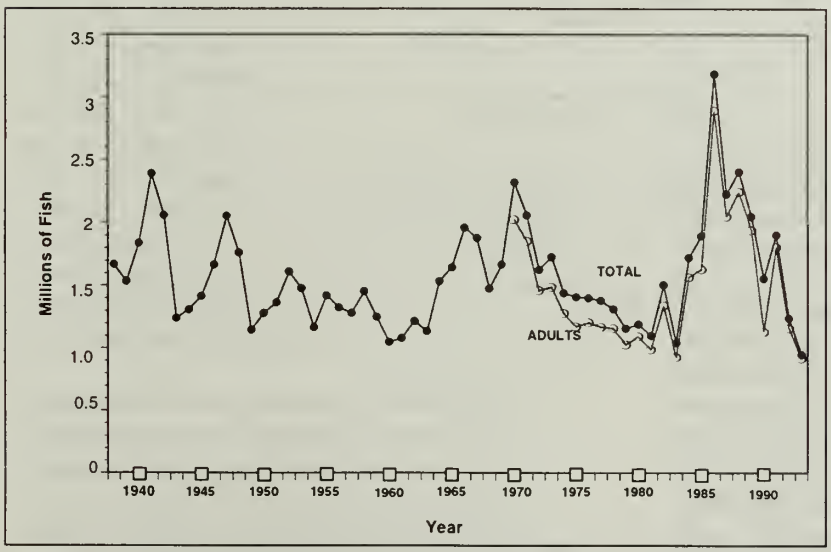


Figure 2-3. Minimum number of salmon and steelhead entering the Columbia River, 1938 to 1993 (Source: WDFW and ODFW, 1994).

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

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
Lower Columbia River (Below Bonnevilie Dam)[a/]								
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
Mid-Columbia (Bonneville Dam to Priest Rapids Dam)[a/]								
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
Snake River								
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
Upper Columbia River (Priest Rapids Dam to Chief Joseph Dam)[a/]								
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.

a/ 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.

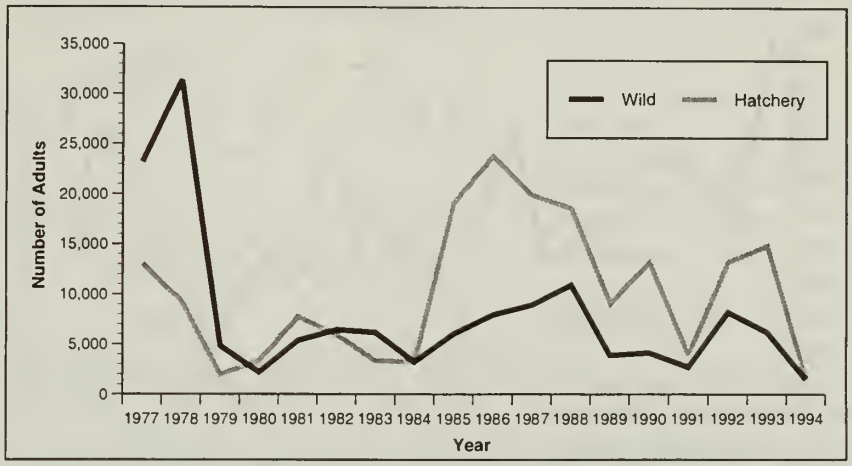


Figure 2-4. Estimated wild and hatchery adult spring chinook salmon passing Lower Granite Dam, 1977-1994 (Source: PSC, 1991; Columbia River Technical Staff, 1993; US v. Oregon Technical Advisory Committee, 1994)

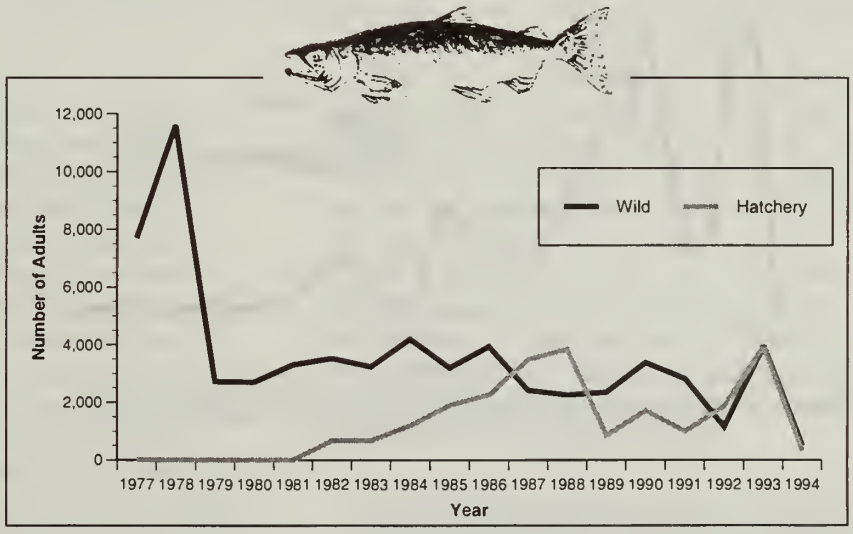


Figure 2-5. Estimated wild and hatchery adult summer chinook salmon passing Lower Granite Dam, 1977-1994 (Source: PSC, 1991; Columbia River Technical Staff, 1993; US v. Oregon Technical Advisory Committee, 1994)

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 2-8). 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

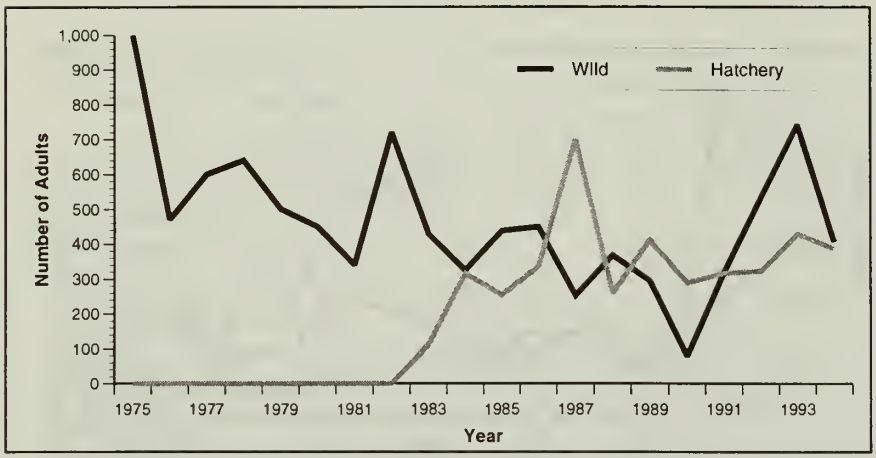


Figure 2-6. Estimated wild and hatchery adult fall chinook salmon arriving at Lower Granite Dam, 1975-1994 (Source: PSC, 1991; Lavoy, 1994, 1995)

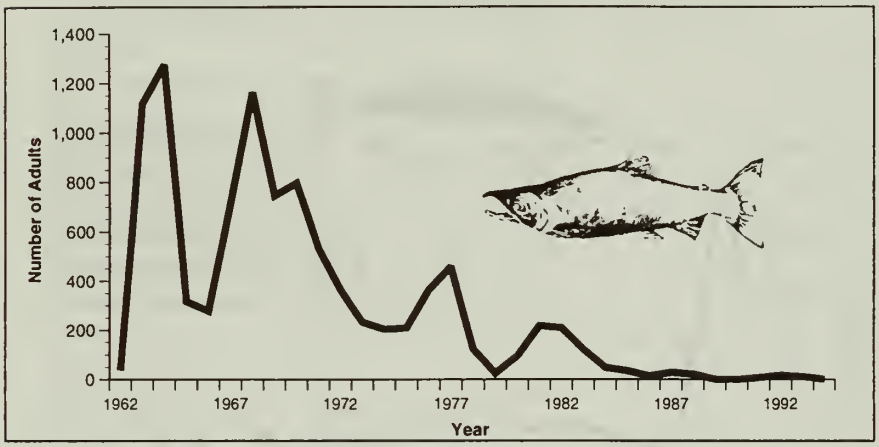


Figure 2-7. Estimated wild spawning Snake River sockeye passing Ice Harbor Dam (1962-1974) and Lower Granite Dam (1975-1994) (Sources: Corps, 1992 and FPC, 1993, 1994)

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

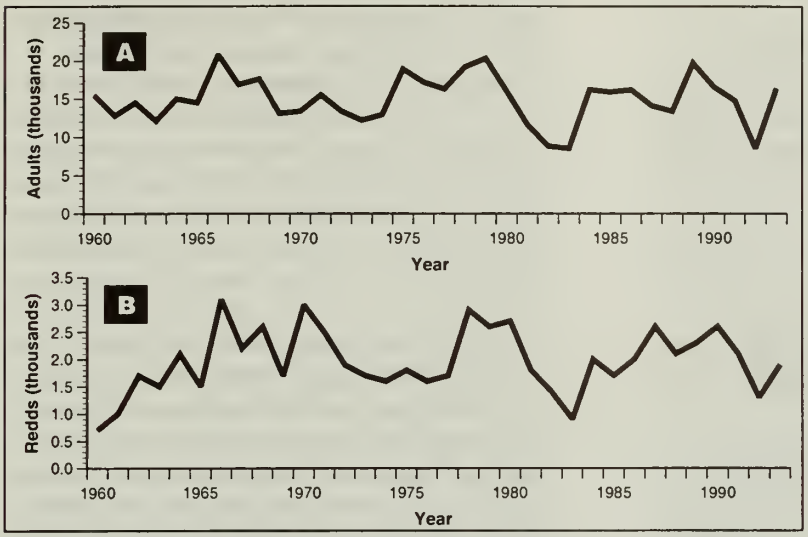


Figure 2-8. Escapement of summer chinook over Priest Rapids Dam (A) and redd indices for summer chinook (B) from Washington tributaries above Priest Rapids Dam, 1960-1993 (Source: WDFW and ODFW, 1994)

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, redside 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 Koocanusa is noted for its kokanee, westslope cutthroat trout, rainbow trout, bull trout, and burbot (Fraley 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 of 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 Koocanusa 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.

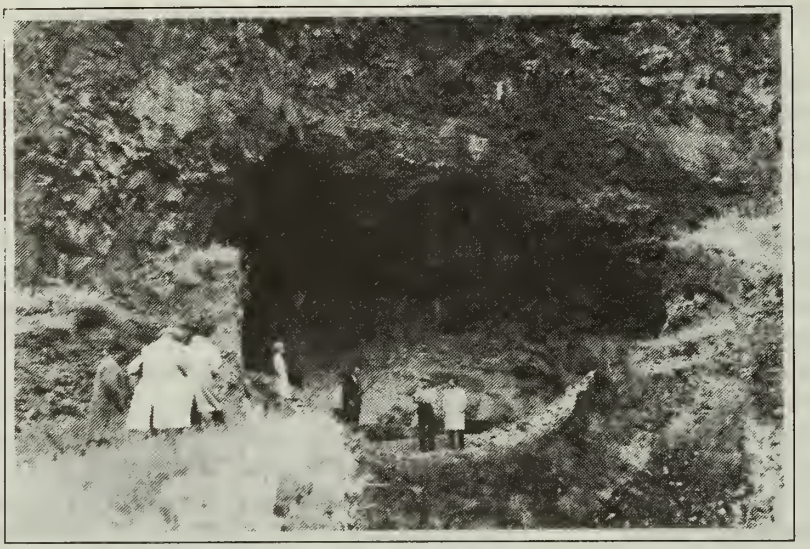
Federal agency cultural resource responsibilities are defined in law. According to Section 301 of the 1992 amendments to the National Historic Preservation Act, a historic property or historic resource is a resource significant in American history, architecture, archeology, engineering, or culture. Historic 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 Sineacquoteen 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 Perces, 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
- Blackfeet 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[a/]	Yakama, Klickitat, 12 others
Walla Walla Treaty of June 9, 1855[a/]	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, not withstanding 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[a/]

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.

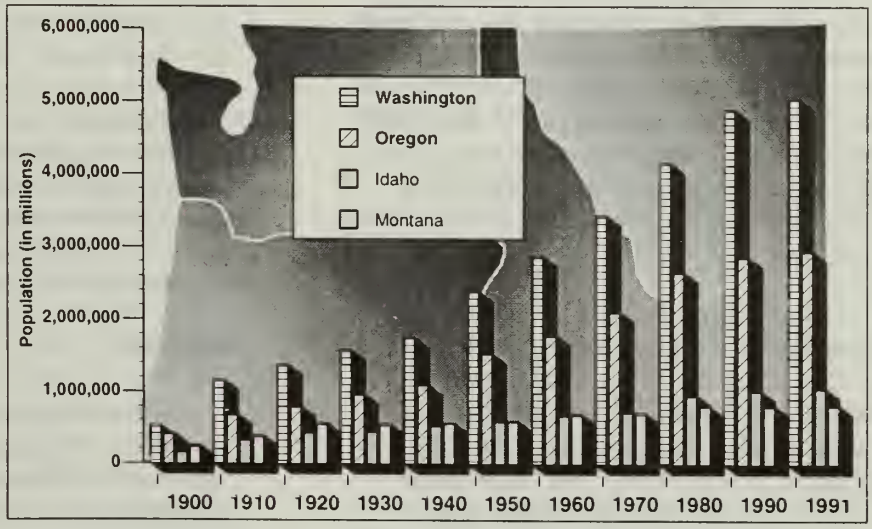


Figure 2-10. Population of Northwest states, 1900 to 1990 (Source: U.S. Census Bureau, 1993, 1988, 1961).

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.



The Columbia River System

Chapter 3

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^3), of which 980,250 acre-feet (1.2 billion m^3) 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[1/]	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^3), of which 42 MAF (51.8 billion m^3) 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

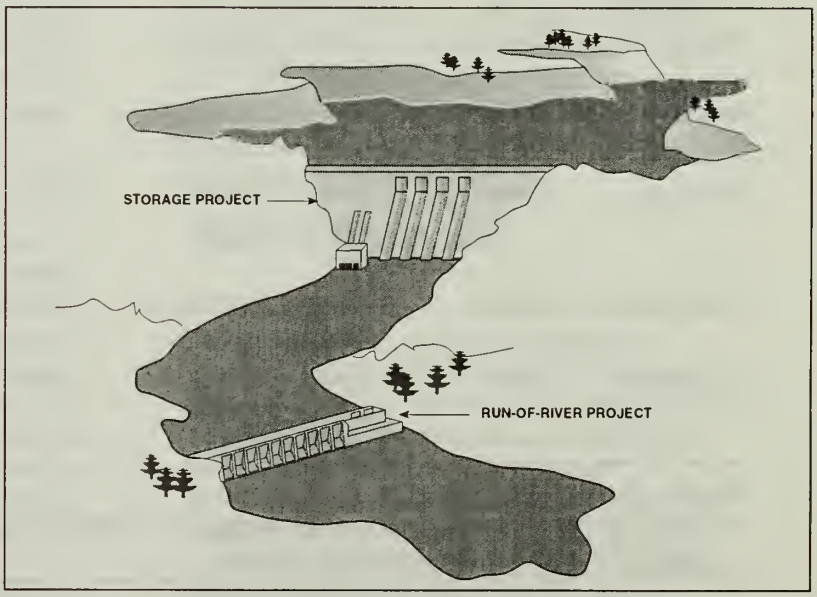


Figure 3-1. Storage and run-of-river projects

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)
Storage Projects					
Libby	Lake Koocanusa	4,979,500	2,287[2/]	NA	2,459
Hungry Horse	Hungry Horse	2,980,000	3,336[2/]	NA	3,560
Albeni Falls	Lake Pend Oreille	1,155,200	2,049.7[2/]	2,051[2/]	2,062.5
Grand Coulee	Lake Roosevelt	5,185,000	1,208[2/]	NA[2/]	1,290
Dworshak	Dworshak	2,015,800	1,445[2/]	NA[2/]	1,600
Run-of-River Projects					
Chief Joseph	Lake Rufus Woods	116,000[1/]	930	930	956
Lower Granite	Lower Granite Lake	49,000[1/]	733	733	738
Little Goose	Lake Bryan	49,000[1/]	633	633	638
Lower Monumental	Lake Herbert G. West	20,000[1/]	537	537	540
Ice Harbor	Lake Sacajawea	25,000[1/]	437	437	440
McNary	Lake Wallula	185,000[1/]	335	337	340
John Day	Lake Umatilla	534,000[1/]	257	Varies	268
The Dalles	Lake Celilo	53,000[1/]	155	155	160
Bonneville	Lake Bonneville	100,000[1/]	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^3). Active storage capacity of the five storage projects ranges from about 1.2 MAF (1.5 billion m^3) at Albeni Falls to nearly 5.2 MAF (6.4 billion m^3) at Grand Coulee. Three Canadian dams—Mica, Duncan, and Keenleyside—add another 20.5 MAF (25.3 billion m^3) 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.

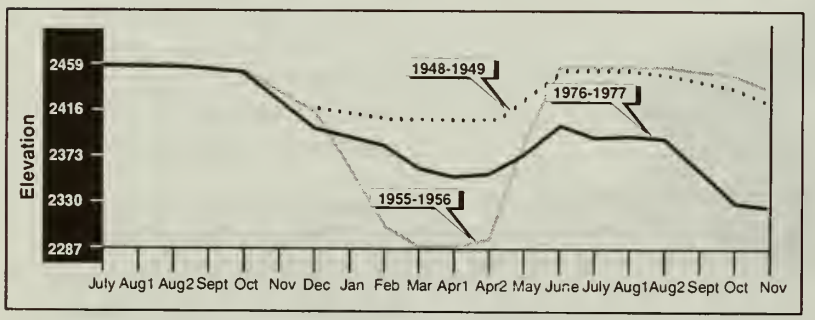


Figure 3-2. Reservoir elevation profile for Libby (Lake Koocanusa) under selected water conditions

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^3) of storage space can be made available for flood control from the Columbia River system. This represents 16.5 MAF (20.4 billion m^3) available at the U.S. storage projects (Grand Coulee, Albeni Falls, Libby, Hungry Horse, and Dworshak) and 20.5 MAF (25.3 billion m^3) 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 navel 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

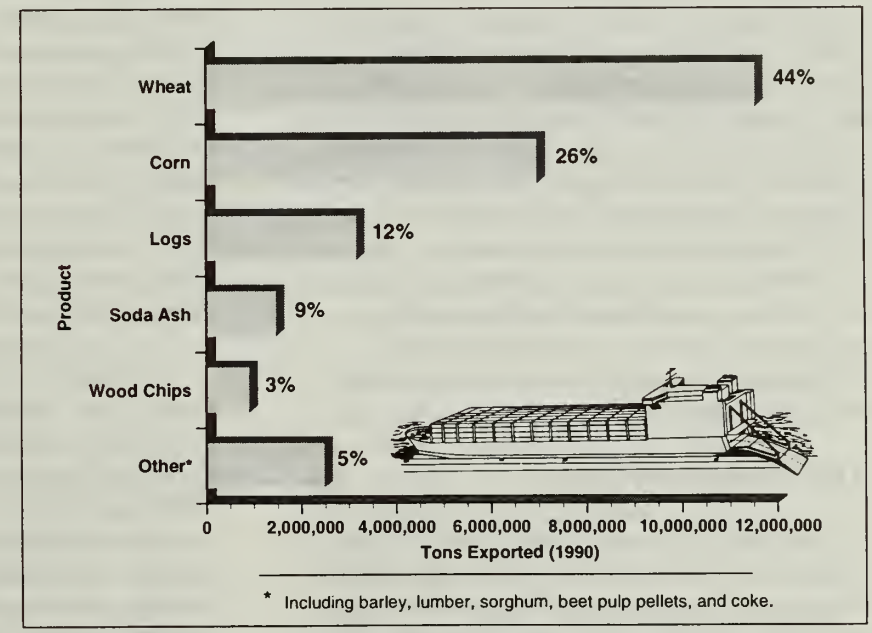


Figure 3-3. Products exported from the Columbia River (Source: Mason, 1991)

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.

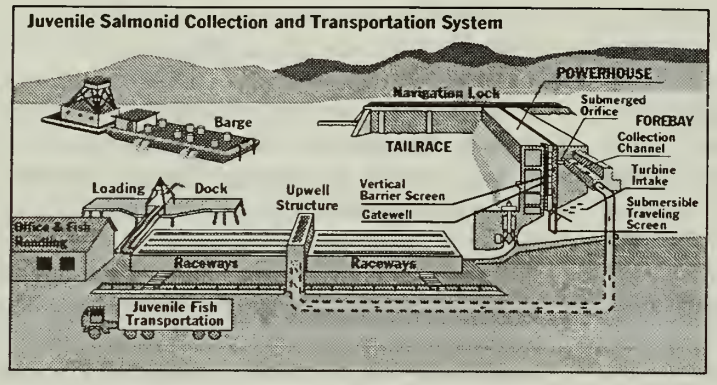
Bonneville Dam has three fish ladders; The Dalles, John Day, McNary, Ice Harbor, and Lower Monumental Dams have two fish ladders each; and Little Goose and Lower Granite Dams each have one fish ladder. Adult fish enter a ladder through collection systems that run along the entire front of a dam's powerhouse, 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



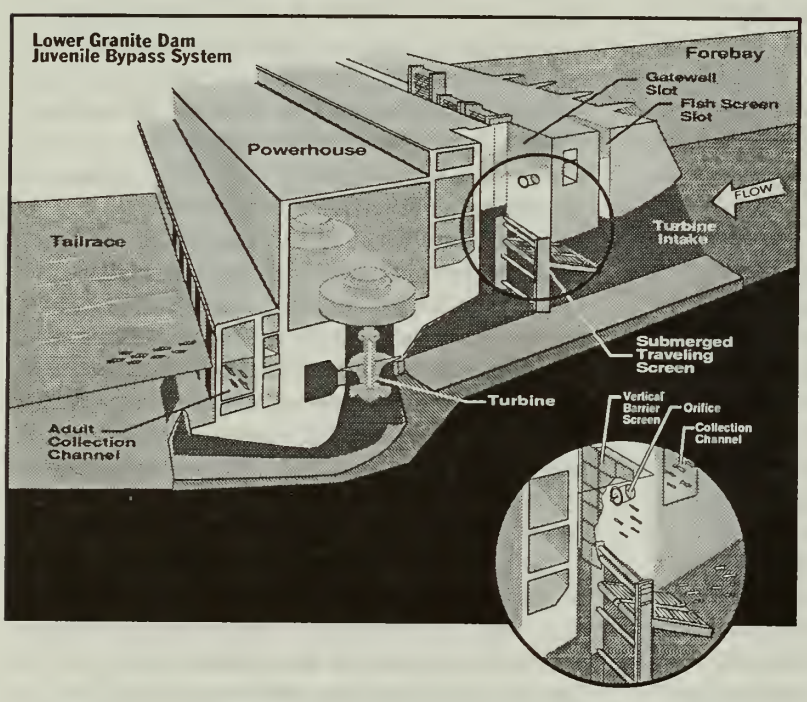


Figure 3-4. Juvenile fish transportation and bypass facilities

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.

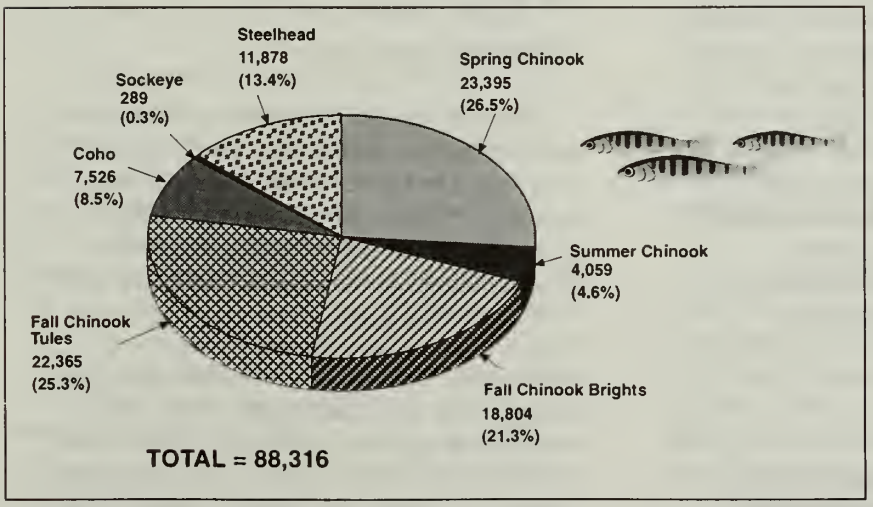


Figure 3-5. Summary of hatchery releases by species for 1992 (numbers in thousands) (Source: CBFWA, 1993)

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^3) of water can be released each spring. The total Water Budget volume includes up to 1.19 MAF (1.5 billion m^3) on the lower Snake River, and up to 3.45

MAF (4.3 billion m^3) 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^3) for flow augmentation on the Columbia River; an additional 300 thousand acre-feet (KAF) (370 million m^3) in the spring and 470 KAF (580 million m^3) 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^3) 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^3) 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 rivers. 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"

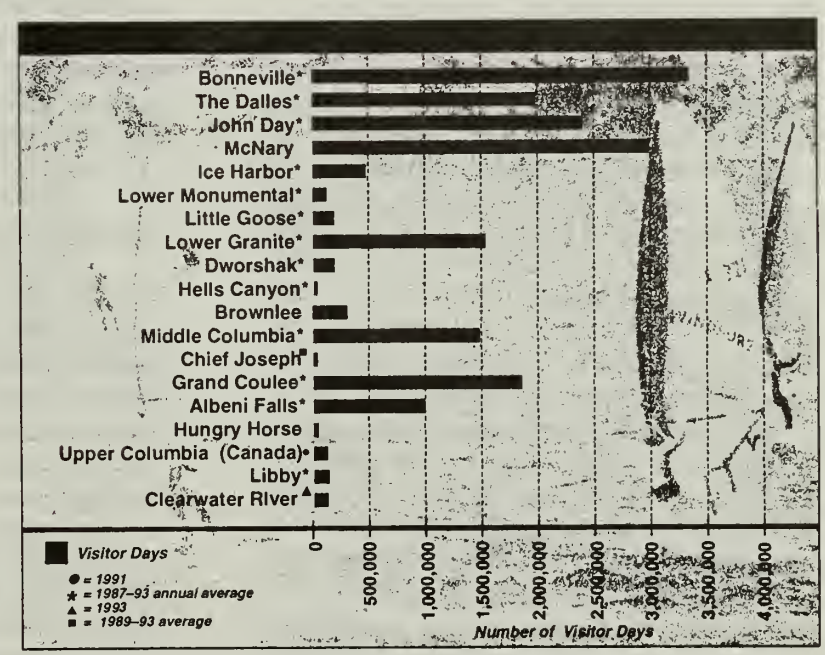


Figure 3-6. Baseline annual recreation use (in visitor days) by project or river reach (Source: Appendix J)

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 Koocanusa 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 Koocanusa 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^3) of water annually and in 1992 produced crops valued at over $550 million. The diversion of 2.3 MAF (2.8 billion m^3) 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^3) 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.

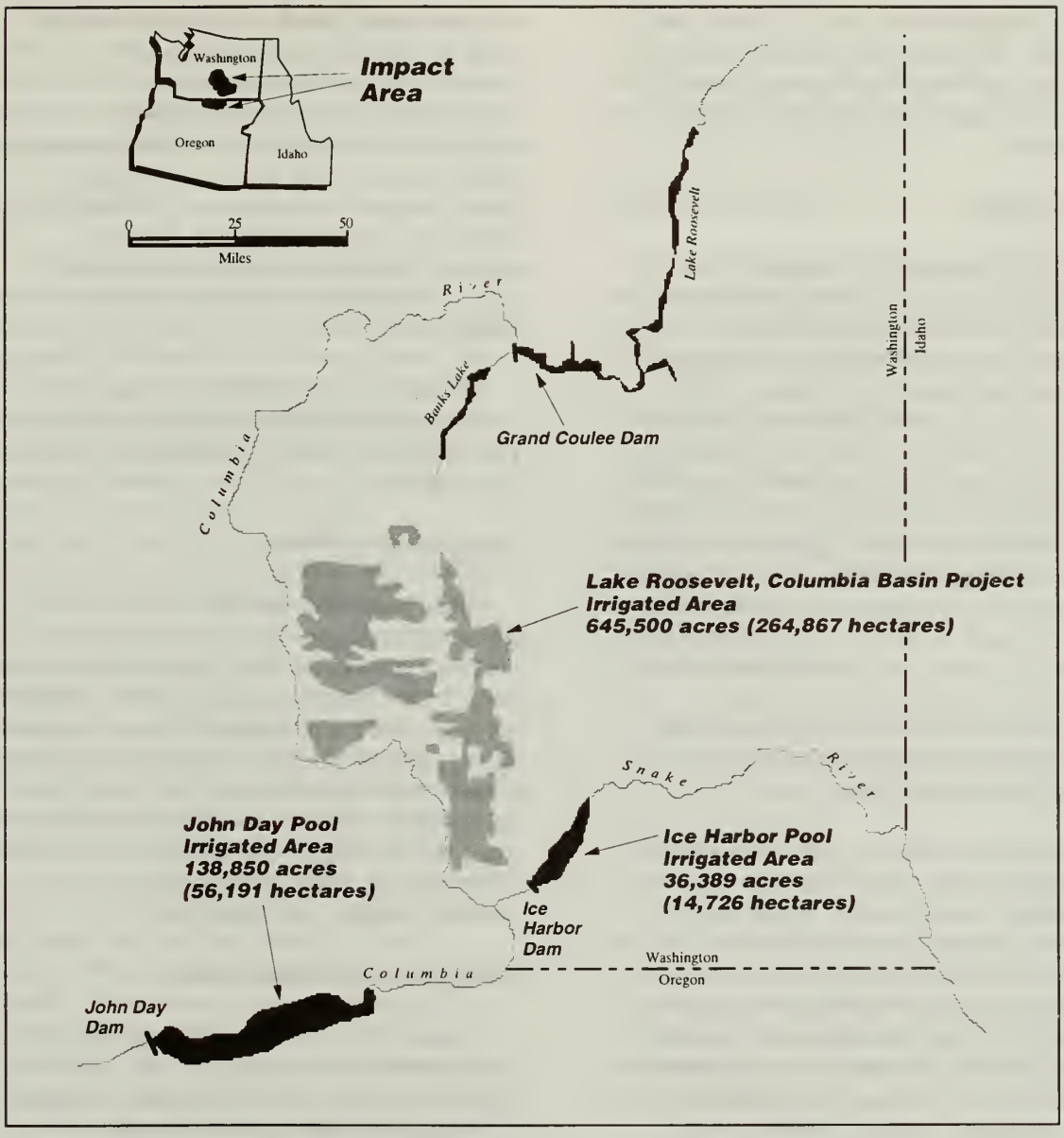


Figure 3-7. Key SOR irrigated areas and acreage (Source: Appendix F)

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 Koocanusa 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 archaeological 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.



System Operating Strategies

Chapter 4

4.0 SYSTEM OPERATING STRATEGIES

Chapter 4.0 presents a complete discussion of alternatives and potential impacts for one of the four SOR actions, selection of a long-term SOS. The chapter is divided into three sections. Section 4.1 describes the SOS alternatives that were evaluated in detail and explains how they were derived. It also addresses the alternatives and operating approaches that were considered at some point in the SOR process but, for various reasons, were not studied in detail for the EIS. Section 4.2 displays the effects of the alternative SOSs on each river use or resource area and documents the results of the SOR full-scale analysis for the SOS decision. Section 4.3 summarizes and compares the projected impacts of the SOSs, and discusses cumulative effects, trade-off relationships, mitigation, and other key factors.

4.1 SOS ALTERNATIVES

The operating procedures for the Columbia River system today reflect a combination of the project-specific requirements established when the Federal dams were built and subsequent individual project and systemwide requirements brought about through various programs or legal agreements. Historically, the two dominant functions of the reservoir system have been power generation and flood control. Issues have since emerged, such as diminishing salmon and steelhead runs and the growing use of reservoirs for recreation, that were not considered when the dams were authorized 30 to 60 years ago. While the Federal agencies have adjusted for these additional and sometimes competing interests, an overall system operating strategy specifically geared to accommodating the multiple uses has not been developed. The alternatives presented in this section propose some possible strategies.

An SOS alternative is a plan for operating the 14 Federal projects in the Columbia River system in a way that considers competing uses of the river. The alternatives prescribe water management actions to operate the system to achieve a desired objective. Alternative strategies range from continuing current practices to adopting major changes. These actions were evaluated for their effect on the overall system.

4.1.1 SOS Development

Technical work groups representing the 10 key river uses and several other critical issues provided the cornerstone of the analysis for the SOR. They played a key role in developing and screening alternatives in the early stages of the SOR, and in conducting the full-scale analysis reported in Sections 4.2 and 4.3. The work groups were guided through screening by the AMG described in Chapter 1. What follows is a synopsis of the alternative development and screening process; a detailed discussion can be found in *Screening Analysis, Volumes 1 and 2* (BPA, Corps, and Reclamation, 1992a).

Identifying Candidate Alternatives

The work groups' mission in developing alternatives was twofold. First, they were asked to develop an alternative that would represent the near-optimum operation for their river use. In other words, they were to describe the system operating scenario that would provide the greatest benefit to, for example, anadromous fish, recreation, or irrigation. The groups were also asked to describe one or more alternatives that, while not ideal would provide an acceptable environment for their river use. The purpose of examining the extreme conditions needed to optimize conditions for a single river use was to learn more about operating relationships, define which uses are compatible and which conflict, and identify under what conditions and to what extent the conflicts occur.

The AMG also offered alternatives for analysis during screening. Some of the AMG alternatives came from the SOR scoping meetings (see Scoping Document, 1991) held in August 1990. Many were suggested by

OPTIMUM CONDITIONS FOR EACH RIVER USE

The work groups identified the optimum operating conditions for their river use in very specific terms, indicating the flows and elevations required at various Federal hydroelectric projects. In general, the types of operation that appear to provide optimum benefits for each river use can be characterized as follows:

- Anadromous Fish—Streamflows as close to "natural" river conditions as possible, with mainstem reservoirs well below spillway levels
- Cultural Resources—Stable reservoir elevations year-round
- Flood Control—Reservoirs drafted in early spring to capture snowmelt inflows
- Irrigation—Full reservoirs April through October (growing season)
- Navigation—No reservoir drawdowns below minimum operating pool
- Power—Eliminate or reduce nonpower operating constraints on the system
- Recreation—Full reservoirs for long summer season (May-October) and stable downstream flows
- Resident Fish—Stable reservoirs year-round, with natural river flows
- Water Quality—Natural river flows with minimum spill
- Wildlife—Draw down and stabilize reservoirs year-round to expose maximum acreage for long-term habitat recovery

activities and events taking place in the region that affect river operations. For example, several alternatives came about as a result of the Salmon Summit and later from the Corps of Engineers' *1992 Columbia River Salmon Flow Measures Options Analysis/Environmental Impact Statement* (OA/EIS) and a drawdown test the Corps conducted at Lower Granite and Little Goose Dams on the Snake River in March 1992. The NPPC's Fish and Wildlife Program amendments were the source of other alternatives for the SOR, as was a 1991 proposal by the CBFWA to increase flows in the Columbia River. Altogether, 90 different ways to operate the river were proposed, many in groups or series because there was little difference between them.

Screening the Alternatives

The second part of each work group's task was to develop a screening model and screen the 90 alternatives, based on impacts to key value measures associated with their river use. In other words, the Anadromous Fish Work Group not only attempted to define the ideal operating conditions for salmon and steelhead in the Columbia River system, it evaluated the impact of the operations proposed by others on anadromous fish populations.

Establishing Value Measures—In order to make such evaluations, the work groups had to establish ways to measure the impacts of the various river operating scenarios on their river use. They defined what were called "value measures" as the yardsticks by which to quantify change. The objective was to define a few measures that could serve as suitable indicators for key resources; it was not to identify all measures that would fully or perfectly capture all effects for each river use. Likewise, the numerical results were used only to compare

alternatives; they were not intended to represent precise predictions or absolute values of impact.

Some work groups had many value measures; others had few. For example, the Wildlife Work Group identified 11 value measures ranging from evidence of indicator species, such as the number of Canada goose nests and otter den sites, to habitat quality and acreage figures. The Water Quality Work Group screened for two measures: water temperature and dissolved gas saturation.

The work groups looked for changes in the value measure results that would take place given differing operating scenarios on the Columbia River system. The quantitative measures were aided by computer programs that churned out hundreds of pieces of data—both numbers and diagrams—for each alternative.

Some work groups also limited the geographic area for their screening analysis. Rather than consider all 14 Federal hydro projects included in the scope of the SOR, most groups chose fewer representative projects or river reaches over which to establish identifiable patterns. For example, the Irrigation Work Group focused its screening analysis on those reservoirs and pools where major pumping activity currently exists and where the impact on irrigation costs could be most significant.

Where Hydroregulation Models Fit Into Screening—Planning and regulation of the system are aided by sophisticated computer programs called hydroregulation models. These models can rapidly calculate the river system's response to a variety of streamflow and operating conditions. From the data the models provide, analysts can estimate the systemwide impacts of projected operations. A more detailed discussion of the hydroregulation models can be found in *Modeling the System: How Computers are Used in Columbia River Planning* (BPA, Corps, and Reclamation, 1992b).

Each of the 90 alternatives was reviewed by the SOR support group, ROSE. ROSE determined whether the alternative had been described precisely enough to be run on a hydroregulation model. If not, the work group was asked to provide more detail about the operating condition it was proposing. When the alternative was sufficiently detailed, the operation was simulated using the computer model.

ROSE ran simulations for all 90 alternatives to determine how the physical river system would respond to each one. Once the hydroregulation model run was completed for an alternative, the work groups were given printouts and graphs that showed the average flows and end-of-month elevations that would result from the proposed operating scenario in each of five representative water years. The water years ranged from very dry to very wet. The next task for the work groups was to analyze how those flows and elevations translated into impacts on their river use. Each group decided independently how to do this part of the analysis. They generally used spreadsheets and other computer programs to determine the environmental effects.

ROSE designated an operating "base case" that each of the work groups would use. The base case for screening was the 1990-91 annual operating plan. This plan represents how the system operated prior to the changes implemented for the 1992 operating year to help the recovery of salmon stocks listed under the ESA. (This base case was used to provide a clear, common benchmark for analysis. It does not represent the No Action Alternative in NEPA terminology. See Section 4.1.3 for further discussion.) The work groups compared the impacts of a particular alternative on their river use to this baseline operation. When the analysis was complete, the work groups ranked each alternative according to its impact on their river use (see *Screening Analysis: A Summary* for a complete listing of the preference or rankings).

Identifying the Alternatives for Full-Scale Analysis

The SOR Interagency Team assigned the alternatives to five groups based on their general operating characteristics:

- Base Case—Alternatives that represent 1991 operations
- Flow Augmentation—Alternatives that modify water storage and flow requirements for the benefit of anadromous fish
- Drawdown—Alternatives that involve lower Snake River and/or John Day reservoir drawdown
- Stable Pools—Alternatives that stabilize storage reservoir elevations
- Power—Alternatives that change power system planning and operation

The team used the numerical results of screening to further sort the alternatives into distinct categories according to their effects on river uses. For example, several of the lower Snake River drawdown alternatives showed similar benefits to anadromous fish, with minimal effects on recreation and resident fish. Wildlife was slightly affected, but there were serious adverse impacts to navigation and irrigation. These alternatives formed a subset within the drawdown group.

Some of the categories reflected a single operating strategy. Others, however, did not alone suggest a strategy, but instead contained an element that could be added to another more distinct operating strategy. Based on these categories and the qualitative and quantitative screening results, the SOR team initially developed 10 candidate system operating strategies. These 10 strategies were presented for public and agency review in September 1992.

Following this review, the team narrowed the 10 strategies down to six strategies for evaluation in full-scale analysis, based on similarities or overlaps among the original 10 candidates. Another strategy was subsequently added to reflect the recommendations of the USFWS and NMFS. This resulted in seven final strategies, all with multiple options, that were evaluated in the Draft EIS. The seven strategies represented a total of 21 different courses of action.

The strategies analyzed in the Draft EIS reflected results of the numerical screening data, the categories of effects described above, and qualitative factors not captured in the numerical results. In addition, other regional activities—Corps' System Configuration Study and the NMFS's ESA and Recovery Plan deliberations—influenced the list of alternatives identified for full-scale analysis.

This Final EIS also evaluates 7 operating strategies, with a total of 13 alternatives now under consideration when accounting for options. The 13 final alternatives represent the results of the third analysis and review phase completed since SOR began. As was done after screening, broad public review and comment was sought on the full-scale analysis results published in the Draft EIS. A series of nine public meetings was held in September and October 1994, and a formal comment period on the Draft EIS was held open for over 4.5 months. Following this last process, the SOR agencies have again reviewed the list of alternatives and have selected 13 alternatives for consideration and presentation in the Final EIS.

Six options for the alternatives remain unchanged from the specific options considered in the Draft EIS. One option (SOS 4c) is a revision to a previously considered alternative, and the rest represent replacement or new alternatives. The basic categories of SOSs and the numbering convention remains the same as was used in the Draft EIS. However, because some of the alternatives have been dropped, the final SOSs are not numbered consecutively. There is one new SOS category, Settlement Discussion Alternatives, which is labeled SOS 9 (see Section 4.1.6 for discussion).

The eventual set of SOS alternatives for the Final EIS are summarized in the following narratives. Table 4-1 presents the basic features

on the alternatives with respect to operations of projects located in the United States. Many of the SOSs evaluated in the Final EIS incorporate one adjustment to the operation of Canadian projects, which is operation of Arrow to allow storage of up to 1 MAF (1.2 billion m^3) of water for spring and summer flow augmentation. The table outlines specific operating requirements the alternative prescribes for individual projects. Hydroregulation model results for the alternatives, which reflect the simulated hydrological outcomes, are included in Appendix A.

The following Sections 4.1.2 through 4.1.8 describe the final alternatives, while Section 4.1.9 reviews the rationale for their inclusion in the Final EIS.

4.1.2 SOS 1–Pre-ESA Operation

This alternative represents one end of the range of the SOR strategies in terms of their similarity to historical system operations. This strategy reflects Columbia River system operations before changes were made as a result of the ESA listing of three Snake River salmon stocks. This SOS has two options:

- **SOS 1a (Pre-Salmon Summit Operation)** represents operations as they existed from 1983 through the 1990 to 1991 operating year, including Northwest Power Act provisions to restore and protect fish populations in the basin. Specific volumes for the Water Budget would be provided from Dworshak and Brownlee reservoirs to attempt to meet a target flow of 85 kcfs (2,380 cms) at Lower Granite Dam in May. Sufficient flows would be provided on the Columbia River to meet a target flow of 134 kcfs (3,752 cms) at Priest Rapids Dam in May. Lower Snake River projects would operate within 3 to 5 feet (0.9 to 1.5 m) of full pool. Other projects would operate as they did in 1990 to 1991, with no additional water provided from the Snake River above Brownlee Dam.
- **SOS 1b (Optimum Load-Following Operation)** represents operations as they existed prior to changes resulting from the Northwest Power Act. It is designed to demonstrate how much power could be produced if most flow-related operations to benefit anadromous fish were eliminated including the Water Budget; fish spill requirements; restrictions on operation of Bonneville's second powerhouse; and refill targets for Libby, Hungry Horse, Grand Coulee, Dworshak, and Albeni Falls. It assumes that transportation would be used to the maximum to aid juvenile fish migration.

4.1.3 SOS 2–Current Operations

This alternative reflects operation of the Columbia River system with interim flow improvement measures made in response to ESA listings of Snake River salmon. It is very similar to the way the system operated in 1992 and reflects the results of ESA Section 7 consultation with NMFS then. The strategy is consistent with the 1992 to 1993 operations described in the Corps' *1993 Interim Columbia and Snake Rivers Flow Improvement Measures Supplemental EIS* (SEIS). SOS 2 also most closely represents the recommendations issued by the NMFS Snake River Salmon Recovery Team in May 1994. Compared to SOS 1, the primary changes are additional flow augmentation in the Columbia and Snake Rivers and modified pool levels at lower Snake and John Day reservoirs during juvenile salmon migration. This strategy has two options:

- **SOS 2c (Final SEIS Operation—No Action Alternative)** matches exactly the decision made as a result of the 1993 SEIS. Flow augmentation water of up to 3.0 MAF (3.7 billion m^3) on the Columbia River (in addition to the existing Water Budget) would be stored during the winter and released in the spring in low-runoff years. Dworshak would provide at least an additional 300 KAF (370 million m^3) in the spring and 470 KAF (580 million m^3) in the summer for flow augmentation. System flood control shifts from Dworshak and Brownlee to Grand

Table 4-1. SOS Alternatives–1

Summary of SOS

SOS 1 Pre-ESA Operation	SOS 2 Current Operations	SOS 4 Stable Storage Project Operation
SOS 1 represents system operations before changes were made as a result of the ESA listing of three Snake River salmon stocks. SOS 1a represents operations from 1983 through the 1990–91 operating year, influenced by Northwest Power Act; SOS 1b represents how the system would operate without the Water Budget and related operations to benefit anadromous fish. Short-term operations would be conducted to meet power demands while satisfying nonpower requirements.	SOS 2 reflects operation of the system with interim flow improvement measures in response to the ESA salmon listings. It is consistent with the 1992–93 operations described in the Corps' 1993 Interim Columbia and Snake River Flow Improvement Measures Supplemental EIS. SOS 2c represents the operating decision made as a result of the 1993 Supplemental EIS and is the no action alternative for the SOS. Relative to SOS 1a, primary changes are additional flow augmentation in the Columbia and Snake Rivers and modified pool levels at lower Snake and John Day reservoirs during juvenile salmon migration. SOS 2d represents operations of the 1994-98 Biological Opinion issued by NMFS, with additional flow aumentation measures compared to SOS 2c.	SOS 4 would coordinate operation of storage reservoirs to benefit recreation, resident fish, wildlife, and anadromous fish, while minimizing impacts to power and flood control. Reservoirs would be managed to specific elevations on a monthly basis; they would be kept full longer, while still providing spring flows for fish and space for flood control. The goal is to minimize reservoir fluctuations while moving closer to natural flow conditions. SOS 4c attempts to accommodate anadromous fish needs by shaping mainstem flows to benefit migrations and would modify the flood control operations at Grand Coulee.

Actions by Project

	SOS 1	SOS 2	SOS 4
LIBBY	**SOS 1a** Normal 1983–1991 storage project operations	**SOS 2c** Operate on system proportional draft as in SOS 1a	**SOS 4c** • Meet specific elevation targets as indicated by Integrated Rule Curves (IRCs); IRCs are based on storage content at the end of the previous year, determination of the appropriate year within the critical period, and runoff forecasts beginning in January • IRCs seek to keep reservoir full (2,459 feet) June-Sept; minimum annual elevation ranges from 2,399 to 2,327 feet, depending on critical year determination • Meet variable sturgeon flow targets at Bonners Ferry during May 25-August 16 period; flow targets peak as high as 35 kcfs in the wettest years
	SOS 1b • Minimum project flow 3 kcfs • No refill targets • Summer draft limit of 5–10 feet	**SOS 2d** • Provide flow augmentation for salmon and sturgeon when Jan. to July forecast is greater than 6.5 MAF • Meet sturgeon flows of 15, 20, and 12.5 kcfs in May, June, and July, respectively, in at least 3 out of 10 years	

KAF = 1.234 million cubic meters

MAF = 1.234 billion cubic meters

Table 4-1. SOS Alternatives–1

SOS 5 Natural River Operation	SOS 6 Fixed Drawdown	SOS 9 Settlement Discussion Alternatives	SOS PA
SOS 5 would aid juvenile salmon by increasing river velocity. The four lower Snake River projects would have new outlets installed, allowing the reservoirs to be drawn down to near the original river elevation. The "natural river" operation would be done for 4 1/2 months in SOS 5b and year-round in SOS 5c. John Day would also be operated at MOP for 4 months, and flow augmentation measures on the Columbia River portion of the basin would continue as in SOS 2c.	SOS 6 involves drawing down lower Snake River projects to fixed elevations below MOP to aid anadromous fish. SOS 6b provides for fixed drawdowns for all four lower Snake projects for 4 1/2 months; SOS 6d draws down Lower Granite only for 4 1/2 months. John Day would also be operated at MOP for 4 months, and flow augmentation measures on the Columbia River portion of the basin would continue as in SOS 2c.	SOS 9 represents operations suggested by the USFWS, NMFS, the state fisheries agencies, Native American tribes, and the Federal operating agencies during the settlement discussions in response to the *IDFG v. NMFS* court proceedings. This alternative has three options, SOSs 9a, 9b, and 9c, that represent different scenarios to provide increased river velocities for anadromous fish by establishing flow targets during migration and to carry out other actions to benefit ESA-listed species. The three options are termed the Detailed Fishery Operating Plan (9a), Adoptive Management (9b), and the Balanced Impacts Operation (9c).	SOS PA represents the operation recommended by NMFS and the USFWS Biological Opinions issued March 1, 1995. This SOS supports recovery of ESA-listed species by storing water during the fall and winter to meet spring and summer flow targets, and protects other resources by setting summer draft limits to manage negative effects, by providing flood protection, and by providing for reasonable power generation.

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a	**SOS 9a** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Provide sturgeon flow releases April-Aug. to achieve up to 35 kcfs at Bonner's Ferry with appropriate ramp up and ramp down rates	**SOS PA** • Operate on minimum flow up to flood control rule curves beginning in Jan., except during flow augmentation period • Strive to achieve flood control elevations in Dec. in all years and by April 15 in 75 percent of years • Provide sturgeon flows of 25 kcfs 42 days in June and July • Provide sufficient flows to achieve 11 kcfs flow at Bonner's Ferry for 21 days after maximum flow period • Draft to meet flow targets, to a minimum end of Aug. elevation of 2,439 feet, unless deeper drafts needed to meet sturgeon flows
SOS 5c Operate on system proportional draft as in SOS 1a	**SOS 6d** Operate on system proportional draft as in SOS 1a	**SOS 9b** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation • Provide sturgeon flow releases similar to SOS 2d • Can draft to elevation 2,435 by end of July to meet flow targets	
		SOS 9c • Operate to the Integrated Rule Curves and provide sturgeon flow releases as in SOS 4c	

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-1. SOS Alternatives–2

Actions by Project

	SOS 1	SOS 2	SOS 4
HUNGRY HORSE	**SOS 1a** Normal 1983–1991 storage project operations	**SOS 2c** Operate on system proportional draft as in SOS 1a	**SOS 4c** • Meet specific elevation targets as indicated by Integrated Rule Curves (IRCs), similar to operation for Libby • IRCs seek to keep reservoir full (3,560 feet) June-Sept.; minimum annual elevation ranges from 3,520 to 3,450 feet, depending on critical year
	SOS 1b • No maximum flow restriction from mid-Oct. to mid-Nov. • No draft limit; no refill target	**SOS 2d** Operate on system proportional draft as in SOS 1a	

	SOS 1	SOS 2	SOS 4
ALBENI FALLS	**SOS 1a** Normal 1983–1991 storage project operations	**SOS 2c** Operate on system proportional draft as in SOS 1a	**SOS 4c** Elevation targets established for each month, generally 2,056 feet Oct.–March, 2,058 to 2,062.5 feet April–May, 2,062.5 feet (full) June, 2,060 feet July–Sept. (but higher if runoff high); Oct.–March drawdown to 2,051 feet every 6th year
	SOS 1b No refill target	**SOS 2d** Operate on system proportional draft as in SOS 1a	

KAF = 1.234 million cubic meters

MAF = 1.234 billion cubic meters

Table 4-1. SOS Alternatives–2

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a	**SOS 9a** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period	**SOS PA** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Strive to achieve flood control elevations by April 15 in 75 percent of the years • Draft to meet flow targets, to a minimum end-of-August elevation of 3,540 feet
SOS 5c Operate on system proportional draft as in SOS 1a	**SOS 6d** Operate on system proportional draft as in SOS 1a	**SOS 9b** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation • Can draft to meet flow targets, to a minimum end-of-July elevation of 3,535 feet	
		SOS 9c • Operate to the Integrated Rule Curves as in SOS 4c	

SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a	**SOS 9a** Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period	**SOS PA** • Operate to flood control elevations by April 15 in 90 percent of the years • Operate to help meet flow targets, but do not draft below full pool through Aug.
SOS 5c Operate on system proportional draft as in SOS 1a	**SOS 6d** Operate on system proportional draft as in SOS 1a	**SOS 9b** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Can draft to meet target flows, to a minimum end-of-July elevation of 2,060 feet	
		SOS 9c • Elevation targets established for each month, generally no lower than 2,056 feet Dec.—April, no lower than 2,057 feet end of May, full (2,062.5 feet) June—Aug., 2,056 feet Sept.—Nov.	

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-1. SOS Alternatives–3

Actions by Project

GRAND COULEE

SOS 1	SOS 2	SOS 4
SOS 1a • Operate to meet Water Budget target flows of 134 kcfs at Priest Rapids in May [1/] • Meet minimum elevation of 1,240 feet in May	**SOS 2c** • Storage of water for flow augmentation from January through April • Supplemental releases (in conjunction with upstream projects) to provide up to 3 MAF additional (above Water Budget) flow augmentation in May and June, based on sliding scale for runoff forecasts • System flood control space shifted from Brownlee, Dworshak	**SOS 4c** • Operate to end-of-month elevation targets, as follows: 1,288 Sept.-Nov 1,287 Dec. 1,270 Jan. 1,260 Feb. 1,270 Mar. 1,272 Apr. 15 1,275 Apr. 30 1,280 May 1,288 Jun.-Aug. • Meet flood control rule curves only when Jan.-June runoff forecast exceeds 68 MAF
SOS 1b • No refill target of 1,240 feet in May • Maintain 1,285 feet June–Sept.; minimum 1,220 feet rest of year • No May–June flow target	**SOS 2d** • Contribute, in conjunction with upstream storage projects, up to 4 MAF for additional flow augmentation • Operate in summer to provide flow augmentation water and meet downstream flow targets, but draft no lower than 1,280 feet	

PRIEST RAPIDS

SOS 1	SOS 2	SOS 4
SOS 1a • Meet May-June flow targets [1/] • Maintain minimum flows to meet Vernita Bar Agreement [2/]	**SOS 2c** Operate as in SOS 1a **SOS 2d** Operate as in SOS 1a	**SOS 4c** Operate as in SOS 1a
SOS 1b • No May flow target • Meet Vernita Bar Agreement		

1/ Flow targets are weekly averages with weekend and holiday flows no less than 80 percent of flows over previous 5 days.
2/ 55 kcfs during heavy load hours October 15 to November 30; minimum instantaneous flow 70 kcfs December to April
KAF = 1.234 million cubic meters MAF = 1.234 billion cubic meters

Table 4-1. SOS Alternatives–3

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft and provide flow augmentation as in SOS 2c	**SOS 6b** Operate on system proportional draft and provide flow augmentation as in SOS 2c	**SOS 9a** • Operate to meet flood control requirements and Vernita Bar agreement • Provide flow augmentation releases to help meet targets at The Dalles of 220-300 kcfs April 16-June 15, 200 kcfs June 16-July 31, and 160 kcfs Aug. 1-Aug.31, based on appropriate critical year determination • In above average runoff years, provide 40% of the additional runoff volume as flow augmentation	**SOS PA** • Operate to achieve flood control elevations by April 15 in 85% of years • Draft to meet flow targets, down to minimum end-of-Aug. elevation of 1,280 feet • Provide flow augmentation releases to meet Columbia River flow targets at McNary of 220-260 kcfs April 20-June 30, based on runoff forecast, and 200 kcfs July-Aug.
SOS 5c Operate on system proportional draft and provide flow augmentation as in SOS 2c	**SOS 6d** Operate on system proportional draft and provide flow augmentation as in SOS 2c	**SOS 9b** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Can draft to meet flow targets, bounded by SOS 9a and 9c targets, to a minimum end-of-July elevation of 1,265 feet	
		SOS 9c • Operate to meet McNary flow targets of 200 kcfs April 16-June 30 and 160 kcfs in July . • Can draft to meet flow targets, to a minimum end-of-July elevation of 1,280 feet • Contribute up to 4 MAF for additional flow augmentation, based on sliding scale for runoff forecasts, in conjunction with other upstream projects • System flood control shifted to this project	

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate as in SOS 1a	**SOS 6b** Operate as in SOS 1a	**SOS 9a** Operate as in SOS 1a	**SOS PA** Operate as in SOS 1a
SOS 5c Operate as in SOS 1a	**SOS 6d** Operate as in SOS 1a	**SOS 9b** Operate as in SOS 1a	
		SOS 9c Operate as in SOS 1a	

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-1. SOS Alternatives–4

Actions by Project

	SOS 1	SOS 2	SOS 4
SNAKE RIVER ABOVE BROWNLEE	**SOS 1a** Normal 1990—91 operations; no Water Budget flows	**SOS 2c** Release up to 427 KAF (190 KAF April 16—June 15; 137 KAF Aug.; 100 KAF Sept.) for flow augmentation	**SOS 4c** Same as SOS 1a
	SOS 1b Same as SOS 1a	**SOS 2d** • Release up to 427 KAF, as in SOS 2c • Release additional water obtained by purchase or other means and shaped per Reclamation releases and Brownlee draft requirements; simulation assumed 927 KAF available	

	SOS 1	SOS 2	SOS 4
BROWNLEE	**SOS 1a** • Draft as needed (up to 110 KAF in May) for Water Budget, based on target flows of 85 kcfs at Lower Granite • Operate per FERC license • Provide system flood control storage space	**SOS 2c** Same as SOS 1a except for additional flow augmentation as follows: • Draft up to 137 KAF in July, but not drafting below 2,067 feet; refill from the Snake River above Brownlee in August • Draft up to 100 KAF in Sept. • Shift system flood control to Grand Coulee • Provide 9 kcfs or less in November; fill project by end of month • Maintain November monthly average flow December through April	**SOS 4c** Same as SOS 1a except slightly different flood control rule curves
	SOS 1b • No maximum flow restriction from mid-Oct. to mid-Nov. • No draft limit; no refill target	**SOS 2d** Same as SOS 2c, plus pass additional flow augmentation releases from upstream projects	

KAF = 1.234 million cubic meters

MAF = 1.234 billion cubic meters

Table 4-1. SOS Alternatives–4

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Same as SOS 1a	**SOS 6b** Same as SOS 1a	**SOS 9a** Provide up to 1.927 MAF through Brownlee for flow augmentation, as determined by Reclamation	**SOS PA** Provide 427 KAF through Brownlee for flow augmentation, as determined by Reclamation
SOS 5c Same as SOS 1a	**SOS 6d** Same as SOS 1a	**SOS 9b** Provide up to 927 KAF through Brownlee as determined by Reclamation	
		SOS 9c Provide up to 927 KAF through Brownlee as determined by Reclamation	

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Same as SOS 4c	**SOS 6b** Same as SOS 4c	**SOS 9a** • Draft up to 110 KAF in May, 137 KAF in July, 140 KAF in Aug., 100 KAF in Sept. for flow augmentation • Shift system flood control to Grand Coulee	**SOS PA** Draft to elevation 2,069 feet in May, 2,067 feet in July, and 2,059 feet in Sept., passing inflow after May and July drafts
SOS 5c Same as SOS 4c	**SOS 6d** Same as SOS 4c	**SOS 9b** • Draft up to 190 KAF April-May, 137 KAF in July, 100 KAF in Sept. for flow augmentation • Shift system flood control to Grand Coulee • Provide an additional 110 KAF in May if elevation is above 2,068 feet and 110 KAF in Sept. if elevation is above 2,043.3 feet	
		SOS 9c Same as SOS 9b	

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-1. SOS Alternatives–5

Actions by Project

	SOS 1	SOS 2	SOS 4
DWORSHAK	**SOS 1a** • Draft up to 600 KAF in May to meet Water Budget target flows of 85 kcfs at Lower Granite • Provide system flood control storage space **SOS 1b** • Meet minimum project flows (2 kcfs, except for 1 kcfs in August); summer draft limits; maximum discharge requirement Oct. to Nov. (1.3 kcfs plus inflow) • No Water Budget releases	**SOS 2c** Same as SOS 1a, plus the following supplemental releases: • 900 KAF or more from April 16 to June 15, depending on runoff forecast at Lower Granite • Up to 470 KAF above 1.2 kcfs minimum release from June 16 to Aug. 31 • Maintain 1.2 kcfs discharge from Oct. through April, unless higher required • Shift system flood control to Grand Coulee April–July if runoff forecasts at Dworshak are 3.0 MAF or less **SOS 2d** • Operate on 1.2 kcfs minimum discharge up to flood control rule curve, except when providing flow augmentation (April 10 to July 31) • Provide flow augmentation of 1.0 MAF plus 1.2 kcfs minimum discharge, or 927 KAF and 1.2 kcfs, from April 10-June 20, based on runoff forecasts, to meet Lower Granite flow target of 85 kcfs • Provide 470 KAF from June 21 to July 31 to meet Lower Granite flow target of 50 kcfs • Draft to 1,520 feet after volume is expended, if Lower Granite flow target is not met; if volume is not expended, draft below 1,520 feet until volume is expended	**SOS 4c** Elevation targets established for each month: 1,599 feet Sept.-Oct.; flood control rule curves Nov.-April; 1,595 feet May; 1,599 feet June-Aug.;

KAF = 1.234 million cubic meters

MAF = 1.234 billion cubic meters

Table 4-1. SOS Alternatives–5

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b • Operate to local flood control rule curve • No proportional draft for power • Shift system flood control to lower Snake projects • Provide Water Budget flow augmentation as in SOS 1a • Draft to refill lower Snake projects if natural inflow is inadequate **SOS 5c** • Operate to flood control during spring • Refill in June or July and maintain through August • Draft for power production during fall	**SOS 6b** Same as SOS 5b **SOS 6d** Same as SOS 5b	**SOS 9a** • Remove from proportional draft for power • Operate to local flood control rule curves, with system flood control shifted to Grand Coulee • Maintain flow at 1.2 kcfs minimum discharge, except for flood control or flow augmentation discharges • Operate to meet Lower Granite flow targets (at spillway crest) of 74 kcfs April 16-June 30, 45 kcfs July, 32 kcfs August **SOS 9b** • Similar to SOS 9a, except operate to meet flow targets at Lower Granite ranging from 85 to 140 kcfs April 16-June 30 and 50-55 kcfs in July • Can draft to meet flow targets to a min. end-of-July elevation of 1,490 feet **SOS 9c** • Similar to SOS 9a, except operate to meet Lower Granite flow target (at spillway crest) of 63 kcfs April-June • Can draft to meet flow targets to a min. end-of-July elevation of 1,520 feet	**SOS PA** • Operate on minimum flow-up to flood control rule curve year-round, except during flow augmentation period • Draft to meet flow targets, down to min. end-of-Aug. elevation of 1,520 feet • Sliding-scale Snake River flow targets at Lower Granite of 85 to 100 kcfs April 10-June 20 and 50 to 55 kcfs June 21-Aug. 31, based on runoff forecasts

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-1. SOS Alternatives–6

Actions by Project

LOWER SNAKE

SOS 1	SOS 2	SOS 4
SOS 1a • Normal operations at 4 lower Snake River projects (within 3 to 5 feet of full pool, daily and weekly fluctuations) • Provide maximum peaking capacity of 20 kcfs over daily average flow in May	**SOS 2c** • Operate reservoirs within 1 foot above MOP from April 16 to July 31 • Same as SOS 1a for rest of year	**SOS 4c** Same as SOS 2c
SOS 1b Same as 1a, except: • No minimum flow limit (11,500 cfs) during fall and winter • No fish-related rate of change in flows in May	**SOS 2d** Same as SOS 2c	

LOWER COLUMBIA

SOS 1	SOS 2	SOS 4
SOS 1a • Normal operations at 4 lower Columbia projects (generally within 3 to 5 feet of full pool, daily and weekly fluctuations) • Restricted operation of Bonneville second powerhouse	**SOS 2c** Same as SOS 1a except: lower John Day to minimum irrigation pool (approx. 262.5 feet) from April 15 to Aug. 31; operate within 1.5 feet of forebay range, unless need to raise to avoid irrigation impacts	**SOS 4c** Same as SOS 2c, except operate John Day within 2 feet of elevation 263.5 feet Nov. 1 through June 30
SOS 1b Same as 1a, except no restrictions on Bonneville second powerhouse	**SOS 2d** Same as SOS 2c	

KAF = 1.234 million cubic meters

MAF = 1.234 billion cubic meters

Table 4-1. SOS Alternatives–6

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b • Draft 2 feet per day starting Feb. 18 • Operate at natural river level, approx. 95 to 115 ft below full pool, April 16-Aug. 31; drawdown levels by project as follows, in feet: Lower Granite 623 Little Goose 524 L. Monumental 432 Ice Harbor 343 • Operate within 3 to 5 ft of full pool rest of year • Refill from natural flows and storage releases **SOS 5c** Same as SOS 5b, except drawdowns are permanent once natural river levels reached; no refill	**SOS 6b** • Draft 2 feet per day starting April 1 • Operate 33 feet below full pool April 16-Aug. 31; drawdown levels by project as follows, in feet: Lower Granite 705 Little Goose 605 L. Monumental 507 Ice Harbor 407 • Operate over 5-foot forebay range once drawdown elevation reached • Refill from natural flows and storage releases • Same as SOS 1a rest of year **SOS 6d** • Draft Lower Granite 2 feet per day starting April 1 • Operate Lower Granite near 705 ft for 4 1/2 months, April 16-Aug. 31	**SOS 9a** • Operate 33 feet below full pool (see SOS 6b) April 1-Aug. 31 to meet L. Granite flow targets (see Dworshak); same as SOS 1a rest of year • Spill to achieve 80/80 FPE up to total dissolved gas cap of 120% daily average; spill cap 60 kcfs at all projects **SOS 9b** • Operate at MOP, with 1 foot flexibility April 1-Aug. 31; same as SOS 1a rest of year • Spill to achieve 80/80 FPE up to total dissolved gas cap of 120% daily average; spill caps range from 18 kcfs at L. Monumental to 30 kcfs at L. Granite **SOS 9c** • Operate 35 to 45 feet below full pool April 1-June 15 to meet L. Granite flow targets (see Dworshak), refill by June 30; same as SOS 1a rest of year • Spill to achieve 80/80 FPE, as in SOS 9b	**SOS PA** • Operate at MOP with 1 foot flexibility between April 10 - Aug. 31 • Refill three lower Snake River pools after Aug. 31, Lower Granite after Nov. 15 • Spill to achieve 80% FPE up to total dissolved gas cap of 115% 12-hour average; spill caps range from 7.5 kcfs at L. Monumental to 25 kcfs at Ice Harbor

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Same as SOS 2, except operate John Day within 1.5 feet above elevation 257 feet (MOP) from May 1 through Aug. 31; same as SOS 2c rest of year **SOS 5c** Same as SOS 5b	**SOS 6b** Same as SOS 5 **SOS d** Same as SOS 5	**SOS 9a** • Same as SOS 5, except operate John Day within 1 foot above elevation 257 feet April 15-Aug. 31 • McNary flow targets as described for Grand Coulee • Spill to achieve 80/80 FPE, up to total dissolved gas cap of 120% daily average, as derived by state agencies **SOS 9b** • Same as SOS 2, except operate John Day at minimum irrigation pool or 262.5 feet with 1 foot of flexibility from April 16-Aug. 31 • McNary flow targets as described for Grand Coulee • Spill to achieve 80/80 FPE, up to total dissolved gas cap of 120% daily average, as derived by Corps **SOS 9b** Same as SOS 9b, except operate John Day at minimum operating pool	**SOS PA** • Pool operations same as SOS 2c, except operate John Day at 257 feet (MOP) year-round, with 3 feet of flexibility March-Oct. and 5 feet of flexibility Nov.-Feb. • Spill to achieve 80% FPE up to total dissolved gas cap of 115% 12-hour average; spill caps range from 9 kcfs at John Day to 90 kcfs at The Dalles

1 kcfs = 28 cms

1 ft = 0.3048 meter

Coulee would occur through April as needed. It also provides up to 427 KAF (527 million m^3) of additional water from the Snake River above Brownlee Dam.

- **SOS 2d (1994-98 Biological Opinion)** matches the hydro operations contained in the 1994-98 Biological Opinion issued by NMFS in mid-1994. This alternative provides water for the existing Water Budget as well as additional water, up to 4 MAF, for flow augmentation to benefit the anadromous fish migration. The additional water of up to 4 MAF would be stored in Grand Coulee, Libby, and Arrow, and provided on a sliding scale tied to runoff forecasts. Flow targets are established at Lower Granite and McNary.

In cases such as the SOR, where the proposed action is a new management plan, the No Action Alternative means continuing with the present course of action until that action is changed (46 FR 13027). Among all of the strategies and options, SOS 2c best meets this definition for the No Action Alternative.

4.1.4 SOS 4–Stable Storage Project Operation

This alternative is intended to operate the storage reservoirs to benefit recreation, resident fish, wildlife, and anadromous fish while minimizing impacts of such operation to power and flood control. Reservoirs would be kept full longer, but still provide spring flows for fish and space for flood control. The goal is to minimize reservoir fluctuations while moving closer to natural flow conditions. For the Final EIS, this alternative has one option:

- **SOS 4c (Stable Storage Operation with Modified Grand Coulee Flood Control)** applies year-round Integrated Rule Curves (IRCs) developed by the State of Montana for Libby and Hungry Horse. Other reservoirs would be managed to specific elevations on a monthly basis; they would be kept full longer, while still providing spring flows for fish and space for flood control. The goal is to minimize reservoir fluctuations while moving closer to natural flow conditions. Grand Coulee would meet elevation targets year-round to provide acceptable water retention times; however, upper rule curves would apply at Grand Coulee if the January to July runoff forecast at the project is greater than 68 MAF (84 billion m^3).

4.1.5 SOS 5–Natural River Operation

This alternative is designed to aid juvenile salmon migration by drawing down reservoirs (to increase the velocity of water) at four lower Snake River projects. SOS 5 reflects operations after the installation of new outlets in the lower Snake River dams, permitting the lowering of reservoirs approximately 100 feet (30 m) to near original riverbed levels. This operation could not be implemented for a number of years, because it requires major structural modifications to the dams. Elevations would be: Lower Granite—623 feet (190 m); Little Goose—524 feet (160 m); Lower Monumental—432 feet (132 m); and Ice Harbor—343 feet (105 m). Drafting would be at the rate of 2 feet (0.6 m) per day beginning February 18. The reservoirs would refill again with natural inflows and storage releases from upriver projects, if needed. John Day would be lowered as much as 11 feet (3.3 m) to minimum pool, elevation 257 feet (78.3 m), from May through August. All other projects would operate essentially the same as in SOS 1a, except that up to 3 MAF (3.7 billion m^3) of water (in addition to the Water Budget) would be provided to augment flows on the Columbia River in May and June. System flood control would shift from Brownlee and Dworshak to the lower Snake River projects. Also, Dworshak would operate for local flood control. This alternative has two options:

- **SOS 5b (Four and One-half Month Natural River Operation)** provides for a lower Snake River drawdown lasting 4.5 months, beginning April 16 and ending August 31. Dworshak would be drafted to

refill the lower Snake River projects if natural inflow were inadequate for timely refill.

- **SOS 5c (Permanent Natural River Operation)** provides for a year-round drawdown, and projects would not be refilled after each migration season.

4.1.6 SOS 6–Fixed Drawdown

This alternative is designed to aid juvenile anadromous fish by drawing down one or all four lower Snake River projects to fixed elevations approximately 30 to 35 feet (9 to 10 m) below minimum operating pool. As with SOS 5, fixed drawdowns depend on prior structural modifications and could not be instituted for a number of years. Draft would be at the rate of 2 feet (0.6 m) per day beginning April 1. John Day would be lowered to elevation 257 feet (78.3 m) from May through August. All other projects would operate essentially the same as under SOS 1a, except that up to 3 MAF (3.7 billion m^3) of water would be provided to augment flows on the Columbia River in May and June. System flood control would shift from Brownlee and Dworshak to the lower Snake projects. Also, Dworshak would operate for local flood control. This alternative has two options:

- **SOS 6b (Four and One-half Month Fixed Drawdown)** provides for a 4.5-month drawdown at all four lower Snake River projects beginning April 16 and ending August 31. Elevations would be: Lower Granite—705 feet (215 m); Little Goose—605 feet (184 m); Lower Monumental—507 feet (155 m); and Ice Harbor—407 feet (124 m).

- **SOS 6d (Four and One-half Month Lower Granite Fixed Drawdown)** provides for a 4.5-month drawdown to elevation 705 feet at Lower Granite beginning April 16 and ending August 31.

4.1.7 SOS 9–Settlement Discussion Alternatives

This SOS represents operations suggested by USFWS and NMFS (as SOR cooperating agencies), the state fisheries agencies, Native American tribes, and the Federal operating agencies during the settlement discussions in response to a court ruling in the *IDFG v. NMFS* lawsuit. The objective of SOS 9 is to provide increased velocities for anadromous fish by establishing flow targets during the migration period and by carrying out other actions that benefit ESA-listed species. The specific options were developed by a group of technical staff representing the parties in the lawsuit. The group was known as the Reasonable and Prudent Alternatives Workgroup. They developed three possible operations in addition to the 1994-98 Biological Opinion. This strategy has three options:

- **SOS 9a (Detailed Fishery Operating Plan [DFOP])** establishes flow targets at The Dalles based on the previous year's end-of-year storage content, similar to how PNCA selects operating rule curves. Grand Coulee and other storage projects are used to meet The Dalles flow targets. Specific volumes of releases are made from Dworshak, Brownlee, and upper Snake River to try to meet Lower Granite flow targets. Lower Snake River projects are drawn down to near spillway crest level for 4.5 months. Specific spill percentages are established at run-of-river projects to achieve no higher than 120 percent daily average total dissolved gas. Fish transportation is assumed to be eliminated.

- **SOS 9b (Adaptive Management)** establishes flow targets at McNary and Lower Granite based on runoff forecasts. Grand Coulee and other storage projects are used to meet the McNary flow targets. Specific volumes of releases are made from Dworshak, Brownlee, and the upper Snake River to try to meet Lower Granite flow targets. Lower Snake River projects are drawn down to minimum operating pool levels and John Day

is at minimum irrigation pool level. Specific spill percentages are established at run-of-river projects to achieve no higher than 120 percent daily average for total dissolved gas.

- **SOS 9c (Balanced Impacts Operation)** draws down the four lower Snake River projects to near spillway crest levels for 2.5 months during the spring salmon migration period. Full drawdown level is achieved on April 1. Refill begins after June 15. This alternative also provides 1994-98 Biological Opinion flow augmentation (as in SOS 2d), IRC operation at Libby and Hungry Horse, a reduced flow target at Lower Granite due to drawdown, limits on winter drafting at Albeni Falls, and spill to achieve no higher than 120 percent daily average for total dissolved gas.

4.1.8 SOS PA–Preferred Alternative

This SOS represents the operation recommended by NMFS and USFWS in their respective Biological Opinions issued on March 1, 1995. SOS PA is intended to support recovery of ESA-listed species by storing water during the fall and winter to meet spring and summer flow targets, and to protect other resources by managing detrimental effects through maximum summer draft limits, by providing public safety through flood protection, and by providing for reasonable power generation. This SOS would operate the system during the fall and winter to achieve a high confidence of refill to flood control elevations by April 15 of each year, and use this stored water for fish flow augmentation. It establishes spring flow targets at McNary and Lower Granite based on runoff forecasts, and a similar sliding scale flow target at Lower Granite and a fixed flow target at McNary for the summer. It establishes summer draft limits at Hungry Horse, Libby, Grand Coulee, and Dworshak. Libby is also operated to provide flows for Kootenai River white sturgeon. Lower Snake River projects are drawn down to minimum operating pool levels during the spring and summer. John Day is operated at minimum operating pool level year-round. It should be noted that the NMFS Biological Opinion recommends this operation, on the condition that appropriate mitigation measures are assured. Specific spill percentages are established at run-of-river projects to achieve 80-percent FPE, with no higher than 115-percent 12-hour daily average for total dissolved gas measured at the forebay of the next downstream project.

4.1.9 Rationale for Selection of the Final SOSs

Table 4-2 summarizes the changes in the set of SOS alternatives from the Draft EIS to the Final EIS. SOSs 1a and 1b are unchanged from the Draft EIS. SOS 1a represents a base case condition and reflects system operation during the period from passage of the Northwest Power Planning and Conservation Act until ESA listings. It provides a baseline alternative that allows for comparison of the more recent alternatives and shows the recent historical operation. SOS 1b represents a limit for system operation directed at maximizing benefits from development-oriented uses, such as power generation, flood control, irrigation, and navigation and away from natural resources protection. It serves as one end of the range of alternatives and provides a basis for comparison of the impacts to power generation from all other alternatives. Public comment did not recommend elimination of this alternative because it serves as a useful milepost. However, the SOR agencies recognize it is unlikely that decisions would be made to move operations toward this alternative.

In the Draft EIS, SOS 2 represented current operation. Three options were considered. Two of these options have been eliminated for the Final EIS and one new option has been added. SOS 2c continues as the No Action Alternative. Maintaining this option as the No Action Alternative allows for consistent comparisons in the Final EIS to those made in the Draft EIS. However, within the current practice category, new operations have been developed since the original identification of SOS 2c. In 1994, the SOR agencies, in consultation with the NMFS and USFWS, agreed to an operation that was

Table 4-2. Summary of alternatives in the Draft and Final EIS.

Draft EIS Alternatives	Final EIS Alternatives
SOS 1 Pre-ESA Operation SOS 1a Pre-Salmon Summit Operation SOS 1b Optimum Load Following Operation	SOS 1 Pre-ESA Operation SOS 1a Pre-Salmon Summit Operation SOS 1b Optimum Load Following Operation
SOS 2 Current Practice SOS 2a Final Supplemental EIS Operation SOS 2b Final Supplemental EIS with Sturgeon Operations at Libby. SOS 2c Final Supplemental EIS Operation - No-Action Alternative	SOS 2 Current Practice SOS 2c Final Supplemental EIS Operation—No-Action Alternative **SOS 2d 1994-98 Biological Opinion Operation**
SOS 3 Flow Augmentation SOS 3a Monthly Flow Targets SOS 3b Monthly Flow Targets with additional Snake River Water	[Deleted for Final EIS]
SOS 4 Stable Storage Project Operation SOS 4a1 Enhanced Storage Level Operation SOS 4a3 Enhanced Storage Level Operation SOS 4b1 Compromise Storage Level Operation SOS 4b3 Compromise Storage Level Operation SOS 4c Enhanced Operation with Modified Grand Coulee Flood Control	SOS 4 Stable Storage Project Operation **SOS 4c Enhanced Operation with Modified Grand Coulee Flood Control**
SOS 5 Natural River Operation SOS 5a Two-Month Natural River Operation SOS 5b Four and One-Half Month Natural River Operation	SOS 5 Natural River Operation SOS 5b Four and One-Half Month Natural River Operation **SOS 5c Permanent Natural River Operation**
SOS 6 Fixed Drawdown SOS 6a Two-Month Fixed Drawdown Operation SOS 6b Four and One-Half Month Fixed Drawdown Operation SOS 6c Two-Month Lower Granite Drawdown Operation SOS 6d Four and One-Half Month Lower Granite Drawdown Operation	SOS 6 Fixed Drawdown SOS 6b Four and One-Half Month Fixed Drawdown Operation SOS 6d Four and One-Half Month Lower Granite Drawdown Operation
SOS 7 Federal Resource Agency Operations SOS 7a Coordination Act Report Operation SOS 7b Incidental Take Statement Flow Targets SOS 7c NMFS Conservation Recommendations	**SOS 9 Settlement Discussion Alternatives** **SOS 9a Detailed Fishery Operating Plan** **SOS 9b Adaptive Management** **SOS 9c Balanced Impacts Operation** **SOS PA Preferred Alternative**

Note: Bold indicates a new or revised SOS alternative; Draft EIS SOS 7 options replaced with SOS 9 options for Final EIS.

reflected in the 1994-98 Biological Opinion. This operation (SOS 2d) has been modeled for the Final EIS and represents the most "current" practice. SOS 2d also provides a good baseline comparison for the other, more unique alternatives. SOSs 2a and 2b from the Draft EIS were eliminated because they are so similar to SOS 2c. SOS 2a is identical to SOS 2c except for the lack of an assumed additional 427 KAF of water from the upper Snake River Basin. This additional water did not cause significant changes to the effects between SOSs 2a and 2c. There is no reason to continue to consider an alternative that has impacts essentially equal to another alternative. SOS 2b is also similar to SOS 2c, except it modified operation at Libby for Kootenai River white sturgeon. Such modifications are included in several other alternatives, namely SOSs 2d, 9a, 9c, and PA.

SOSs 3a and 3b, included in the Draft EIS, have been dropped from consideration in the Final EIS. Both of these alternatives involved anadromous fish flow augmentation by establishing flow targets based on runoff forecast on the Columbia and Snake Rivers. SOS 3b included additional water from the upper Snake River Basin over what was assumed for SOS 3a. This operation is now incorporated in several new alternatives, including SOSs 9a and 9b. Public comment also did not support continued consideration of the SOS 3 alternatives.

SOS 4 originally included five options in the Draft EIS. They were similar in operation and impact. In SOSs 4a and 4b, the primary feature was the use of Biological Rule Curves for Libby and Hungry Horse reservoirs. SOS 4c also included these rule curves but went further by optimizing the operation of the other storage projects, particularly Grand Coulee and Dworshak. For the Final EIS, the SOR agencies have decided to update the alternative by substituting the IRCs for the Biological Rule Curves and by eliminating SOSs 4a and 4b. The IRCs are a more recent, acceptable version of minimum elevations for Libby and Hungry Horse. Significant public comment in support of this alternative with IRCs was received. Similar to SOS 2 above, SOSs 4a and 4b were not different enough in operation or impacts to warrant continued consideration.

The Natural River (SOS 5) and the Spillway Crest Drawdown (SOS 6) alternatives in the Draft EIS originally included options for 2 months of drawdown to the appropriate pool level and 4.5 months of drawdown. The practicality of 2-month drawdowns was questioned during public review, particularly for the natural river. It did not appear that the time involved in drawing down the reservoirs and later refilling them provided the needed consideration for other uses. Flows are restricted to refill the reservoirs at a time when juvenile fall chinook are migrating downstream and various adult species are returning upstream. The 2.5-month drawdown strategies (SOSs 5a, 6a, and 6c) have been dropped from the Final EIS. However, 2.5-month spillway crest drawdown at all four lower Snake projects is still an element in SOS 9c, so the impacts associated with this type of operation are assessed in the Final EIS.

A new option was added to SOS 5, namely SOS 5c. This option includes natural river drawdown of the lower Snake River projects on a permanent, year-round basis. The Corps received comment on this type of alternative during the review of Phase I of the SCS, a reconnaissance assessment of potential physical modifications for the system to enhance fish passage. Many believe the cost for such modification would be less than that required for periodic, temporary drawdowns, which would require specialized facilities to enable the projects to refill and operate at two different pool elevations.

SOS 7 Federal Resource Agencies Operations, which included three options in the Draft EIS, has been dropped from the Final EIS and replaced with an alternative now labeled as SOS 9 that also has three options. SOS 7a was suggested by the USFWS and represented the state fishery agencies and tribes' recommended operation. Since the issuance of the Draft EIS, this particular operation has been revised and

replaced by the DFOP (SOS 9a). The SOR agencies received comment that the DFOP was not evaluated, but should be. Therefore, we have included this alternative exactly as proposed by these agencies; it is SOS 9a. SOSs 7b and 7c were suggested by NMFS through the 1993 Biological Opinion. This opinion suggested two sets of flow targets as a way of increasing flow augmentation levels for anadromous fish. The flow targets came from the Incidental Take Statement and the Conservation Recommendation sections of that Biological Opinion. The opinion was judged as arbitrary and capricious as a result of legal action, and these operational alternatives have been replaced with other alternatives that were developed through settlement discussions among the parties to this lawsuit. SOSs 7b and 7c have been dropped, but SOSs 9b and 9c have been added to represent operations stemming from NMFS or other fishery agencies. In particular, SOS 9b is like DFOP but has reduced flow levels and forgoes drawdowns. It is a modification to DFOP. SOS 9c incorporates elements of operation supported by the State of Idaho in its "Idaho Plan." It includes a 2.5-month spillway crest drawdown on the lower Snake River projects and several other elements that attempt to strike a balance among the needs of anadromous fish, resident fish, wildlife, and recreation.

Shortly after the alternatives for the Draft EIS were identified, the Nez Perce Tribe suggested an operation that involved drawdown of Lower Granite, significant additional amounts of upper Snake River water, and full pool operation at Dworshak (i.e., Dworshak remains full year round). It was labeled as SOS 8a. Hydroregulation of that operation was completed and provided to the Nez Perce Tribe. No technical response has been received from the Nez Perce Tribe regarding the features or results of this alternative. However, the elements of this operation are generally incorporated in one or more of the other alternatives, or impose requirements on the system that could not be met without changes in state water laws. Therefore, this alternative has not been carried forward into the Final EIS.

The Preferred Alternative (SOS PA) represents operating requirements contained in the 1995 Biological Opinions issued by NMFS and USFWS on operation of the FCRPS. These opinions resulted from ESA consultation conducted during late 1994 and early 1995, which were a direct consequence of the lawsuit and subsequent judgement in *IDFG v. NMFS*. The SOR agencies are now implementing this operating strategy and have concluded that it represents an appropriate balance among the multiple uses of the river. This strategy recognizes the importance of anadromous fish and the need to adjust river flows to benefit the migration of all salmon stocks, as well as the needs of resident fish and wildlife species at storage projects.

4.1.10 SOS Alternatives Not Studied in Detail

The SOR Interagency Team considered a number of alternative ways to address the project purposes in the SOS. Alternatives that the Interagency Team decided not to study in detail for this EIS are briefly described below.

A broad range of changes in system operations was considered for the SOR, including some fairly radical proposals. During scoping, many actions were suggested that were outside the scope of the study, which was limited to the operation of the Columbia River system. Additional alternatives of this type were suggested in review comments on the Draft EIS. Alternatives beyond the scope of the SOR included structural modifications at the projects to improve specific resource areas, and actions independent of project operations that go beyond the jurisdiction of the Federal agencies involved in the SOR. While such alternatives were not studied in detail in this EIS, many are being or have been considered in other studies undertaken by one of the SOR agencies or other parties within the region (see Chapter 10 of this EIS, and *Scoping Document, Appendix 1: Related Activities*). The SOR work groups suggested alternatives in the early stages of their work, but many of these alternatives were not carried

forward for further study after screening, for a variety of reasons.

Structural Modifications at the Projects

The Corps' System Configuration Study (SCS) is evaluating major structural modifications to some of the 14 Federal projects in response to the NPPC's Phase 2 and Phase 3 amendments to its regional Fish and Wildlife Program. Structural measures were suggested for study during the SOR, but were not pursued because they are part of the SCS or are otherwise beyond the SOR scope. These measures include:

- Modifying adult fish ladder entrances and exits to improve adult passage survival
- Installing juvenile bypasses at all major dams with high fish mortality rates
- Installing fish screens at dams and over irrigation diversion outlets
- Developing fish byways to divert and rejoin the rivers
- Constructing a smolt canal paralleling the Snake and Columbia Rivers from just below the mouth of the Clearwater to just below Bonneville Dam
- Developing new facilities and equipment to improve the juvenile fish transportation program
- Installing locks at additional dams to expand the navigation system
- Modifying recreational facilities to allow their use over a wider range of operating conditions.

While structural measures themselves are not a part of the SOR, system operations that would be possible only with significant project modifications are represented in some of the system operating strategies.

Nonproject Alternatives

Early in the SOR, some alternatives were suggested that pertained to river uses but did not directly involve operations at the 14 Federal projects within the SOR scope. Most of these alternatives emphasized fish and wildlife concerns, topics that drew a lot of attention during SOR scoping. Fisheries managers and other interests have had most of these concepts under consideration for a decade or more. Many have been or will be implemented through the NPPC's Fish and Wildlife Program amendments, or through agency responses to ESA requirements. In other cases, it is possible that the measures will not be implemented due to a lack of incentives or political consensus. Such measures include the following:

- Improving streams and watersheds to restore salmonid spawning and rearing habitat
- Preserving and enlarging wildlife habitat by protecting watersheds, re-establishing native vegetation, discouraging grazing and cropping in erosion-prone areas, and planting cottonwoods and poplars for riparian wildlife
- Expanding research on hatchery programs and preservation of native fish stocks, and improving hatchery operations to both increase survival of hatchery fish and reduce competition with wild fish
- Encouraging propagation of fish species that are more adaptable to current operations
- Banning or lifting commercial fishing on the Columbia River
- Prohibiting fishing with gill nets
- Further limiting catches and the length of fishing seasons and instituting larger minimum sizes for fish that can be kept by anglers

- Undertaking a comprehensive review of logging and mining practices, agricultural runoff, and municipal and industrial pollution to determine their effects on anadromous fish
- Modifying irrigation delivery systems and methods to conserve water for instream use
- Examining the possible use of increased cogeneration, improved irrigation efficiency; and energy conservation to save water and thereby improve flows for anadromous fish
- Implementing controls for nonpoint sources of water pollution to improve the quality of runoff entering streams
- Energy and capacity marketing that would shift or adjust load shape.

SOS Alternatives Not Carried Forward from Screening

As noted above, in screening the SOR agencies grouped many alternatives by their operating similarities. In formulating the strategies to be carried forward to full-scale analysis, only one alternative representative of each type was put on the list, in most cases. Some alternatives were dropped from further consideration when screening information indicated they were not viable. Still others were eliminated because they were already under study in other related regional activities, such as the Corps' SCS.

The SOR publication, *Screening Analysis, Volumes I and 2* contains a full description of the results of the screening analysis, ranking of alternatives, and the initial development of candidate strategies.

While some of the screening alternatives included selected drawdown measures for lower Columbia River projects, the SOS alternatives evaluated in the Draft and Final EIS (see Section 4.1) do not incorporate any specific operational changes at McNary, The Dalles, or Bonneville on the lower Columbia. This was because the Corps' 1992 OA/EIS (Corps et al., 1992) indicated that without major structural modifications, operation of the four lower Columbia River reservoirs at or near minimum operating pool levels would cause significant adverse impacts to water users. The NPPC and the Corps are continuing to investigate drawdown actions at John Day because it is the largest lower Columbia reservoir and might yield measurable water velocity increases. Based on the 1992 analysis, lead agencies believe that the costs and resource impacts of operational changes at McNary, The Dalles, and Bonneville outweigh the potential flow improvement benefits. Consequently, these types of actions are not included in the SOS alternatives.

Non-Treaty Storage

The Columbia River Treaty required Canada to provide 15.5 MAF (19.1 billion m^3) of usable storage at Mica, Keenleyside, and Duncan Dams. The Canadians also built storage on the Columbia River system in excess of that required by the Treaty (termed non-Treaty storage). This additional storage capacity includes about 2 MAF behind Revelstoke Dam, an additional 5 MAF (6.2 billion m^3) of usable storage at Mica, and 2 feet (0.6 m) of storage behind Keenleyside above the normal full elevation. Agreements in addition to the Treaty are required to operate non-Treaty storage space.

Prior to the current NTSA, an older agreement covered the operation of 2 MAF (2.5 billion m^3) of non-Treaty space in Mica. In the operation of the old NTSA from 1983 to 1990, there was a distinct pattern of storing when flows were high and releasing when flows were low. This pattern is apparent among water years as well as among seasons. In high water years, non-Treaty space may be filled and then the stored water released in later low flow years. There is also a pattern of filling in the late winter and spring, and releasing water in the late summer, fall, and winter.

The current NTSA, signed in 1990, is an agreement between British Columbia Hydro and Power Authority (B.C. Hydro) and BPA establishing a means of using 4.5 MAF (5.6

billion m^3) of storage space in Mica. The other 0.5 MAF (0.6 billion m^3) of Mica space B.C. Hydro retained for its own use. There are also small amounts of space behind Keenleyside and Revelstoke that B.C. Hydro may occasionally make available at its discretion. Each party gets the use of 2.25 MAF (2.8 billion m^3) of the space and receives all of the energy produced by its water releases from non-Treaty space, and suffers all of the energy losses when water is stored in that space. For example, if B.C. Hydro released 5 kcfs (140 cms) of water from non-Treaty storage, it would keep the energy produced at its Mica and Revelstoke plants and would also receive all of the energy produced at the U.S. plants (Grand Coulee to Bonneville) by this release. Conversely, if B.C. Hydro stored some water, it would have to send to the United States the energy that would have been produced in the United States by the water that they stored, as well as foregoing some energy production at their own plants. The intent is that the party storing or releasing would be affected by that action, while the other party would be unaffected in terms of energy. All inflow into Mica is by definition Treaty inflow, so the only way to put water into non-Treaty space is to reduce Mica outflows by foregoing generation and delivering energy to replace the other party's losses.

The NTSA is secondary to, and is not allowed to conflict with, the Columbia River Treaty. The new NTSA, like the old one, does not stipulate the purposes for which NTSA must be used, nor does it preclude its use for any purpose. A companion agreement between BPA and the CBFWA does state that NTSA shall not be operated in a manner in which fish are worse off than if the NTSA had not existed. A companion agreement between BPA and mid-Columbia utilities allows them to share benefits and costs of the NTSA.

The NTSA adds system flexibility for many uses. It has been used to serve firm loads, to enhance fish flows, to store surplus energy, and to produce nonfirm energy when markets are good. Water in non-Treaty space is also valuable because the water-to-energy conversion factor is as high as any sources on the Federal system. This is because when water is released, the energy produced at both the United States and Canadian projects is returned to the releasing party. An amount of water in non-Treaty space will produce nearly twice as much energy as a similar amount of water from Grand Coulee or Keenleyside. In the spring, if BPA is attempting to store energy, water stored in non-Treaty space will provide almost twice as much energy for the same reduction in flow compared to putting the water in Keenleyside or Grand Coulee. From an energy perspective, this high energy content makes non-Treaty storage a great place to store water, but a very poor choice to provide higher streamflows during energy surpluses.

The use of NTS water for flow enhancement has some limits. The NTSA provides that B.C. Hydro can at any time claim unacceptable impacts on their system and prevent all storing or releasing by either party, so the ability to release water when needed for fish cannot be ensured. Further, water released during fish migration periods (which are usually the most opportune time to store) must be replaced at another time of year. This would quite possibly be at higher energy prices, which can get very expensive since each unit of water has such a high energy content. In addition, the rate of release may be restricted at Mica, Revelstoke, or Keenleyside due to operational constraints in Canada.

Because the NTSA was designed to be used by both BPA and B.C. Hydro as a way to absorb short-term energy availability variations of the hydro system (gluts and shortages), the contract rights of the parties to store or release water are not firm. They can only be exercised with the concurrence of the other party at the time of the action. Thus, while BPA cannot promise an operation to help fish, the NTSA is likewise not obligated to any operation that harms fish. As a result, although the NTSA may actually be used to meet a commitment of the hydro system at times, it cannot be viewed as a separate source of water for consideration in the SOR.

Confederated Tribes of the Umatilla Indian Reservation Alternative

Subsequent to the close of comment on the Draft EIS, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) proposed an operating alternative for consideration in the Final EIS. Briefly, this alternative is a variation on or modification of the DFOP evaluated as SOS 9a. Key features of the CTUIR alternative include operation of all four lower Snake River projects and John Day at natural river levels year-round; spill at McNary, The Dalles, and Bonneville to achieve 80 percent FPE in the spring and 90 percent FPE in the summer; and a 50 percent reduction in the October-through-March flood control space currently required at the storage projects, so as to be able to meet spring and summer fish flow targets.

The SOR agencies determined that it would not be practicable or necessary to conduct a full-scale analysis of the CTUIR alternative to the same level as the 13 final SOSs. Nevertheless, the agencies agreed that this proposed operation should be investigated and addressed in the Final EIS. Working through the CTUIR contract for SOR participation, the Tribe, the Tribe's contractor, and the CRITFC developed operational specifications as input to hydroregulation modeling. ROSE performed a series of hydroregulation iterations for the CTUIR alternative, which at this point was termed SOS 9d.

The SOR agencies then asked the work groups to consider SOS 9d and address its expected effects. The Power and Anadromas Fish Work Groups were requested to provide quantitative impact results. The other work groups were requested to prepare, at a minimum, a qualitative assessment of the implications of SOS 9d for their respective resource area. The work group contributions are reported below, following the same order of resource areas as is used in Section 4.2. Impact issues for these areas are also discussed in depth in Section 4.2. Impact issues for these areas are also discussed in depth in Section 4.2.

Earth Resources

Earth resources impacts from SOS 9d would be comparable to those of SOS 5c, but somewhat greater in extent because of the drawdown of John Day to natural river level in SOS 9d (compared to operation at MOP in SOS 5c). Initially, erosion and mass wasting from the drawdown to natural river levels would contribute large volumes of sediment from the lower Snake River reservoirs and John Day. These volumes have not been specifically calculated for SOS 9d, but they would be similar to the figures presented in Section 4.2.1 for SOS 5c. Because there would be no annual drawdown-refill cycle, however, within about 5 to 15 years erosion rates at these projects would diminish to background levels. Relatively large water level fluctuations at the storage reservoirs, combined with greater duration of shoreline exposure as a result of refill failures, would lead to significant increases in erosion and mass wasting at the storage projects.

The material eroded from the lower Snake River projects and John Day after implementation of SOS 9d would be deposited in McNary pool (which would receive the bulk of the sediment) and The Dalles pool. The useful lifespans of these two projects would be reduced, although the increased deposition would decrease markedly after several years. Sedimentation generated by shoreline erosion at the storage projects would increase significantly. SOS 9d would permanently lower the water table near the lower Snake River and John Day by approximately 100 feet (30 m). This would cause some wells to go dry, and others to have decreased yields. Effects on wells would be most concentrated or significant around John Day, and would affect M&I water supplies as well as domestic users.

Water Quality

At Lower Granite, May and June flows would be the highest under SOS 9d; flows would be about the same under all SOSs from July to October. At Priest Rapids and The Dalles, SOS 9d flows would be highest from April through

October. Lower Granite would have the lowest pool from April to October, and Dworshak would have one of the lowest (in the 1,510 to 1,550-foot range). HYDROSIM's output shows some spill at Lower Granite from April to August even during a low-flow year, such as 1929. It is believed, however, that this may be a misnomer because a natural river system should not have caused any spill. SOS 9d would cause the highest spill of all alternatives at Priest Rapids (113,200 cfs spill in June) and at The Dalles, which would spill nearly 250,000 cfs on average in June.

Water temperature model runs, using 1929, 1959, 1962, 1973, and 1974 HYDROSIM-regulated flows, indicated water temperatures under SOS 9d would be warmer in the lower Snake River reservoirs and cooler in the lower Columbia River at and below John Day compared to SOS PA.

SOS 9d would have the most extreme effects of all alternatives, especially compared to the other SOS 9 options and SOS PA. It would keep reservoirs very low in the summer and would affect summer water temperatures.

Operation of the lower Snake River reservoirs at natural river pool throughout the year is likely to create heavy sediment transport in the first few (5 to 10) years. Exposed reservoir banks would quickly erode until they reached a stable profile. Reservoir banks that are now exposed year-round would be more severely affected by wind and precipitation.

Under a drawdown scenario, water would be moving faster through the reservoirs and the water surface exposed to solar radiation would be reduced compared to normal operation. However, less water body would be available to absorb this radiation, so water temperatures would increase. Dworshak and Brownlee would be operated at relatively lower pool elevations and would have a smaller volume of cool water to contribute to the lower river. These factors combined would increase peak summer temperatures in the lower Snake River reservoirs, and increase the duration of warmer temperatures. These warm temperatures would last longer. And, because water depth would be much more shallow, pockets of cool water that can now be found at several spots in the reservoirs would also be more scarce. On the other hand, in the lower Columbia River, water temperature model runs predict that the operation proposed for John Day Reservoir would decrease the number of days water temperatures would exceed 20°C at John Day and below.

Maintaining a high level of streamflows during the spring and summer would mean annual flow recession; therefore, greater bank erosion would occur over a longer period. This condition would also increase incidences of involuntary spill because of limited powerhouse hydraulic capacities and unit outages due to routine preventive maintenance and service.

Spill might not affect reservoirs that would be drawn down to natural river levels (lower Snake River and John Day Reservoirs), but would be a major factor at the mid-Columbia PUD dams and Bonneville Dam. Bonneville's powerhouse hydraulic capacity is about 220 kcfs, and its pool is not big enough to store excess inflows. Under SOS 9d, a monthly flow of 426 kcfs in May and 483 kcfs in June at The Dalles would cause a spill of 206 and 263 kcfs, respectively, during normal Bonneville powerhouse operation, and even more during unit outages. Tailwater total dissolved gas levels could be significantly higher than 125 percent. Despite the goal of achieving 80/90 percent FPE, this goal would not be achievable because of the spill caps imposed.

Of all the projected water quality impacts, dissolved gas would be most seriously effect under SOS 9d. In general, all flow alternatives that are required to comply with water quality standards cannot achieve the desired FPE levels. Therefore, SOSs that do not rely this heavily on flows and that entail other forms of fish passage improvements would have a higher chance of improving salmon recovery.

Air Quality

The air quality concerns for SOS 9d are the same as for the other SOSs: the potential for windblown emissions, high ambient PM_{10}, TSP, and hazardous air pollutant concentrations, and the indirect impacts resulting from generating replacement electricity.

Under SOS 9d, Lower Granite Reservoir (one of three reference projects for illustrating potential direct air quality impacts) would return to its natural river elevation, about 23 feet (7.0 m) lower than any of the other alternatives. This would expose a greater area of sediments to wind erosion for all months of the year. PM_{10} emissions for this alternative would be greater than for SOSs 5c and 5b, which, for the other alternatives, had the largest estimated emissions for Lower Granite. The exposed sediments would be subject to wind erosion until the sediments were vegetated or washed away.

Libby would be operated at elevations of 2,348 to 2,362 feet (715.7 to 719.9 m) for the entire year under SOS 9d. Although the other alternatives call for drafting to lower elevations, this would only occur during March and April when weather conditions are still cold and damp. SOS 9d would leave the reservoir at lower elevations during the summer, when the hot and windy conditions would increase the potential for wind erosion. Some of the highest wind speeds at Kalispell were measured during the summer.

The natural river elevation is lower than all other reservoir elevations evaluated for John Day. Large areas of exposed sediments would be susceptible to wind erosion, especially during the summer. Particulate matter emissions would be greatest at John Day for SOS 9d.

In general, SOS 9d would result in lower reservoir elevations than all other alternatives. These lower elevations would expose larger areas of sediment to wind erosion, especially during the dry summers. SOS 9d would result in higher PM_{10} and total suspended particulate (TSP) emissions and concentrations than all other alternatives. For this alternative, PM_{10} concentrations greater than the 150 $\mu g/m^3$ AAQS would extend to greater distances away from the source of the emissions. PM_{10} concentrations greater than 5 $\mu g/m^3$, and thus noticeable above background concentrations, would extend to greater distances away from the shoreline than under the other alternatives.

The potential for windblown emissions would be a concern, especially the blowing dust in areas that are located near project reservoirs. These areas include the Wallula Junction area near Ice Harbor and McNary, Clarkston and Lewiston located on the Lower Granite Reservoir, and Sandpoint located on Lake Pend Oreille.

Some of the Lake Roosevelt and Lower Granite sediments contain contaminants. Exposing these contaminants to wind erosion would increase the probability that air concentrations would be higher than concentrations considered safe for human health. The potential for increased contaminant concentrations would increase for SOS 9d, compared to other alternatives.

Of all the SOSs, SOS 9d represents the greatest amount of lost electricity generation. Replacement electricity would have to be generated by new or existing fossil-fueled plants, or purchased from other areas. Replacing lost electricity would result in additional emissions of criteria air pollutants and CO_2, a greenhouse gas. These indirect air quality impacts would be greatest for SOS 9d.

If John Day and the lower Snake River were drawn down to their natural levels, materials and goods normally barged on the river system would instead be hauled by truck or rail. Because the other drawdown alternatives would only disrupt navigation on the lower Snake River, while SOS 9d would essentially shut down navigation above Bonneville Dam, SOS 9d would have significantly greater effects through transportation mode switching. Increased use of truck or rail transport would increase air emissions, which would represent another indirect air quality impact.

Anadromous Fish

SOS 9d was proposed by the CTUIR as a primary method to enhance anadromous salmon and steelhead stocks within the Columbia River System. SOS 9d in-river survival would exceed that of SOS 2c (the base case) for all Columbia River Basin stocks (Table 4-3). However, CRISP1.5 predicts that SOS 2c survival of Snake River spring, summer, and fall chinook; Dworshak Steelhead; Methow summer chinook; and Hanford fall chinook, with transport would be higher. There are two factors that influence these results: 1) under SOS 2c, with transport, Methow spring chinook and Wenatchee steelhead are transported from McNary Dam only and, thus, do not benefit from the additional transport sites available to the Snake River stocks; and 2) survival of these two stocks, with transport, assumes the 1986 transport/in-river ratio (TIR) (76 percent transport survival for Methow spring chinook and 90 percent transport survival for Wenatchee steelhead). In contrast, in-river survival under SOS 9d is noticeably less than survival with transport under the base case for Methow summer chinook and Hanford fall chinook because the base case assumes 98 percent fixed barge survival for these two stocks. Most of the in-river survival improvement under SOS 9d, compared to the base case without transport, would likely be attributable to drawdown of the lower Snake and John Day reservoirs and higher mainstem flows. Similar comparisons would hold for SOS 2d compared to SOS PA.

Estimates of adult returns under SOS 9d fall between the two alternatives that have similar operation characteristics, SOS 9a (four-pool drawdown of Snake River projects without transport) and SOS 5 (natural river operation of Snake River projects with transport from McNary only), in total escapement in 30 to 40 years. The Stochastic Life Cycle Model (SLCM) predicts adult returns for SOS 9d to be higher than returns for SOS 9a for the four Snake River stocks and mid-Columbia Methow summer chinook, but about the same for Hanford Reach fall chinook. Both SOSs 9a and 9d draw down the lower Snake projects and neither assumes the use of transport; therefore, the difference in adult returns of Snake River stocks may be due to the fact that turbine mortality is assumed under SOS 9a but no turbine mortality is assumed under SOS 9d. The higher returns of Methow summer chinook for SOS 9d compared to SOS 9a are primarily due to the drawdown of John Day Reservoir, because neither alternative assumes any transport from McNary Dam. SLCM-predicted adult returns under SOS 9d for Methow summer chinook and Hanford fall chinook are lower than any other alternative except SOS 9a. Again, these lower returns are due to the lack of transport at McNary Dam. When SOS 9d is compared to SOS 5 (natural river), SOS 5 had higher escapement for all 6 stocks evaluated, which is attributable to fish transport at McNary Dam with SOS 5.

For four of the six stocks analyzed, SLCM results show a marked decline in adult abundance, compared to the base case (SOS 2c) with transport, when forecast 30 to 40 years into the future. Median spawning escapement for Snake River spring chinook decreases from about 6,000 to about 2,000 fish; Snake River fall chinook decreases from about 5,000 to about 470; Dworshak hatchery steelhead decline from about 15,000 to 8,500; and the Methow summer chinook stock decreases from about 570 to about 140. For Snake River summer chinook, there is a modest decrease in spawning escapement from about 850 under SOS 2c to about 760 under SOS 9d. Hanford fall chinook spawning escapement remains at about 32,000 for both alternatives, although its total harvest declines by about 15 percent. The transport survival hypotheses used here were those used in the *Anadromous Fish* portion of Section 4.2. As with juvenile survival, similar comparisons in adult return trends occur between SOSs 9d and PA as between SOSs 9d and 2c.

The lowering of lower Snake River reservoirs to river bed would increase available spawning habitat, primarily for fall chinook, by returning the reach to a flowing river having suitable spawning substrate similar to SOS 5c. SOS 9d would also create an increase in the

Table 4-3. Estimated Columbia River Basin juvenile salmonid survival to below Bonneville Dam using CRiSP1.5, SOS 2c vs SOS 9d

Stock	SOS 2c (No Action) In-River Survival (%)	SOS 2c (No Action) Survival with Transport[1/] (%)	SOS 9d In-River Survival (No Transport) (%)
Snake River Spring Chinook	26	51	43
Snake River Summer Chinook	28	47	46
Snake River Fall Chinook	5	46	19
Dworshak Hatchery Steelhead	17	63	35
Methow Spring Chinook	24	25	29
Methow Summer Chinook	3	7	5
Hanford Fall Chinook	19	34	29
Wenatachee Steelhead	18	22	25
Deschutes River Spring Chinook[2/]	48	N/A	51
Rock Creek Steelhead[2/]	36	N/A	42

1/ Assumes 1986 TIR transport hypothesis except for Snake River fall chinook, Methow summer chinook, and Hanford fall chinook, which use the 98 percent fixed barge survival transport hypothesis.
2/ This stock is not transported.

spawning area for fall chinook in the John Day pool reach, which was considered to have a substantial naturally spawning stock of fall chinook prior to construction of that dam (Fulton, 1968).

SOS 9d would likely have effects on shad, lamprey and sturgeon similar to those anticipated under SOS 5c. However, the effects would probably be more pronounced with the drawdown of John Day pool to natural river bed.

Resident Fish

The following constitutes a qualitative assessment of resident fish impacts by project or river reach under SOS 9d (note that all results assume no load following, which would cause impacts to resident fish spawning, rearing, and food production in rivers if it should occur):

Bonners Ferry Flows (Kootenai River)—This operation mimics natural river flows and in general should benefit resident fish. Sturgeon and some resident species should be assisted to the extent that spring flows are limiting these stocks. However, this alternative would cause major spring flooding in many years, and this is not the desired outcome of resident fish managers.

Lake Koocanusa Elevation—In the hydroregulation results, SOS 9d causes major

reservoir fluctuations and includes many years of deep drafts. Refill failures also occur, though in some years refill occurs or is approached. All of this large and inconsistent fluctuation would cause major problems with benthic food organism production. Food organisms would be frozen and desiccated in many years. Vegetation cannot establish permanently in the fluctuation zone when refill does not occur, because later inundation would kill much of it. Hence, terrestrial insects would not be reliably provided as a food source either. The result is that resident trout growth, and ultimately reproduction, would be reduced. Heavy outflows in spring might wash out large numbers of kokanee and zooplankton, reducing the plankton forage base for remaining kokanee, which provide prey for kamloops rainbow trout.

Hungry Horse/Columbia Falls Flows (Flathead River)—Simulated flows approximate natural runoff patterns as in the Kootenai River. These flows should benefit fish using the Flathead River, assuming temperature control of Hungry Horse releases is achieved.

Hungry Horse Elevation—As with Lake Koocanusa, major drafts, fluctuations, and refill failures would affect benthos, which would reduce growth and reproduction of trout. Other impacts are the same as for Lake Koocanusa, with the exception that kokanee and kamloops are not present in Hungry Horse.

Albeni Falls Outflow (Pend Oreille River)—The SOS 9d operation mimics natural river flows. However, smallmouth bass spawning might be diminished by higher-than-optimal spring flows.

Lake Pend Oreille—Operations under SOS 9d are varied and problematic for resident fish. In some years, the lake level would remain very low, causing problems for kokanee spawning and warm-water fish habitat requirements. Refill occurs in some years, but not in others. This would also cause problems for warm-water fish as would the occasional spring draft. The winter "draw-up" in SOS 9d should benefit kokanee and warmwater species, but there is little benefit and possibly a detriment to raising the pool in the winter only to lower it again.

Lake Roosevelt—SOS 9d causes some severe simulated elevation fluctuations, and filling seldom occurs at Lake Roosevelt. Riverine conditions with low pool and high flow are created in many years but are not maintained consistently enough from year to year to allow for sound management of either a lake-type fish community or a riverine fish community. Probable short-water retention times would reduce plankton production and fish growth.

Brownlee—Simulated operations at Brownlee reflect inconsistent filling and drafting, including some spring drafting that, sometimes severely, would dewater redds of warm-water fish and reduce spawning. Spring filling after early May would inundate warm-water fish redds with cold water, impairing egg survival.

Dworshak Reservoir—Large simulated variations in pool elevation occur here, with filling rare. Spring drafts in some years would harm warm-water fish spawning by dewatering redds, as would spring filling after early May, by inundating redds with cold water.

Lower Snake and Columbia River Mainstem Projects—Year-round stability at these projects should benefit resident fish in general.

Wildlife

Generally, SOS 9d would be similar to other SOS 9 alternatives with regards to wildlife impacts (see Section 4.2.6). River flows would be high in the spring and summer and drop to very low levels in the late summer and fall. The effect on reservoir levels would vary by individual site. At storage reservoirs, the impacts would be similar to the other alternatives that involve significant drafting. The impacts at run-of-river reservoirs would generally be similar to other SOS 9 options or SOS PA, except at John Day, where an extremely low elevation would be established.

The pattern of river flows in SOS 9d attempts to duplicate the natural flows that existed in the system. This would support natural wildlife patterns of distribution and species diversity in those areas where the river channel is not significantly modified (e.g., the Flathead River below Kerr Dam). However, where the river channel is modified—as by levees on the Kootenai River below Bonner's Ferry—the amount of unvegetated habitat (cobble, etc.) should increase without a commensurate increase in other habitats (wetlands or riparian). The resultant impacts to wildlife resources systemwide would likely be somewhat negative, as large portions of the existing river channels are modified and would limit the development of new habitat in response to the new, more natural flow pattern.

While SOS 9d would increase drawdowns at the major storage reservoirs (Grand Coulee, Dworshak, etc.), the impacts would be similar to other alternatives (mostly SOS 9) that increase drawdown. At reservoirs with existing large drawdowns (Dworshak is the classic example), the additional increment of drawdown is not expected to cause any significant additional impacts. Reservoirs where the existing drawdowns are not too severe would suffer greater impacts to wildlife.

Run-of-river reservoirs such as Bonneville, the mid-Columbia dams, and Chief Joseph would not be affected. The lower Snake reservoirs would be operated as in SOS 5c, which would have some significant negative impacts to wildlife. John day is a special case and would suffer severe impacts from the large, year-round drawdown proposed in SOS 9d. However, some recovery of habitat values would be likely over time.

SOS 9d would generally have negative impacts to wildlife throughout the system. While some areas would experience little impact. others would sustain significant negative impacts.

Cultural Resources

The overall effect of SOS 9d on cultural resources would be to reduce substantially the level of ongoing impact. There are 354 known archeological sites in the lower Snake River and John Day pools, and it is likely that there are many additional sites that archaeologists have not yet discovered. Drawdown to natural river level under this alternative would immediately halt the deterioration of these sites that is caused by shoreline wave action and inundation. The drawdown would at first subject these sites to a variety of adverse impacts because of exposure in the devegetated reservoir pools. These impacts would include vandalism and artifact theft, and surface erosion from wind and water. As the former pools revegetated, however, the vegetation would afford some protection from both vandalism and erosion. Deterioration of the sites would be slowed and permanent access to them for scientific study and traditional cultural practice would be restored. Included are several sites listed on the National Register of Historic Places and many that are eligible for listing on the National Register.

SOS 9d would also change system operations in a way that would increase the rates of exposure of archeological sites within a drawdown zone at all of the storage projects. This effect would be most pronounced at Hungry Horse, where the known sites would be exposed 93 percent of the time, according to the Cultural Resources Work Group's computer simulation model of system operation. This high rate is partly due, however, to the fact that archaeological survey has only recently begun at Hungry Horse, and most of the known sites (24 in number) are high in the reservoir pool, above the minimum water level at the time of survey. There would be a corresponding decrease in the rate of shoreline erosion at the known storage reservoir sites, but this would not entirely offset the increase in site exposure. Despite some increase in the rate of site exposure at the storage projects, the net effect of SOS 9d would be beneficial because of the restoration of a large number of archeological sites at the lower Snake River projects and John Day.

Native Americans

The projected impacts of SOS 9d on Native American resources and concerns are uncertain, and appear to be variable among resources, tribes and geographic areas. SOS 9d was proposed by the CTUIR as the alternative that would best protect and restore their treaty rights (and the rights of the other lower-river tribes) to anadromous fish. As discussed previously in Section 4.1.10, the SOR anadromous fish modeling indicates that SOS 9d would increase in-river survival compared to SOS 2c, but that survival under SOS 2c with transport would still exceed survival estimates for SOS 9d. Consequently, the SOR modeling generally shows decreases in adult returns for SOS 9d compared to SOS 2c. These results must be interpreted carefully, however, because the SOR modeling is based on fish transportation assumptions that have long been at issue between the tribes and the SOR agencies. From the tribal perspective, SOS 9d is probably the most advantageous alternative for treaty fishing rights. Based on the model results, the SOR agencies question whether SOS 9d would ultimately benefit treaty rights and the Indian trust assets that anadromous fish represent for the lower-river tribes.

SOS 9d would have negative consequences for some other resources that are important to Native Americans, particularly resident fish and wildlife. The SOR Wildlife Work Group concluded that SOS 9d would generally have negative wildlife impacts throughout the system, with significant negative impacts (at least in the short and medium term) at the lower Snake River projects, John Day, and possibly some of the storage reservoirs. SOS 9d would result in major drafts, fluctuations, and/or refill failures at all five of the Federal storage projects that would have severe adverse consequences for resident fish. Consequently, SOS 9d would generally harm the treaty rights and trust assets of the upriver tribes.

The effects of SOS 9d on cultural resources would vary somewhat among projects, but were considered to be positive overall. The storage projects would generally experience an increase in the rate of archeological site exposure, which would be partially offset by a decrease in the rate of shoreline erosion. The greatest projected effects would be at the lower Snake River projects and John Day, where the long-term restoration of a large number of archeological sites and access for traditional cultural practice was considered to be a significant benefit.

In addition to these impacts on specific resources, SOS 9d would have a significant long-term effect on the total river environment along the lower Snake River and the John Day reach of the Columbia. With revegetation and recovery of the river corridor over the years, most Native Americans would probably believe that SOS 9d would provide significant benefits to the overall integrity and naturalness of the river environment.

Aesthetics

Aesthetically, SOS 9d would have significant adverse effects throughout much of the river system. SOS 9d would result in much lower pool elevations, and therefore greater duration and extent of reservoir shoreline exposure at all five of the storage projects. This effect would be most pronounced during the summer, when the greatest numbers of viewers are present. While the average annual shoreline exposure by project was not determined for SOS 9d (see Section 4.2.9 for such information on the other SOSs), comparison of the hydroregulation results suggests that SOS 9d would rate significantly higher (worse) than the other SOSs by this measure.

SOS 9d would also permanently expose the entire inundated pool area at the lower Snake River projects and John Day. This would result in a major reduction in aesthetic quality at these five projects that would last for many years. The exposed areas would eventually revegetate and recover the appearance of a more natural riverine landscape, but this would be a lengthy process.

Recreation

Of the alternative operating strategies evaluated under the SOR, SOS 9d would have the most severe impacts on recreation across the system. Despite modified flood control rule curves, meeting high minimum monthly flow requirements would result in extremely low pool elevations during the summer recreation season at all of the storage projects in the system, including Hungry Horse, Grand Coulee, Libby, Albeni Falls, and Dworshak. Over the 50-year average, summer monthly pool elevations at all of these projects would be lower than any other alternative, with corresponding impacts on recreation facilities and activities. Extremely high minimum flows would impair recreational use of some rivers, such as the Kootenai, while benefiting others such as the Clearwater. Permanent drawdown of John Day and the four lower Snake River projects to natural river levels would make virtually all existing water-related recreation facilities at those projects unusable and would severely restrict accessibility, at least until such time as replacement facilities could be developed.

The SOR Recreation Impact Assessment Model was used to estimate changes in recreation visitation and consumer surplus values under SOS 9d. The model results are based primarily on the 50-year average pool elevations and flows derived from the SOS 9d hydroregulation. The exceptions were for the run-of-river projects covered by the model, including John Day and Lower Granite. (The model uses Lower Granite demand curves to estimate visitation and consumer surplus for the other lower Snake River projects). SOS 9d would permanently draw down these projects to natural river levels, with resulting forebay elevations of 210 and 600 feet (64 and 182.9 m), respectively. Pool elevations at those levels fall below the recreation demand curves estimated by the models and result in zero estimated trips. The Recreation Work Group does not believe that this would be an accurate representation of recreation demand; while the impact of natural river drawdown at these projects would be severe, some recreational use would continue.

Consequently, it was necessary to modify the hydroregulation results for those projects. At natural river, the surface profile of the rivers would vary with flow but would be much higher at the upper ends of the reservoir areas. For example, with a forebay elevation of 210 feet (64 m) and a flow of 150 kcfs (4,200 cms), the river surface at the upper end of the John Day Reservoir would be near elevation 240 feet (73.2 m). Since most of the major recreation sites on the project are located in the upper one-third of the project, it was assumed that this pool elevation accurately represents potential conditions at John Day under SOS 9d and was used in the model. Similarly, elevation 651 feet (198.4 m) was chosen as an appropriate river elevation for Lower Granite.

Visitation (in recreation days) and consumer surplus values for SOS 9d were compared against several baseline strategies, including SOS 1, SOS 2c, SOS PA, and actual 1992-1993 visitation. The projected impacts for each project and river reach are summarized below.

Lake Koocanusa—SOS 9d is by far the worst alternative for recreation at Lake Koocanusa. During the average summer, lake elevations would never rise within 100 feet (30.5 m) of full, severely limiting use of most recreation facilities on the lake and rendering much of the upper half of the lake in Canada unusable. Estimated annual visitation is 817,804 recreation days, a decrease of approximately 18 percent from either SOS 1a, 2c, or PA. For comparison, the next-worst alternative for recreation at Lake Koocanusa is SOS 9a, with estimated annual visitation at about 950,000 days of use.

Kootenai River—SOS 9d is also by far the worst alternative for recreation on the Kootenai River below Libby Dam. Average monthly releases from Libby result in extremely high downstream flows (30 to 40 kcfs [850 to 1,130 cms]) in May and June, followed by very low flows (4 kcfs [113 cms]) in August. Estimated annual visitation is 8,425 recreation days, a decrease of approximately 75 percent from either SOS 1a, 2c, or PA. For comparison, the next-

worse alternative for recreation on the Kootenai River is SOS 9a, with estimated annual visitation at about 14,000 days of use.

Hungry Horse—SOS 9d is by far the worst alternative for recreation at Hungry Horse. Summer reservoir elevations would be extremely low, barely rising within 100 feet (30.5 m) of full for the entire season. Reservoir conditions would prohibit boat access, result in huge unsightly mudflats, and create additional safety problems in the large drawdown area. Use of land-based facilities would drop off as the lake recedes. Estimated annual visitation is 51,797 recreation days, a decrease of approximately 60 percent from either SOS 1a, 2c, or PA. For comparison, the next-worse alternative for recreation at Hungry Horse is SOS 9a, with estimated annual visitation at about 91,000 days of use.

Lake Pend Oreille—SOS 9d is also by far the worst alternative for recreation at Lake Pend Oreille. Average lake elevations would range from 3 to 8 feet (0.9 to 2.4 m) below full throughout the summer, impairing use of most recreation facilities on the lake. Estimated annual visitation is 817,804 recreation days, a decrease of approximately 33 percent from either SOS 1a, 2c, or PA. For comparison, the next-worse alternative for recreation at Pend Oreille is SOS 9a, with estimated annual visitation at about 1 million days of use.

Columbia River, Canada—Recreational impacts for the upper Columbia River in Canada were not modeled. However, SOS 9d produces huge average monthly flows from combined releases in Brilliant and Keenleyside Dams during May, June, and July. These flows would be expected to have severe negative impacts on recreational use during those months.

Grand Coulee—SOS 9d is by far the worst alternative for recreation at Lake Roosevelt. During the average summer, lake elevations would never rise within 30 feet (9.1 m) of full, severely impairing use of most recreation facilities on the lake. Estimated annual visitation is 859,100 recreation days, a decrease of approximately 48 percent from either SOS 1a, 2c, or PA. For comparison, the next-worse alternative for recreation at Grand Coulee is SOS 9a, with estimated annual visitation at about 1.25 million days of use.

Chief Joseph—Recreational impacts for the Chief Joseph Project (Lake Rufus Wood) were not modeled. No significant impacts are expected.

Mid-Columbia PUD Projects—Recreational impacts for the Mid-Columbia PUD Projects (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) were not modeled. However, SOS 9d produces huge average monthly flows during May, June, and July. These flows would be expected to have severe negative impacts on recreational use of the Mid-Columbia projects during those months. Under existing conditions, high spring flows flood out some recreation facilities and high velocities create unsafe swimming and boating conditions. The extremely high flows under SOS 9d would be expected to exacerbate those conditions.

Hanford Reach—Recreational impacts for the Hanford Reach of the Columbia River were not modeled. However, SOS 9d produces huge average monthly flows during May, June, and July (260, 305, and 195 kcfs [7,360, 8,638, and 5,522 cms], respectively). Under current high flow conditions (greater than 120 kcfs [3,398 cms]) boating use of the river markedly decreases. SOS 9d flows would be expected to have severe negative impacts on recreational use of the Hanford Reach during those months.

Snake River, Hells Canyon—Recreational impacts for the Hells Canyon Reach of the Snake River were not modeled. Flow conditions for SOS 9d are very similar to those of SOS 9a. Both of these alternatives result in very high summer releases from Brownlee Dam that are the highest of any of the alternatives in August. The high flows are at the upper end of or exceed the optimum boating conditions through much of the season and would create boating hazards.

Dworshak Lake—Along with SOS 9b, which is very similar, SOS 9d is the worst alternative for recreation at Dworshak Lake. During the average summer, lake elevations would never rise within 80 feet (24.4 m) of full, severely limiting use of most recreation facilities on the lake. Estimated annual visitation is about 133,000 recreation days, a decrease of approximately 34 percent from SOS 2c and about 11 percent from SOS PA.

Clearwater River—SOS 9d would be one of the better alternatives for recreation on the Clearwater River.

Lower Snake River—Under SOS 9d, all four lower Snake River projects would be permanently drawn down to natural river level. Along with SOS 5c, which calls for the same operation, this alternative would have the most severe impacts on recreational use of these projects. Virtually none of the existing water-based recreation facilities, including boat ramps, marinas, boat docks and swimming beaches, on all four of these lakes would be usable at any time of the year. Access to and from the lake for anything other than small hand carry craft would be virtually impossible, at least until such time as replacement access facilities were developed.

McNary Project—Recreational impacts for the McNary Project (Lake Wallula) were not modeled. No significant impacts are expected.

John Day Project—Under SOS 9d, Lake Umatilla would be permanently drawn down to natural river level. This alternative would have by far the most severe impacts on recreational use of any of the alternatives under consideration. Virtually none of the existing water-based recreation facilities, including boat ramps, marinas, boat docks, and swimming beaches, would be usable at any time of the year. Access to and from the lake for anything other than small hand carry craft would be very difficult, at least until such time as replacement access facilities were developed. Estimated annual visitation is about 196,000 recreation days, a decrease of over 90 percent from either SOS 1a, 2c, or PA. For comparison, the next-worst alternative for recreation at John Day is SOS PA, which calls for a permanent drawdown to MOP and has estimated annual visitation of about 1.5 million days of use.

The Dalles/Bonneville Projects and Columbia River Below Bonneville—Recreational impacts for the lowest two projects and for the Columbia River below Bonneville Dam were not modeled. However, SOS 9d produces huge average monthly flows during May (383 kcfs [10,847 cms]), June (432 kcfs [12,234 cms]), and July 252 kcfs [7,137 cms]). These flows drastically exceed those experienced under any other alternative. The average monthly flow for June is 130 kcfs (3,682 cms) greater than the next highest alternative (SOS 9b). May and June flows would far exceed the maximum optimum flow for recreation through the reach of about 250 kcfs (7,080 cms). Consequently, SOS 9d would be expected to have severe negative impacts on recreational use of the lower Columbia reach during those months. Under existing conditions, high spring flows flood out some recreation facilities and high velocities create unsafe swimming and boating conditions. The extremely high flows under SOS 9d would be expected to exacerbate those conditions.

System Summary—As indicated by the project- and reach-specific summaries above, SOS 9d would have severe negative impacts on recreation systemwide. Estimated annual system-wide visitation under SOS 9d is approximately 12.6 million recreation days. This is far lower than the estimated visitation of any of the 13 alternative SOSs evaluated in detail.

Flood Control

The impacts to flood control under SOS 9d would be as follows:

- At all locations, floods would occur in many years in which the hydrology is known to be near or below normal.

- Reservoir elevations would be kept artificially high during the drawdown period and, in many cases, refill would occur before the flood peak has passed.

- The 50 percent exceedence frequency stage at Bonners Ferry for SOS 9d is 11 feet over that of SOS 2c, which translates to a major flood every other year on the average.

- At The Dalles (the system control point) three regulated floods in 50 simulation years exceeded 800 kcfs (22,660 cms), each representing a catastrophic flood. For SOS 2c, no simulated floods exceeded this level.

Navigation

Snake and Columbia River Navigation—Without significant structural modifications, navigation above Bonneville Dam would be essentially shut down under SOS 9d. The elevations of water at the four Snake River dams would be well below the minimum operating depth for the navigation locks. The McNary pool elevation would be high enough for barge transportation, but because John Day pool would be below MOP, only intra-pool transportation would be possible. Because the outflow from Bonneville Dam would violate current operating restrictions in the late fall in some years, it is assumed that navigation on the Bonneville pool might likewise be impaired. The physical impacts of this type of permanent drawdown would be dramatic. Ports and facilities along the mainstem pools would be inoperable.

Dworshak Dam Log Rafting Operations—Log rafting operations would be suspended in most years for most of the summer season under SOS 9d.

Lake Roosevelt Ferries—For SOS 9d, there are significantly more simulation years in which the elevation of Lake Roosevelt is lowered enough to disrupt ferry service for two or more months each year.

High Flows Below Ice Harbor and Lower Monumental Dams—High flow problems below Lower Monumental and Ice Harbor Dams would be significantly more likely with SOS 9d than for any other SOS analyzed. However, if barge transportation through the locks would not be possible, the problem is a moot point in the analysis.

Deep Draft Navigation on the Lower Columbia River—It is not possible to analyze SOS 9d impacts without daily flow generations. Based on the average monthly flows shown for Bonneville Dam, it is likely that the impacts would be similar to or slightly worse than those reported for the drawdown alternatives.

In summary, it is likely that SOS 9d would be the worst alternative for navigation.

Power

SOS 9d would substantially reduce the 50-year average annual hydro energy generation. In the power system analysis, average annual hydro energy generation was reduced by 4,262 aMW as compared to SOS 2c, the No Action Alternative. This is almost four times the loss in energy generation for SOS 9a, the SOS with the most severe reduction in energy generation among the final 13 SOSs. Although not quantified, it is estimated that capacity impacts would also be severe, likely at least double those shown for SOS 9a in the winter. In simulated low-water periods, Libby, Hungry Horse, and Grand Coulee are all empty in the winter, leading to severe capacity impacts from head loss and inability to release water needed for downstream power generation.

The same spreadsheet model used to calculate power system impacts in Appendix I, Power, was used to evaluate the effects of SOS 9d. Only changes in total regional energy costs were quantified. These changes were estimated as compared to SOS 2c. The numbers reported here are consistent with the numbers shown in Appendix I, Power, Table 5-2.

SOS 9d increased total regional energy costs by $941 million in operating year (OY) 1996 and $1.1 billion in OY 2004 in 1996 dollars. Again, this is nearly four times the costs of SOS 9a. The simulated loss of hydropower generation required the acquisition of 3,000 aMW of combined-cycle combustion turbines in OY 1996 and 5,500 aMW of combustion turbines in OY 2004. Costs would likely be even higher than estimated for OY 1996, since acquisition of CTs would not be possible in that short of time. Regional deficits would be so great in some months in low-water conditions that curtailments would be required, because not enough power could be brought into the region. For example, in January under 1932 water conditions, nearly 10,000 aMW would be required to meet regional loads in OY 1996. Interties are not capable of importing that much power.

Again, although not quantified, capacity costs could run several hundreds of millions of dollars, leading to a total regional cost for SOS 9d well in excess of $1 billion per year.

Irrigation/M&I Water Supply

Implementation of SOS 9d would affect irrigation and M&I users of six projects: Grand Coulee, John Day, Ice Harbor, Little Goose, Lower Monumental, and Lower Granite.

Overall, these impacts under SOS 9d would be greater than for any of the 13 SOSs, evaluated in detail for the Final EIS. The impact on John Day users would be especially severe, compared to the effects of the other operations that have been evaluated for John Day. The following discussion summarizes a qualitative assessment of the effects of SOS 9d for Grand Coulee, John Day, and the lower Snake River projects.

Grand Coulee—Prior to formulation SOS 9d, SOS 9a had the greatest impact (increase) on irrigation pumping cost. The hydroregulations showed SOS 9a drafting Lake Roosevelt to very low levels during the spring and summer. The hydroregulation for SOS 9d shows an even greater number of months over the period of record with Lake Roosevelt at the minimum elevation of 1,208 feet ([368 m] top of inactive storage). The cost of pumping irrigation water for the Columbia Basin Project would increase from $911,300 for SOS 2c (the No Action Alternative) to $946,200 for SOS 9a and $989,500 under SOS 9d, which is an increase of 8.6 percent.

There is concern by Grand Coulee Project management about the operability of the pumping system from Lake Roosevelt to Banks Lake under such conditions. With the lower Lake Roosevelt levels, the head differential between reservoirs would increase, thus reducing the efficiency or even precluding the use some of the 12 pumping units. The question becomes one of being able to meet irrigation demand from Banks Lake during critical peak irrigation demand periods. The physical impact would be that Banks Lake elevation would decline as the pumping units would not be able to keep up with irrigation demand. During critical water periods, the pumping units would be operated for extended periods, and at head differential greater than historical levels. The impacts of increased wear on the pumping units, the increased risk of non-delivery, and the inability to meet irrigation demand were not evaluated in detail.

John Day—The 113.5-foot (34.6-m) drawdown of John Day from the normal operating pool level elevation of 263.5 feet (80.3 m) to the natural river elevation of 150 feet (45.7 m) would have a significant impact on irrigation and M&I pumpers. The existing pumping plant modification cost curve developed for the relatively small drawdown of 6.5 feet (2 m) for the Final EIS analysis would not be adequate for evaluating the SOS 9d drawdown. In many cases, a new river pumping plant system would need to be designed, rather than modifying the existing plant by extending the intake pipe or lowering the intake units into the reservoir pool.

To continue service to the 139,5000 acres (56,456 ha) irrigated from the John Day Pool, other alternatives to pumping plant modification

should be reviewed, such as drilling wells. It is anticipated that alternatives would be considerably more costly than the $14.3 million to modify irrigation pumps required for the 6.5-foot (2 m) drawdown previously analyzed. A buyout of the irrigated farms could be considered if pumping alternatives were not feasible. However, under a buyout scenario, using a capitalized land value of $600 to $900 per acre ($1,480 to $2,220 per ha) the buyout cost could range from $83.7 million to $125.5 million.

In addition to the irrigation plants, modification or replacement of M&I pumping systems would be required. Once again, it is anticipated that modification or replacement cost for M&I systems under SOS 9d would be considerably greater than the $39.5 million in capital costs identified for drawdown to MOP under several SOSs.

Annual operation, maintenance, and power costs for both irrigation and M&I pumpers would be higher under SOS 9d than for other SOSs evaluated in detail.

Lower Snake River Projects—M&I pumping occurs at all four lower Snake River projects. Irrigation (36,389 acres [14,727 ha]) only occurs from the Ice Harbor pool. SOS 9d would require additional modification or replacement for irrigation and M&I pumping systems. As for John Day, existing cost curves for plant modification under other drawdown scenarios might not be adequate for plants that need to be located directly at river level.

Pumping plant modification cost and annual operating and maintenance costs under SOS 9d would be greater than for SOS 5b or 5c, because there would be an additional drawdown ranging from 11 to 24 feet (3.4 to 7.3 m). An estimate of the increased pumping cost for irrigation and M&I pumpers was not made for SOS 9d. Under SOSs 5c and 5b, the capital cost of plant modification was estimated at $28.3 million for irrigation systems and $6.6 million for M&I systems.

Annual operation, maintenance, and power costs for both irrigation and M&I pumpers would be higher under SOS 9d than for other SOSs evaluated in detail.

Economics

An assessment of potential economic impacts of implementing SOS 9d was conducted by the EAG, based on physical impact data developed by the other SOR work groups. Because the analysis was very preliminary in nature, actual impacts could be much higher or lower than those shown in Table 4-4. Despite the preliminary nature of the analysis, the economic impacts presented in the table are considered to be reasonably representative of the general magnitude of direct economic impacts that would result from implementation of SOS 9d. The cost of modifying John Day Dam to operate at the level of the natural river, however, was not estimated and is not shown. The results of the analyses which were conducted are presented by river use in absolute terms and relative to SOS 2c, the no action alternative. As indicated by the impacts shown in the table, costs related to flood damages in the upper Columbia River, shallow draft navigation, power generation, and irrigation from the John Day pool would be significantly increased. Recreation and anadromous fish benefits would decrease with implementation of this SOS. Annual costs and benefits were developed using a discount rate of 3.0 percent.

Pacific Northwest Coordination Agreement

Like all SOSs produced during the course of the SOR, SOS 9d could be accommodated by any of the five PNCA alternatives without significant impacts to the objectives of SOS 9d.

However, this strategy could have some impacts on the need for any of the PNCA alternatives. Because this SOS appears to fully dedicate all system storage for anadromous fish operation, very little storage would be left for power coordination. Unlike the other SOSs in the Final EIS, this SOS takes the remaining

Table 4-4. Summary of direct annual economic impacts associated with SOS 9d. Page 1 of 2

River Use	Economic Impact ($1,000)	Change from SOS 2c $1,000	Change from SOS 2c Percent	Comments
Anadromous Fish	42,860.0	(890.0)	(2.0)	The amount shown is the estimated commercial and recreational value based on "high" recreation and commercial values. Since the value shown is a "benefit" this negative benefit represents a system cost (loss of output).
Flood Control				Values shown are average annual expected damages.
Upper Columbia	10,247.5	3,275.0	212.9	
Clearwater	8.9	(1.4)	(13.6)	
Tri-Cities	0	0	0	No impact.
Lower Columbia	0	0	0	Analysis was limited to mainline levee protected areas, primarily in the Portland metropolitan area.
Total	n/a	n/a	n/a	
Irrigation and M&I Water				Values shown are the increase in capital and O&M costs over current conditions with SOS 2c. Costs associated with SOS 2c were not estimated.
Lower Snake	n/a	n/a	n/a	Impacts on the lower Snake River would be the same as SOS 5c. Costs specific to the lower Snake projects, however, are not readily separable from the total costs developed for SOS 5c. Therefore, they are not shown.
Grand Coulee	989.0	77.7	8.5	Additional impacts would occur, but they have not been evaluated.
John Day	n/a	n/a	n/a	The likely alternative is canals from the McNary pool on the Oregon and Washington sides of the river. Costs were not estimated, but the Corps' System Configuration Study found that canals in Oregon and Washington would cost 5 and 40 times, respectively, more than pump modifications required for drawdown to MOP.
Total	n/a	n/a	n/a	

Table 4-4. Summary of direct annual economic impacts associated with SOS 9d. Page 2 of 2

River Use	Economic Impact ($1,000)	Change from SOS 2c $1,000	Change from SOS 2c Percent	Comments
Navigation				
Dworshak Reservoir	n/a	n/a	n/a	The elevation of the pool would be consistently and significantly below what it would be with SOS 2c. However, because the reservoir is only marginally usable for transport of logs with the SOS 2c operation, the marginal economic impact of this alternative would not be very large. Based on average monthly pool elevations, economic impacts could be expected to be about the same as those for SOS PA.
Shallow Draft	473,925.0	59,498.0	14.4	Values shown are the total estimated transportation costs for all commodities now shipped on the Columbia/Snake waterway and the difference (increase) in costs compared with the current operation of the system which allows year-round navigation.
Total	n/a	n/a	n/a	
Power	1,897,000.0	941,000.0	98.4	System costs shown are for operating year 1996, assuming the system was operated as specified in SOS 9d. Average annual costs were not computed for this alternative. Costs do not include potential changes in capacity costs.
Recreation	71,260	(243,529)	(77)	The values shown represent system benefits or outputs. Therefore, the decrease in these benefits, compared with SOS 2c, is a cost to the system (decrease in benefits).

Note: n/a = not available

flexibility offered by the Treaty storage in Canada and operates it for fish flows. This would conceivably give the non-Federal power producers a legitimate argument for relief from CEAA obligations, which in turn could eliminate their need for a power coordination agreement.

4.2 IMPACTS OF THE SOS ALTERNATIVES

Section 4.2 is designed to provide the reader with a basic understanding of the effects of the SOS alternatives evaluated in detail in the EIS. This section displays the effects of the alternative SOSs for each river use or resource area. More complete detail on the analysis of the SOS alternatives and their implications can be found in Appendices A through 0. Section 4.3 presents a comparison of the alternatives.

How Effects Are Discussed
Impact Issues
• Key Issues
• How, Why, and Where System Operations Affect Resources
Effects of SOS Alternatives
• Changes Resulting from SOSs
• Magnitude and Extent of Changes

The effects of the SOSs are discussed by the resource or subject areas within the Columbia River system that are affected by system operations. These are: earth resources, water quality, air quality, anadromous fish, resident fish, wildlife, cultural resources, Native Americans, aesthetics, recreation, flood control navigation, power, irrigation, municipal and industrial water supply, economics, and social effects. For each subject, the stage is first set by explaining how operations affect the resource and river use. Under the subheading "Impact Issues," the discussion identifies specific issues examined in the effects analysis. These issues derive from scoping, information and comments, prior controversy, concern within specific communities, and other factors that render them key to the analysis. The discussion also explains the impacts, or how, why, and where system operations affect the resource or river use (e.g., reservoir elevation influences on recreational use).

The next section describes the "Effects of Alternatives" for each resource and use. The discussion identifies the sources and directions of change that result from each alternative; characterizes the magnitude, extent, and duration of change; and illustrates these changes with simple graphics and tables. The agencies have tried to use the same format (issue-by-issue discussion) for each resource to facilitate comparison. For some resource areas, however, (e.g., wildlife) the effects were better described by deviating from the standard format. To present a more understandable discussion of a highly complex system, this EIS attempts to avoid the extensive quantification of effects that traditionally appears in EISs, leaving such detail to the appendices.

The impact analyses generally present the effects of the SOS alternatives both in absolute terms and in comparison to existing conditions. SOS 2c, the No Action Alternative, provides the benchmark for comparative analysis because it best represents existing conditions and the point of departure for analysis of potential future operations. Chapter 1 of the EIS explains the need for and scope of the SOR, which relate to the operation of the Columbia River System given its current configuration. The basis for comparison must be existing conditions, which reflect the current system configuration. During the SOR process, some commentors suggested that pre-dam conditions should be the basis for comparison. The SOR agencies did not adopt this suggestion because comparison of existing and pre-dam conditions would only be necessary if a return to pre-dam conditions were within the range of reasonable alternatives, which is not the case.

The discussions in Section 4.2 refer frequently to the hydroregulation model results for each SOS. These river flow and reservoir elevation patterns provide the basis for virtually all of the impact analyses. The reader is

encouraged to consult Appendix A, River Operation Simulation, for detailed information on hydrologic conditions.

4.2.1 Earth Resources

This section examines the impacts of system operations on geology and groundwater. These impacts are manifested in three ways—shoreline modification by erosion and mass wasting, sedimentation in the reservoirs, and changes in groundwater levels. Appendix L, Soils, Geology, and Groundwater, provides background information on the geologic setting and more detailed descriptions of the impacts.

Earth Resources Impact Issues

Rivers have altered the landscape for thousands or millions of years. Their form and position are a result of a delicate balance between sediment-carrying capacity and sediment supply. Changes in sediment capacity and supply depend on the nature of the change and the setting of each river. Many of the rivers in the Columbia River Basin have been altered in some way. Most notable among these is the Columbia River itself, which has few remaining reaches of free-flowing water.

Damming a river represents a fundamental change, at least in the short term, in the river's regime. Filling the reservoirs behind the dams creates changes that alter two geomorphic systems: rivers and hillslopes.

All river activity is controlled by a base level, the level below which rivers cannot downcut. In a natural system, sea level is the base. Reservoirs act as local base levels, interrupting the dynamic equilibrium of rivers and tributary streams flowing through the area. As expected, tributaries and mainstem rivers slow at their contact with a reservoir; this contact also reduces flow upstream. Sediment that would otherwise be carried downstream drops out of the water within the reservoir so that water exiting the reservoir contains relatively little sediment. All reservoirs have this effect, and the amount of sediment coming from the upstream basin primarily determines the useful life span of the reservoir. Basins producing large quantities of sediment tend to fill reservoirs faster than those producing relatively little sediment.

Prior to reservoir filling, the hillslopes are exposed only to the forces of gravity which can cause rock falls, soil to creep, and small-scale landslides. After a reservoir is filled, water becomes superpositioned on hillslopes and new forces begin to operate on the hillslopes. Four main variables control response of the hillslope system to reservoir filling and operation: pool level fluctuation, shoreline orientation, shoreline geology, and reservoir climate. Within the scope and projected period of the proposed system operations, only pool level fluctuation is truly variable at a reservoir. Pool level fluctuations affect both the river system and the hillslope/soil system.

Pool level fluctuations (drafting and refilling) occur whenever the inflow into a reservoir does not equal the outflow. The changes that influence pool level fluctuations are: (1) increasing outflow, such as power peaking operations, flow augmentation, or flood control space management; (2) decreasing outflow, such as holding back spring floods; and (3) changing the timing of outflow releases. For storage reservoirs, drafting and filling curves are generally smooth, but are occasionally interrupted. These curves vary with changes in runoff and the demand for electricity. Pool levels change seasonally and, where peaking occurs, daily. At run-of-river projects, relatively static pool levels concentrate wave erosion in a narrow range of elevation along shoreline slopes.

Erosion and Mass Wasting

The two types of projects, storage and run-of-river, have very different erosion processes due to the differences in their operation. Pool level fluctuation is the primary difference between the two types of projects. Run-of-river projects typically have a 3-foot (0.91-m) to 5-foot (1.5-m) pool elevation range (P_R) annually,

which is a small enough P_R so that mass wasting is relatively minor. For example, a study at Priest Rapids on the mid-Columbia River indicated there had been no significant shoreline erosion after 14 years of operation (CH2M Hill, 1975). Additionally, waves concentrate on a narrow zone of shoreline. Therefore, relatively stable shorelines can develop, and the surface that waves (and precipitation) can affect is relatively small. In addition, run-of-river reservoirs are relatively narrow, and the fetch (distance across the reservoir, that affects wave energy) can be short. Conversely, the fetch can sometimes be several miles of the reservoir's length, resulting in large waves.

Significant pool level fluctuations occur seasonally, and in some cases, daily, at storage reservoirs. The P_R of storage reservoirs affects all the processes acting on the shorelines, such as wave erosion, freeze-thaw weathering, incision, mass wasting, surface erosion, and groundwater movement. Figure 4-1 shows examples of some of these processes. Both the magnitude and rate of pool level fluctuation affect these processes.

Pool level fluctuation increases the area exposed to shoreline wave erosion and surface erosion. The greater the seasonal pool level variation, the more total wave and surface erosion occurs, because the surface area that waves can attack increases as pool elevation range increases. When a storage reservoir is drafted during the colder parts of the year, shoreline soils and sediments are subject to freeze-thaw cycles. During spring thaw, melting of one zone in a sediment column above a still-frozen layer may result in mass movement of the upper thawed unit. In addition, reservoir embayments that have ice may erode as the pool level drops, and the weight of the ice contributes to mass wasting of the shoreline.

The rate of drafting may affect mass wasting and groundwater movement in the shoreline materials. When the reservoir level is stable, unconsolidated shoreline materials become saturated. If the level drops quickly, the increased weight of the saturated materials, along with removal of lateral support from the water, can cause slumping. Draining of the saturated materials may increase mass wasting through sapping (see Figure 4-1). Sapping occurs when water moves downward through porous materials and encounters a layer of decreased permeability. The water then flows horizontally until it reaches the intersection of the less permeable layer with the surface. At this point, the water can remove tiny particles from the sediment, creating a cavity, which undermines the more permeable sediments and leads to collapse.

Existing site-specific data on location or rates of shoreline erosion or recession within the Columbia River system are scarce to non-existent. While landslide areas on some reservoirs have been studied, the information as a whole is spotty. The SOR studies addressed geologic conditions of the shoreline around the affected reservoirs from the available literature. This minimal information indicates that significant shoreline erosion and mass wasting are occurring, particularly at storage reservoirs.

Sedimentation

Pool level fluctuations affect the river system by redistributing sediments within a reservoir and affecting the behavior of tributary streams entering the reservoir. Since dam construction, deltas have been deposited at the mouths of these tributaries. Seasonal pool level fluctuations tend to flush out some or most of the sediment accumulated in these deltas. The sediments typically get deposited lower in the reservoir, although the finest particles may remain in suspension and be carried out of the reservoir as turbid water. Over the long term, reservoirs fill with the accumulated sediment that they trap. The rate of accumulation, and thus the useful life of a reservoir, depend on the sediment inflow and velocity through the reservoir.

Groundwater Processes

Although groundwater is affected by pool level fluctuations, few studies have examined the behavior of groundwater during pool level

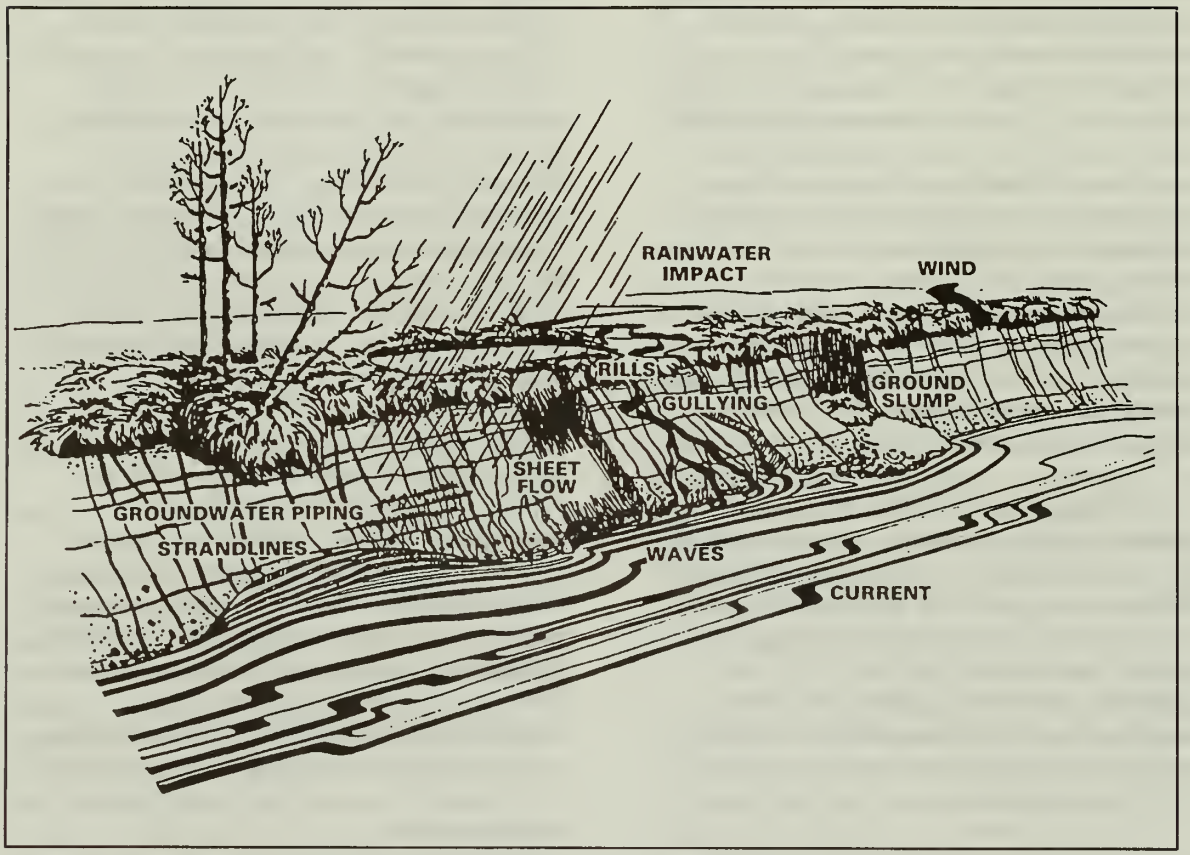


Figure 4-1. Shoreline erosion processes and characteristics that contribute to erosion. Sheet flow, rills, gullying, and rainwater impact are all surface erosion processes, while slumping is a mass-wasting process. Strandlines are a result of wave erosion. (Source: Gatto and Doe, 1983)

fluctuations. As a result, determining site-specific impacts of changes in reservoir operation would require detailed three-dimensional groundwater modeling. In addition, there are few wells near reservoirs in the Columbia River Basin, because water needs in most areas are met with surface water. Because of these limitations, a qualitative assessment of the effects of changes in pool level fluctuations was performed.

Near reservoirs, the gradient of groundwater movement is toward the reservoir. The groundwater most free to fluctuate with pool level is in the unconfined aquifers. These aquifers have a water table which changes with the amount of infiltrating water. Therefore, the effects of pool level on these aquifers occur in the immediate vicinity of reservoirs. A drop in pool level has an effect on the water table that varies with the nature of the aquifer material. In highly permeable aquifers, the ratio of pool level drop to water table drop may be 1:1. In low-permeability aquifers, the water table may only drop a fraction of the amount of pool level drop.

Because water supply wells are frequently located in the upper unconfined aquifer, it is likely that wells near the reservoirs already experience some fluctuation. They now must be installed to allow continued production when pool levels are low. If a well is very close to a

reservoir, however, and the depth interval from which water is withdrawn (in unconsolidated deposits) is narrow, abnormally low pool levels could make the well go dry. Raising the pool level above the normal elevation would raise the water table, but this increase would not diminish water supply for the wells.

Effects of SOS Alternatives

Qualitative and quantitative analyses were used to assess the SOS impacts on geology and groundwater. In general, the selection of a qualitative or quantitative analysis was based on the availability of applicable data and the degree of change in expected impacts. While all of the SOS alternatives would continue erosion, sedimentation, and groundwater impacts from operations, some would introduce major changes in these physical processes. The quantitative effort was focused on these alternatives. Chapter 3.0 of Appendix L gives a detailed outline of the methods used and the data limitations in the quantitative analysis.

To provide a context for assessing SOS impacts, operational impacts of each alternative were compared to baseline conditions. In terms of geologic processes, baseline conditions are those that evolved under historical system operations, as best represented by SOS 1b. The rate of change in these conditions has been modified slightly at some projects (primarily Dworshak and Grand Coulee) since 1983, through operating patterns represented by SOS 1a, and subsequently by SOS 2c. While the actions included in SOS 2c have generally been in effect since the 1992 operating year, these operations are not drastically different from SOS 1a, and as yet have not likely caused any identifiable change in baseline conditions.

Erosion and Mass Wasting

A useful indicator of erosion intensity is the total P_R. While local geology and reservoir geometry greatly influence the relationship of P_R to total erosion, P_R helps to indicate trends in erosion that can be expected at a given reservoir. As indicated above, pool-level fluctuations influence most of the processes acting on the shoreline. In addition, changes in P_R tend to outlast effects of other changes related to pool levels. For instance, if the P_R is reduced by 30 percent and the average annual pool elevation is decreased, the surface area above the average annual maximum level reached would increase, and would be exposed to more surface erosion (overland flow, rilling, gullying). The resulting erosion would, however, be limited by prior removal of detachable particles (when waves could attack the shore at these elevations) and by revegetation. In addition, wave erosion tends to produce greater volumes of sediment than surface erosion. Thus, the net effect would be an overall decrease in shoreline erosion.

Figure 4-2 shows the simulated P_R at each affected reservoir for each SOS. This figure was compiled from the hydroregulation model results for each SOS. Projects for which the P_R would be unchanged from current conditions, regardless of SOS, are not included in Figure 4-2 and are not addressed in the following discussion. These projects include Canadian projects (except Keenleyside); Chief Joseph and the mid-Columbia PUD; and McNary, The Dalles, and Bonneville Dams on the lower Columbia River.

SOS 1, Pre-ESA Operation—This alternative would continue historical patterns of shoreline erosion and mass wasting. The impacts of SOSs 1a and 1b would be nearly identical.

At Grand Coulee, both SOSs 1a and 1b would cause continued significant erosion and mass wasting. P_R would average about 60 feet (18.28 m) for either SOS 1a or SOS 1b. There are at least 82 active landslides (slides that have moved within the last 10 years) around Lake Roosevelt (Reclamation, 1992). In the initial period of reservoir operation, about 500 landslides occurred along Lake Roosevelt between 1941 and 1954 (Jones et al., 1961). Jones et al. (1961) demonstrated a clear relationship between P_R and landslides. Because there is little evidence of Lake Roosevelt shorelines stabilizing (approaching equilibrium

form), this level of landslide activity could be expected to continue for decades with operation under SOS 1.

The initial period of operations at Dworshak resulted in documented slides along approximately 13 miles (21 km) of shoreline (Gatto and Doe, 1983), which is about 10 percent of the total shoreline length. The authors believed that daily fluctuations in pool level of up to 5 feet (1.5 m) during drafting and refilling periods contributed significantly to landslides. Similar patterns of mass wasting would continue under SOS 1a and SOS 1b.

There is some evidence that comparable erosion and mass wasting conditions have developed at the other storage reservoirs. Hungry Horse Reservoir exhibits significant shoreline erosion in its upstream reaches, as well as several large, active landslides. Libby has had rockslides, but these were unrelated to pool fluctuation (Voight, 1979). Brownlee has experienced significant mass wasting, with numerous active landslides along its shoreline (BPA, 1985). Lake Pend Oreille, behind Albeni Falls Dam, has experienced as much as 5 feet (1.5 m) of shoreline retreat at one location during a 12-year period (Gatto and Doe, 1983). Although 5 feet (1.5 m) of retreat is not normally significant, this amount occurred on a reservoir with a P_R of only 11 feet (3.4 m).

Future operation under SOS 1a or 1b would continue the historical pattern of erosion and mass wasting. Some shoreline retreat, attributable to wave erosion, would continue at Lake Pend Oreille. Based on the erosion rate reported in the one applicable prior study, the average rate of shoreline retreat would likely be

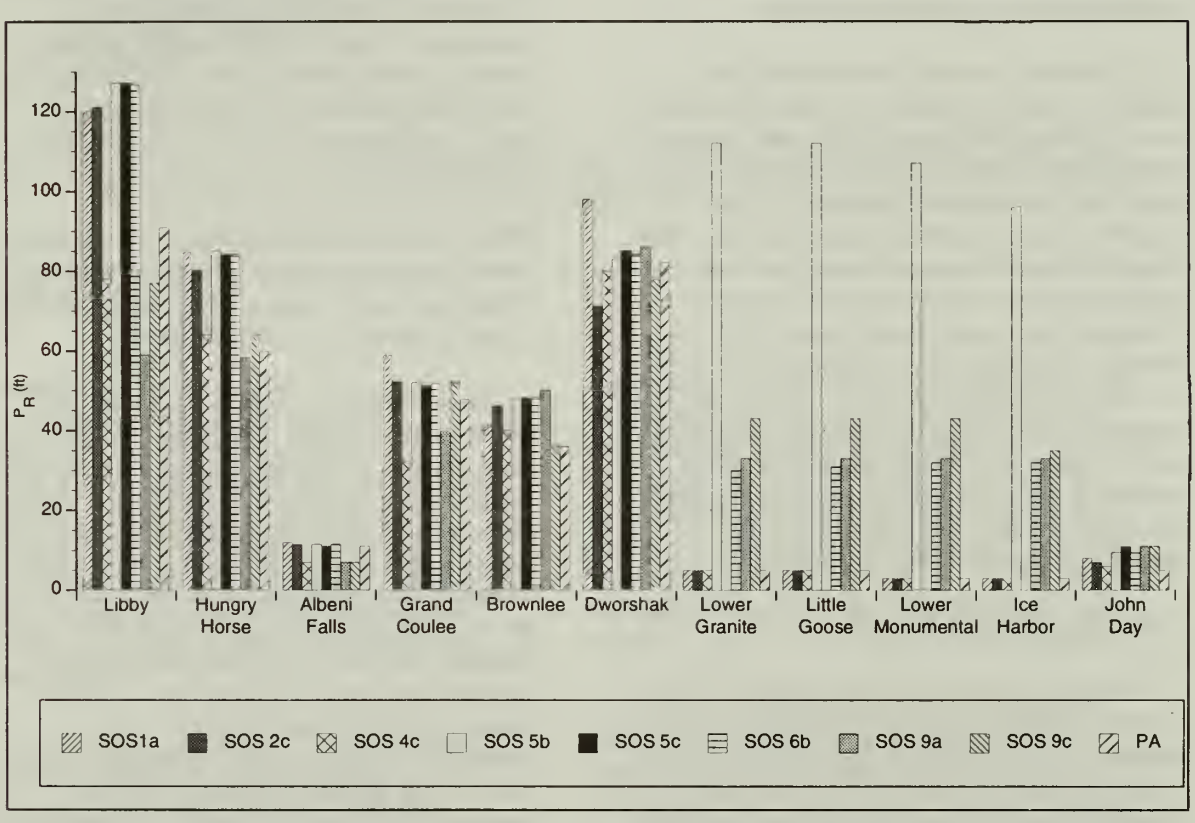


Figure 4-2. Total average pool elevation range (P_R) at affected projects for representative SOSs, by alternative

about 0.4 feet (0.1 m) per year. Localized conditions such as bedrock ledges could limit or prevent further shoreline retreat in some areas. Comparable information on erosion rates is not available for the other storage reservoirs. Most of the erosion in these reservoirs occurs in the drawdown zone below the full-pool elevation and is not readily evident or easily studied. Mass wasting, which is more evident, would likely continue at the same or slightly decreasing rate.

Available information indicates that the run-of-river projects have generally experienced only minor amounts of shoreline erosion and mass wasting. This result is primarily due to relatively stable pool levels and riprap shoreline armoring that has prevented erosion or mass wasting in many locations. Among the run-of-river projects, several low-angle slides have been documented at John Day (Gustafson, 1992), but shoreline erosion does not appear to be significant. Current erosion and mass wasting patterns, such as the minor landslides at John Day, would continue at the run-of-river projects under SOS 1a or 1b.

SOS 2, Current Operations—For most reservoirs, current operations are the same as or a minor departure from historical operations. Therefore, erosion and sedimentation would remain within historical ranges for most reservoirs. For the other reservoirs, continuing current operations would cause differences from historical conditions as summarized below.

Current operations (SOS 2c) continued over the long term would accelerate erosion slightly at Brownlee compared to historical conditions due to a minor increase (less than 10 feet [3 m]) in P_R. The slight increase in the rate of drafting might also lead to a minor increase in mass wasting. Overall, however, shoreline erosion at the storage projects would remain within historical ranges. Shoreline erosion at Hungry Horse and Grand Coulee would decrease slightly, while erosion at Dworshak could decrease significantly.

Operating John Day near elevation 262.5 feet (80 m) and the lower Snake River projects near minimum pool would expose the shoreline within the normal operating range for a longer duration. This scenario would lead to a short-lived increase in erosion, and possibly mass wasting, at these run-of-river projects.

SOS 2d would have essentially the same impacts as current operations, with two minor exceptions. Grand Coulee would experience slightly less erosion due to a 5-foot (1.5-m) reduction in P_R. At Brownlee, an additional but small cycle of draft/refill would occur each year, increasing the amount of time for erosion and mass wasting processes to affect the shoreline.

SOS 4, Stable Storage Project Operation—SOS 4c would generally reduce shoreline erosion and mass wasting.

P_R at Libby under SOS 4c would be reduced by nearly half, compared to historical conditions. Erosion would also be less at Hungry Horse, for which SOS 4c would reduce the P_R by about 25 percent.

Albeni Falls would experience a slight decrease in erosion under SOS 4c, with P_R reduced from about 11 feet (3.4 m) to 7 feet (2.1 m). SOS 4 would result in about the same P_R at Brownlee as with historical conditions. The annual draft in these cases would be about 10 feet (3 m) less than reported previously for SOS 2.

SOS 4c would decrease erosion at Dworshak slightly, due to an 18 percent decrease in the total draft. SOS 4c would also generally reduce erosion at Grand Coulee, where annual drafting would be nearly halved. A major reduction in erosion and mass wasting would result.

Under SOS 4c, the run-of-river projects would generally operate the same as in SOS 2. Therefore, there could be a very slight increase in erosion and mass wasting at the lower Snake River projects. John Day would operate within 2 feet (0.6 m) of elevation 263.5 feet (80.3 m) during the late spring and summer, which is essentially midway between the average elevation for SOSs 1a and 2c.

SOS 5, Natural River Operation—This alternative would be fundamentally different from SOSs 1 through 4 in both the magnitude and location of impacts. Drawing the four lower Snake River projects down to natural river level for 4.5 months each year or permanently would expose large areas of reservoir shoreline to erosion.

A simple shoreline erosion model was developed as part of the quantitative analysis conducted for water quality (see Appendix L for details). This model estimated the volume of reservoir sediments eroded by four processes: surface erosion, slumping/sapping (mass wasting), tributary incision, and wave erosion. There are no detailed studies of shoreline behavior during drawdown, and the model relied heavily on the 1992 drawdown test for empirical information. The model focused on Lower Granite because more information is available for that reservoir than others. Surface erosion was estimated using the universal soil loss equation (a standard method for estimating soil erosion from a variety of surfaces, developed by the U.S. Soil Conservation Service). The surface area was estimated using the pre-dam river terrace topography. Armored areas, such as riprap and coarse-grained alluvial fans, were subtracted from the total estimated area exposed. Slumping/sapping was estimated using data from the 1992 drawdown test. Geometry of slumps was estimated using photos and knowledge of the behavior of slumped materials. Total slumped material was estimated for the 1992 drawdown test and adjusted for drawdown level and shoreline geometry. Tributary erosion was similarly estimated, using aerial photos and ground-based photos. Volumes of eroded materials were estimated for each major tributary using channel geometry. These estimates were adjusted for pool levels in SOS 5 and SOS 6, since both are lower than the maximum drawdown in the 1992 test. Wave erosion was estimated using the geometries of wave-cut terraces along the reservoir shoreline. Several classes of exposed areas were developed based on slope and geomorphic conditions. The volumes were multiplied by the number of terraces at various sites of uniform slope, and adjusted for the slope as well. The estimates were extrapolated for areas that would be exposed under SOS 5 and SOS 6.

Estimates for each process were calculated for three different scenarios: low, moderate, and extreme. Because the 1992 test occurred during unusually calm conditions, the estimated wave erosion, for example, was assumed to represent a low erosion scenario. Surface erosion, mass wasting, and incision were also considered to represent the low end of the possible spectrum of erosion. For the moderate scenario, weather conditions during the test were compared to average conditions for that period and correspondingly adjusted. Adjustments were also made for the timing and duration of the proposed drawdowns.

Erosion estimates for the other three lower Snake reservoirs were made using the average erosion per mile under the moderate erosion scenario on Lower Granite, and multiplying by the mileage along those reservoirs. This estimate was adjusted for the amount of available sediment, noting that the dam construction sequence went progressively upstream in a relatively short period. This means that the other dams did not have very much time to accumulate thick sediments; most sediments have been trapped by Lower Granite. Some reservoirs, though, have major tributaries draining highly erosive land (the Palouse region), so further adjustments were made to account for these major sources of sediment.

Estimates of the erosion in the following years were based on best professional judgement, in lieu of sediment routing. Most erosion is likely to occur in the first few years, with the amount of erosion rapidly tapering off, as the easily erodible sediments are removed and the coarser, pre-dam sediments exposed. Surfaces would become somewhat armored with time. However, because an average of 3 million cubic yards (2.3 million m^3) of sediment flow down the Snake into Lower Granite, most of these sediments would remain within the reservoir, assuming at least half reach the reservoir at times other than the drawdown.

The erosion model results indicate that about 900,000 cubic yards (688,000 m^3) of sediment would erode from Lower Granite alone during the first year of operation under SOS 5b. Figure 4-3 shows estimated erosion at Lower Granite for the drawdown alternatives (SOSs 5, 6, 9a, and 9c). Another 2.5 million cubic yards (1.9 million m^3) of sediment would erode from the other three lower Snake River reservoirs during the first year, for a total of 3.4 million cubic yards (2.6 million m^3) from the four projects. Erosion would decrease rapidly during the first 6 years of operation, then reach a relatively constant level as lag deposits developed along the exposed shorelines and reduced the volume of available sediment. The constant rate for all four lower Snake projects would be between 700,000 and 1.3 million cubic yards (535,220 and 993,980 m^3) per year, which is considerably less than the total estimated annual sediment influx to the lower Snake of 3 million cubic yards (2.29 million m^3). The rate has a large margin of error because of high degrees of uncertainty in sediment wedge geometry, contribution of pre-existing sediments, and variability in weather patterns. The rates for SOS 5b fall within this range. Under SOS 5c, erosion would be significantly less due to the elimination of the drawdown-refill cycle. Within 5 to 15 years, the amount eroded would decrease to background levels, and sediment leaving the Snake River would be approximately equal to the sediment influx in the river.

The stability of fill material along the reservoir margins would be reduced as water drained out of the fill during the annual drafting period. This would cause slumping and piping, and result in damage to embankments and port facilities along the lower Snake River reservoirs.

SOS 5 also provides for operation of John Day at minimum pool (elevation 257 feet [78.3 m]) for much of the spring and summer, when the reservoir elevation is normally between 265 and 268 feet (80.8 and 81.7 m). This scenario would effectively double the total annual draft, but would not significantly affect erosion along Lake Umatilla's shoreline over the long term. The lower pool could contribute activity along a landslide west of Alderdale on the north shore of the lake (Gustafson, 1992).

Conditions at the storage reservoirs under SOS 5 would generally be similar to those reported for SOS 1. Compared to historical conditions, differences among the storage projects would generally be in the range of 5 to 10 feet (1.5 to 3 m). P_R at Dworshak would be 20 feet (6.1 m) lower, and would decrease erosion and mass wasting.

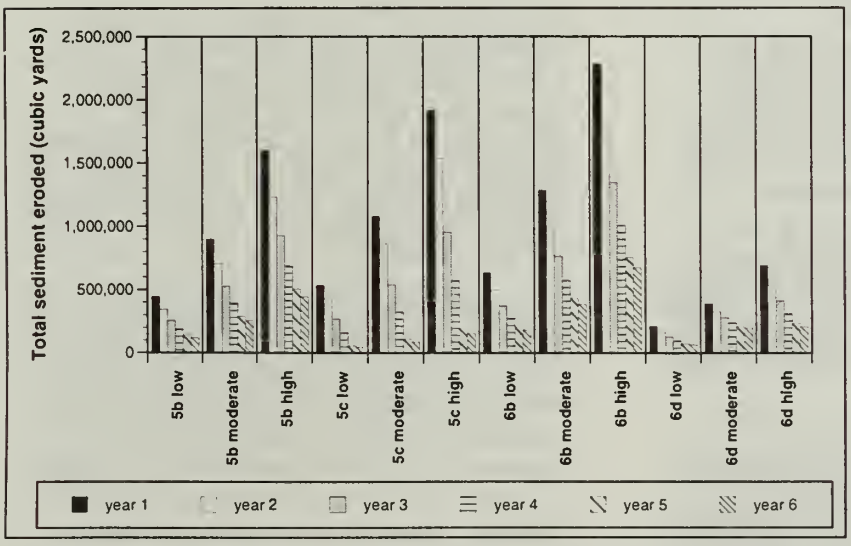


Figure 4-3. Total sediment eroded from lower Snake River reservoirs under average conditions, SOS 5 and 6 (Source: Appendix L; 1 cubic yard = 0.765 cubic meter)

SOS 6, Fixed Drawdown—This alternative is similar to SOS 5, involving drawdown of all four lower Snake River projects (SOS 6b), or of Lower Granite only (SOS 6d), to fixed elevations. However, the degree of impact would not be as great because the depth of drawdown would be approximately 33 feet (10 m) per dam, as opposed

to about 100 feet (30.5 m) with the natural river operation.

Nonetheless, SOS 6 would still cause major increases in erosion and mass wasting. SOS 6b would mobilize about 1.5 million cubic yards (1.14 m^3) of sediment during the first year, which is half as much sediment as produced under SOS 5b. The yearly rate of erosion after 6 years under SOS 6b would be less than half of that under SOS 5b, being roughly 500,000 cubic yards (76,460 and 382,300 m^3). The rate is significantly less because most sediment would be retained within each reservoir. Under SOS 6d, the erosion rate would be roughly 300,000 cubic yards (38,230 and 229,380 m^3).

Again, SOS 6 would cause some damage to embankments and port facilities. Unlike SOS 5, which has river bank erosion, shoreline wave erosion would become the dominant erosion process.

The impacts of SOS 6d on erosion would essentially mirror those of SOS 6b, but would be limited to Lower Granite and its vicinity. The estimated volumes of sediment mobilized in Lower Granite 390,000 cubic yards (298,194 m^3) for SOS 6d. Little Goose would trap most of the sediment passed through Lower Granite.

SOS 9, Settlement Discussion Alternatives—The three options under SOS 9 present very different potentials for impacts. The two that involve drawdown, 9a and 9c, would generally have significantly more effects than 9b.

Erosion and mass wasting would be significantly reduced under 9a at both Libby and Hungry Horse, due to the decrease in P_R. Areas currently seasonally inundated and then exposed would become vegetated and not subject to wave or surface erosion.

Erosion would increase at several reservoirs. At Brownlee, an additional draft/refill cycle would cause a significant increase in the amount of shoreline exposed to wave attack. At Dworshak, the P_R would increase slightly, resulting in a moderate increase in erosion and mass wasting. A short term increase in wave-generated sediment would also result, since the average annual low pool elevation would be lowered by 10 feet.

The lower Snake River projects would be significantly affected, as the drawdown to near spillway crest would cause erosion problems similar to, although not as extensive as, that under the other drawdown alternatives. At Lower Granite alone, approximately 1.5 million cubic yards (1.15 million cubic meters) of sediment would be mobilized during the first year. Approximately 4.3 million cubic yards (3.2 million cubic meters) of eroded sediment would be generated at the other lower Snake River projects during the first year, assuming typical weather conditions. Erosion and mass wasting would decrease rapidly after the first year. It is estimated that after about 6 years, the sediment influx from erosion would stabilize at a background level.

At Grand Coulee and John Day, the P_R would increase, but not enough to make a detectable change in shoreline erosion. Albeni Falls would experience a slight decrease in the amount of shoreline erosion, since P_R would decrease slightly.

Under SOS 9b, erosion and mass wasting would decrease slightly over the long term at Libby, Hungry Horse, and Grand Coulee. These would increase at Brownlee and Dworshak, as additional draft/refill cycles would be added to each. John Day and the lower Snake River projects would experience effects as under current conditions.

SOS 9c would significantly change the operations of a number of the project reservoirs. Due to the 36 percent decrease in P_R, erosion and mass wasting at Libby would significantly decrease. Similarly, Hungry Horse would experience a 20 percent decrease in P_R, leading to a noticeable decrease in erosion and mass wasting. Albeni Falls would be operated as under 9b, and thus effects would be the same.

The lower Snake River projects, being drawn down to near spillway crest, would experience significant effects. The 40-foot (12.2 m) drawdown would cause approximately 1.3 million cubic yards (994,000 m) of sediment to be eroded. The patterns of erosion and mass wasting would be similar to those under SOS 6, with a peak each year at the beginning of a drawdown, tapering off during the middle of the drawdown, and a small increase during the refilling. Slumping would occur in the unconsolidated sediments, especially in deltas and embayments. Erosion and mass wasting would decrease rapidly within a few years after the initial drawdown, but would eventually reach a background level.

Effects of SOS 9c on John Day would be similar to those under SOS 5, with a slight increase in erosion and mass wasting.

SOS PA: Preferred Alternative—Under this option, shoreline erosion and mass wasting would experience a net decrease at Libby and Hungry Horse, due to significant decreases in P_R. At Albeni Falls, Grand Coulee, and Brownlee, shoreline erosion and mass wasting would be similar to that under current operations. At Dworshak, P_R would increase, resulting in a slight increase in shoreline erosion and mass wasting.

At John Day, a temporary increase in erosion and mass wasting would occur as the pool level was lowered to MOP. The effects of the lowering might be short lived. If the pool level were held at about 257 feet (78.3 m) year round, shorelines would be able to establish equilibrium profiles eventually. Long-term erosion due to pool fluctuation would thus be minimal and similar in amount to that under current conditions. However, use of the 3- to 5-foot (1- to 1.5-meter) seasonal fluctuation allowed under the Biological Opinion might prevent the equilibrium condition and result in long-term erosion comparable to other run-of-river projects.

Sedimentation

The amount of sedimentation is linked with the amount of erosion and has two sources—river scour and bank erosion. Appendix M, Water Quality, presents the results of the HEC-5Q and HEC-6 studies. Conclusions presented in this section are based on these studies, which consider both sources of sediment.

The results show the effects of the operation alternatives on silt concentrations along the length of the Snake River. Silt concentrations are a proxy for sedimentation; where the silt concentrations are high, the river velocity is low. Deposition of sediment, particularly the coarser silt and sand particles, is likely in these areas. Smaller-size particles were not modeled, but numerous studies show that fine silt and clay particles stay suspended much longer than the coarser particles.

SOS 1, Pre-ESA Operations—Sedimentation would remain within historical ranges. Upstream reservoirs would trap much of the sediment, while tributaries to the lower reaches of mainstem rivers—the Columbia, the Snake, and the Kootenai—would contribute some sediment to lower-elevation reservoirs. Tributaries ending at reservoirs would continue to extend their deltas out into the water.

Serious sedimentation problems have developed at Lower Granite under pre-ESA operations. Sediment has accumulated at a maximum rate of 0.23 foot per year (0.07 m/yr). Dredging is already necessary to maintain shipping channels and port facilities in the Clarkston area (Corps, 1985). Under these operations, dredging would be necessary in the future to keep the freeboard capable of containing floods within the levee system.

Sedimentation in most downstream reservoirs would be limited to gradual filling of the reservoirs and occasional, minor redistribution of sediment within the reservoirs. The water quality studies did not specifically address SOS 1; however, because the operations do not

vary significantly between SOS 1 and SOS 2, the results from the SOS 2 analysis can be assumed to approximate the conditions under SOS 1. These results are discussed below.

SOS 2, Current Operations—Sedimentation patterns would change slightly in the reservoirs where erosion would decrease. This would be predominantly a redistribution of sediment in the reservoir, and not a net change in sedimentation. Therefore, there would be essentially no impact on sedimentation systemwide, relative to historical conditions. The water quality studies show that the maximum silt concentration on the Snake River would be at 20 milligrams per liter (mg/l) at the upper end of Lower Granite Reservoir.

SOS 4, Stable Storage Project Operation—SOS 4c would generally reduce the rate of sedimentation within reservoirs, due to the decrease in erosion. Sediment would continue to accumulate in essentially the same locations as at present.

SOS 5, Natural River Operation—Significant changes in sedimentation would result under both SOS 5 options. Sediment previously trapped behind the lower Snake River dams would be flushed to the Columbia River, with McNary Reservoir (Lake Wallula) trapping most of the sediment. Navigation channels could be affected and would possibly need dredging. Most of the sediment influx from upstream currently occurs during the spring and early summer. Because this sediment would be transported through the lower Snake River reservoirs during the annual drawdown period, the reservoirs would experience little if any net sedimentation under both options, but particularly under SOS 5c, since no retention of sediment would occur. The water quality studies show that the greatest increase in sediment accumulation would occur upstream of McNary, at RM 320 to 325 on the Columbia River and RM 0 to 10 on the Snake River. The maximum accumulation would be approximately 230 kg/m^2. The lifespans of the four lower Snake River projects would be extended; however, the lifespan of McNary would be shortened.

SOS 6, Fixed Drawdown—A pulse of fine sediment would be flushed out of the Snake River system and into the Columbia River under SOS 6b or 6d. The coarser sediments would be retained behind the Snake River dams. McNary Dam would trap most of the sediment released into the Columbia River. According to the water quality analysis, the pulse of sediment would be significantly smaller than that of SOS 5 and, after 2 years, would be comparable to background tributary inputs. The net decrease in sediment accumulation would add slightly to the life of the lower Snake River projects, while the life span of McNary would decrease slightly. Under SOS 6d, a smaller pulse of sediment would be deposited in Little Goose. Lower Granite's lifespan would not be increased significantly.

SOS 9: Settlement Discussion Alternatives—The major effect of SOS 9a would be sedimentation of McNary Reservoir. The sediment eroded from the lower Snake River projects would be deposited mostly at the confluence of the Snake and Columbia Rivers. Shipping lanes could be affected. Sedimentation in the lower Snake projects would decrease, however, since they would be releasing significant amounts each year.

Storage projects would experience a decrease in the amount of shoreline-derived sediment as shoreline erosion decreases. Sedimentation would decrease significantly at Libby and Hungry Horse; it would decrease slightly at Albeni Falls. Shoreline-generated sedimentation would increase at Brownlee and Dworshak due to accelerated shoreline erosion. Grand Coulee would experience the same patterns and amount of sedimentation as under current operations.

Under SOS 9b, sedimentation from shoreline erosion would decrease slightly at Libby, Hungry Horse, Albeni Falls, and Grand Coulee. However, similar to 9a, sedimentation would increase at Brownlee and Dworshak. On the four lower Snake River projects, sedimentation patterns would remain within historical ranges.

Sedimentation from shoreline erosion and mass wasting would decrease significantly under SOS 9c at Libby, slightly at Hungry Horse, and at Albeni Falls. This is due to the decrease in shoreline erosion and mass wasting resulting from less pool level fluctuation. At Brownlee, an extra draft/refill cycle would increase erosion and thus sedimentation, while sedimentation at Dworshak and Grand Coulee would remain within historical ranges.

As under SOS 9a, the lower Snake River projects and McNary would experience major changes in sedimentation patterns, with McNary receiving large amounts of sediment from the eroding shorelines and reservoir bottoms on the lower Snake River projects. The lifespan of McNary could decrease, while sedimentation in the Snake River projects would decrease. Minor increases in sedimentation near shore would occur at John Day, due to a slight increase in shoreline erosion.

SOS PA: Preferred Alternative—Sedimentation from shoreline erosion and mass wasting would increase slightly at Dworshak, but would decrease slightly at Libby, Hungry Horse, Grand Coulee, and Brownlee. At John Day, a pulse of sedimentation would occur during the first few years following lowering of the pool level. Gradually, sedimentation from shoreline erosion and mass wasting would return to within historical ranges. Sedimentation at other run-of-river projects would remain within historical ranges.

Groundwater

SOS 1, Pre-ESA Operation—Historical patterns of groundwater fluctuations would continue with future operation under SOS 1a and SOS 1b. The water table near the storage reservoirs generally fluctuates greatly during the year as a result of fluctuations in reservoir elevations, with the degree of effect decreasing with distance away from the shoreline. The magnitude of seasonal fluctuations would differ among the storage reservoirs; pool level fluctuations are relatively minor at Lake Pend Oreille, for example, but are much greater at Dworshak or Hungry Horse. Very little fluctuation in water tables near run-of-river projects occurs with normal operations. Historical operations may have decreased the yields of some groundwater wells near the storage reservoirs on a seasonal basis. This condition would continue under SOS 1a or 1b.

SOS 2, Current Operations—Groundwater fluctuations under SOS 2 would follow patterns generally similar to those under historical operating conditions. There would be a slightly greater fluctuation in groundwater levels at Libby and Brownlee during the spring and summer. The water table near the lower Snake River reservoirs would drop by up to 5 feet (1.5 m) from its normal spring and summer elevation. This effect would only occur very close to the reservoirs, and would not be noticeable in groundwater wells. Similar conditions would occur at John Day, but the decrease in elevation would be 5.5 feet (1.7 m) or less.

SOS 4, Stable Storage Project Operation—Water table fluctuations around Libby and Hungry Horse under SOS 4 would decrease significantly compared to historical conditions. A slight decrease would occur at Albeni Falls, Grand Coulee, and Dworshak. Unconfined aquifers near other reservoirs would experience fluctuations similar to those under current or historical operations.

SOS 5, Natural River Operation—The 1992 drawdown test of Lower Granite decreased the water table level up to 0.5 mile (0.80 km) from the reservoir. A similar pattern of groundwater conditions would occur under this alternative. However, the effects of SOS 5 would be greater in magnitude, extent, and duration. The natural river operation would lower the water levels in the reservoirs by approximately 100 feet (30.5 m), while the 1992 test involved a drawdown of up to approximately 40 feet (12.2 m). Therefore, SOS 5 would lower the water table much more than did the 1992 drawdown test. The greater water table reduction would translate into a wider zone of effect around each

reservoir, probably extending up to 1 mile (1.6 km) away from the reservoirs. The groundwater effects of the 1992 drawdown test were also limited to a 1-month period, while SOS 5b would affect water tables for 5 or 6 months each year, and permanently under SOS 5c.

The natural river operation under SOS 5b would seasonally affect shallow groundwater wells within the zone of water table reduction. Most of the affected wells would be in the Lewiston-Clarkston area or near Ice Harbor east of Pasco. Some wells might temporarily go dry, and alternate sources of water might have to be obtained. The yield from other wells might be reduced.

Under SOS 5c, water tables near the lower Snake reservoirs would decrease dramatically and approach pre-project levels within the first year. Some wells would go dry and others would experience decreased yield.

Storage projects would experience only slight changes in water table fluctuation, relative to historical conditions, under SOS 5. The prescribed operation for these projects is similar to that for SOS 1a, and differences in respective pool levels between SOS 1 and SOS 5 would generally be 10 feet (3 m) or less.

Under both options, some wells along the John Day reservoir could be affected, experiencing decreased yield. The City of Boardman Ranney well would not be affected, however, due to the limitations of its pump capacity (CH2M HILL, 1992).

SOS 6, Fixed Drawdown—Groundwater levels would drop in the aquifers hydraulically connected to the lower Snake River reservoirs under SOS 6. Effects on groundwater would be similar to those described for SOS 5, but would be significantly less in magnitude and extent. The depth of drawdown under SOS 6 would only be one-third as much as under SOS 5. Consequently, the water table decline would be much less under SOS 6 and would not extend as far from the reservoirs. Nevertheless, wells within the groundwater impact zone would be significantly affected. Again, effects on wells would be concentrated near Lewiston-Clarkston and near the western end of the Ice Harbor pool (Lake Sacajawea). Because of its greater seasonal duration, SOS 6b would lower the water table and affect wells. Under SOS 6d, these effects would be limited to groundwater levels near Lower Granite only, and to wells near the Lewiston-Clarkston area. Some wells near Lake Umatilla could be affected by the decrease in pool level to MOP.

Groundwater effects at the storage projects under SOS 6 would be essentially the same as those reported previously.

SOS 9, Settlement Discussion Alternatives—Groundwater fluctuations near reservoirs would change significantly on some reservoirs, depending on the option.

Under all three options, groundwater fluctuations at Grand Coulee would decrease very slightly, and water table elevations would be slightly lower near the reservoir during the summer.

Under SOS 9a, groundwater fluctuations would increase at Dworshak, while under 9b and 9c, they would decrease.

At Brownlee, fluctuations would be similar to those under current operations for all three options, except that there would be an additional fluctuation caused by the extra draft/refill cycle.

On the four lower Snake River projects, options 9a and 9c would cause significant groundwater fluctuations near the reservoirs, as under SOS 6b. Wells in the Lewiston/Clarkston area within 0.5 mile of the reservoir shoreline would be most affected, and the water table near the shoreline would drop. Some wells might go dry, and others might experience a decreased yield. The effects would be somewhat more extensive under 9c than under 9a because the drawdown level is lower.

The water table near Lake Umatilla would be affected slightly by the 9 foot (2.7 m) drop in pool level under options 9a and 9c. The effects

would be similar to those under options 6b and 6d, except that the water table would be low during April through August. Although the Ranney well in Boardman would not be affected (CH2M HILL, 1992), other wells near Lake Umatilla could experience decreased yield.

SOS PA: Preferred Alternative—The only significant changes in groundwater fluctuations from current operations would occur at Libby, Hungry Horse, Dworshak, and John Day. Due to decreased pool level fluctuations, groundwater in unconfined aquifers connected hydraulically to the reservoir would experience a decrease in annual fluctuations compared to current conditions at both Libby and Hungry Horse. In addition, the higher average annual pool level elevation at Hungry Horse would mean a higher near-reservoir water table.

At John Day, numerous wells would be affected by permanent lowering of the pool elevation to 257 feet (78.3 m). Wells developed in the Pasco Gravels aquifer could be directly affected, losing yield or going dry. Increases in pumping costs could occur.

4.2.2 Water Quality

Columbia River system operations can influence water quality by regulating streamflows and pool elevations. The quantity of flow is regulated throughout the basin—from the headwaters downstream to the mouth. Regulation at the dams causes the flow to be either stored in, withdrawn from, or passed directly through the pools. Pool elevations fluctuate in response to releases at the dams and to natural inflows. Flow and elevation are critical factors in controlling water volume and velocity within reservoirs. The volume of water spilled and the volume and velocity in the reservoirs influence the three significant water quality issues analyzed in the SOR: water temperature, dissolved gases, and sediment transport.

The influences of flow and elevation on these three main issues are described first, followed by identification of the potential effects of specific alternatives. More detailed information can be found in Appendix M, Water Quality. The effects are compared to a baseline condition. SOS 2c is used to represent this condition for evaluation of water temperature and dissolved gases.

Two of the three main water quality parameters could be analyzed in a highly quantitative manner because of the large amount of monitoring data available on them. Total dissolved gases and water temperatures are monitored in real-time at the dams. Sediment data were collected primarily during the 1992 Lower Granite Dam Drawdown test. This limited set of data provided the basis for the sediment transport analysis. Less data were available for all other water quality parameters, so only three were selected for quantitative analysis. Ammonia, lead, and DDT were selected to represent nutrient, metal, and organic pollutants known to exist in the river system. The lesser amount of data available on these water quality parameters resulted in a more qualitative evaluation of their effects.

Water Quality Impact Issues

Exceedance Threshold Levels

The SOR Water Quality Work Group selected value measures for the analysis and threshold levels for the value measures. The thresholds are not necessarily the current water quality standards. The group then predicted the number of days that the threshold would be exceeded for each SOS.

The value measure for water temperature is the predicted number of days exceeding 63°F (17°C). This temperature is below the current regulatory standard of 68°F (20°C) on the Columbia River. The value measure for dissolved gas is the predicted number of days exceeding 110-, 120-, and 130-percent saturation of total dissolved gases. The current regulatory standard for the Columbia River is 110 percent. Fishery interests have requested the regulating agencies consider increasing the 110-percent standard. Therefore, 120- and 130-percent thresholds were also evaluated. The value

measure for sediment is the predicted number of days exceeding a suspended silt concentration of 25 mg/l. There is no regulatory standard for suspended silt. Turbidity is closely related to silt, however, and there is a turbidity standard. However, this standard is based on increases of 5 Nephelometric Turbidity Units (NTU, see Glossary), or 5 percent, above ambient conditions which are not constant. The suspended silt threshold was selected on the basis of protection for fish.

Influence of Streamflow and Pool Elevation

Streamflow is the volume of water that passes a point during a specific period of time. Dilution, gas entrainment, flow velocity, and scour are partially functions of streamflow. The concentration of a substance in a water body will be diluted when mixed with streamflows having a lower concentration. The same holds true for mixing water of different temperatures.

Gas entrainment is the process that mixes gas from the atmosphere into the water. Gas entrainment generally increases with streamflow volume, particularly if high streamflows require spill at dams. Tailwaters at a dam become supersaturated when high volumes of water plunge down a spillway.

Sediment transport is the process in which inorganic clay, silt, and sand soil particles, and organic phytoplankton (algae) particles and other organic detritus are swept away or deposited in the water column (flow). Water velocity (speed) and depth influence sediment transport, and are a function of streamflow.

Pool elevation relates to the volume of water stored in the pool, the pool surface area, the velocity and residence time of flow through the pool, and exposed bank area. Each of these attributes affects water temperature, total dissolved gas saturation, and sediment transport.

Water Temperature

The major effect of the dams on the Columbia River on water temperature has been to delay the occurrence of maximum temperatures in late summer, and to delay early autumn cooling. Regulating streamflow alters the timing of river heating and cooling relative to the natural patterns normal to the life history of fish.

Air and water attempt to exchange heat to reach an equilibrium temperature. Radiant heat from the sun warms both the atmosphere and water bodies, but water heats up and cools down more slowly than air. Air temperature, wind, humidity, and solar radiation determine the equilibrium temperature. Water temperatures generally change towards ambient air temperatures. Also, water heating and cooling rates increase and decrease indirectly with the volume of water. High streamflows will tend to remain close to mean water temperatures, whereas low streamflows will vary more. In addition, the velocity of flow generally increases directly with streamflow. The higher the velocity, the less time water in the system is exposed to the air, and the less time there is for heating or cooling. Higher flow velocities are typically shallower in depth and lower in volume, however, thus counteracting the temperature attenuation effect of higher streamflows. The SOR water temperature model accounted for all of these temperature relationships.

Pool elevation adjustments can be used to control water temperatures, but the relationships are complex and differ between storage and run-of-river projects. Storage pools are deep and stratify thermally during the summer. Run-of-river pools are shallow and have a more uniform temperature distribution. In either case, more water is stored at higher pool elevations, and water temperature is more resistant to rising air temperatures. Resulting increases in pool surface areas can offset this temperature attenuation effect by increasing the heat exchange with the atmosphere. Lower elevations can reduce this exchange and reduce residence and heating times in the pool.

Because storage reservoirs are usually thermally stratified during the summer, their

deep waters are much cooler than inflows during this time. Discharges from storage projects (with multi-level intakes) can be adjusted to a desired temperature. Projects that do not have selective withdrawal facilities typically are restricted to discharges from deep storage. In some cases, this results in discharging excessively cool water during the summer, while in other cases, cool discharges are desired to reduce downstream water temperatures.

Dissolved Gas

Gas saturation is mainly caused by spill—water sent over the spillways of a dam. Total dissolved gas saturation is directly related to the amount of spill. Dissipation of gases is incomplete between projects with little or no lateral inflow. Forced spill is always a potential, especially during high run-off years, since projects have fixed hydraulic capacities. When there is more water in the river than the power system can use, forced spill cannot be easily controlled. Voluntary spill is done mainly for fish passage, and usually happens during the spring and summer at selected projects on the juvenile fish outmigration routes.

Everything else being equal, the potential for gas entrainment in the tailwater increases with the vertical distance that water falls over a dam spillway. Spilling water mixes with air, then plunges into the tailwater stilling basin. Spilling at high heads allows for deeper plunging and more gas entrainment, but the volume of spill has a greater influence on dissolved gas saturation than the vertical distance of the fall.

Sediment Transport

Increased streamflows result in increased sediment transport and turbidity. The friction forces created by water flowing across river beds mobilizes of the bed sediments. This scouring phenomenon is attributable to flow velocity and depth, both of which generally increase directly with streamflow. Scoured sediments entering the water column either settle out or remain in suspension and are transported farther downstream. Spring runoff generates the greatest sediment transport and turbidity levels during the year. Tributary sediment inflows generally settle out near their confluence with the main river, forming deltas that are periodically scoured away. Coarser sediments entering a reservoir typically deposit at the head of pools. The finer sediments, such as silt and clay, are deposited near or transported past the dams. Higher streamflows will carry sand downstream. Pollutants entering the mainstem can adsorb to sediments, mostly to silt and clay, and be transported and accumulate with them.

Pool elevation influences the amount of bank area exposed to erosive elements, the length of the pool, and the volume of sediment accumulation. Bank erosion is accelerated when pool elevations fluctuate, as described in Section 4.2.1. Sediments delivered from local and upstream inflows settle out in a pool. Higher pool elevations, a longer pool, and more local tributaries and adjacent land area contribute to greater sediment accumulation in the pool. Sediments slowly fill in the pool over time. If the pool elevation were lowered significantly, the accumulated sediments could be scoured and transported downstream. The distance of transport for suspended sediments would depend on the final drawdown pool elevation, the hydraulics of the stream, and the amount of flow.

General Effects of Key Operations Measures

The seven strategies include varying mixes of flow augmentation, stable storage, and drawdown operations. The effects of these river regulation schemes on water temperature, dissolved gases, and sediment transport are discussed at a conceptual level in the following text. These concepts are then applied in the subsequent assessment of the model results for the specific SOS alternatives.

Flow Augmentation

Flow augmentation causes more streamflow to be discharged through the system at selected times. Therefore, forced spill and increased gas

supersaturation would be more likely with flow augmentation than without. Flow augmentation would also lead to higher volumes of spill at projects operating for voluntary spill, unless the spill percentages were reduced.

Water temperature control capability in the Columbia River Basin is limited. There are few reservoirs that are large and deep enough to provide adequate storage of cold water. Currently, flow augmentation water is stored over the winter in Lake Roosevelt, Arrow Lakes, and Brownlee and Dworshak Reservoirs. Augmentation releases in the summer should work, in a limited way, to decrease temperature immediately downstream. Flow augmentation should help support water temperature control objectives, because it entails storage of cool water in the spring and later release of that water in the summer.

The temperature of the flows released from augmentation sources is critical to the degree of temperature control. Grand Coulee, Hungry Horse, and Brownlee do not currently have selective withdrawal capabilities. Libby has selective withdrawal facilities but is too far upstream to be effective in reducing temperature to benefit anadromous fish. Dworshak's storage is too limited in relation to Snake River streamflows to have a large effect on river temperature. Flow augmentation water from the middle and upper Snake Rivers would probably be at equilibrium temperature by the time it reaches Brownlee Reservoir and would not decrease receiving water temperatures significantly. The SOR water temperature model predicted that any water released from Brownlee would reach equilibrium water temperature before it flowed out of Hells Canyon.

Stable Storage Operations

Stable pool operations would likely affect sediment transport, gas saturation, and water temperature. Stable pools would mean there would be little change in storage, and discharges would be similar to inflows at most times of the year.

Higher average pool elevations would result from stable storage operations. This would generally reduce sediment transport. More bank area is exposed to surface erosive forces at lower pool elevations causing greater delivery of sediment into the pool. Little downstream sediment transport would occur because most of the sediments from the eroded banks should settle out and deposit in the slow flowing pools.

Stable storage operations would result in higher discharges from storage projects during the spring runoff. This could contribute to a higher spill volume with an increased gas saturation. High pool elevations could also increase the potential for greater gas saturation because of the greater head at the dam, but this is a much lesser factor than spill volume.

Streamflows would be passed more directly through pools with a stable storage operation, resulting in little effect on water temperature. This operation would provide little or no summertime water temperature reduction because there would be no cool water releases from storage projects in summer.

Drawdown

Drawdown operations would increase flow velocity through affected pools, but would not add streamflow to the system. Drawdown effects would be greatest on sediment transport, but should provide some temperature and total dissolved gas saturation reduction.

Drawdown operations could reduce water heating rates on the Snake River due to increased flow velocity. Refilling the lower Snake River projects with cool Dworshak releases could have an additional cooling effect. As in a stable storage operation, the lower pool elevations would account for shorter heating periods. This effect could be offset by accelerated heating from low streamflows.

A drawdown operation should not increase gas supersaturation in the Snake River over current conditions. Snake River drawdowns would begin in late winter or early spring,

before peak runoff, so it should be possible to draft the pools through the turbines. This would avoid spill and ensuing gas supersaturation.

Drawdown would be the only type of operation that would significantly increase sediment transport. Flow augmentation and stable pool operations should not induce nearly as much scouring as drawdown operations. Generally, the greater the drawdown in elevation and in duration, the greater the sediment transport. The Snake River and the Columbia River immediately downstream of the confluence (McNary pool) should be the only reaches in the system affected by these operations.

The redistribution of pollutants that have accumulated in the lower Snake River pools is an issue associated with sediment transport. The Corps has detected nutrients, pesticides, heavy metals, and dioxins in the Snake River pool bed sediments. Point and non-point sources of these pollutants are likely to include industrial discharges, sewage treatment plants, and agricultural, urban and mining activities. Most of these pollutants remain adsorbed to sediments, but some could become dissolved in the water column when disturbed by drawdown. The duration of sediment suspension increases the extent of downstream transport and desorption.

Effects of Alternatives

The following discussion summarizes the results of the model analysis of the SOS alternatives. The results are presented in value measures termed exceedance days. These are the predicted number of days per year that an operation would raise the water temperature, percentage gas saturation, or silt concentration above the specified thresholds. Appendix M, Water Quality, describes the analysis methods in full and contains the entire set of modeling results. Only the outstanding differences in exceedances, defined as a difference of 7 or more days, are included in this discussion.

Water Temperature

The greatest impact on water temperature is expected in the lower Snake River (Table 4-5). Releases of cool water from Dworshak Reservoir could reduce water temperatures throughout the lower Snake River reach. Releases from Grand Coulee and Brownlee Dams could reduce water temperature even more in the mid-Columbia and mid-Snake during years when a large volume of cool water is stored behind these dams. Elevated temperatures are most frequent during low-flow. During low-flow years, releases from Brownlee from flow augmentation would counteract the cooling effect of Dworshak releases on the lower Snake River water temperature.

SOS 1, Pre-ESA Operation Current—Water temperatures predicted for SOS 1 operations are not significantly different from the current (SOS 2c) operations. Compared to the other SOSs, SOSs 1a and 1b would be two of the best water temperature reducing alternatives, but only during high-flow years.

The only major difference between SOSs 1a and 1b involved Little Goose and Ice Harbor. Under high-flow conditions, SOS 1a had 11 more exceedance days than SOS 1b at Little Goose. Under low-flow conditions, SOS 1a had 28 fewer days than SOS 1b at Ice Harbor. By itself, the difference between 10 and 28 days exceeding 63°F (17.2°C) for 13 stations may be significant for one form of aquatic life, but not another.

SOS 2 Current Operations—Both SOS 2c and SOS 2d would create water temperatures near the average for all SOSs. The number of days exceeding 17.2°C at The Dalles for SOS 2c is among the best of all SOSs, but the range of exceedance from the best to the worst SOS is only 4 days. In the mid-Columbia (represented by Priest Rapids), the SOS 2 alternatives would be near the lower end of the exceedance day range for all SOSs. The opposite would occur in the lower Snake (represented by Lower

Table 4-5. Temperature model simulation results, number of days exceeding 63°F[a/]

	Low-1929			Average-1962			High-1974			5-year Average		
SOS	LG	PR	TD	LG	PR	TD	LG	PR	TD	LG	PR	TD
1a	79	79	93	71	71	93	79	66	83	74	71	89
1b	66	75	93	70	71	93	79	63	83	69	70	89
2c	67	67	90	81	70	92	82	67	83	78	70	88
2d	82	77	94	70	74	94	84	70	86	79	74	91
4c	74	70	90	74	70	89	80	64	83	75	68	88
5b	58	82	90	58	79	90	65	58	83	61	72	88
5c	71	85	93	73	83	94	76	68	88	74	77	92
6b	62	72	91	70	70	93	81	67	83	69	70	89
6d	61	72	90	69	70	92	80	67	83	68	70	88
9a	79	76	93	82	73	94	86	72	88	82	74	92
9b	84	75	93	85	72	93	84	71	87	84	74	91
9c	81	80	95	81	73	93	86	71	88	82	76	92
PA	69	77	92	74	71	92	78	67	87	76	73	91

LG = Lower Granite Dam
PR = Priest Rapids Dam
TD = The Dalles Dam
5-year Average (1929, 1959, 1962, 1973, 1974)
a/ 17.2°C

Granite). Here, the SOS 2 alternatives would be near the upper end of the water temperature exceedance day range for all SOSs.

SOS 4, Stable Storage Project Operation—The only significant departures from baseline simulated temperatures were found in the mid-Columbia and lower Snake. Exceedance days computed for SOS 4 were greater than for SOS 2 under low-flow conditions in these reaches.

SOS 5, Natural River Operation—Overall, SOS 5b would exceed of the 17.2°C water temperature threshold the least of all alternative. It would have fewer exceedances in the lower Snake and throughout the entire Columbia River than SOSs 2c and 5c. Temperatures in the upper and lower Columbia River would exceed the threshold more often for SOS 5c than SOS 2c. Model simulation results indicated that temperature exceedances for specific high- and low-flow years were lowest for SOS 5b. Temperatures under SOS 5b would not be reduced as much for the lowest flows.

SOS 6, Fixed Drawdown—For extremely low-flow years, SOS 6b and 6d would have the least system-wide temperature threshold exceedances. However, compared to SOS 2c, the temperature reductions are insignificant.

SOS 9, Settlement Discussion Alternatives—These alternatives have the most severe effects on water temperature. Exceedances are high under all conditions in every major reach of the system. The difference in exceedance between the No Action Alternative (SOS 2c) and SOS 9 is significant.

SOS PA, Preferred Alternative—Overall, water temperatures are not significantly different under SOS PA compared to SOS 2c. However, for individual low- and average-flow years, exceedances were among the worst under SOS PA.

Dissolved Gas

Table 4-6 presents the model results for gas supersaturation. For clarity of presentation, Table 4-6 shows gas supersaturation simulation results for only one dam on each of the three main trunks of the Columbia River Basin. The results at other dams are described in the text where differences in results are significant.

SOS 1, Pre-ESA Operation—The results for the two SOS 1 options are not significantly different at the 130- and 120-percent gas supersaturation exceedance levels. Comparisons of the predicted 110-percent gas saturation level exceedance between SOS 1a and the No Action Alternative indicated that the No Action Alternative would reduce gas supersaturation in the mid-Columbia reach, but increase gas levels in the lower Snake and lower Columbia Rivers. The computed exceedance days for SOS 1a in the mid-Columbia reach were 11 fewer than the No Action Alternative because of generally less spill in May and June at the mid-Columbia dams under SOS 1a. The higher exceedance differences were predicted for the lower Snake River. The computed exceedance days for SOS 1a in were 22 to 31 more than the no action alternative at Ice Harbor.

SOS 2 Current Operations—Neither SOS 2c nor SOS 2d would create extraordinary gas supersaturation exceedances of the 110 percent standard relative to all the other SOSs. Relative to each other, SOS 2d would have significantly less exceedances than SOS 2c (No Action Alternative). On the lower Snake (Ice Harbor), SOS 2d would be in the low end of the exceedance range for all SOSs, and SOS 2c would be mid-range. On the mid-Columbia (Priest Rapids), SOS 2d would be mid-range, and SOS 2c near the high end. On the lower Columbia (The Dalles), both would be mid- to low range.

SOS 4, Stable Storage Project Operation—The overall ranking of SOS 4c is among the best for gas supersaturation for medium flow years. However, the 6-year average exceedance of 110 percent saturation at Priest Rapids is the highest of all SOSs. Nevertheless, compared to the No Action Alternative, the mid-Columbia reach would not significantly increase exceedances over current operations. On the lower Snake and Columbia, SOS 4c exceedances would be slightly less than the No Action Alternative.

SOS 5, Natural River Operations—The model simulations show that dissolved gas exceedance levels computed for current operations would significantly decrease in the lower Snake River as a result of natural river operation. Additionally, the overall rankings of SOSs 5b and 5c are the best of all alternatives. SOS 5c would have significantly less exceedances than SOS 5b on the lower and mid-Columbia during low and average flow years. However, during high flow years, SOS 5b would have the least exceedance on the lower Snake. On the Columbia during high flow, SOSs 5b and 5c would have typically high exceedances at Priest Rapids, but only SOS 5c would significantly reduce exceedances at The Dalles. The 6-year average exceedance for SOS 5c was the lowest of all the alternatives on the Columbia, and nearly equal to the lowest on the Snake. SOS 5b had the lowest 6-year average exceedance at Ice Harbor.

SOS 6, Fixed Drawdown—The simulations indicate that fixed drawdown of all lower Snake River projects should result in decreased gas supersaturation from Lower Monumental to John Day. The computed number of days exceeding the 110-percent level in the affected Snake River reach for SOS 6b ranged from 11 to 25 fewer than for the No Action Alternative for all flows. Predicted differences in the Columbia were insignificant.

SOS 6d had significantly higher exceedances at Ice Harbor than SOS 6b for all flows. The difference between SOS 6b and SOS 6d would be insignificant on the Columbia.

SOS 9, Settlement Discussion Alternatives—These alternatives are the worst for gas supersaturation from an overall and reach-specific perspective. The only reach

Table 4-6. Total dissolved gas model simulation results, number of days exceeding 110-percent saturation

	Low-1973			Average-1959			High-1974			6-year Average[1/]		
	IH	PR	TD	IH	PR	TD	IH	PR	TD	IH	PR	TD
1a	68	19	46	77	28	34	83	86	97	77	32	51
1b	67	21	44	77	32	36	83	85	100	75	33	50
2c	47	28	36	37	45	36	61	97	101	46	43	48
2d	23	14	13	18	54	49	23	79	78	21	33	33
4c	40	34	32	33	62	41	61	96	92	43	49	45
5b	2	27	23	2	43	25	1	94	83	2	42	32
5c	0	2	0	4	14	0	26	87	38	5	19	6
6b	22	27	30	20	43	32	50	94	97	27	42	42
6d	43	27	34	29	43	33	65	94	102	42	42	47
9a	49	27	132	32	61	131	82	90	127	65	38	130
9b	85	13	138	47	109	128	91	97	122	93	36	129
9c	49	12	134	65	31	106	58	82	102	60	28	117
PA	24	14	135	20	42	119	24	97	116	23	34	125

IH = Ice Harbor Dam forebay
PR = Priest Rapids Dam forebay
TD = The Dalles Dam forebay
1/ 6-year average based on 1938, 1959, 1962, 1973, 1974, and 1977 water conditions.

where these SOSs were not worst was the mid-Columbia (SOS 4c was worst). The worst 6-year average exceedance at The Dalles was from SOS 9a (82 days greater than the No Action Alternative). The worst 6-year average exceedance at Ice Harbor was from SOS 9b (91 days greater than the No Action Alternative). In the mid-Columbia, the 6-year average exceedance would be less than the No Action Alternative, but not by more than 15 days (SOS 9c). SOS 9c would have the least exceedance of all SOS 9 alternatives.

SOS PA, Preferred Alternative—This alternative is exceptionally poor for gas supersaturation in the lower Columbia as indicated by the predicted high exceedances at The Dalles. The 6-year average exceedance of 110 percent for SOS PA was only 5 days less than the worst alternative (SOS 9a), and 77 days more than the No Action Alternative. In the mid-Columbia and lower Snake reaches, the exceedance for SOS PA was in the mid- to low range for all SOSs.

Sediment

Sediment effects were evaluated for the No Action Alternative and for all the drawdown options in SOSs 5 and 6. The SOS used as the No Action Alternative for the full-scale sediment analysis was SOS 2c without upper Snake River flow augmentation. In the Draft EIS, this alternative was SOS 2a, but it is referred to as the No Action Alternative in this section. The SOR Water Quality Work Group concluded that

the results from simulations of current operations adequately estimate the sediment transport during all non-drawdown SOSs (1, 2, 9b, and PA) SOSs 9a and 9c were not simulated in the enhanced HEC-5Q modeling, but its sediment transport should be similar to SOS 6, because SOS 9 drawdown depths and durations are about the same as in SOS 6. Table 4-7 shows the exceedances of the 25 mg/l silt concentration (about 18 NTUs) threshold for these alternatives as annual percentages. The maximum exceedance for the first simulation year is shown to demonstrate the predicted worst-case, short-term effects. The flow condition corresponding to this case is also shown here. The 15-year average exceedance computed from the entire 5 years of simulations for low, average, and high flow conditions was used to show persistence of sediment transport after the initial scouring expected during the first year. Long-term cumulative exceedances are also indicated in the 15-year average columns of this table.

Silt transportation from the Snake River to Lake Umatilla on the Columbia River is not expected to increase due to the proposed drawdown SOSs. The simulated silt concentrations for Lower Granite, Ice Harbor, Priest Rapids, and John Day represent the sediment transport in each of the major trunks of the Columbia River in the SOR study area. Table 4-4 shows zero exceedance in the lower and mid-Columbia trunks, and exceedances of over 30 percent in the lower Snake. The models indicate there would be transport of sediment from the lower Snake River during drawdown, and deposition in the Columbia River near the confluence.

SOS 2, Current Operations—The No Action Alternative represents baseline conditions and effects from SOSs 5, 6, and 9. The exceedance of the 25 mg/l silt level for the No Action Alternative is zero percent. This essentially means that significant sediment transport does not currently occur, nor should it occur with operations other than drawdown.

SOS 5, Natural River Operation—The natural river operation would generate the most lower Snake River sediment transport of all the SOS alternatives. The computed exceedance at Lower Granite and Ice Harbor under SOS 5b was 36 percent. High flows should create the maximum silt concentrations in the lower Snake River during the initial drawdown under SOS 5. The percent exceedance for SOS 5b should drop a third of the first year's value to 25 percent in the long term. The remaining sediment transport is likely to come from continued bank erosion and scour of the channel bed. The longer 12-month drawdown (SOS 5c) would transport more silt than the 4.5-month drawdown.

SOS 6, Fixed Drawdown—Model results indicate that fixed drawdown on all the lower Snake River dams should generate one-half to two-thirds of the sediment transport level of SOS 5b during initial drawdown. The decrease is expected at Ice Harbor because sediment scoured from upstream is deposited and scoured again in Lake Sacajawea. Simulations of the 4.5-month drawdown did not produce different exceedances. Most of the sediments would still likely settle out during the drawdown period. The computed long-term exceedances for both lower Snake River locations were down to 3 to 5 percent. The remaining sediment transport would likely come from lateral inflows from bank erosion, and not from continued channel scouring.

The modeling also showed that no transport of silt exceeding 25 mg/l would be expected at Ice Harbor if only Lower Granite were drawn down (SOS 6d). Any silt scoured from the bed of Lower Granite pool should be deposited upstream of Ice Harbor Dam.

SOS 9, Settlement Discussion Alternatives—Of the three SOS 9 alternatives, only SOS 9b did not involve a drawdown of any lower Snake reservoir. Therefore, SOS 9b sediment transport impacts would be insignificant as in the No Action Alternative. SOS 9a and SOS 9c both involve a 4.5 month drawdown of the four lower Snake reservoirs. These SOSs would create sediment transport impacts similar to SOS 6b. SOS 9c sediment

Table 4-7. Sediment simulation results[a/]

SOS	Lower Granite 15-Year Average	Lower Granite 1st-Year Maximum	Lower Granite Flow	Ice Harbor 15-Year Average	Ice Harbor 1st-Year Maximum	Ice Harbor Flow
2a	0	0	b/	0	0	b/
5a	21	29	High	21	29	High
5b	25	36	High	23	36	High
6a	5	18	High	5	24	High
6b	5	17	High	3	21	High
6d	5	17	High	0	0	b/
9a	5	17	High	3	21	High
9b	0	0	b/	0	0	b/
9c	5	17	High	3	21	High
PA	0	0	b/	0	0	b/

SOS	Priest Rapids 15-Year Average	Priest Rapids 1st-Year Maximum	Priest Rapids Flow	John Day 15-Year Average	John Day 1st-Year Maximum	John Day Flow
2a	0	0	b/	0	0	b/
5a	0	0	b/	0	0	b/
5b	0	0	b/	0	0	b/
6a	0	0	b/	0	0	b/
6b	0	0	b/	0	0	b/
6d	0	0	b/	0	0	b/
9a	0	0	b/	0	0	b/
9b	0	0	b/	0	0	b/
9c	0	0	b/	0	0	b/
PA	0	0	b/	0	0	b/

a/ Measured by long- and short-term percentage exceedance of 25 mg/l silt concentration threshold.
b/ Simulated silt concentrations did not exceed 25 mg/l under any of the flow conditions modeled.

transport would be closer to SOS 6b because both do not involve flow augmentation from the upper Snake River.

SOS 9a includes some flow augmentation during the drawdown period so flow velocity through the lower Snake reservoirs would be greater than SOS 6b and SOS 9c. However, the relative increase in flow velocity due to flow augmentation would cause an insignificant increase in reservoir bed sediment scouring. Therefore, SOS 6b sediment transport adequately represents SOS 9a.

SOS PA Preferred Alternative—SOS PA sediment transport would be the same as the No Action Alternative because neither SOS involves reservoir drawdowns on the lower Snake.

Other Water Quality Parameters

The full-scale water quality model was used to simulate the transport of lead, DDT, and ammonia in the mainstem Columbia and lower Snake Rivers. As in the analysis of sediment transport, the concentrations of these parameters were compared using exceedance thresholds that were selected to determine differences between the drawdown alternatives and other operations. The results indicate that only DDT and lead exceedances would vary between SOS 2 and drawdown operations.

SOS alternatives that would result in marked changes in water flow and circulation patterns could indirectly affect a variety of other water quality parameters by modifying the mixing of point-source discharges to the river system. The potential for this type of impact is acknowledged in the following discussion, but such site-specific effects could not be modeled in the full-scale analysis.

Exceedance Thresholds—The lead, DDT, and ammonia thresholds were chosen to show differences between SOSs. Like the thresholds selected for water temperature and sediment transport, these also do not necessarily coincide with water quality standards. The exceedance threshold is 15 micrograms per liter (μg/l) for lead, 0.0004 μg/l for DDT, and 0.1 mg/l for ammonia. They are water column total concentrations. Generally, the thresholds are below water quality standards.

The standards for lead and ammonia are dependent on other factors that vary within the system and over time. The U.S. Environmental Protection Agency (EPA) standard for lead (based an average hardness in the Columbia River of 57 mg/l) is 25 μg/l, and for ammonia (based on an average water temperature of 59°F [15°C], and a pH of 8.0) is 0.75 mg/l NH_3+NH_4. The model results show no exceedance of the ammonia standard. The only variation between the computed exceedances of SOS 2 and drawdown operations was shown for SOS 5b. This variation was relatively minor, so details of ammonia exceedances will not be discussed.

The standard for total DDT in the water column is 0.001 μg/l. The DDT threshold for the analysis is actually below current detection limits. The model showed that this DDT standard was not exceeded, so the analysis threshold was lowered to show the differences between SOSs. The DDT water column total concentrations computed by the model are most likely attributable to desorption of pollutants that have accumulated in the Snake River bottom sediments, which would get scoured into the water column during drawdown operations. Only sediment data were available for DDT, so it was assumed that DDT was not detected in the water column. The model results verify this assumption.

Lead and DDT—The model results for lead and DDT show trends similar to those found for silt (see Figures 4-4 and 4-5). SOS 5b should generate the greatest lead and DDT exceedances of all the options. Again, no significant departure from SOS 2 is expected at the Columbia River locations—Priest Rapids and John Day Dams. The reduction in exceedance between SOS 5b and SOS 6a/b, and between Lower Granite and Ice Harbor Dams, is also similar to that for silt.

The similarity of exceedance patterns between silt, DDT, and lead in the lower Snake River is because when silt is eroded and transported, lead and DDT will also be transported. The lead and DDT that were measured in pond sediments in 1992 were input into the full-scale model. The model computed total lead and DDT water column concentrations using estimations of silt in transport and sediment chemical data on Snake River reservoir beds. The range of computed total lead and DDT concentrations at Lower Granite are 10 to 40 μg/l and 0.0002 to 0.0004 μg/l, respectively. At Ice Harbor, lead and DDT concentrations ranged from 6 to 40 μg/l and 0.0002 to 0.0009 μg/l, respectively.

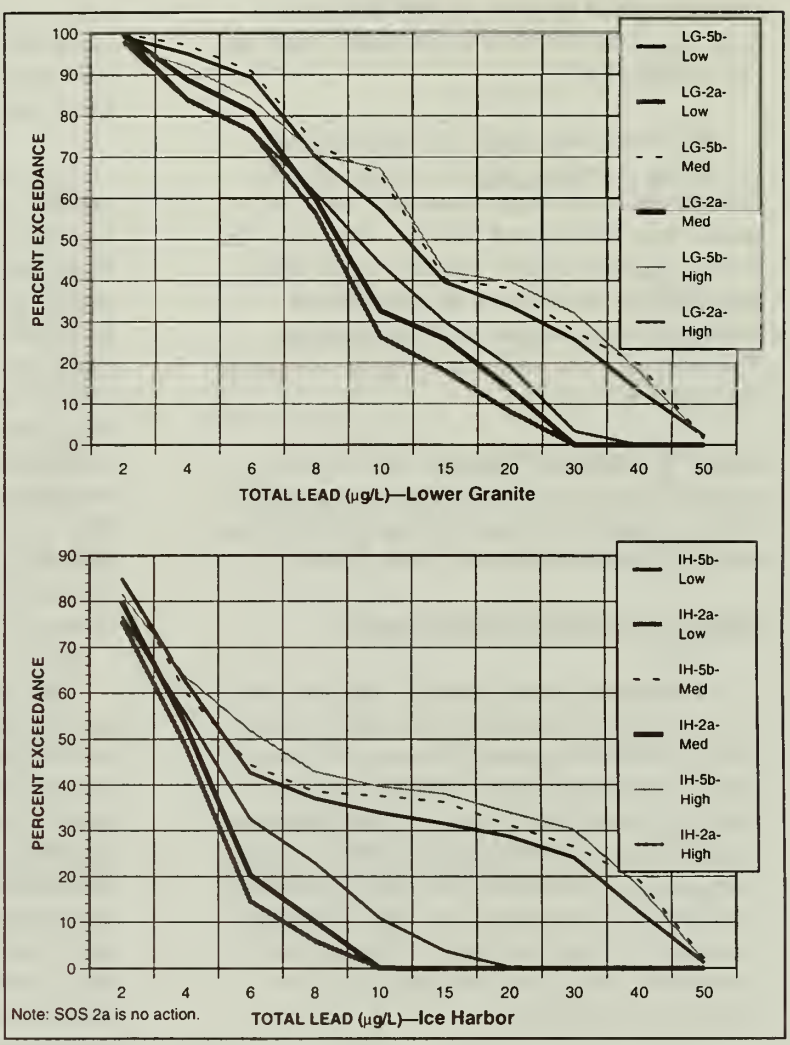


Figure 4-4. Simulated total lead exceedance curves for Lower Granite and Ice Harbor

The exceedance difference between SOS 2 and SOS 5b at Lower Granite Dam is better shown by exceedance curves. At an exceedance threshold of 25 μg/l lead, the model shows an exceedance increase of about 25 percent for SOS 5b over SOS 2. This result is closer to the silt trends expected at Lower Granite Dam. Figures 4-4 and 4-5 show lead and DDT exceedance curves for SOS 2a and SOS 5b generated from model simulations at Lower Granite and Ice Harbor Dams.

The trends in the computed exceedances indicate that lead and DDT accumulated in the lower Snake River sediments would be transported downstream with the sediments during drawdown. For the natural river operation, lead and DDT would deposit in the Columbia River just downstream of the confluence with the Snake River. For the SOS 6 options, the lead and DDT would deposit in the partially drawn down pools. The process of desorption of the contaminants from sediment particles could produce a sediment-cleansing effect, but it might also cause water quality standard exceedances in the water column. There may be impacts on sediments in upper Columbia storage reservoirs (e.g., Lake Roosevelt) as well.

Point Source Discharges—As noted in Section 2.1.2, a number of urban and industrial users discharge point-source effluents to the river system under NPDES permits. These

permits require that the discharges be diluted sufficiently that water quality standards for the spectrum of regulated parameters are not violated beyond a specified mixing zone. Any changes in water elevation, flow, or circulation patterns could influence the mixing and dilution of these discharges. Consequently, SOS alternatives that would markedly change flow and circulation patterns at specific locations could conceivably diminish the ability of dischargers to meet the terms of their NPDES permits. Determining the extent, frequency, and magnitude of this potential problem for the entire study area would require highly site-specific and detailed analysis that is beyond the scope of the SOR investigation. (Through prior studies and comment on the Draft EIS, the SOR agencies are aware that effluent discharge from the Potlatch Corporation mill in Lewiston could be affected by SOS alternatives that include drawdown of Lower Granite Reservoir. Potlatch has estimated that discharge modifications to accommodate drawdown would cost from $0.5 million to $1.0 million.) Monitoring measures incorporated as part of the SOS implementation should detect any operations effects on NPDES-permitted discharges, however. Any problems identified through monitoring could be addressed by ongoing short-term operational adjustments or in future revisions of the SOS.

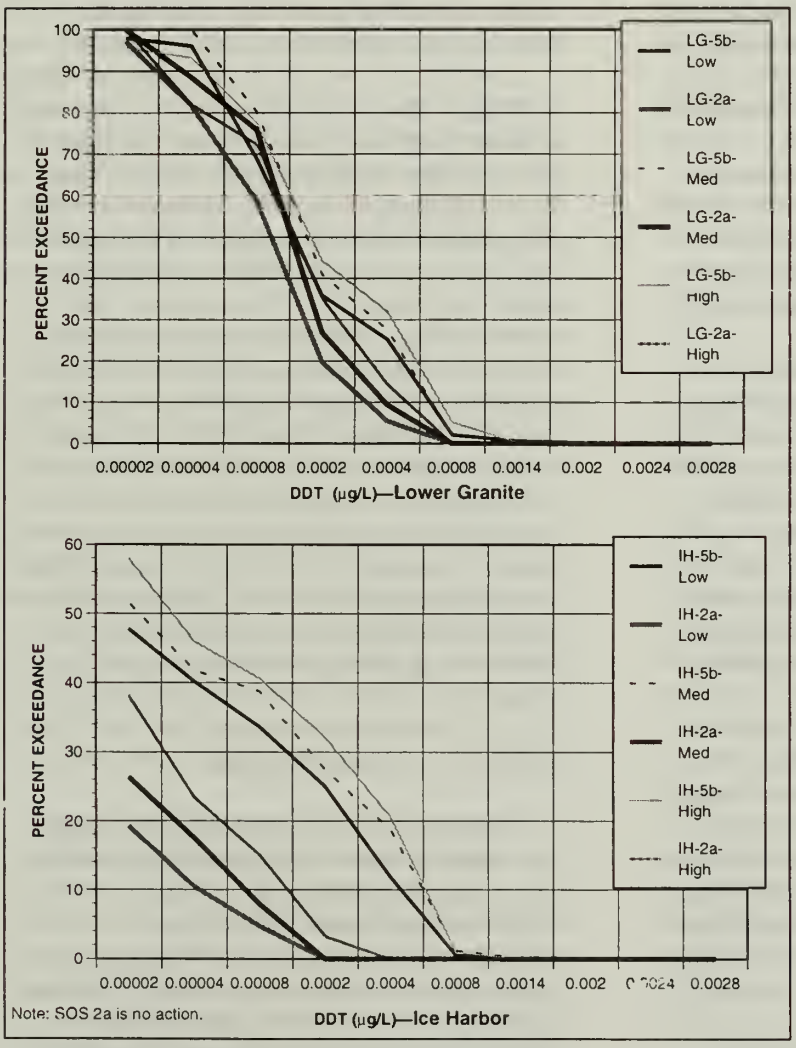


Figure 4-5. Simulated DDT exceedance curves for Lower Granite and Ice Harbor

4.2.3 Air Quality

The SOR assessment of air quality impacts focused primarily on dust blowing from exposed reservoir sediments. The following discussion of air quality issues and SOS alternatives has been summarized from Appendix B, Air Quality.

Air Quality Impact Issues

Although air quality is not a major resource issue for the SOR, scoping indicated that dust blowing from exposed reservoir shorelines was a concern for some people. The SOR agencies identified specific potential issues related to direct air quality impacts, including exceedances of air quality standards, nuisance effects of blowing dust, health effects from fine particulate matter and airborne chemicals attached to dust; and to indirect

air quality impacts associated with replacement power sources.

Direct Air Quality Impacts

Reservoir drafting exposes shoreline areas that are normally underwater to the drying action of the sun and wind. In the Columbia River system, most of these shoreline areas are covered with fine sediments, such as silt and clay. Dry lake sediments are typically crusted, limiting the potential for wind erosion. If the crust is disturbed, high speed winds (greater than 9 m/sec or 20 mph, the threshold velocity for generating wind-blown emissions) will begin to remove the finer surface particles. Later, a faster wind may remove the larger particles from the exposed surface. If the surface is disturbed again, additional material will become available for wind erosion. Particulate matter concentrations are dependent upon the area of sediment exposed and the weather conditions at the time of exposure. Clear, windy summer days typically provide the weather conditions most conducive to high levels of blowing dust.

Large suspended particles will quickly settle within a short distance of their origin. Finer particles will be carried greater distances. Impacts would occur primarily around reservoirs located in the drier portions of the Columbia River Basin, and would affect both local residents and recreational users of the projects. An estimated 40,000 people live within 1 mile (1.6 km) of the shorelines of the key reservoirs. Approximately 4.5 million people visit these shorelines each year for recreation.

AAQSs establish limits on pollution concentrations, frequencies, and exposure times for sources of air pollution other than point sources (such as industrial stacks). They include standards for toxic pollutants and for particulate matter less than 10 microns in diameter (PM_{10}) that can be inhaled into the lungs. Although air quality in the Columbia River Basin generally meets AAQSs, the most common types of entries on the nonattainment area list involve PM_{10}. Ambient PM_{10} and TSP monitoring is conducted throughout the Columbia River Basin. Most of the monitoring stations are located in known areas of air quality problems. Only a few monitoring stations are near SOR reservoirs. It is very difficult to distinguish between particulate matter originating from exposed lake sediments and other background particulate matter.

Effects people could experience from windblown dust include poor visibility; irritation of the eyes, nose, and mouth; and accumulation of dust on objects. As a result, blowing dust may interfere with recreational activities and cause discomfort to local residents. Residents of Rexford, Montana, for example, have complained to the Corps about dust blowing from exposed shorelines at Lake Koocanusa.

PM_{10} is the portion of particulate matter that is small enough to bypass the nose and upper airways, enter the lungs, and be absorbed into the bloodstream (EPA, 1986). Adverse health effects can occur when air levels of PM_{10} are high. These effects can include worsening of asthma and bronchitis. They are more likely to occur in young children, older adults, smokers, and people with underlying lung problems, such as asthma or emphysema (Lambert et al., 1992; Pope, 1991; Dockery et al., 1989). In addition to health effects from the PM_{10}, health problems from inhalation of chemicals that are bound to the particulate matter could occur if the chemical concentrations in the air are high enough. These potential health problems could include cancer or non-cancer effects (such as nerve damage) and would vary depending on which chemical is inhaled.

Indirect Air Quality Impacts

Changes in river operations could decrease the amount of hydroelectric power generated, at least on a seasonal basis, and require replacement generation from thermal powerplants (such as gas- or coal-fired plants). Additional thermal generation would increase air pollution around the affected thermal plants. Chemical emissions from these powerplants could be a problem if they cause air quality standards to be exceeded or if levels are high

enough to cause health problems. Since the powerplants that serve the region are located in Washington, Oregon, and California, these indirect air quality impacts could occur locally or in other regions.

Effects of Alternatives

Fugitive Dust Emissions

Lake sediments that are exposed by drafting will be subject to drying and wind erosion. Factors that contribute to the generation of windblown dust are wind speed, the amount of exposed shoreline, the amount of fine material in the surface of the sediments, the moisture content of the sediments, the frequency of winds strong enough to begin to move the sediments, the frequency with which the surface is disturbed (thus making more material available for wind erosion), and the roughness of the exposed surface. The nature of these factors as they pertain to the Columbia River reservoirs are not well understood at this time.

Using representative data, PM_{10} emissions were estimated for three projects (Lower Granite, Libby, and John Day) for all of the SOS alternatives. These three projects were selected because they were considered representative of the key sediment exposure scenarios that could occur under one or more SOS alternatives. Specifically, Libby represents potential exposure and dust emissions from seasonal drafting of a storage reservoir; Lower Granite represents lower Snake River drawdown conditions; and John Day is a special case in which a shallow drawdown could expose a relatively large shoreline area.

PM_{10} emissions (mass per unit area) are a function of wind speed at the surface of the sediments; the magnitude of the wind speed greater than the frictional threshold velocity will determine the PM_{10} emissions. Short-duration, high-speed winds are responsible for most of the emissions. The analysis used wind data from Kalispell, Spokane, and Yakima and followed EPA guidance in calculating emissions (EPA, 1990). The analysis used three wind speeds (fastest mile, maximum 1-hour wind speeds, and highest 99th percentile 1-hour wind speeds) to provide a range of expected emission rates. Emissions calculated using the fastest mile result in the highest emissions. The fastest mile also occurs the least frequently (once in 30 years). Emissions calculated with the maximum 1-hour wind speed will occur at a frequency of about once or twice every 5 years. The 1-hour 99th percentile wind speed will occur at a frequency of about 9 hours per year. However, this wind is sometimes is not sufficient to generate emissions.

Total PM_{10} emissions are dependent on the exposed area. The relationship between the surface elevation and area of the reservoir was used to estimate the area and width of exposed sediments for each alternative, for the three projects investigated. PM_{10} emission rates for three projects, three wind speeds, and all SOS alternatives are presented in Appendix B. Following the EPA methodology, TSP emission rates would be twice the estimated PM_{10} emission rate.

For Lower Granite Reservoir, the maximum PM_{10} emissions would initially result from SOS 5b or 5c, as the natural river operation would result in the greatest area of exposed sediments. The calculated emission rates for SOS 5b ranged from about 400 kg/km of exposed shoreline for 99.9th-percentile winds to over 5,500 kg/km for fastest-mile winds (see Appendix B, Section 3.1). For SOS 5b, the reservoir would be drafted from April through July. During the rest of the year, the sediments would be partially replenished. Under SOS 5c the sediments would be exposed all year. PM_{10} emissions for this alternative would resemble those of SOS 5b for a period of years, until the sediments were vegetated or washed away. Estimated emissions for SOSs 6b, 6d, 9a, and 9c are all about the same magnitude, and are approximately one-quarter to one-third as much as the emissions for SOS 5.

The estimated PM_{10} emissions for the Libby project are larger than emissions for Lower Granite. Libby would typically be drafted in

March and April, resulting in lower maximum winds than the winds used to estimate Lower Granite emissions. However, a much larger area would be exposed at Libby, resulting in higher emission rates for all alternatives. Estimated emissions for Libby are about equal for all SOSs.

Predicted PM_{10} emissions for the John Day project are moderate for SOSs 5b, 5c, 6b, 9a, and 9c, and are much lower for the remaining alternatives.

It may be somewhat difficult to put these emission rates into perspective. Following the EPA (1990) guidance, a 30-ton (27,216 kg), fully-loaded, 10-wheel dump truck traveling 30 mph (48 km/h) on a gravel road will generate 44 kg/km of PM_{10} emissions. Using the 99.9th percentile wind speed for the Lower Granite project, only four alternatives (SOSs 6b, 6d, 9a, and 9c) result in emissions greater than the dump truck example. All of the alternatives for the Libby project result in PM_{10} emissions greater than the dump truck example. Small changes in surface elevation result in large areas of exposed sediments at Libby. For the John Day project only two alternatives (SOSs 9a and 9c) are predicted to result in PM_{10} emission greater than the dump truck example, for the 99.9th percentile wind speed.

PM_{10} Concentrations

Windblown dust is transported and diluted by the wind. Estimated PM_{10} emissions were modeled using a standard Gaussian dispersion model, wind speeds representative of the conditions that will result in windblown dust, and a straight uniform shoreline configuration. Emissions representative of most of the alternatives for each of the three projects investigated were used in the modeling. All emissions were assumed to take place during a 1-hour period. Several wind directions were considered; winds nearly parallel to the shoreline will result in the largest concentrations adjacent to the source of the emissions, and winds perpendicular to the shoreline will produce the largest concentrations at some distance from the shore area.

The maximum PM_{10} concentrations calculated through this analysis were 206 $\mu g/m^3$ for Lower Granite, 157 $\mu g/m^3$ for John Day, and 139 $\mu g/m^3$ for Libby. The highest PM_{10} concentrations are predicted to occur immediately adjacent to the source of emissions, and will quickly diminish with distance from the shore area. The PM_{10} concentrations for all three projects decrease rapidly within 0 to 200 meters of the source (the beach), and decrease much more slowly for distances beyond 200 meters (see Appendix B, Figure 4-1). Concentrations greater than the 150 $\mu g/m^3$ AAQS are predicted to occur only within 20 to 30 m of the area of exposed sediments. Windblown dust in concentrations significantly greater than background concentrations (5 $\mu g/m^3$) are predicted to occur within 3 to 5 km of the exposed sediments. These distances will be greater for the alternatives that result in larger areas of exposed sediments (SOSs 5b and 5c for Lower Granite, for example), and for higher wind speeds (the fastest mile wind speeds, for example).

In summary then, the PM_{10} concentration estimates indicated that reservoir drafting as a result of SOS alternatives would intermittently generate sufficient dust to be noticeable only for residents or recreationists on or very near the beach. PM_{10} concentrations over a greater distance from the reservoir would be elevated over background levels, but this effect would consist of a relatively small absolute increase over a low background level. Any of the SOS alternatives could produce those kinds of dust effects at Libby, while only drawdown and/or natural river alternatives would produce the PM_{10} concentrations discussed above at Lower Granite and John Day.

The analysis results for the three representative projects can be applied to the remaining SOR reservoirs by comparing respective elevation patterns. The hydroregulation model predicted annual average surface elevations of all SOR reservoirs for each

alternative. The annual average reservoir elevations for SOS 2c represent a base case. For a given reservoir, the elevation difference between SOS 2c and the other alternatives is related to the amount of shoreline exposed for that alternative. These elevation differences provide a means of estimating which alternatives have the greatest potential for windblown emissions. A lower surface elevation will result in a greater amount of exposed shoreline and, therefore, a larger potential for high PM_{10} emissions and concentrations. The differences in the annual average surface elevations by project and alternative are presented in Section 5.1 of Appendix B.

There is little or no variation in simulated annual average reservoir elevations at the McNary, The Dalles, Bonneville, and Chief Joseph projects for all of the alternatives. Deep drawdowns would occur under SOSs 5b, 5c, 6b, and 9a for Ice Harbor, Lower Monumental, and Little Goose projects. Large drawdowns for Lower Granite are expected for SOSs 5b, 5c, 6b, 6d, and 9a. The average surface elevation at the Dworshak project would decrease for SOSs 2d, 9b, and PA. Large drafts are predicted for Grand Coulee for SOSs 9a and 9b. Lower elevations are expected at Libby for SOSs 9a and PA, while large drawdowns are expected at Hungry Horse for SOS 9a.

Consequently, the analysis results for Lower Granite illustrate the potential physical conditions from drawdown or natural river operations at Little Goose, Lower Monumental, and Ice Harbor, although there are much smaller resident and recreationist populations at the latter three projects than at Lower Granite. Because Libby is a very large project and has the deepest simulated drafts among the storage reservoirs for virtually all SOS alternatives, PM_{10} emissions and concentrations for Hungry Horse, Dworshak, and Grand Coulee would generally be much less than the Libby estimates for a given SOS.

PM_{10} monitoring is conducted in areas with known or suspected air quality problems. Only a few of the projects are located in areas where monitoring is conducted near the reservoirs (see Section 2.2). Only one area, the Sandpoint area located on Lake Pend Oreille, is a PM_{10} nonattainment area. The shallow areas of Lake Pend Oreille are located a considerable distance to the east of Sandpoint. It is not expected that the SOR reservoirs would contribute to ambient concentrations greater than the AAQS at any of the monitoring locations. Several SOR reservoirs are located in areas where nearby monitoring data indicate that the background PM_{10} concentrations are high. These areas include Ice Harbor (located near Kennewick and Wallula Junction), Grand Coulee (located near Spokane), Albeni Falls (located near Sandpoint), Libby (located near Libby), and Hungry Horse (located near Whitefish). Large background concentrations in areas such as Spokane are associated with industrial emissions and wood smoke, and will take place during periods of stagnant winds and low-level atmospheric inversions. Conversely, high wind-generated emissions from the SOR reservoirs would occur during periods of high wind speeds and good atmospheric dispersion. Wind-generated emissions resulting from exposed lake sediments would result in large PM_{10} concentrations immediately adjacent to the source of the emissions.

The upstream end of Lower Granite Reservoir is located adjacent to Clarkston, Washington and Lewiston Idaho, which are both TSP nonattainment areas. The possibility for elevated particulate matter emissions adjacent to the emission sources has been demonstrated by the analysis presented in Appendix B. A detailed evaluation of the air quality impacts associated with drafting Lower Granite would have to wait until site-specific data can be collected.

The lake sediments may contain contaminants which, when dry, could become part of the windblown emissions. If large concentrations of these contaminants were present, they could result in a health threat. Data sufficient to rigorously estimate emissions of hazardous and toxic air pollutants resulting from reservoir drafting are not available. Chemical

concentrations have been measured for selected locations in Lake Roosevelt by EPA (1992). The Corps has also sponsored limited sampling of sediments in the Lower Granite, Little Goose, and Ice Harbor pools on the lower Snake River and in the Columbia River near the confluence with the Snake (Pinza et al., 1992; Crecelius and Gartisen, 1985; Crecelius and Cotter, 1986). Most of this work has focused on Lower Granite. While data coverage is not sufficient for a specific analysis, it can be assumed that alternatives that would expose the greatest amount of sediments in areas where industrial discharges have contaminated the sediments would have the greatest potential for hazardous and toxic emissions.

Lake Roosevelt and Lower Granite are the key reservoirs for which chemical sediment concentration data are available. These two projects also are more likely than others to contain significant amounts of chemical contaminants. Lake Roosevelt receives smelter and municipal discharges from sources just upstream in British Columbia. Lower Granite receives discharges from industrial operations and municipal wastewater discharges from sources just upstream (including a pulp and paper mill) in the Lewiston and Clarkston area. Pollutants of concern include sediments contaminated with arsenic and iron. The hydroregulation models indicate that drafting of Lake Roosevelt would be essentially the same as or less than current operations under most of the SOS alternatives, including SOS PA. The only alternatives that would create significant potential for dispersion of exposed sediments from Lower Granite are the natural river and drawdown operations (SOSs 5, 6, 9a, and 9c), which would require further environmental analysis before they could be implemented. Consequently, the SOR agencies do not believe that the issue of human health concerns from potential air emissions of contaminated sediments requires further analysis at this time.

Indirect Air Quality Impacts

Changes in river operation could decrease the amount of hydroelectric power generated, at least on a seasonal basis, and require replacement generation from thermal power plants (such as gas- or coal-fired plants). One response to this power impact would be to acquire new generating resources, and the other would be to purchase power from existing sources. Either response could require energy generation from thermal powerplants, which would result in impacts to air quality. Both cases are described in more detail in Appendix I, Power.

With respect to acquiring new resources, the alternative resources available and their respective impacts on air quality are described in detail in BPA's Resource Programs EIS (BPA, 1993a). Air emissions vary considerably for most pollutants among the different thermal power technologies, with conventional coal-fired technology producing the greatest emissions. Natural gas-fired plants are relatively clean-burning and efficient and have accounted for all recent additions to Northwest thermal power capacity. The SOR Power Work Group assumed that gas combustion turbines would be built if power system managers adopted the new-resource response.

Purchasing replacement power supplies would also involve several options. Depending upon future resource availability when a given SOS might be adopted, BPA could conceivably purchase power from utilities in the Northwest, Canada, or California. Each of these three sources has a different resource mix with a different potential for indirect air quality impacts. Other Northwest utilities operate a mix of hydroelectric and thermal resources. Most electricity in British Columbia is generated by hydroelectric plants. California power resources are predominantly thermal with a mix of nuclear and oil-fired plants.

Natural gas-fired power plants have accounted for all or nearly all the recent additions to the power generating capacity of the Pacific Northwest. Given the diversity of choices available for replacing Columbia River hydropower, air quality impacts resulting from use of thermal generation for replacement power

can only be addressed in a generic sense. For this evaluation it has been assumed that all of the lost power would be replaced by natural gas-fired generators. The nature of these power plants, whether combined cycle, cogeneration, or peaking units, is not specified in this analysis. Furthermore, the actual size and location of individual units cannot be determined at this point.

The total emissions resulting from replacing power normally generated by the Columbia River system can be estimated for a mix of combustion technologies, including new natural gas-fired combustion turbines, existing gas and oil fired combustion turbines, existing coal-fired power plants, and purchasing power (BPA 1995). Total emissions for criteria air pollutants were estimated for each SOS alternative for the years 1996 and 2004 (Appendix B).

The emission estimates for 1996 represent an older mix of sources including coal-fired power plants and older combustion turbines. Emissions from this mix are greatest for SOSs 5b, 5c, 9a, 9b, and 9c, but do not vary widely for the entire set of alternatives. For example, estimated sulphur oxide (SO) emissions ranged from 33,000 metric tons (SOS 1b) to 35,000 metric tons (SOSs 5b, 5c, 9a, 9b, and 9c) per year. Nitrous oxide (NO_x) emission estimates range from 86,000 metric tons (SOS 1b) to 94,000 metric tons (SOSs 5c and 9a). By 2004, replacement power generation would likely rely on new combustion turbines burning mostly natural gas. The pollutants of concern for these facilities would be primarily NO_x. NO_x emissions would be greatest for SOSs 5b and 5c, at 111,000 and 109,000 metric tons per year, respectively. Again, however, the range among the SOS alternatives is relatively small, with the lowest emission rate being 98,000 metric tons per year (for SOSs 9a and PA).

Overall, the air pollutant emission estimates indicate that all of the SOS alternatives would result in measurable indirect air quality impacts, with the level of emissions generally proportional to the amount of replacement generation involved. However, the relatively close range of the emission estimates indicates that there would not be major differences among the SOS alternatives on this impact measure.

It is likely that new generating units would be built with emission control devices such as Selective Catalytic Reduction (SCR) for CO and NO_x emission reduction, advanced low-NO_x combustors, and water injection for NO_x control. Construction of new generating plants would be subject to local, state, and Federal air quality regulations, and would require that the project owners obtain construction and air discharge permits. The new generating facilities would probably also be subject to Prevention of Significant Deterioration (PSD) regulations and to New Source Performance Standards (NSPS) set forth in 40 CFR Part 60, Subpart GG. New facilities would be built only if they comply with all applicable emissions and ambient standards, including the AAQS.

4.2.4 Anadromous Fish

The Anadromous Fish Work Group evaluated the SOS alternatives primarily on their ability to increase the survival of anadromous fish migrating through the Columbia River system. They looked at both juvenile downstream passage and adult upstream return. The work group divided the alternatives into four categories: flow control, drawdown, natural river, and combination. The flow control alternatives include all options for SOSs 1, 2, and 4. These alternatives share the same current system configuration but differ in regard to flow quantity and timing. These alternatives include the No Action Alternative (SOS 2c) and the NMFS 1994 Biological Opinion operation (SOS 2d), which represent how the system was operated in 1992-93 and in 1994, respectively. The SOS 6 drawdown options involve lowering either one or four lower Snake River reservoirs approximately 33 feet (10 m) below normal operating level. The natural river options (SOSs 5b and 5c) involve lowering the four lower Snake River reservoirs to near original streambed level for 4.5 months (5b) or permanently (5c). There are four combination alternatives that include various actions. SOSs

9a (DFOP) and 9c (Balanced Impacts) involve major drawdown of the four Snake River projects and high spill levels at all projects, while 9a eliminates all fish transport. The remaining alternatives, SOS 9b (Adaptive Management) and SOS PA (Preferred Alternative), use a combination of flow targets, drawdown to MOP, and moderate spill as methods intended to enhance survival.

This section summarizes the anadromous fish impact assessment, based on the detailed report on methods and results presented in Appendix C, Anadromous Fish. The discussion of issues that affect anadromous fish is followed by a quantitative assessment of the effects of the SOS alternatives on selected stocks of anadromous salmon and steelhead. The assessment is based on models of downstream passage survival for juvenile fish and life-cycle projections of adult returns. The quantitative section includes assessments of downstream passage survival with and without transport, and of the effects different transport survival hypotheses have on overall survival and alternative rankings.

Anadromous Fish Impact Issues

The anadromous fish issues can generally be grouped according to whether they affect juvenile salmonids, adult salmonids, other anadromous stocks, or hatcheries. Another issue is the effect fish transport has on overall survival. The primary impact issues concern interrelationships among flow, water particle travel time, fish travel time, species, river reach, and survival.

Effects on Juvenile Salmonids

The two primary areas of juvenile salmon mortality within the hydrosystem are dam passage mortality and reservoir mortality. Dam passage mortality is associated with smolts' ability to successfully pass through the various routes. Differing levels of mortality are associated with the various passage routes through each dam.

Reservoir passage mortality occurs throughout the system of reservoirs. Sources of reservoir mortality are primarily predation and gas bubble trauma. Flow and temperature also play a large role in these survival mechanisms. Many smolts are collected from the bypass channels as they pass the dams. These fish are then transported downstream, avoiding the mortality factors associated with subsequent reservoirs and dams.

Flow also plays an important role in initiating and sustaining migration for some stocks. Some scientists also believe that higher flows reduce travel times, thus reducing the threat of predation and disease.

The various factors associated with smolt mortality are presented as follows:

Dam Passage Effects
- Juvenile bypass and collection facilities
- Turbines and spillways

Reservoir Effects
- Predation
- Dissolved gas
- Flow
- Rearing habitat

The following discussions summarize current knowledge of these factors and how they affect survival, and describe how the SOS alternatives would affect these survival factors.

Juvenile Bypass and Collection Facilities—Submerged traveling screens divert fish migrating past lower Snake and most lower Columbia River dams away from the turbines (see Section 3.3.3). Mid-Columbia River dams currently do not have these screens, but may have them in the future. Many of the fish diverted at Lower Granite, Little Goose, Lower Monumental, and McNary Dams are transported downstream by barge or truck and released below Bonneville Dam. Researchers estimate that more than 70 percent of Snake River steelhead and yearling spring and summer chinook smolts, and up to 40 percent of subyearling fall chinook arriving downstream,

are transported around dams. The percentage of mid-Columbia River fish transported is lower because they are only collected at McNary Dam.

Some migrating fish are killed at juvenile bypass and transport facilities. Mortality through juvenile bypasses, excluding outfall mortality, ranges from much less than 1 percent up to 3 percent (Ceballos et al., 1991; Monk and Williams, 1991; Brege et al., 1987). Additional mortality, estimated at 2 percent, occurs during transport. Opinions vary on whether additional mortality occurs to fish as a result of transport, and whether there is a net benefit to fish being transported compared to remaining in the river. A quantitative evaluation of the response of salmonids to transport is provided in subsection *Effects of Alternatives—Quantitative Assessment*. The quantitative effects of transport are summarized in the main CRiSP model results subsection; the complete analysis is presented in Appendix C.

The turbine diversion and transport effects of SOSs 1, 2, 4, 9b, and PA on anadromous salmon and steelhead would be similar. SOSs 5, 6, 9a, and 9c would substantially reduce diversion and/or transport from the Snake River projects under traditional operating procedure, because the lower Snake River projects would be drawn down to or below spillway crest level under these alternatives. The effects of transport are included in the main quantitative analysis model for all alternatives.

Turbines and Spillways—Fish passage through turbines or over spillways would change substantially under some of the alternatives. Some of the migrating fish still go through turbines, although current operations attempt to prevent this. Turbine mortality results from turbine blades hitting fish or from hydraulic pressure or shear forces. Overall fish mortality is affected by the number of fish passing through turbines and the efficiency of turbine operation. Higher mortality occurs when turbines operate either below or above peak efficiency. Estimates of turbine passage mortality range from 2 to 32 percent (Ledgerwood et al., 1990; Weber, 1954; Long et al., 1968). A mortality range of 9 to 20 percent, with an average of 6 to 15 percent, is considered typical (Fisher et al., 1993). Many turbine (and spillway) mortality studies done several decades ago may be outdated. Recent preliminary tests in spring 1993 estimated yearling chinook turbine survival of 82.3 and 90 percent at Lower Granite and Little Goose Dams, respectively (Iwamoto et al., 1994).

Spillway mortality is estimated to be an average of 2 percent per project (NPPC, 1986). Estimates range from 0 to 27.5 percent (Long et al., 1968) depending on operation and structural modifications such as the presence of spillway flow deflectors (flip lips). Iwamoto et al. (1994) estimated preliminary Little Goose spillway survival of yearling chinook at 100 percent during moderate spill conditions. During higher spill (flows over 10 kcfs per bay), the efficiency of flip lips could be diminished and mortality could increase. Direct spillway mortality results primarily from abrasion, but many juvenile salmonids may die later through indirect means such as descaling, stress, predation, or reduced viability due to dissolved gas supersaturation exposure. However, accurate estimates of the portion of delayed mortality from spillway or turbine passage are unavailable.

Stunned or disabled fish are more susceptible to predation. Indirect mortality, such as increased susceptibility to disease and/or immediate or later predation, can occur with turbine or spillway passage.

Turbine and spillway mortality under the flow control alternatives and, to a lesser extent, SOSs 9b and PA, would correspond to the existing conditions described above. SOSs 5, 6, 9a, and 9c would have highly varied effects on these two mortality factors. The model analysis addresses the differences. However, in these cases, the estimated effects are more speculative because the major changes in the system structures and operation have not been tested before.

Predation—One of the major causes of juvenile fish loss during migration is predation by

resident fish (Poe and Rieman, 1988). Predation is considered by some to cause mortality equal to or greater than that caused by passage at dams (Rieman et al., 1991). The primary predator in many areas of the Columbia River system is the northern squawfish (Beamesderfer et al., 1990). In some areas, such as Lower Granite Reservoir, smallmouth bass might be a more important predator on subyearling chinook (Curet, 1993). Predation within the Columbia River system occurs throughout the reservoirs, but is often concentrated just below and above the dams (Poe and Rieman, 1988). Much of the predation on subyearling chinook might occur in shallow water areas along the shore (Curet, 1993). The level of predation is affected by many factors, including velocity, turbidity, location, predator abundance, prey abundance, and temperature. Of these, temperature is a major controlling factor (Beamesderfer et al., 1990).

The SOS alternatives could significantly influence predation. In many cases, a given action would likely have positive and negative effects on predation, so the net effects are unclear. Operations that result in reduced temperature during migration should reduce overall predation if other factors remain the same.

Predators often avoid high-velocity areas, so higher river velocity should reduce predation. The major predators also require slow water areas for egg incubation and subyearling rearing. Among the major predators, smallmouth bass would be affected most by increased velocities because they are more dependent on shallow, low-velocity areas. Squawfish would be affected less because they are more adapted to a flowing river environment than are smallmouth bass.

Reduced reservoir size could have negative effects by concentrating predators, or it could have positive effects by reducing predators' habitat area. Both outcomes were reflected in different model runs for each of the SOS alternatives in the smolt survival analysis.

SOSs 5, 6, 9a, and 9c would increase turbidity. This increase would restrict predators' ability to see juvenile salmon and steelhead and thereby reduce predation. Turbidity increases would be most pronounced in the first year of any drawdown operation and less in following years, with corresponding effects on predation.

Dissolved Gas—Some of the alternatives could increase mortality for salmon and steelhead juveniles from gas bubble disease. This disease is well documented on the Columbia River system (Ebel et al., 1975; Weitkamp and Katz, 1980). Factors that contribute to this disease include the level of supersaturation, duration of exposure, water temperature, physical condition of the fish, swimming depth of the fish, and its life stage (Ebel and Raymond, 1976; Weitkamp and Katz, 1980). Flip lips constructed at most dams have generally reduced the potentially high levels of gas supersaturation that caused significant fish mortality in the 1970s.

Currently, Federal and state agencies and tribes disagree about the severity of effects of gas supersaturation levels that exceed the existing Federal and state standard of 110 percent. Current beliefs are based on different interpretations of historical and current gas effects studies in the Columbia River system and the laboratory. More details on the various documentation addressing dissolved gas effects were presented in Draft EIS Appendix C, Volume C-1, Exhibit D and Appendix 6 of the Detailed Fishery Operating Plan (CBFWA, 1993).

Limited recent documentation of excessive fish mortality from gas bubble disease exists because of inadequate monitoring efforts. Although current operations during lower flow years provide for limits on continuous spill, dissolved gas concentrations known to be detrimental are exceeded annually. The cause-and-effect relationship of gas bubble disease symptoms is not easily demonstrated because bubbles can grow internally throughout a fish's body, disrupting neurological, cardiovascular, respiratory, osmoregulatory, and other physiological functions (Weitkamp and Katz, 1980; Stroud et al., 1975). At some levels of

adverse gas effects, external symptoms of gas bubble disease are not apparent; therefore, assessing effects to fish populations by external examination only is unreliable and would not reflect behavioral effects (Draft SOR Appendix C, Volume C-1, Exhibit D). The gas bubble trauma monitoring during 1995 at the dams indicated very limited effects of elevated gas levels (occasionally greater than 120 percent) (FPC weekly reports for 1995). However, studies below Ice Harbor during early May 1995 found very high mortalities when fish were restricted to shallow (1- and 4-m-deep) cages when measured gas levels were 128 percent (FPC weekly report #95-10, May 12, 1995).

The current national and state standard is a maximum of 110-percent saturation. Adverse effects in the Columbia River system are observed at higher levels. Some suggest that near 120-percent saturation is an acceptable level because laboratory evidence shows that some fish may adjust their behavior to compensate for the elevated levels (CBFWA, 1993). However, Alderdice and Jensen (1985) found that substantial numbers of fish exposed to gas saturation of 110 to 112 percent did not move to greater depths, which would reduce the effects of elevated gas saturation, even when these depths were available. They concluded that this indicated there was a physiological component that affected the fish's ability to select greater depths at higher gas saturation levels. However, this has not been demonstrated in the field condition of the river.

Dissolved gas levels below dams currently peak at 120 to 140 percent during high spill years and 110 to 120 percent during low spill years. While gas saturation is a complicated issue depending on such variables as spill pattern, tailwater conditions, operations upstream, and specific spillway characteristics, the most important factor affecting gas saturation is the amount of spill. Data from the 1992 Lower Granite physical drawdown test show that periods of moderate spill (greater than about 40 kcfs) resulted in tailwater gas saturation over 120 percent (Wik et al., 1993). Most alternatives would have little effect on increased gas saturation compared to existing conditions. However, SOSs 9a, 9b, and 9c would allow gas saturation levels from increased spill to reach 120 percent. SOS PA also would increase gas saturation levels to a lesser degree (maximum controlled level of 115 percent) from enhanced spills, possibly increasing risk to migrating fish.

Flows and Water Velocities—There is general consensus among the scientific community that there is some degree of positive relationship between increased river flows and juvenile fish survival. However, the relationship is only a general one, and there is considerable disagreement about exact survival benefits of increased flow, particularly at flows greater than moderate levels. Past studies indicate that the quantity of flow has various correlations with travel time and smolt survival (Sims and Ossiander, 1981; Sims et al., 1983; Berggren and Filardo, 1993; memorandum from Michele DeHart, FPC, Portland, Oregon, October 16, 1991; Petrosky, undated). The general relationship between flow and survival emerged primarily from early studies on the Snake River by Sims and Ossiander (1981) and Sims et al. (1983), who found that survival of yearling chinook and steelhead appears to be higher during years with higher flow. Later analyses of this study, as well as additional data, developed relationships that were considered to peak at certain flow levels in the range of 85 to 140 kcfs in the Snake River (Sims et al., 1983). These conclusions were clouded by the effects of high dissolved gas levels that occurred in the river during those years with higher flows and only about one-half of the existing turbine complement in operation. Dissolved gas levels were reduced considerably in later years by addition of a full complement of turbines and the addition of flip lips on dam spillways.

No recent studies have been conducted that directly measure the effects of flow on yearling chinook smolt survival in the Snake or Columbia Rivers. However, NMFS/University of Washington researchers conducted smolt survival studies in the Snake River during 1993 and 1994 (Iwamoto et al., 1994 and Muir et al., 1995). The 1993 study was a pilot study that used

hatchery spring chinook in the Lower Granite pool over a limited flow range and time period. This study was done with fish releases between April 15 and 21, 1993. Flows were from 60 to 70 kcfs (1,680 to 1,960 cms) over most of this period, and ranged up to 90 kcfs (2,520 cms). No mortality was detectable (i.e., 100 percent survival) over the 20-mile (32 km) Lower Granite pool reach between release and recapture at the dam.

The 1994 study was more extensive, occurring from a release period of April 16 to May 10 and at flows ranging from about 40 to 90 kcfs (1,120 to 2,520 cms). Muir et al. (1995) found survival of hatchery spring chinook of 92 percent from the release point (about 22 miles [35 km] above Lower Granite Dam) to the Lower Granite tailrace. Survival from the original release point to the Lower Monumental tailrace was 66 percent. Survival estimates over this same reach were slightly higher for the limited number of wild spring chinook sampled, and lower for hatchery steelhead. Muir et al. (1995) concluded that little of the mortality measured to the Lower Granite tailrace could be attributed to reservoir passage, considering the mortality that occurs from dam passage (primarily turbine mortality). They also believed that similar low reservoir mortality would be expected at the other lower Snake River reservoirs for the same reasons. That is, with exception of poor tailwater conditions at one dam, most of the mortality measured was a result of dam passage and not reservoir passage. They did not attempt to interpret the effects of flow on survival in these studies. However, most of the data in these studies were collected at flows less than the 85 to 140 kcfs (2,380 to 3,920 cms) range in which historical data indicate peak downstream passage survival has occurred (Sims et al., 1983).

There remains uncertainty about which stocks respond to increased flows, whether the response occurs or is continued in all geographical areas of the river, the importance and level of increased flow, the effects on travel time, and the optimum ranges of flows (Giorgi, 1991; Kindley, 1991; Stevenson and Olsen, 1991; Marsh and Achord, 1992; Sims and Miller, 1982). Flow and travel time relationships have sometimes been found to be significant for yearling chinook and steelhead at low flows in the Snake and lower Columbia Rivers with the dams in place. However, this relationship is not clear at higher flows (Giorgi, 1991; Kindley, 1991; Hilborn et al., 1993 as cited in Cada et al., 1993).

The effects of flow on yearling chinook and steelhead in the mid-Columbia River have been evaluated by the Fish Passage Center (1994). Through regression analysis they indicated that flow correlates with the migration rate to McNary Dam for these stocks. Other factors such as date of release, temperature, and origin (for steelhead only) are significant and often more important than flow in determining the migration rate of these fish.

McNeil (1992) included stocks from the mid-Columbia and found that for five "species" (brood runs) of juvenile salmonids in the Columbia and Snake Rivers, only 5 of 117 tests of the linear correlation of migration timing to flow quantity had a significant positive relationship. Three of those relationships were found for yearling chinook and the other two for subyearling chinook (four of these are based primarily on mid-Columbia stocks). McNeil (1992) did not contradict or modify any significance of uncertainty associated with existing flow/survival or flow/travel time relationships.

Recent analyses indicate the flow travel/time relationship is weak in some areas of the system. In the John Day pool, no significant relationship was found between flow and travel time for yearling chinook in 1989 and 1990 (Stevenson and Olsen, 1991). Marsh and Achord (1992) concluded that the outmigration of yearling chinook through Lower Granite Reservoir appeared to be independent of flow.

The relationship between subyearling chinook travel time and flow levels is unclear. Travel times correlated moderately or weakly with flow in some tests (Berggren and Filardo, 1993;

NMFS, 1993) and not at all in other tests (Sims and Miller, 1982). The FPC (1994) found no significant relationship between travel time and flow for subyearling chinook from Rock Island Dam to McNary Dam. This relationship is made unclear by the level of smolt development (Kindley, 1991), the size of fish (memorandum from Michele DeHart, FPC, Portland, Oregon, October 16, 1991), and the relative distance traveled or relative changes in flow (Berggren and Filardo, 1993).

Conflicting results concerning the effects of flow on fall chinook survival from the mid-Columbia were recently presented by Hilborn et al. (1993) and Norman (1992), with Hilborn et al. (1993) showing significant positive effects and Norman (1992) showing negative effects on survival of adult returns of discharge during juvenile outmigration.

Selected flow/survival relationships developed through past research are incorporated directly or indirectly in the computer models used to analyze the SOS alternatives (see Appendix C). The effects of flow on survival are incorporated in the discussion of model results.

Rearing Habitat—Rearing habitat is important during migration for all stocks. It is especially important for subyearling fall chinook and mid-Columbia River summer chinook because they spend more time in the mainstem rivers during migration. Factors that affect the quality and use of the habitat include species, depth, velocity, substrate, benthic and pelagic food supply, temperature, and turbidity. Salmonids use backwater and slough habitat in the lower Columbia River during the spring and summer (Zimmerman and Rasmussen, 1981; Parente and Smith, 1981). Underyearling chinook in the mid-Columbia River also use shallow-water, low-velocity areas (Dauble et al., 1989). Fall chinook in the Snake River reservoirs prefer low-velocity sandy habitat less than 20 feet (6 m) deep (Bennett et al., 1993; Curet, 1993). Fall chinook in Lower Granite pool rear about 75 to 112 days before migrating downstream (Curet, 1993), while those in Columbia reservoirs, such as John Day, may rear longer (Sims and Miller, 1982). Much of this rearing, however, occurs away from the shallow-water areas prior to migration (Curet, 1993). The rearing period of steelhead and yearling chinook (and probably sockeye) in any reservoir is no more than a few days. These fish are less oriented to shallow shorelines, although they probably rely on food sources produced in these areas, so changes in shallow-water habitat would be less critical for these stocks.

Stranding of juvenile salmonids during drawdown with SOSs 5, 6, 9a, or 9c is also a possibility, particularly in shallow pocketed areas. During the March 1992 drawdown test, 21 juvenile salmonids were found stranded (Wik et al., 1993). The stranding effects might be worse than in 1992 because the drawdown would occur when more fish would be present in the reservoir. The gradual drawdown rate of 2 feet (0.6 m) per day would limit the number of fish stranded, allowing fish to move out of the area and avoid stranding.

Rearing habitat quality and quantity could be greatly reduced under some SOS alternatives but changed little under others. Shallow-water fall chinook rearing areas would be most adversely affected by SOS 5 because these areas would be dewatered. In the long term, these habitats would reestablish under SOS 5c. SOSs 6, 9a, and 9c would have similar effects on Snake River stocks. Snake River fall chinook would be most affected because of their longer residence time and greater reliance on these areas. Stocks using rearing habitat in the lower Columbia River would be affected less. SOSs 5, 6, 9a, and PA would dewater much of the shallow backwater habitat in Lake Umatilla. This dewatering would primarily affect Columbia River summer chinook. SOSs 2, 4, 9b, and 9c would also dewater shallow rearing habitat in Lake Umatilla, but to a much lesser degree.

SOSs 5b, 6, 9a, and 9c would reduce the available food supply for the affected stocks in two primary ways. One would be by dewatering the shallow areas where most of the benthic food

organisms originate (Bennett, 1991). The second would be by increasing flushing, thereby reducing the zooplankton that are another important food source for rearing and migrating salmon and steelhead. Food sources for Snake River fall chinook may already be in short supply in the reservoirs (Curet, 1993).

The permanent natural river drawdown option (SOS 5c) would have similar effects the first year. However, in subsequent years the establishment of a river environment may improve food supply as stream insect populations, common food for salmonids, become established.

Temperature reductions in most areas would benefit rearing salmonids. The preferred temperature for salmon and trout is typically less than 59°F (15°C), while normal conditions in the reservoirs exceed this temperature in the late spring and summer. As discussed previously, SOS 5 would reduce Snake River temperatures most often, while SOSs 6, 9a, and 9c would reduce high temperatures to lesser degrees. These temperature changes would be beneficial to rearing fall chinook in the Snake River. None of the alternatives would have much effect on temperatures in the other reaches of the Columbia River System.

Some alternatives would increase suspended sediment, which could have adverse effects on some species and life stages of salmon and steelhead. This would be particularly true during the first year the alternatives were implemented. The models indicate that the highest suspended sediment concentrations would occur under SOS 5, with peak average water-column concentrations approaching 5,000 mg/l during the first year. SOS 6 would have the next highest levels, with peak concentrations of less than 500 mg/l. Similar levels would be expected for SOSs 9a and 9c. After the first year, estimates of peak values decrease to less than 200 mg/l for SOS 5b and less than 50 mg/l for SOSs 6, 9a, and 9c. SOS 5c would not have elevated levels after the first year because the river level would remain unchanged from the first year's drawdown. The highest concentrations should occur as drafting is completed (approximately April 15) in the lower Snake River reservoirs. Based on 1992 drawdown test measurements, these peak values would persist for about 1 week or less if weather and hydraulic conditions remained unchanged (Wik et al., 1993). However, if storm events occurred or flow increased markedly, higher levels could persist longer, but would likely remain lower than the peak values at the end of the drafting period.

Water quality standards for protection of fish habitat usually require suspended sediment concentrations of less than 30 mg/l for high protection and less than 100 mg/l for moderate protection (Lloyd, 1987). Some studies indicate short-term exposure causes direct mortality at a concentration of less than 1,200 mg/l (Noggle, 1978; Stober et al., 1981). Direct mortality of salmon and trout from short-term exposure (usually less than 4 days) generally requires concentrations of over 7,000 mg/l and more commonly over 18,000 mg/l (Servizi and Martens, 1991; Newcombe and MacDonald, 1991). Therefore, direct mortality of migrating Snake River spring and summer chinook and steelhead from the expected concentrations would be unlikely under any alternative. Snake River fall chinook that rear in the reservoirs for several weeks or months could suffer direct mortality under SOS 5, depending on the duration of the elevated levels and location of the fish. These impacts would be limited to the first year's actions. Secondary short-term effects, which include avoidance of turbid waters, reduced feeding success, reduced resistance to disease, and increased stress, are triggered at much lower concentrations—typically in the hundreds of mg/l (Noggle, 1978; Newcombe and MacDonald, 1991; Servizi and Martens, 1992; Alabaster and Lloyd, 1982; Lloyd, 1987). These effects would apply to Snake River stocks under SOS 5 and possibly SOSs 6, 9a, and 9c.

Salmonid Response to Transport

The fish transportation program is an integral part of the Federal Columbia River Power

System (FCRPS). Because this operation affects a large number of fish, transport survival has a very significant effect on overall juvenile fish survival and return of stocks that originate above McNary Dam. Recently, questions have been raised about the benefits of this program.

The issue of the relative benefits of transportation in protecting juvenile salmonids from dam and reservoir mortality was first raised in 1990 during the scoping phase of the SOR. At that time, and continuing through the early study phases, the Anadromous Fish Work Group analyzed the benefits of transportation in its juvenile fish passage models and life-cycle models.

In December 1993, in a suit unrelated to the SOR, Judge Malcolm Marsh ruled in *Northwest Resource Information Center (NRIC), Inc. et al. vs. NMFS et al. 93-870MA (9th Cir.)* that the Corps and NMFS had not adequately analyzed the benefits of transportation. The judge required the Corps to take a "hard look" at the program.

The Juvenile Fish Transportation Program Technical Appendix (Appendix C, Volume C-2) of the SOR Draft EIS took a "hard look" at the fish transport program. This appendix evaluated in detail the effects of current transportation procedures in both a quantitative and qualitative fashion. The Final EIS Appendix C includes a less detailed version of this analysis. It also evaluates, in a qualitative fashion, alternatives to transportation, alternative methods of transportation, and new collection facilities. Alternatives to current transportation evaluated include dam removal, increased spill, canal/pipeline, and others. Alternative methods of transport evaluated were varied means of conveyance (e.g., net pens) and changed operating tactics and technology (e.g., size separation, reduced collection density, barge temperature and sound control, varied timing of transport, and further downstream release location). Two new facilities were also evaluated including a further upstream collector above Lower Granite pool and surface collectors at dams. Some of the activities will be implemented in the future such as the size separator and reduced density, while others like a surface collector are receiving more intensive evaluation in the future.

The main purpose of the SOR is to evaluate, in quantitative fashion, the effects of selected alternatives on fish survival. Therefore, the EIS does not include the analysis of possible future alternatives to the current transport procedure or detailed qualitative evaluation of transport; these discussions can be found in Appendix C.

Transport Evaluation Summary

The following summarizes current knowledge on the effects of transportation on juvenile survival and two of the major survival factors affecting this survival, stress and disease (see Appendix C of the Final EIS and Appendix C, Volume C-2 of the Draft EIS for a complete discussion of these factors).

The major method of measuring the effectiveness of transportation on survival is that indicated by the Transport/In-River Ratio (TIR). In the Draft EIS, the TIR was referred to as the Transport Benefit Ratio (TBR) or the Transport Control Ratio (TCR). The TIR is a ratio of the number of adults returning to a given location from a transported group of marked juveniles, to the number of adults returning to the same location from the control group of marked juveniles released to migrate downstream in-river. Basically, whenever the true TIR exceeds 1:1 there would be more benefit to transporting fish than allowing them to migrate downriver untransported.

Transport/In-River Ratio—The Corps has funded 17 TIR tests with spring and summer chinook smolts transported from the lower Snake River dams to downstream of Bonneville Dam between 1968 and 1989. Fourteen tests produced enough adult returns to be considered useful. Eleven of the 14 showed transport benefits significantly greater than 1:1, two were not significantly higher than 1:1, and one (1976) showed benefits significantly less than 1:1. Given changes in the migration corridor since

1968, the 1986 and 1989 TIRs are considered the most (although by no means totally) representative of current in-river conditions. These tests yielded TIRs of 1.6:1 (1986) and 2.46:1 (1989).

For fall chinook and steelhead, Matthews (1992) concluded that research indicates a clear benefit to survival with transport. Studies from 1978 to 1983 found a TIR of 1.8:1 to 8.0:1 for fall chinook from McNary Dam. Too few fish have been present to conduct direct studies of Snake River fall chinook. Subsequent studies at McNary Dam in the late 1980s again yielded TIRs averaging 3.5:1 (ranging from 1.7:1 to 7.1:1) (Harmon et al., 1995). For steelhead TIRs were apparently higher in the late 1970s than recently (Matthews et al., 1992). But lower values are reflective of better in-river passage conditions than decreased benefits of transport (Williams and Matthews, 1994). Matthews (1992) also concluded that straying (fish returning to areas other than the stream or hatchery of origin) was not a significant factor for returning transported adults.

Transport of sockeye from the mid-Columbia did not yield a clear benefit from transport. The TIR was less than 1:1 for studies conducted from 1984 and 1986. While some later studies have indicated increased survival from transport, apparent technical problems with some of the studies possibly affected the results.

The Ad-Hoc Transportation Review Group (TRG), consisting of representatives of the USFWS, Washington Department of Fisheries (WDF), Columbia River Inter-Tribal Fish Commission (CRITFC), Idaho Department of Fish and Game (IDFG), and Fish Passage Center (FPC), reviewed available information concerning the benefit of transport on Snake River spring/summer chinook and steelhead, mid-Columbia spring chinook and sockeye, and McNary fall chinook (Olney et al., 1992). They concluded that the measures of benefit from transporting fish (i.e., TIR greater than 1.0) for most of these stocks, particularly wild stocks, were not accurate. They based this conclusion on returns of wild stocks to selected areas and questions of the validity of the way studies were conducted. The primary concern has been that "control" fish are not true controls because they are handled, marked, and in some cases, transported above or below dams before being released to migrate in-river. Other researchers (Williams and Matthews, 1994) pointed out that transport and in-river conditions have improved considerably since much of the transport research was done and that new research is needed to more accurately assess current conditions. This analysis was begun by NMFS for the Corps in 1995.

Because of the controversy over transportation benefits to fish survival among regional groups and agencies, the USFWS contracted with Mundy et al. (1994) to conduct an independent peer review of transport studies. This evaluation concluded that transportation improves relative survival of certain species and life stages under certain situations. Mundy et al. (1994) stated, "While juvenile salmon transportation may not be discounted as a recovery measure, the factual basis is insufficient to determine the relative efficacy of transportation as a mitigative measure for recovery of salmon populations listed as threatened and endangered in the Snake River Basin." However, information was inadequate in many areas to draw specific conclusions about benefits.

Stress—Stressful situations and continued exposure to stress decrease juvenile survival. Smolts collected for transportation are known to be stressed during collection and loading. However, the juveniles recover during the actual barge or truck journey. There is a brief period of stress again upon release.

During in-river passage, on the other hand, fish are stressed each time they pass through the turbine, bypass, or spillway. Therefore, fish passing from Lower Granite Reservoir to the river below Bonneville Dam are subject to eight repeated stressful situations. If spill is causing gas supersaturation, they may be subjected to additional prolonged high stress levels.

Since the beginning of the transportation program, stress research has led to modifications in facilities or operations that have resulted in minimizing stress and reducing mortality in the collection and transportation program.

Disease—Elliott and Pascho (1994) have demonstrated that Bacterial Kidney Disease (BKD) disease organisms are prevalent in the river as well as in the collection and transportation system, and that the majority of fish, both hatchery and wild, are infected by the time they reach Lower Granite Dam.

Adult Anadromous Salmon and Steelhead

Adverse effects on survival of adult salmon and steelhead while passing upstream can also be categorized as dam passage effects and reservoir effects. Effects of dam passage relate to the ability of fish to find and ascend the ladders and not fall back downstream. Reservoir conditions affect the ability of adult fish to pass upstream and the amount of available spawning area in the mainstem reaches of the Columbia and Snake Rivers. Successful passage of reservoirs is related to the water quality of the reservoir, including dissolved gas levels and temperatures, which directly or indirectly affect survival. Large numbers of adult salmon and steelhead die while passing through the reservoirs and over the dams of the Columbia and Snake Rivers. How this mortality is distributed among natural causes, the dam and reservoir system, and other human causes is not known. NMFS (1994) considered the loss from passage through the dam and reservoir system to be one of the main sources of loss of adult chinook salmon. Overall, losses during migration are higher for fall chinook than spring and summer chinook (NMFS, 1994). Those of sockeye are much lower (Ross, 1993), while steelhead losses may be comparable to spring chinook (Bjornn and Peery, 1992). Snake River stocks appear to have higher losses than Columbia River stocks. While measured losses of fish are higher (memorandum from Chris V. Ross, Fisheries Biologist, NMFS, Portland, Oregon, January 30, 1995) NMFS (1995) considered losses of Snake River spring/summer chinook, fall chinook, and sockeye attributable to passage through the federal hydroelectric system from Bonneville to Lower Granite Dam to be 20.9, 39.4, and 15.2 percent, respectively.

Dam Passage—While adult salmon appear to migrate faster through reservoirs than through rivers, passage delays do occur at dams. Delays can contribute to mortality because adult salmon rely on food stored in their body once they enter the river. Passage rate at dams is influenced by whether the fish can find entrances to fish ladders. This is often affected by the quantity and location of spill and turbine flow (Bjornn and Peery, 1992). The proper mix of flow through turbines and over the spillway is often needed for the most effective passage conditions at dams. Based on an assumed migration rate of 1.8 mph through reservoirs, Turner et al. (1983) found that migration through Little Goose pool and over Lower Granite Dam took about 1 day longer than expected during spill levels of zero to 25 kcfs, and 7 days longer at spill levels of 25 to 125 kcfs. Bjornn et al. (1992, 1993) noted that the effects of low nighttime spill on relative delay of migration was not apparent in the lower Snake River. This conclusion was based on the similarity of migration rates at Lower Monumental Dam, with nighttime spill rates ranging from about 10 kcfs in 1991 and 20 kcfs in 1992, to those with no spill at Little Goose Dam. During 1993, only the highest spills affected migration rates at Little Goose and Lower Granite Dams (Bjornn et al., 1994). Researchers noted high spills (greater than 60 kcfs) at the Snake River projects made fish ladder attraction flows difficult to locate (Turner et al., 1983). During high spill tests (100 kcfs) without turbine operation at Lower Granite Dam in 1991, researchers also observed that flow patterns near ladder entrances would have made it difficult for fish to locate ladder entrances (Wik et al., 1993). This conclusion was based on observations of flow patterns, not observed fish behavior.

There is also the problem of fish falling back over the dams; it is related to spill quantity. For spring and summer chinook on the Snake River, researchers found that at low or no spill flow,

fallback was less than 10 percent, while at high spill fallback was about 40 percent (Bjornn and Peery, 1992). Based on limited Snake River studies relating to fallback, high flow would be flows greater than 150 kcfs and spill over 100 kcfs (Bjornn and Peery, 1992). These low fallback rates during low or no spill were confirmed at Lower Granite Dam in 1991 and 1992 at 5 percent and 3 percent, respectively (Bjornn et al., 1992, 1993). Fallback for steelhead at low flow is higher than for salmon. While some fish may be lost in this manner, most fish reascend and pass upstream after they fall back.

All of the alternatives would have little effect on adult passage success for Columbia River stocks. The same is true of the effects of flow control alternatives on Snake River stocks; however, marked reductions in passage success might occur with the natural river operation and some of the alternatives that include drawdown. Experience gained over the years from operational testing at the older dams improved the fish passage designs at dams built later. Site-specific testing at later facilities has also improved their operation. This experience would be of little use in developing functional fish passage facilities for SOSs 5, 6, 9a, and 9c because they would have very different hydraulic conditions. The effect of the natural river alternatives (SOSs 5b and 5c) is not known, but it could be detrimental to adult fish. Because of the sensitivity of salmon and steelhead to flow patterns for detecting passage routes, it is possible that adult passage could be greatly restricted under these alternatives. This restriction would primarily affect Snake River spring and summer chinook and sockeye salmon. SOSs 6b, 6d, 9a, and 9c could also impede or prevent adult passage. Because the fish ladders at the four lower Snake River dams would not function at proposed drawdown levels (except the Lower Granite Dam exit), the ladder entrance and exit locations and supplemental attraction flow would have to be greatly modified from current designs. With drawdown to near spillway crest (SOSs 6b, 6d, 9a, and 9c), reduced tailwater depth would require deepening and lengthening the ladder entrances to accommodate fish passage at all flow levels. While the intent is to design entrances so they meet agency-specified flows (velocity at the entrances and attraction flows), this may not be possible. Research to develop optimum fish passage with existing facilities is still ongoing. The potential to increase adult delay by making major modifications to the existing system is quite high. As an example of the effect of changes that might occur, the physical model effort at WES indicates that as little as 15 percent of the flow as spill could create undesirable tailwater flow patterns. The changes in hydraulics even without spill might substantially affect adult fish ability to find the ladder entrance even with design modifications. The modifications could result in less adult fish passage. Lower Granite Dam has a functional, but relatively untested, lower-level fish passage facility that could be used under SOSs 6b, 6d, 9a, or 9c. Whether this facility would help adult fish pass the dam is not known, and it could be worse than the existing facilities.

Reservoir Delays—The general migration rate for adult salmon through reservoirs is faster than through comparable river areas (Bjornn et al., 1992, 1993). Past estimates of rates have indicated a decrease for steelhead during "zero-flow" periods in reservoirs when spill and turbines are not operated. However, these lags in migration rate might be related to high temperatures that often occur during test periods (Bjornn and Peery, 1992). More recent steelhead migration studies designed to test the effect of zero flow have found no evidence of delay. Temperatures, high in the early summer and low in the fall, have played a more important role in migration rates through reservoirs (Bjornn et al., 1992, 1993, 1994). The increase in reservoir velocity with some drawdown alternatives (SOSs 5, 6, 9a, and 9c) might cause some slight delay in upstream migration depending on the magnitude of increase.

Suspended Sediment—Elevated suspended sediment levels, as would occur in the first year of the natural river or drawdown operations, could delay adult migration. UW laboratory

studies of adult chinook salmon found that these fish avoided natal stream waters (waters they were reared in as juveniles) when concentrations of suspended sediment (volcanic ash) of 350 mg/l occurred (Whitman et al., 1982; Brannon et al., 1981). These studies suggest that suspended sediment concentrations in this range could delay or inhibit upstream migration of chinook salmon. The first year Snake River concentrations of up to 5,000 mg/l under SOS 5 and 500 mg/l under SOSs 6, 9a, and 9c would occur. The second year concentrations would be less than 250 mg/l for these alternatives, except SOS 5c, which would be less. This sediment would affect primarily Snake River spring chinook, because the peak levels would occur during their migration period. Other alternatives are not predicted to elevate suspended sediment to levels that would hurt adult fish migration.

Dissolved Gas—As with juvenile fish, gas supersaturation can cause mortality in adults. It caused significant losses before the installation of flip lips. Dissolved gas concentrations occasionally still reach levels that can be harmful to adults during migration. From 1965 to 1970, it was estimated that 6 to 60 percent of adult salmon were killed by gas supersaturation (Wietkamp and Katz, 1980). Levels where effects were noted were most often over 120 percent saturation. Levels above those considered safe (110 percent) still occasionally occur on the Columbia and Snake Rivers, but some of the fish mortalities associated with dissolved gas supersaturation are believed to have been reduced through changes in operations and construction of flip lips (Ebel, 1979). Additional mainstem generating units and upstream storage capacity have also contributed to reduced gas levels. However, recently adverse effects of high spill on adult salmon have been observed. Bjornn et al. (1994) studied the migration of adult spring chinook and noted that, of radio-tagged fish released at John Day in 1993, 24.3 percent recaptured at Lower Granite had signs of "head burns." None of the fish had these burns at the time of tagging. However, none of these fish had any external physical signs that could definitely be identified as characteristic of gas bubble trauma such as blisters, hemorrhages, or distended eyes (FPC, 1994). During this migration, high spill occurred at several of the Snake River projects. These physical characteristics were observed during periods of high spill in the 1960s and 1970s; they suggest a relation between injuries observed on adult salmonids and conditions during years with high levels of spill. However, no cause/effect relation to gas bubble disease has been documented.

Compared to existing conditions, most SOSs would have little effect on gas saturation. The natural river alternative, however, would reduce the occurrence of higher gas saturation levels in the Snake River. Increased spill under SOSs 9a and 9c, and to lesser degree 9b and PA, would markedly increase occurrences of elevated concentrations in the spring and summer in the Snake River. This increased gas saturation would increase the mortality risk for adult migrants, primarily for Snake River spring chinook and some summer chinook.

Temperature—In the past, elevated temperatures caused the death of adult salmon migrating through the Columbia and Snake Rivers. Temperatures over 70°F (21°C), which occur frequently in the Snake River during fall chinook migration, may impede upstream salmon and steelhead migration (EPA and NMFS, 1971).

Most alternatives would have little effect on the occurrence of higher temperatures (greater than 62.9°F [17.2°C]) during normal years (see water quality results). The greatest differences would occur under SOS 5, which would result in a higher frequency of cooler temperatures during most years in all lower Snake River reservoirs, although temperatures in the mid-Columbia River would increase markedly only during warm and low-flow years under this alternative. This temperature change could make migrating conditions better for Snake River fall chinook, but worse for mid-Columbia fall chinook. The magnitude of these effects on adult salmon and steelhead remains unknown.

Spawning Habitat—Historically, much of the mainstem Columbia and Snake Rivers contained spawning regions, primarily for fall chinook (Fulton, 1968). Some of these regions are currently submerged under the existing mainstem pools. However, the lower Snake River contained only limited spawning habitat for Snake River fall chinook (Waples et al., 1991). Some of these areas may also have been used by steelhead, as mainstem areas currently are in the Hanford Reach of the Columbia River. The quantity and importance of this region for steelhead spawning is not known. With the exception of SOS 5c, which would have year-round natural river drawdown of the lower Snake River, no alternative would have any effect on current or past spawning areas of salmon or steelhead. SOS 5c, however, would increase the available mainstem Snake River spawning area for fall chinook and possibly steelhead. The drawdown would increase sediment transport within the lower Snake River reach, and after an unknown number of years, would clear much of the fines from bottom gravel, thereby increasing the potential spawning area for fall chinook and possibly for steelhead.

Effects of Alternatives–Quantitative Assessment

Model Descriptions—Overall

The Anadromous Fish Work Group used computer models to determine the overall survival of juvenile fish and adult returns to the tributaries for non-transported fish. Computer modeling was used because models can look at the combined effects of the alternatives, present quantitative results, and compare the alternatives with respect to their effects on the survival of anadromous salmon and steelhead stocks.

Over the last 10 years, several computer models have been developed to assess the effects of river operations and mitigation on Snake and Columbia River salmon and steelhead. These models fall into two categories: juvenile passage and life-cycle. Juvenile passage models predict downstream survival of juvenile salmon and steelhead from the time they leave the tributaries until they arrive below Bonneville Dam. Life-cycle models predict adult return (escapement) to the major tributaries above Federal dams. The life-cycle models typically use the juvenile passage models, in addition to consideration of other factors affecting adult survival, to predict adult returns.

Three juvenile passage models are currently in use within the region. Requests were made by the Anadromous Fish Work Group for all three passage models to be used in the analysis of smolt migration. However, only two were available for use in the Draft EIS: PAM (Passage Analysis Model, NPPC) and CRiSP 1.4/1.4.5 (Columbia River Salmon Passage Model, UW). In addition, the Draft EIS reported results of model runs from the State and Tribal Fisheries Agencies (STFA) Fish Leaving Under Several Hypotheses/Empirical Life Cycle Model (FLUSH/ELCM) system. The Anadromous Fish Work Group also solicited the use of this life-cycle model for the Final EIS, but it was not available. Because of competing workload demands from related study processes, the NPPC and STFA modelers were unable to analyze SOS alternatives for the Final EIS.

For the Final EIS analysis, the Anadromous Fish Work Group used one juvenile passage model: the Columbia River Salmon Passage (CRiSP) Model. The Center for Quantitative Sciences at the UW's School of Fisheries developed CRiSP. The Stochastic Life Cycle Model (SLCM), developed by Resources for the Future, was the only model used to predict adult returns. A more thorough discussion of these models is presented in Appendix C, Anadromous Fish.

The passage models for the analysis depended on the HYDROSIM model to supply estimates of flow conditions at dams and reservoirs under the SOS alternatives. HYDROSIM estimates flow conditions, based on a 50-year historical flow record from 1929 through 1978, to predict average monthly flows

for each 50-year period (April and August have bi-monthly output). The model estimates flow, spill, and reservoir elevation for each alternative for a 50-year period.

The model analysis considered the effects of the SOS alternatives on juvenile survival and adult return for different stocks from selected regions of the basin. Selected stocks of spring, summer, and fall chinook and summer steelhead were evaluated. The CRiSP1.5 model evaluated the effects of the alternatives on 10 fish stocks from the middle (four stocks) and lower Columbia (two stocks) and Snake (four stocks) Rivers. SLCM used the CRiSP juvenile passage survival estimates to predict adult escapement for six of these stocks.

CRiSP1.5 uses several submodels to describe the various elements of mortality, including fish travel time, predation rate, gas bubble trauma, and the multiple routes of dam passage (see Appendix C). The CRiSP version 1.5 differs slightly from the CRiSP versions 1.4 and 1.45 used in the Draft EIS primarily in three ways: how gas saturation affects mortality, how subyearlings respond to flow, and in the calibration methods. Generally, lower mortality is assigned to in-river migrants during saturation levels of less than 120 percent than was assigned in earlier versions of the model, resulting in lower in-river mortality during dam spill periods. One of the largest differences from earlier CRiSP versions was that the model had greater insensitivity of subyearling chinook migration rate to flow velocity; that is, changes in flow velocity had less effect on migration rate. The changes in calibration are discussed in Appendix C. A detailed description of the model and its calibration mechanisms can be found in *Columbia River Salmon Passage Model—CRiSP1* (Anderson et al., 1993).

Juvenile survival was analyzed using two sets of assumptions. The first was that all fish traveled in-river and were not transported. The second was that an alternative specific portion of downstream migrating fish would be collected and transported from various hydroelectric facilities and released below Bonneville Dam. The alternatives range from transport of nearly all fish that are collected at Lower Granite, Little Goose, Lower Monumental, and McNary dams to total eliminations of all transport from any facilities. The portion of fish transported is dependent both on ability to collect fish (e.g., during total drawdown in the Snake River no fish could be collected in this reach) and on alternative-specific requirements concerning how collected fish are treated (e.g., some alternatives require release of a portion of the fish collected directly back to the river below the dam where they were collected). Under this second analysis, various assumptions of the survival rate for transported fish were used. These transport survival assumptions are summarized in the subsection *Model Description-Juvenile Transport*, and are discussed in detail in Appendix C. Adult returns were determined using the resulting passage survival calculated from one of the transport survival models.

SLCM is a simulation model that includes a series of components corresponding to various stages within the life cycle of salmon and steelhead, with transitions from one life stage to the next. The life stages include downstream survival, ocean mortality and harvest, escapement upriver, and survival from spawning ground to juvenile production. The outmigrating smolt survival for SLCM was generated from CRiSP1.5. A unique feature of SLCM is its ability to incorporate a stochastic variation into each step of the life cycle to account for the natural variability and uncertainty of the estimates.

The model was used to estimate returning stocks for 30 to 40 years in the future. The SLCM estimates reflect only the effects of each SOS alternative, considering no other actions beyond system operations. All alternatives, except SOS 9a, include analysis of effects on stocks with and without transport of fish. The only SLCM parameter that changes with system operations in this analysis is smolt passage survival. The model's primary purpose is not to predict actual numbers of surviving juvenile fish or adult fish returning in the future, but to compare the results of different system operation

alternatives. A detailed description of this model can be found in Lee and Hyman (1992).

In adjusting parameter values (such as survival rates) for the model analysis, the work group chose to address only those values that would be directly affected by SOR actions and for which reasonable current estimates could be made. The group did not consider the potential effects of many other actions independent of the SOR that have been taken or may occur in the future. While changes in these other parameters could affect future juvenile survival and adult returns, many are highly speculative with respect to their effects on fish and their implementation prospects. In addition, changes in other parameters would have complicated the analysis of effects of the SOR actions.

The juvenile passage model estimates three types of effects: fish travel time through the Columbia and Snake River system, survival of juvenile fish migrating solely in the river, and overall juvenile fish survival with transportation included. Overall survival, which includes proportional survival of all juveniles transported and not transported, is assessed for all stocks and alternatives. The life-cycle model estimates adult escapement with transport of juveniles based on one transportation survival model for each stock. Most fish usually have been transported from the collector dams (Lower Granite, Little Goose, Lower Monumental, and McNary) to below Bonneville Dam. Transport and in-river migration are two fundamentally different travel modes for juvenile fish. In addition, the fish transport program is controversial within the region, and the choice between transport and in-river migration is a major issue in the regional anadromous fish debate. Fish transport models are discussed in the next subsection. Appendix C presents a more detailed discussion.

A key component in analyzing fish survival is the inclusion or exclusion of fish transportation. All alternatives except SOS 9a include analysis of effects on stocks with and without transport of fish. SOS 9a includes no transportation, while SOSs 5b, 5c, 6b, 6d, and 9c include an evaluation of transport from McNary to below Bonneville (except for Snake River fall chinook, which would be transported from Lower Granite under SOS 9c). The two lower Columbia River stocks—Deschutes spring chinook and Rock Creek steelhead—cannot include transportation because no facilities exist below their area of origin.

The models evaluated results for juvenile fish travel time, juvenile fish survival, and adult returns. The survival results were examined and compared to average flow years. Juvenile survival was estimated for fish migrating in-river and for those transported.

Model Descriptions—Juvenile Transport

Transportation of smolts downstream might cause mortality from high levels of stress or increased disease transmission. These biological uncertainties raised the question of whether to continue transporting fish, and/or under what river conditions. Because of these uncertainties, transportation modeling was conducted to answer two questions. The first was to determine under what conditions, if any, different stocks of fish would be better off remaining in the river and not being transported. The second question was what would be the overall survival of stocks under each of the SOS alternatives using varied transport survival hypotheses. The EIS discussion emphasizes the second task because the primary goal of the SOR is to evaluate different operations alternatives. Survival with transport is compared with in-river survival for all alternatives except SOS 9a, which has no transport. All stocks, except the two lower river stocks (8 of 10 stocks), were evaluated for effects of transport on overall survival.

The CRiSP1.5 model was used for survival estimates with transport and in-river fish for all alternatives and stocks.

Transportation Survival Hypotheses

The analysis used three categories of transport hypothesis: fixed barge survival, fixed survival for 1986 TIR, and adjusted survival.

The latter two transportation survival hypotheses attempted to account for any differential mortality, compared to in-river migrants, that transported smolts may experience in the estuary and during early ocean residence.

Fixed Barge Survival Estimates—The simplest transport survival hypothesis is that of observed barge survival of 98 percent to a release point below Bonneville Dam. This hypothesis was included for all transported stocks evaluated.

Fixed Transportation Survival Based on 1986 TIR—These values were derived from the TIR studies. These values were used for spring/summer chinook and steelhead.

Assuming that adult returns parallel juvenile survival, it follows that—

Example:

$$\textbf{TIR} = \frac{\text{returning 90 "transported" adults}}{\text{returning 90 "control" adults}} = \frac{\text{survival of transported juveniles}}{\text{survival of "control" juveniles}}$$

$$\textbf{therefore:}\quad \text{Juvenile Transportation Survival} = \text{TIR x Juvenile "Control" Survival}$$

Table 4-8 shows the transport survival values calculated for the four stocks assessed in this way. Only 1986 and 1989 migration years had sufficient data to develop these relationships. However, the 1989 data were not used in the final analysis because the results were similar to the fixed barge survival value of 98 percent.

This analysis assumes that the transportation survival estimates do not vary with flow, or with the location from which the smolts are collected. So that once a smolt is loaded into the barge, it will survive at the fixed rate derived above regardless of flow and location.

Fixed Transportation Estimates Based on Adjusted TIR Values—Some authorities, particularly the state agencies and tribes, question the accuracy of the TIRs in estimating survival. Because of this, it has been suggested that the 1986 TIR value be adjusted downward to 0.7:1 for spring chinook to account for any biases produced by the TIR study methods (STFA, 1994). Table 4-9 shows the resulting survival values for Snake River and Methow River spring chinook. (For a complete discussion of the assumptions relating to the Juvenile Fish Transport Program (JFTP) survival values, see the Draft EIS Appendix C-2, Technical Exhibit I, *Assumptions Underlying the Evaluations of the Juvenile Fish Transportation Program*.)

Values Not Used: Variable Transportation Survival TIR Estimates Based on 1977 and 1986 TCR—Another transport survival hypothesis is that survival decreases with reduced flows because fish arriving at the dams for collection and transportation in low flow years are in poorer condition than fish arriving in high flow years. This hypothesis was evaluated in detail in the Draft EIS Appendix C-2. For various reasons, including changes in the hydrosystem and fish passage facilities since 1977, as well as operation of the CRiSP1.5 model, this hypothesis was not included in the Final EIS. A detailed discussion is presented in Appendix C. Included in the Draft EIS is a comparison of the effects of transported to in-river survival during various flows and alternatives. For all SOSs evaluated in the Draft EIS using the variable transport survival hypothesis, total Snake River spring chinook survival was estimated to be higher with the inclusion of transport at all but the highest flows.

Model Results Comparing Transportation Survival Estimates to In-river Estimates

Once the theories on transportation survival have been defined, they can easily be compared to calculated in-river survival estimates. In-river survival estimates are calculated for each of the 50 historic water conditions using CRiSP1.5.

Table 4-8. CRiSP1.5 fixed (1986) transport survival

Stock	1986 "Control" Survival (Percent)	1986 TIR	Derived Transport Survival (Percent)
Snake River Spring and Spring Chinook	48	1.6:1	76
Dworshak Hatchery Steelhead	45	2:1	90
Methow Spring Chinook	48	1.6:1	76
Wenatchee Steelhead	45	2:1	90

Once this is complete, the results of the transportation hypothesis and the in-river survival estimates are calculated for each alternative.

The comparison of average in-river survival to transportation survival among the previously mentioned transportation theories (up to three per species as described above) for the selected alternatives using CRiSP1.5 are included in the overall juvenile survival comparison that follows.

Downstream Passage Model Results, (CRiSP1.5)

The stocks discussed below are grouped according to three river reaches. The first group includes stocks that begin their migration in the Snake River, mostly above Lower Granite Dam. The mid-Columbia River stocks originating in the Hanford Reach and above Priest Rapids Dam form the second group, and the lower Columbia River stocks are the third.

CRiSP1.5 results are applicable to transported and non-transported fish. Traditionally, a small portion of most Snake River and a moderate portion of mid-Columbia River stocks are not transported. There were minor differences in in-river survival for mid- and lower-Columbia River stocks among the alternatives. None of the alternatives would appreciably increase survival of mid-Columbia or lower river stocks. The natural river alternative, SOS 5, had a substantially higher estimated in-river survival for all Snake River stocks than any other alternative. The natural river alternative is estimated to substantially increase the in-river survival of Snake River stocks over existing conditions. Because of the uncertainty of dam passage survival values, the drawdown and combination alternatives, particularly SOSs 6b, 9a, and 9c, could markedly increase or decrease in-river survival of Snake River stocks relative to any flow-control alternative. Snake River fall chinook had the widest range of survival among the

Table 4-9. CRiSP1.5 1986 adjusted transport survival

Stock	1986 "Control" Survival	1986 Adjusted TIR	Derived Transport Survival
Snake River Spring and Spring Chinook	51%	0.7:1	36%
Methow Spring Chinook	51%	0.7:1	36%

alternatives, showing the largest relative increase with SOS 5 and decrease with SOS 9c.

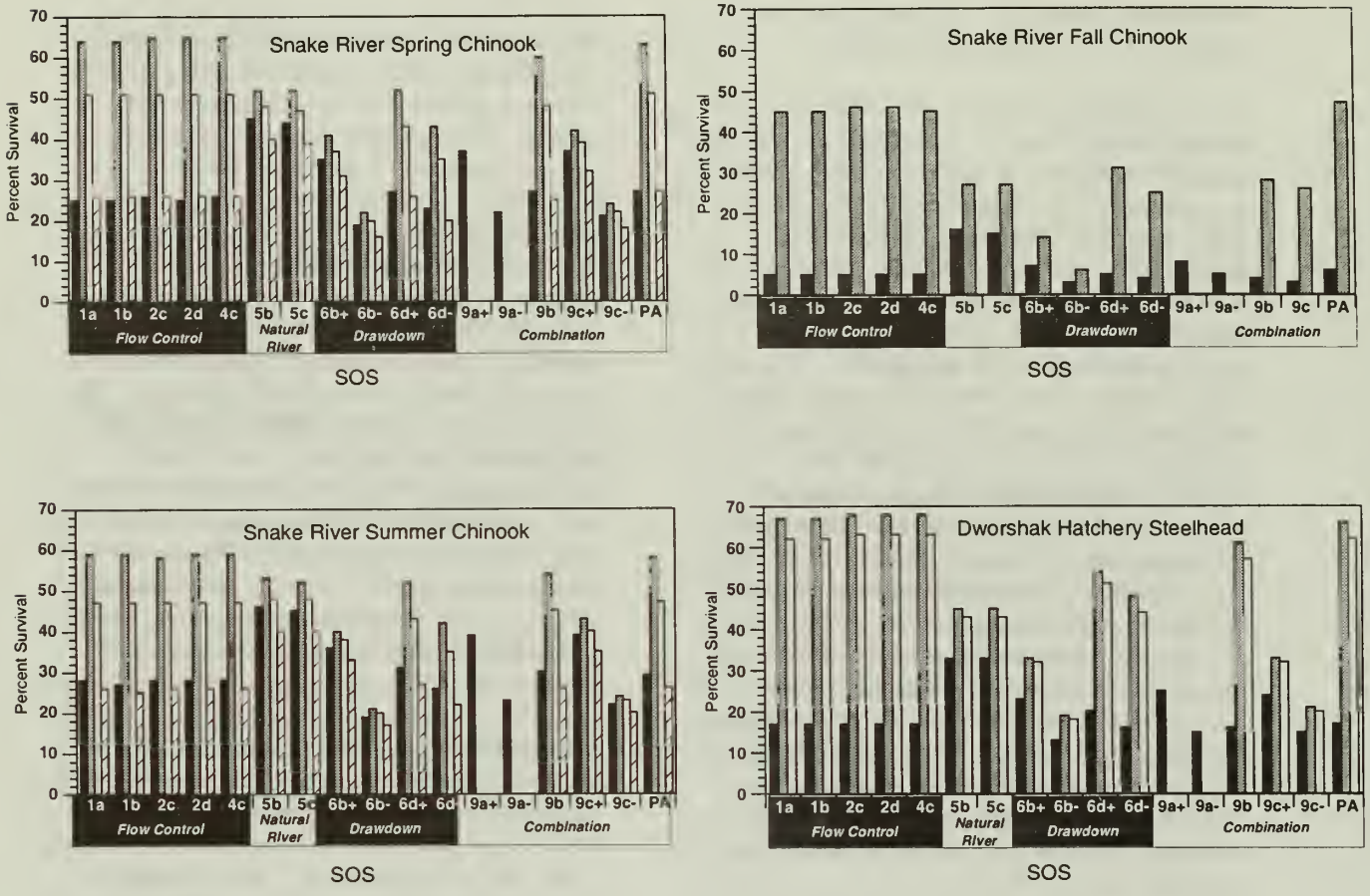
The ranking of alternatives and relative survival changes, from in-river to with-transport, was primarily dependent on which transport model was assumed. This was especially true for Snake River and some mid-Columbia River stocks. The fixed survival model, which was used for all transported stocks, resulted in much greater overall survival for all stocks where transport occurred for all alternatives. Overall survival based on the 1986 TIR transport model, although lower, was still much higher than in-river survival in most cases. These two transport survival models usually resulted in higher overall survival for Snake River stocks occurring with flow control alternatives or SOS 9b or SOS PA. The overall survival results of the natural river alternatives were usually close for the Snake river stocks, although fall chinook results were much lower. Except for Methow River spring chinook, the mid-Columbia stocks had much higher overall survival with transport than for in-river migration for all alternatives under these two transport hypotheses. Little difference occurred among alternatives for mid-Columbia river stocks.

The results of the 1986 adjusted TIR transport model, which was used only for Snake River spring and summer chinook and Methow River spring chinook, had overall survival values similar to in-river for most alternatives, with the natural river alternative having the highest overall survival. The lower-river stocks were unaffected by the transport models because they are downstream of all transport facilities.

Snake River Stocks—
Spring Chinook In-River: Below are the survival estimates for Snake River fish, modeled as though the whole population were migrating in-river. Predicted survival of in-river migrants parallels the observed travel time measures (see later section). In reality, however, very few of these fish remain in-river during their juvenile migration. Depending on flow conditions and the level of spill, up to 85 percent of Snake River stocks are transported by truck or barge to below Bonneville Dam. Overall juvenile survival estimates, including transport, follow. The greatest average survival for spring chinook in-river migration was with the natural river options. These options showed an average survival of around 45 percent to below Bonneville Dam under 50-year average water conditions (Figure 4-6). SOSs 6b, 6d, 9a, and 9c have the potential to either increase or decrease juvenile survival compared to existing conditions depending on the use of either optimistic or pessimistic assumptions about juvenile survival in this untested operation. Of these, the Lower Granite drawdown (SOS 6d) with optimistic assumptions is only slightly higher than any of the flow control alternatives at 27 percent survival. The average survival value varies only slightly for the flow control alternatives, averaging about 25 percent smolt survival. SOSs 9b and PA have survival slightly higher than the flow control alternatives at 27 percent.

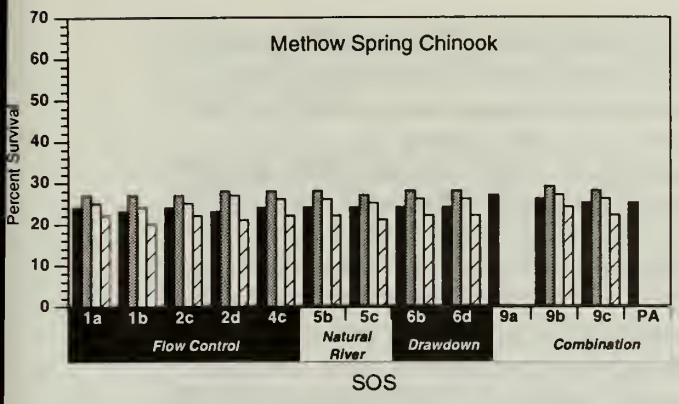
Spring Chinook—With Transport: Based on the fixed barge and 1986 TIR transport hypotheses, total survival was usually double or higher than the in-river survival for SOSs 1, 2, 4, 9b, and PA (Figure 4-6). Other alternatives' total survival were also higher than in-river survival, although differences were less for these two transport hypotheses. Under the 1986 adjusted TIR hypothesis, total survival was nearly the same as in-river survival for SOSs 1, 2, 4, 9b, and PA, while lower for the drawdown (SOSs 6b, 6d, 9a, and 9c) and natural river (SOSs 5b and 5c) alternatives.

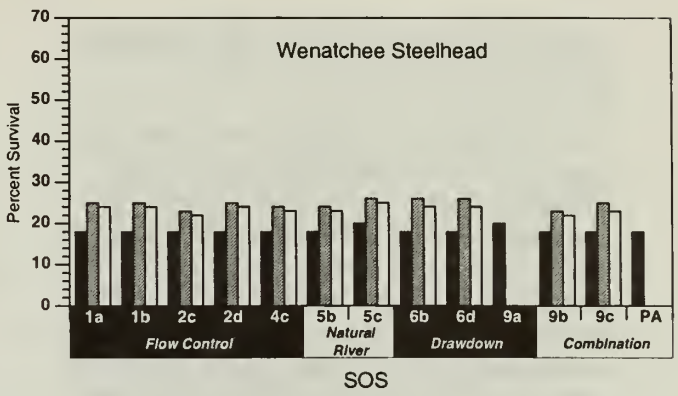
The fixed barge and 1986 TIR have similar rankings among the alternatives. All flow control alternatives had similar overall survival (64 to 65 percent fixed; 51 percent 1986 TIR) and were higher than other alternatives. Slightly lower overall survival occurred for SOSs 9b and PA (60 to 63 percent fixed; 48 to 50 percent 1986 TIR). The natural river alternatives were also slightly lower (52 percent fixed; 47 to 48 percent 1986 TIR). Even with optimistic assumptions, the drawdown alternatives have much lower survival (less than 52 percent and

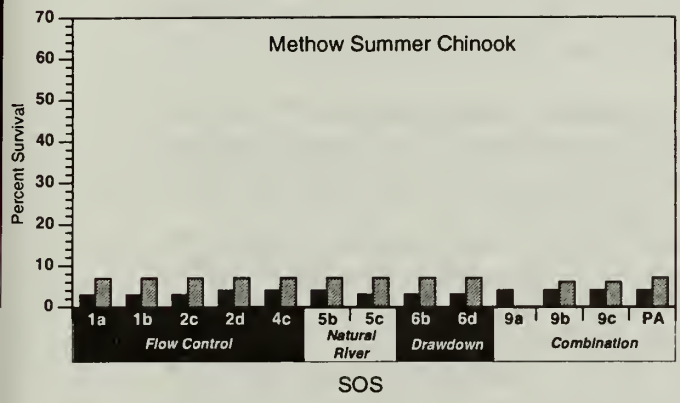


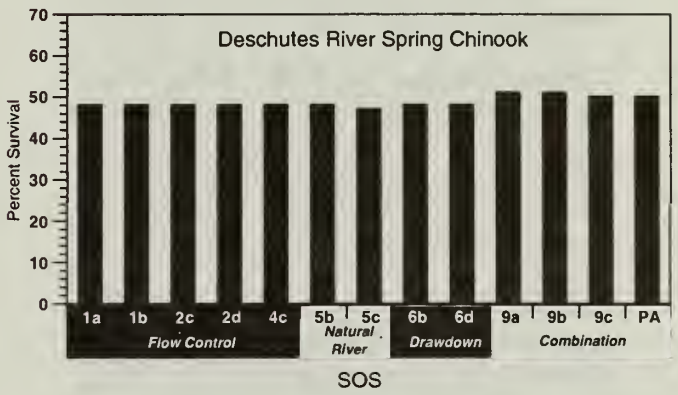
Note: SOSs 9a, 9a+, and 9a- have no fish transport.

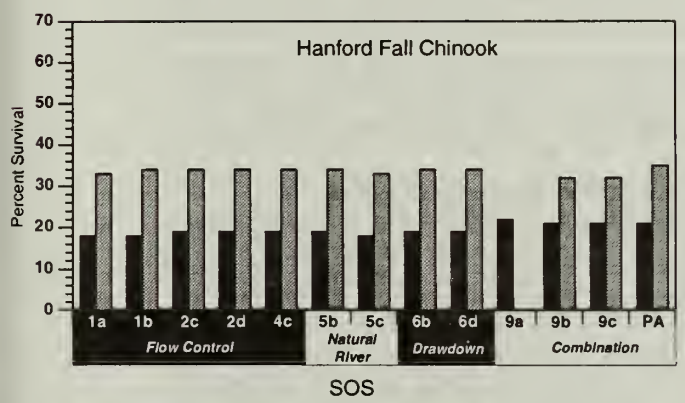
Figure 4-6. CRiSP1.5 estimated juvenile passage survival assuming average water year for in-river only migration, and with fish transport using varied transport survival models (source: Appendix C).
Page 1 of 2

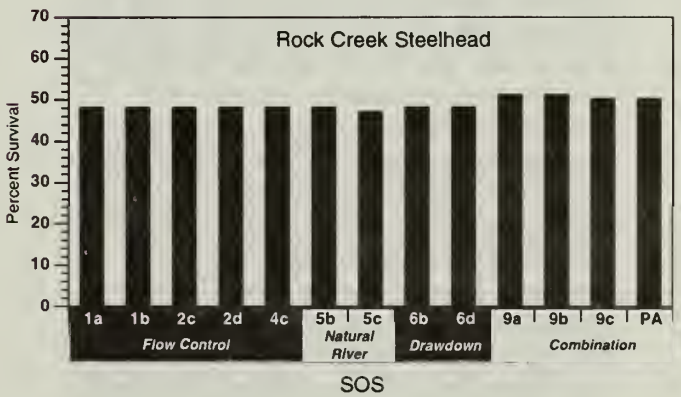












Transport Survival Hypotheses

Inriver Survival | Fixed Barge | 1986 TIR | 1986 Adjusted TIR

Note: SOSs 9a and PA (Methow Spring Chinook and Wenatchee Steelhead only) have no fish transport.

Figure 4-6. CRiSP1.5 estimated juvenile passage survival assuming average water year for in-river only migration, and with fish transport using varied transport survival models (source: Appendix C).
Page 2 of 2

43 percent, for fixed and 1986 TIR hypotheses, respectively) than other alternatives.

The 1986 adjusted TIR hypotheses results, which assume much lower transported fish survival, altered the overall ranking of the alternatives. The natural river alternatives had the highest survival at about 40 percent. The optimistic alternatives, SOSs 6b+ and 9c+, were next highest at 31 to 32 percent. With pessimistic assumptions, however, these had the lowest total survival (16 to 18 percent) among alternatives. The flow control alternatives, optimistic SOS 6d+, SOS 9b, and SOS PA, had an intermediate range of overall survival (25 to 27 percent).

Summer Chinook—In-River: Snake River summer chinook estimates follow much the same trend as spring chinook for average in-river survival (Figure 4-6). Natural river options provide the best survival results with about 46 percent in-river survival.

Summer Chinook—With Transport: The trends were similar to spring chinook among the transport hypotheses, with total survival being much higher with transport than in-river migration only for the fixed and 1986 TIR hypotheses for all but SOSs 6b and 9c (and SOS 5 for the 1986 TIR hypothesis). The reason that some alternatives did not have higher survival with transport was because little transport occurred with these alternatives. The highest survival among alternatives was for flow control alternatives, and SOS PA for these two transport hypotheses, and for natural river for the 1986 TIR hypothesis. The adjusted 1986 TIR hypothesis indicated highest survival among the alternatives with natural river; however, total survival was less than in-river survival for the same alternatives with this transport hypothesis.

Fall Chinook—In-River: Snake River fall chinook in-river survival trends were similar to other chinook stocks (Figure 4-6). The natural river options are still preferable to any other in-river migration, with mean survivals being about 16 percent and all others less than 9 percent. Flow control alternative survivals, while much lower than natural river at 5 percent, are about in the middle range of the remaining alternatives for in-river survival. The alternatives with drawdown components range around the flow control alternative survival, depending on assumptions. Those alternatives with optimistic passage assumptions (SOSs 6b+, 6d+, and 9a+) range from 5 to 8 percent survival; alternatives with pessimistic assumptions range from 3 to 5 percent survival. SOSs 9c had the lowest in-river survival of 3 percent primarily because drawdown does not occur during the major migration period for this stock, while the higher spill that would occur during migration would reduce survival due to increased gas saturation. SOS PA had a survival in the middle range of the alternatives at 6 percent.

Fall Chinook—With Transport: Under the fixed barge hypothesis, survival with transport is much higher, typically 2 to 9 times higher for the same alternatives than in-river survival alone. The flow control alternatives and SOS PA have the highest survival, ranging from 45 to 47 percent. The one-pool drawdown (SOS 6d), four-pool drawdown (SOS 9c), natural river, and SOS 9b have similar survival values about half those of flow control alternatives, ranging from 25 to 31 percent. The highest and lowest values of this group are for SOSs 6d+ and 6d-. The lowest values were for extended period four-pool drawdown alternative SOS 6b (6 to 14 percent). These lower values were primarily because fewer fish are transported from McNary Dam.

Dworshak Hatchery Summer Steelhead—In-River: The trends for other Snake River stocks also hold true for Dworshak hatchery summer steelhead. The natural river alternative still has the highest in-river survival results at 33 percent average. As with spring chinook, the primary reason for this higher survival for natural river is from the elimination of turbine mortality in the Snake River. The next highest average survival (23 to 25 percent) was for alternatives having drawdown and optimistic dam passage assumptions (SOSs 6b+, 6d+, 9a+, and 9c+). These same alternatives with pessimistic assumptions had the lowest survival values, 13 to 16 percent. The flow control alternatives, including base case (SOS

2c), and combination alternatives (SOSs 9b and PA) had only a slightly higher average survival (16 to 17 percent).

Dworshak Hatchery Summer Steelhead—With Transport: The results of the two survival hypotheses used, fixed barge and 1986 TIR, were nearly identical. For all alternatives that included transport (SOS 9a has none), overall survival was much higher than in-river survival alone. Increase in survival ranged from about 25 to 400 percent over in-river values for the same alternatives. Highest average total survival occurred with all flow control alternatives and SOSs 9b and PA, with most exceeding 60 percent survival. The one-pool drawdown alternative (SOS 6d) with optimistic assumptions was the next highest (51 to 54 percent for the two hypotheses). The one-pool drawdown with pessimistic assumptions (SOS 6d-) and natural river alternatives were next highest, at 43 to 48 percent, considerably lower than the highest group. The remaining alternatives (SOSs 6b and 9c) were much lower than the highest group at 18 to 33 percent for both transport survival hypotheses. These results are generally reflective of high survival values used for transported fish, causing those alternatives that transported the greatest portion of steelhead to have the highest total survival.

Snake River In-River Summary: In-river survival estimates for the natural river options are greater than for all other alternatives. The four-pool drawdown scenarios, with optimistic assumptions (SOSs 6b+, 9a+, 9c+), increase survival estimates over the in-river estimates produced for flow control alternatives. The one-pool drawdown, with optimistic assumptions, has usually only slightly higher survival than most flow-control alternatives and SOSs 9b and PA. The drawdown scenarios with pessimistic assumptions (SOSs 6b-, 6d-, 9a-, and 9c-) did not improve survival for any stock.

Snake River Transport Summary: The overall survival and ranking of alternatives was highly dependent on which transport survival model was used. The 1986 adjusted TIR transport hypothesis, which assumes low transport survival, applied only to spring and summer chinook. This hypothesis resulted in overall survival and alternative ranking about the same as in-river conditions. The natural river alternatives were highest in overall survival followed by the four-pool drawdown alternatives with optimistic assumptions (SOSs 6b+ and 9c+). The flow control and PA alternatives were in the middle rank of survival for this hypothesis.

In contrast, the fixed barge and 1986 TIR transport hypotheses resulted in much higher overall survival for alternatives that included a large amount of transport than for in-river survival. This was most noticeable for fall chinook that had overall survival ranging from 2 to 9 times higher with transport than for in-river only. These two hypotheses had all of the flow control alternatives and SOS PA with the highest overall survival. SOS 9b usually was next in ranking, followed by natural river. The optimistic assumption four-pool drawdown alternatives (SOSs 6b+ and 9c+) were usually next, except for fall chinook which had its lowest survival for SOSs 6b+ and 6b- due to the lack of transport during the 4.5-month drawdown in the Snake River. The one-pool drawdown (SOS 6d) and pessimistic assumption four-pool drawdown alternatives (SOSs 6b- and 9c-) were generally the lowest in overall survival.

Mid-Columbia Stocks—Methow River Spring Chinook In-River: As expected, there is little difference in survival for Methow River spring chinook among any of the alternatives over the 50-year in-river migration. The drawdown and natural river alternatives do not substantially affect flows for mid-Columbia stocks. Mean survival ranges from 23 (SOSs 1b and 2d) to 27 (SOS 9a) percent for all alternatives.

Methow River Spring Chinook—With Transport: Overall survival increased slightly with transport under both transport hypotheses for all alternatives. Similar to in-river survival, there is little difference among alternatives. The fixed barge total survival ranged from 27 to 29

percent, while the 1986 TIR model values ranged from 24 to 27 percent. These values equal an increase of about 12 to 20 percent and 4 to 17 percent (most less than 8 percent) in relative survival over in-river survival for the same alternatives, for the two transport hypotheses, respectively. Transport has less effect on this stock than on the Snake River stocks because no fish transport occurs before McNary Dam for Mid-Columbia stocks.

Methow River Summer Chinook: Like that of Methow River spring chinook, summer chinook in-river survival shows slight differences among the alternatives for the 50-year period, ranging from 3 to 4 percent for all alternatives (Figure 4-6).

Methow River Summer Chinook—With Transport: Relative survival increased substantially (50 to over 100 percent by alternative) with transport for summer chinook, with total survival ranging from 6 to 7 percent based on the fixed barge hypothesis. However, overall survival, even with transport, remains low and differences among alternatives remain slight.

Hanford Reach Fall Chinook—In-River: Hanford Reach fall chinook respond about the same as the Methow River summer chinook. But their overall in-river survival values are higher because they have fewer dams to negotiate. In-river survival averaged 18 (SOS 1) to 22 (SOS 9a) percent for 50 years.

Hanford Reach Fall Chinook—With Transport: Like summer chinook, transport increased relative survival substantially (50 to 90 percent) based on the fixed barge hypothesis. Total survival varied little among alternatives ranging from 32 to 35 percent.

Wenatchee Steelhead: All alternatives provided similar in-river survival for Wenatchee steelhead, averaging 18 to 20 (SOSs 5c and 9a) percent for the 50-year period.

Wenatchee Steelhead—With Transport: The two transport hypotheses had similar results with average survival ranging from 23 to 26 and 22 to 25 percent for the fixed barge and 1986 TIR hypotheses, respectively. These values are typically greater than 20 percent higher than in-river survival estimates for the same alternatives.

Mid-Columbia In-River Summary: Natural river and drawdown alternatives would not affect mid-Columbia stocks in-river survival. Changes in Snake River flows would be attenuated by the time they mix with the flows from the Columbia River.

Mid-Columbia stocks had slight overall in-river survival improvement with alternatives that relied primarily on spill for fish passage (SOSs 9a and 9b), especially in combination with lower John Day pool levels (SOS 9a).

Mid-Columbia with Transport Summary: Based on the fixed barge 1986 TIR transport hypothesis, overall survival of all stocks was improved with transport. Except for Methow spring chinook, these survival increases were substantial for all alternatives with these two hypotheses, with some exceeding 100 percent increase. A decrease in survival with transport, relative to in-river survival, occurred for Methow spring chinook with the adapted 1986 TIR transport hypothesis. However, even with transport, survival remained low for Methow summer chinook. No alternative was consistently better for all stocks and little difference occurred in overall survival among alternatives based on either transport model.

Lower Columbia Stocks—The Deschutes spring chinook are not transported, because they enter the mainstem below McNary Dam, the last fish transport facility. There was little difference among alternatives for this stock, with survival averaging 47 (SOS 5c) to 51 (SOSs 9a and 9b) percent during the 50-year period.

The Rock Creek steelhead, which is also below transport facilities, had trends similar to Deschutes spring chinook. This stock showed little variability of survival among the

alternatives, ranging from 35 to 37 percent for the 50-year period.

Survival varied little among alternatives primarily because mainstem flows varied little among alternatives. Also, changes in dam configurations for some alternatives occurred upstream of these stocks' origin.

Summary: Natural river and drawdown alternatives would not directly affect lower Columbia stocks. Changes in Snake River flows would be less noticeable by the time they mix with the larger flows from the Columbia River. These fish enter the river downstream of the last transport site; hence, they are not transported. Lower Columbia river stocks showed some slight survival improvement for the combination alternatives that emphasize spill for passage at dams, including SOSs 9a, 9b, and 9c.

Downstream Travel Time

The CRiSP1.5 model calculated travel time for in-river migration from the stream of origin to below Bonneville Dam. Table 4-10 summarizes the results.

Although there are differences among stocks, as expected, the natural river operation (SOS 5) would provide the fastest in-river travel times for Snake River stocks. Travel times for SOS 5 were followed by alternatives having four-pool drawdown (SOSs 6b, 9a, and 9c). The shortest travel times for fall chinook occurred with SOS 5 and 4-pool draw down alternatives (SOSs 9a and 6b).

Other than the much lower travel times of natural river alternatives, average differences among alternatives were slight for Snake River stocks, ranging from 0 to 4 days between slowest to fastest.

Travel time for mid-Columbia stocks varied little among alternatives, ranging from only 1 to 3 days (about 10 percent difference or less). The combination alternative SOS 9a was consistently among the lowest in travel time. No differences in travel time occurred for lower Columbia River stocks.

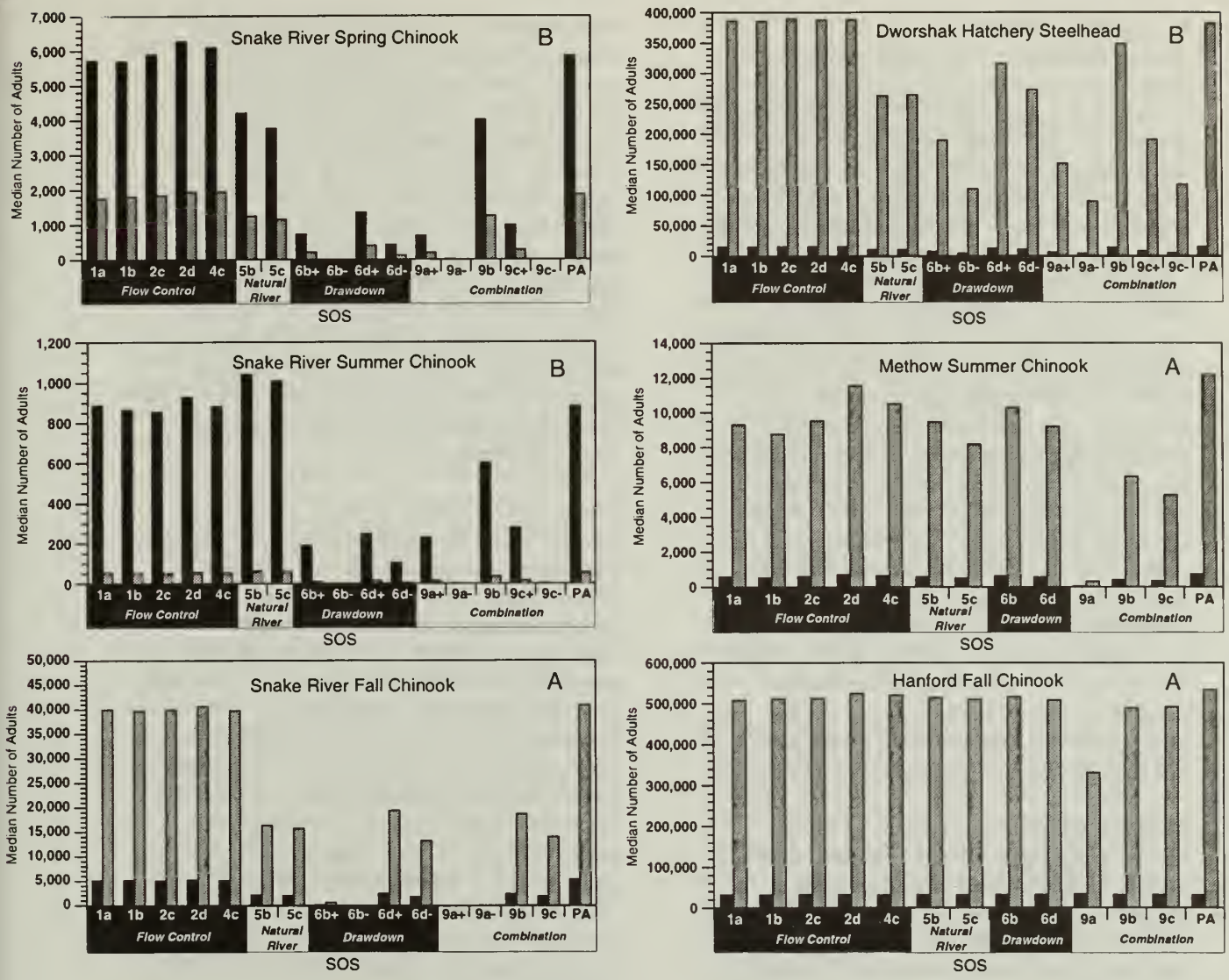
Returning Adults

The purpose of this analysis was to compare changes in adult return and harvest numbers across several operating strategies; it was not to evaluate salmon recovery. The SOR analysis includes only changes in system operations that affect juveniles. The estimated number of returning adults is based on changes in in-river juvenile survival rates, so, among the alternatives, adult trends mirror those of estimated juvenile survival. Effects from other factors, which can have major impacts on adult returns, were not modeled. These changes include ocean conditions; harvest (reduced or increased ocean and in-river); and adult migration (e.g., improved or decreased dam passage, reduced fallback through turbines, increased gas saturation, and temperature changes). Adult passage factors may be affected by different SOS actions, particularly those involving drawdown or natural river operations. The SOR staff recognizes that these factors affect the number of returning adults.

Numbers of adults returning to the subbasins were estimated for migration with transport only using the SLCM model (Figure 4-7). The transport survival models presented in the EIS Main Report were those the staff believed most representative of the actual barge survival conditions for the specific stocks. Adult escapement and harvest estimates based on other transport survival models, that were included for juvenile survival discussion, are presented in Appendix A of the Anadromous Fish Appendix C. The optimistic and pessimistic assumptions are determined separately. SLCM results in some cases overestimate total harvest numbers. The harvest numbers for Dworshak hatchery steelhead and Snake River fall chinook are too high, while mid-Columbia summer chinook might be too high. This affects neither the ranking of the alternatives nor the estimated escapement numbers.

Table 4-10. Average in-river juvenile travel time (days) for surviving fish during 50 average water year conditions based on CRiSP 1.5 model

Stock	Group 1: Flow Control (1a, 1b, 2c, 2d, 4c)	Group 2: Drawdown (6b+, 6b-, 6d+, 6d-)		Group 3: Natural River (5b, 5c)	Group 4: Combination (9a+, 9a-, 9b, 9c+, 9c-, PA)
	Flow control in-river	(6b+, 6b-) Four-pool drawdown; no transport; includes drawdown of John Day to MOP	(6d+, 6d-) Lower Granite Reservoir drawdown; no transport at LGR; continued transport at other projects; John Day to MOP	Natural Snake River, including John Day to MOP	Varied drawdown; varied Snake River spill, with and without transport
SNAKE RIVER			*Days (Range)*		
Spring Chinook	21 (1b) to 20	18	20	15	20 (PA,9b) to 17 (9c-)
Summer Chinook	25 (1) to 24 (2,4)	23	24	19	24 (PA,9b) to 22 (9a+, 9c)
Fall Chinook	57 (1,4) to 56 (2)	56	56	29	55 (PA,9b,9c) to 54 (9a)
Dworshak Hatchery Summer Steelhead	23 (1b,2d) to 22 (1a,2c,4c)	20	22 (6d-) to 21 (6d+)	16	22 (PA,9b) to 18 (9a+)
MID-COLUMBIA RIVER			*Days*		
Methow River Spring Chinook	27 (4c) to 26	26	26	26	26 (PA, 9c) to 25 (9a,9b)
Method River Summer Chinook	36 (1,2c) to 35 (2d, 4c)	36	36	36	35 (PA) to 33 (9a)
Hanford Reach Fall Chinook	23 (1,2c) to 22 (2d,4c)	23	23	23	22
Wenatchee Hatchery Summer Steelhead	33 to 33	32	32	33 (5c)-32(5b)	33 to 32 (9a)
LOWER COLUMBIA RIVER			*Days*		
Deschutes River Spring Chinook	12 12	12	12	12	12
Rock Creek Steelhead	16 16	16	16	16	16



Note: A = fixed barge survival transport hypothesis; B = 1986 TIR transport hypothesis; no transport for 9a, 9a+, or 9a-.

Figure 4-7. Estimated total harvest and spawner escapement for 30 to 40 years into the future, based on selected transport survival hypotheses using SLCM analysis

Snake River Stocks—

Spring Chinook: The median number of adults produced in 30 to 40 years, as predicted by SLCM using the 1986 TIR transport survival hypothesis, was highest for the flow control alternatives, including the base case alternative (SOS 2c) and combination alternative SOS PA (Figure 4-7). There was little variability among these alternatives with escapement ranging from 5,700 to 6,300, and harvest 1,800 to 1,900 fish, with SOS 2d having the highest values. The natural river options and alternative SOS 9b had slightly lower adult production estimates with 3,800 to 4,200 escaped, and 1,200 to 1,300 harvested. The other alternatives had much lower estimated adult spring chinook production with the optimistic dam passage assumptions. The one-pool drawdown (SOS 6d+) was next highest at 1,400 escaped and 400 harvested fish, respectively. The alternatives with four-pool drawdown and optimistic dam passage assumptions (SOSs 6b+, 9a+, and 9c+) had a total escapement of 700 to 900, and a harvest of 200 to 300 fish. The four-pool drawdown alternatives with pessimistic dam passage assumptions had very low adult production of less than 20 fish total escapement and harvest.

Summer Chinook: Using the 1986 TIR transport hypothesis, summer chinook showed slightly different trends in median adult production in 30 to 40 years than spring chinook using the same models and transport hypotheses. The natural river alternatives had the highest adult production (estimated escapement of 1,000, harvest of 60). The flow control alternatives (including SOS 2c) and SOS PA were only slightly lower with an escapement of 900 and harvest of 50 to 60 fish. SOS 9b has about half the highest values with 600 escaped and 40 harvested. As with spring chinook, four-pool drawdown alternatives (SOSs 6b+, 9a+, and 9c+) with optimistic passage assumptions were much lower with 200 to 300 escaped and 10 to 20 harvested. Less than 5 total fish were estimated to be produced, assuming pessimistic dam passage parameters for these same alternatives.

Fall Chinook: Median fall chinook adult production estimates, assuming fixed barge survival, showed essentially no change among the five flow control alternatives and SOS PA, with estimated median escapement of 5,100 to 5,300 and harvest of 40,000 to 41,000. The natural river alternatives would produce about half as much as the flow control alternatives with an estimated 2,000 escaped and 16,000 harvested. The optimistic one-pool drawdown (6d+) and SOS 9b were nearly the same as natural river, with 2,300 and 19,000 escaped and harvested, respectively. With assumed pessimistic dam passage conditions, SOS 6d- had lower adult production of 1,700 escaped and 13,000 harvested.

Under SOS 6b, where all four Lower Snake projects would be drawn down to near spillway crest during the fall chinook out-migration period, Snake River fall chinook would either become extinct or maintain a minimal population, depending on whether optimistic or pessimistic dam passage conditions are assumed. This is likely due to the absence of transportation for this stock. Under SOS 9a, where there is no transportation assumed, Snake River fall chinook became extinct. Under SOS 9c, even though all four Lower Snake projects would be drawn down to near spillway crest, the pools would be refilled by June 30 each year in time for the transportation program to collect the out-migrating juvenile fall chinook. Under SOS 9c, production is estimated to be about 1,800 spawners and 14,000 harvested.

Dworshak Summer Steelhead: Adult production with transport, using the 1986 TIR transport hypothesis, is estimated to be similar among the flow control alternatives and SOS PA. These SOSs had escapement of about 15,000 and harvest ranging from 382,000 to 388,000. SOS 9b has only slightly less adult numbers, with escapement and harvest of 14,000 and 348,000, respectively. The one-pool drawdown alternative (SOS 6d) with both pessimistic and optimistic assumptions was moderately lower at 11,000 to 13,000 escaped and 316,000 to 273,000 harvested. Natural river alternatives follow with 10,000 escaped

and 263,000 to 264,000 harvest. The four-pool drawdown alternatives (SOSs 6b, 9a, and 9c) had the lowest adult production. Assuming optimistic dam passage conditions, these three alternatives had returns ranging from 6,200 to 7,800 escaped and 151,000 to 191,000 harvested in 30 to 40 years. The pessimistic passage versions of these alternatives returned only 3,600 to 4,800 escaped and 90,000 to 119,000 harvested. SOS 9c, which had no transport at the lower Snake River projects, had similar results to the other drawdown alternatives because little transport of steelhead would occur until McNary Dam, allowing much of the same in-river and dam passage mortality to occur with all three alternatives. Generally, except for natural river alternatives, those alternatives with less disruption to the current operation of reservoirs and transport system had higher overall adult steelhead production.

Snake River Summary: The results of life-cycle modeling, which use hypotheses containing favorable transport survivals, indicate that the greatest number of adults in most cases would occur with any of the flow control alternatives and with SOS PA. With the exception of summer chinook, adult production within 30 to 40 years was estimated to be markedly higher with these alternatives than any of the others. Slight differences among the higher return alternatives occurred within each stock. The one exception to this was for summer chinook, which had slightly higher adult production with either of the natural river alternatives. The natural river alternative for the other three stocks was in the middle range of returns among alternatives, but considerably lower than returns of the highest alternatives. SOS 9b, which includes flow targets, reservoirs to MOP, and frequent spill, also had some of the higher adult production numbers, especially for steelhead. But it too was much lower than the highest producing alternatives. All of the alternatives containing drawdown did considerably worse for adult production, even with optimistic dam passage assumptions, with the one-pool drawdown alternative being the best of this group. With pessimistic passage assumptions, these alternatives were extremely poor, driving some stocks to extinction within the 30- to 40-year period.

Mid-Columbia Stocks—
Methow River Summer Chinook: Adult production in 30 to 40 years, assuming fixed barge survival, would be similar among all alternatives except SOSs 9a, 9b, and 9c, which would be much lower. The estimated escapement of the higher-producing alternatives, including SOS 2c, range from 500 to 700 with a harvest of 8,800 to 12,200. Of these, the highest number of adults was produced with SOSs PA and 2d, which exceed SOS 2c returns by over 20 percent. SOSs 9b and 9c are considerably lower (escapement of 300 to 400, harvest of 5,300 to 6,300). This might be because of reduced fish transport from increased spill at McNary Dam. SOS 9a has extremely low estimated adult production (20 escaped, 300 harvested), primarily because no transport occurs with this alternative, which is assumed to be a great benefit to survival with the fixed barge transport hypothesis.

Hanford Fall Chinook: Other than SOS 9a, there was little difference among the alternatives in adult production estimates of Hanford fall chinook using the fixed barge transport hypothesis. All alternatives have nearly the same escapement (32,000 to 33,000) because of the imposition of a minimum escapement cap of 50,000 at McNary (to simulate the effects of *US v. Oregon* harvest regulations). Harvest of all but SOS 9a is similar, ranging from 492,000 to 532,000. Similar to summer chinook, the highest producing alternatives were SOSs PA and 2d, which were less than 5 percent higher in adult production than SOS 2c. Lack of transport from McNary Dam is the primary reason SOS 9a was greatly lower than the other alternatives, with an estimated 331,000 harvested fish in 30 to 40 years.

Mid-Columbia River Summary: Most alternatives would provide adult production similar to what would occur under existing conditions for Methow summer chinook and Hanford fall chinook. The exception would be SOS 9a for both stocks and SOSs 9b and 9c for

Methow summer chinook. Changes from existing conditions are minor with SOS PA, which has the highest estimated adult production for both stocks and exceeds SOS 2c values. Hanford fall chinook are affected less than most stocks by differences among the alternatives. This is because their outmigration is restricted to a short region of the mid-Columbia and the lower Columbia, where only slight differences in flow and operational characteristics occur among alternatives.

Lower Columbia River Summary: The number of lower river returning adults were not estimated in the Final EIS. Because the adult returns are calculated as a direct function of juvenile survival, and juvenile survival from this region changed little among the alternatives, little or no adult production difference would be expected among the alternatives.

Other Anadromous Stocks

Commercial and recreational anglers fish for other Columbia River anadromous stocks, including white sturgeon, American shad, and Pacific lamprey. Minor or no effects would occur to most of these stocks under the flow control alternatives. Major drawdowns (SOSs 5, 6, 9a, and 9c) could have marked effects on some portions of these stocks. Fish that rear primarily in the specific shallow pool areas that would be dewatered during drawdown would be most affected, primarily juvenile American shad and lamprey in the lower Snake River. Minor effects to rearing fish could occur from operating John Day pool below normal elevations (SOSs 2, 4, 5, 6, 9, and PA). These effects would be worse under SOSs 5, 6, 9a, and PA, which require the lowest elevation for this reservoir. The lowered elevation could reduce the rearing area for shad and lamprey, which use shallow, sandy water areas to rear. This is, however, a relatively small portion of the total rearing area used by these stocks and would likely have only minor effects. Effects may be more pronounced for shad than lamprey; most juvenile lamprey rearing is in tributary streams, while shad rely exclusively on the reservoirs.

American Shad: American shad rearing and spawning habitat in the Snake River would be reduced by the natural river alternative, and to a lesser extent by drawdown under SOSs 6, 9a, and 9c. The numbers of Snake River shad would diminish because of a decrease in shallow, slow-water juvenile rearing habitat or decreased food supply in these areas. Effects on habitat would be worse under alternatives with drawdown past July (e.g., SOSs 5, 6, and 9a) because major juvenile rearing occurs from July through October. Modified adult passage facilities under SOSs 5, 6, 9a, and 9c could also reduce the number of adult upstream migrants that successfully pass over the dams. Dam counts indicate, however, that the relative numbers of fish that use the Snake River or just Lower Granite are less than 10 percent or 1 percent, respectively, of the Columbia River total. Therefore, any reduction in numbers under these alternatives would have a minor overall effect on the Columbia River system population.

Pacific Lamprey: Effects on Pacific lamprey under the natural river and drawdown alternatives and SOSs 9a and 9c should be minor. Most spawning and rearing apparently occurs in tributaries, and drawdown would have little effect on these areas. Dewatering of shallow areas could, however, cause losses of some juveniles that rear buried in the mud and sand for up to 5 years. Based on the fact that fewer juvenile lamprey were counted at Little Goose Dam in 1992 following the experimental spring 1992 drawdown, losses might occur under these alternatives. Depending on how successful future upstream passage facilities would be if the Snake River dams were modified, migration upstream in the Snake River for adults could also be jeopardized under the natural river and drawdown alternatives. The effect of water particle travel time on migration of lamprey is unknown. However, if there is a positive effect on migration, outmigrating juveniles would benefit the most under the natural river alternative and to a lesser extent under SOSs 6, 9a, and 9c. Also, because of increased spill, the natural river alternative and, to a lesser extent, SOSs 9a, 9c, and PA would reduce dam passage

mortality by eliminating or reducing turbine mortality on the Snake River.

Sturgeon: The anadromous form of white sturgeon is mostly restricted to below Bonneville Dam; green sturgeon occur exclusively below Bonneville. These fish should not be affected by any of the alternatives. Primary factors affecting white sturgeon appear to be deep-water habitat and flows below Bonneville Dam, neither of which would be markedly affected under any SOS alternative. Because changes in the lower river are not proposed, the green sturgeon should not be affected.

Isolated populations of white sturgeon in individual reservoirs could, however, be affected under the natural river and drawdown alternatives (see Section 4.2.5, Resident Fish). Spawning success in the mainstem reservoirs is affected by water velocity during spawning, with better spawning success occurring in higher flow years (Hanson et al., 1992). Alternatives that substantially increase reservoir velocity during the April and July spawning period (SOSs 5, 6b, 9a, and 9c) might benefit sturgeon populations in reservoirs by improving spawning conditions. Lower Granite's spawning white sturgeon are unlikely to be affected because of ample spawning area in the Snake River above the reservoir. The preferred rearing habitat is the deeper water in most reservoirs; Lower Granite Reservoir is one exception, where sturgeon make greater use of shallower (less than 66 feet [20 m]) areas (Bennett et al., 1993). While little reduction in this habitat would occur under most alternatives, the natural river options would reduce this area substantially in the Snake River reservoirs. Whether the benefit of increased flows on spawning success would be offset by reduced rearing area in the Snake River reservoirs is unknown.

Hatcheries

SOSs 5, 6b, 9a, and 9c could threaten the water supply pipeline of the Lyons Ferry Hatchery. If this pipeline were lost, the production from this hatchery could be interrupted or reduced, unless or until an alternative water supply were developed. The hatchery is designed to rear 116,400 pounds (52,798 kg) of steelhead, 101,800 pounds (46,175 kg) of fall chinook, 8,800 pounds (3,922 kg) of spring chinook, and 45,000 pounds (20,412 kg) of rainbow trout.

Operation of John Day pool near elevation 262.5 feet (80.01 m) (SOSs 2, 9b, and 9c) or 257 feet (78.3 m) (SOSs 5, 6, 9a, and PA) could reduce water supply to the Umatilla Hatchery. The current well system has apparently been affected by a low reservoir pool level. Water supply problems could reduce fish production at this facility (Corps et al., 1993).

4.2.5 Resident Fish

Resident fish populations in the Columbia and Snake Rivers are affected by dam operations in a variety of ways. Most potential effects are related to spawning success, early survival of juveniles, and the availability of food sources. The potential that each of these factors has to change the overall reservoir and riverine fish populations depends on the duration and extent to which populations are exposed to a given factor and whether populations are limited by it. For instance, if food levels normally present in a reservoir far exceed levels required to maintain the fish populations, reductions in food production may not affect those populations. How resident fish populations may be affected by system operations is described below, with special emphasis on those resources identified as special concerns during SOR scoping. Appendix K, Resident Fish, presents a more detailed discussion of the impacts.

Resident Fish Impact Issues

Spawning Success

The effect of variations in water level on spawning success typically has a greater direct influence on fish production than any other factor. Most of the exotic fish species in the SOR reservoirs spawn in shallow-water areas, often in clean rock, or on vegetation, when it is available. Lower water levels in the reservoirs

during the spring and summer spawning season often reduce the volume of shallow-water habitat by draining backwaters and shallow embayments along the perimeter of the reservoir. The shallow-water area remaining is normally devoid of aquatic vegetation and tends to contain more silt than areas at higher elevation. The remaining habitat, therefore, is often of poorer quality than is normally found at higher pool levels. Egg survival might be reduced as a result.

Variations in water level while eggs are developing, as is often encountered with peaking power production or longer term drawdowns in spring and early summer, can expose the developing eggs to air and dry them out before they hatch. Such drawdown situations during the incubation period are not uncommon and can result in the loss of an entire year's fish production.

Reductions in water level can also expose the shallow deltas at the mouths of tributaries. The resultant water depth across these deltas is often very shallow and can prohibit fish from entering streams and reaching upstream spawning grounds. Likewise, low flows in riverine stretches may also prevent the upstream movement of fish out of the reservoirs to spawn.

Some native resident fish species (e.g., white sturgeon) require higher water flows in the spring and early summer to stimulate spawning. In some areas, the absence of sufficiently high flows has resulted in substantial reductions of fish populations.

Food Availability

Food in reservoirs includes plankton and small fish; organisms that reside in and on the rocks and silt in the bottom of reservoirs (benthic organisms); larvae of terrestrial insects that lay their eggs in water; and terrestrial insects that fly near and often fall into the water. Food sources in rivers include plankton introduced from upstream reservoirs, benthic organisms, and terrestrial insects (both larvae and adults).

Terrestrial insects are most abundant in waters that are clean and have abundant overhanging vegetation. When reservoirs are drawn down or river flows reduced, the water's edge recedes from the surrounding riparian vegetation, reducing the number of terrestrial insects available as food for fish.

Benthic organisms are most common in shallow-water areas. When water levels are reduced, those organisms present in the shallow-water areas often dry out and die, thereby reducing the availability of an important food source. Increases in siltation can also affect the production of benthic organisms, both in shallow and deeper waters.

Plankton production in reservoirs is highest with warm-water temperatures, moderately high nutrient levels, and longer water retention times. Increases in flow rates reduce water retention time and flush nutrients from the reservoir. Phytoplankton growth is subsequently reduced. Zooplankton, which are important in the diets of many reservoir fish species, feed on phytoplankton. Therefore, a reduction in the abundance of phytoplankton also tends to reduce in the abundance of zooplankton. Finally, increased flows increase the loss of plankton past the dams.

Survival of Juveniles

The reductions in food availability described above can reduce the feeding success of young fish and, as a result, reduce growth and survival of those fish. Decreases in the number of juvenile fish in the reservoirs subsequently limit the food available for adult fish that prey on smaller fish species.

Variations in flow also affect the rate at which fish are lost passing through the dams (entrainment). Larval and many juvenile fish are unable to swim against heavy currents. Hence, increased flows tend to carry these small fish into the turbines where an unknown percentage of them die.

Reductions in water level in the reservoirs and the resulting reductions in the total volume of water stored in the reservoir tend to concentrate the reservoir's fish population into a smaller area and away from the full-pool littoral areas, which are the most productive. If the volume of water has been reduced significantly, competition for the available food resources increases and feeding success might decrease. The smaller volume of water also reduces the area available for smaller fish to hide from predators.

Small fish often congregate in shallow-water areas, such as backwater pools, where food is abundant and larger predators are less common. Rapid reductions in the water level in the reservoirs can strand fish in backwater pools, which become separated from the main body of the reservoir. Many of the fish stranded in these areas die due to increases in water temperatures above tolerable levels and predation by seagulls and other birds. These backwater areas often dry up while water levels are down, in which case all fish stranded in these pools die.

Water Quality Effects

Substantial changes in the water level in the reservoirs and changes in flow in the riverine stretches of the Snake and Columbia Rivers can affect river temperature. Shallower waters warm more quickly in the sunlight as do slow-flowing waters in rivers. Increasing temperatures tend to increase phytoplankton production. Provided that growth of algae is not great enough to begin choking waters, the increased temperature and phytoplankton growth will tend to increase feeding success and growth of most warmwater fish species in the Columbia and Snake Rivers.

Some species, however, do not respond well to increases in temperature. For instance, bull trout, a species warranting protection but currently precluded from listing under the Endangered Species Act, prefer temperatures of 59°F (15°C) or less. All species have an upper temperature tolerance level above which growth is reduced and mortality occurs. If temperatures increase above 72°F (22°C), growth of many native species such as trout may begin to decrease. At temperatures in excess of 79°F (26°C), some of these temperature-sensitive native species might not be able to survive.

In riverine stretches of the rivers downstream of storage reservoirs, water released from the dams is often drawn from the depths of the reservoir where water is typically very cold. Increased water releases during the summer growing season might decrease water temperature in the river. The decreased temperatures decrease metabolic rates which reduce the growth rates of fish present in those reaches. Cold-water releases can also delay spawning of some cool-water species; this delay has been observed for smallmouth bass in the Hanford Reaches. Cold-water releases, however, may benefit cold-water species (e.g., trout) during summer months.

Large changes in the temperature regime in a river or reservoir over a period of many years might cause changes in species compositions of the plankton and fish community. Those species better adapted to the new temperature regime will reproduce more quickly than those that are adapted to the old temperature pattern. Hence, the most abundant species might change over several generations. The plankton community might change substantially in a single season. The fish population, however, would change much more slowly. An occasional year of warmer or colder water temperatures is not likely to have a substantial overall effect on the fish community.

Changes in turbidity can also affect plankton and fish growth and survival. Increases in turbidity reduce the sunlight entering the water and, hence, reduce phytoplankton production. The change in phytoplankton production can subsequently reduce zooplankton production, which will affect fish feeding success and growth. Increases in turbidity also reduce the ability of fish to see through the water. Those fish that depend upon sight to find food will therefore be less successful at feeding. The reduced feeding success and resulting decreased growth may be offset by reduced mortality due

to predation since larger sight-feeding fish are less likely to see and, hence, catch smaller fish. Phytoplankton can be the cause of turbid conditions, especially in high-nutrient situations.

Finally, release of water over the spillways of dams often increases the quantity of gas in the water to levels in excess of 100-percent saturation. If the gas levels are sufficiently high, they can kill fish exposed to the saturated waters. The resident fish populations can move downstream of the saturated waters; however, fish are often attracted to the tailrace of dams where large numbers of dead and stunned fish exiting the turbines provide an ample and readily available food source. Therefore, a substantial number of fish may be exposed to supersaturated waters.

Trends in Resource Management That Might Affect Future Fish Production Independent of Dam Operation

The listing of species under the ESA has had, and will continue to have, a substantial effect on the management of waterways. Additional future listings may affect the management of water resources to protect and enhance aquatic habitat. Changes in resource management in response to additional listings could include restriction of development in key watersheds, mandated flow releases, restriction of water withdrawals, and the development of active habitat restoration programs. The Kootenai River white sturgeon is a resident fish species listed under the ESA. White sturgeon are found downstream of Libby Dam. Bull trout, which are present in many of the system reservoirs, have "warranted but precluded" status for listing under the ESA. Protection of species that are designated as state Threatened or Endangered Species or Species of Special Concern may also motivate changes in watershed management. Species with State listings include westslope cutthroat trout (Montana), redband trout (Montana, Idaho), shorthead and torrent sculpin (Montana), Snake River white sturgeon (Idaho), sandrollers (Idaho), and burbot (Idaho).

Other trends that may affect resource management in the future include recent developments in the use of a watershed approach to forest and range management. These efforts are likely to emphasize protecting riparian habitats and restoring aquatic habitat. In other instances, resource managers have turned their attention to the protection and enhancement of native fish species in the hope of reducing the potential for additional listings under the ESA. Management agencies have, consequently, become less inclined to stock non-native sportfish species, which may compete with native populations. Therefore, future conditions are likely to include increased protection of native fisheries resources and aquatic habitats which would be expected to benefit, or at least reduce the rate of decline of, resident fish populations.

Effects of SOS Alternatives

The following discussion summarizes the general direction of projected trends in fish populations in the Columbia and Snake Rivers for each of the SOS alternatives relative to baseline conditions. There are two benchmarks or baseline conditions; SOSs 1a and 2c are both relevant points of reference for comparative analysis. This summary is based on the analysis results reported in detail in Appendix K, Resident Fish.

To assess the differences among the alternatives, the Resident Fish Work Group used models developed to provide an index of fish production under various water management scenarios. These models were developed for four storage reservoirs in the Columbia River portion of the system (Lake Pend Oreille, behind Albeni Falls Dam; Hungry Horse Reservoir; Lake Koocanusa, behind Libby Dam; and Lake Roosevelt, behind Grand Coulee Dam), two storage reservoirs in the Snake River drainage (Dworshak and Brownlee); one run-of-river project on the Snake River (Lower Granite); and one run-of-river project on the lower Columbia River (John Day). Each model was tailored to the specific fish populations of concern and characteristic biological and physical processes

for the specific reservoir. The models provided an index of fish abundance or production for each reservoir under each alternative. Values of the indices are not directly comparable between reservoirs.

Sufficient data were not available to develop quantitative models for all areas or species potentially affected by the alternatives. The work group used qualitative evaluations in such cases, including interviews with local fisheries experts, reviews of scientific literature on fish populations and habitat use in the specific reservoirs, or similar information on comparable reservoirs where specific information was lacking. Evaluations concentrated on biodiversity, species-specific concerns, and sportfisheries. Where biology and hydrology of a modeled system were similar to one of the unmodeled areas and the expected effects of the alternatives on hydrology were also similar, estimates of the effects of alternatives were extrapolated from the modeled system to the unmodeled one.

The discussion below summarizes the expected effects of the alternatives relative to the baseline situations on a geographic basis. Where possible, areas where the effects of the alternatives are expected to be similar are discussed together. Overall basinwide effects are summarized at the end of the discussion.

Lake Koocanusa (Libby)

Lake Koocanusa is a storage reservoir, and water surface elevations have historically fluctuated widely on an annual basis. Large fluctuations in water surface elevation (exceeding 100 feet [30 m]) and frequent failure to refill have limited the quantity of food available for resident fish populations and reduced fish growth and reproductive success. These events have occurred under operating patterns that correspond to SOSs 1a and 1b.

The annual pattern of modeled water surface elevations is substantially the same under SOSs 1a and 1b. Therefore, fish production would be very similar in each case, although SOS 1b would be slightly worse in drought years.

Competition for the decreased abundance of food concentrated in a smaller area results in reduced growth of kokanee at lower water elevations. Insect-eating species, such as cutthroat trout, rainbow trout, and mountain whitefish, feed on aquatic insect larvae found along the shores of the reservoir near terrestrial vegetation, which serves as a food source for the adult insects. Lowering water elevations dewaters the shoreline areas, desiccating larvae present in these areas. Refill failure reduces the shoreline area available to support larvae and increases the distance between pool margins and terrestrial vegetation. Hence, the availability of aquatic larvae can be substantially reduced. Large variations in reservoir elevations have dramatically changed the species composition of the insect population. Species of terrestrial insect larvae favored by fish, such as mayflies and caddisflies, are rarely found in the reservoir. Chironomids, a smaller midge that can prosper in deeper waters, currently dominate the larval insect populations in the reservoir. Refill failure, by increasing the distance from the shoreline to the water, also reduces availability of terrestrial insects to fish who feed on them.

Water temperature is also an important factor in both food production and kokanee growth. The deeper waters of the reservoir tend to be colder than optimum for aquatic production. Reduced reservoir volumes also reduce the volume of water at optimum temperatures for fish growth and food production. At lower reservoir elevations, fish are concentrated in a smaller volume of water where they compete for reduced prey populations. The size of the fish populations in Lake Koocanusa has stabilized at low numbers, reflecting the effects of large fluctuations in reservoir elevation.

SOSs 2c and 2d result in essentially identical annual water surface elevation patterns and refill probability. The primary differences are that SOS 2d has a slightly higher probability of refill during drought conditions than SOS 2c, and drawdown is not as great during median and

high-flow years. In both cases, the depth of reservoir drafting is slightly reduced in wet years, and for SOS 2c in extreme drought years, compared to SOS 1. In moderately dry years, however, the depth of drafting would be slightly greater. The probability of refill is very similar to SOS 1 except in drought years, when the more shallow drafting would increase the probability of refill. The differences in water surface elevation would provide for slight increases in phytoplankton, zooplankton, and benthic production (Figure 4-8). These would result in slight increases in kokanee growth. Although the abundance of reservoir food resources would increase slightly, variations in reservoir elevation would continue to allow for only minimal production of preferred prey items.

Minimum reservoir elevations and the probability of refill would be better for resident fish under SOSs 2c and 2d than under SOSs 1a or 1b in most years. In drought years, however, the reservoir might be drafted deeper under SOS 2 than under SOS 1. The difference in water surface elevations would provide for improved overall prey production and fish growth, although production in low-water years would be reduced. The long-term impacts of deeper drafting during low-water years would depend on the extent and duration of such drought periods.

SOS 4c was intended to enhance reservoir elevation and, hence, productivity in the reservoir. SOS 4c would maintain water elevations at substantially higher levels during wet and dry years than is predicted for SOS 2, although reservoir levels would still fluctuate between 64 and 111 feet (19.5 m and 33.8 m) annually. The increase in water levels would slightly enhance phytoplankton and zooplankton production. As modeled, benthic production, the volume of warmer water, and, consequently, fish growth would substantially increase, providing the highest productivity of all SOS options in Lake Koocanusa.

Elevation patterns for SOSs 5 and 6 are similar to SOS 1; consequently, the model predicts that they would support poor productivity relative to SOSs 2 and 4.

Of any alternative, SOS 9a has the least chance of refill; consequently, SOS 9a has the lowest overall predicted aquatic production, except for benthic production (Figure 4-8). SOS 9b also has low probability of refill most years, but overall drawdown is less than most alternatives, resulting in aquatic production similar to or higher than most SOSs except SOSs 4c and 9c. SOS 9c is essentially the same as SOS 4c, resulting in relatively high levels of aquatic production.

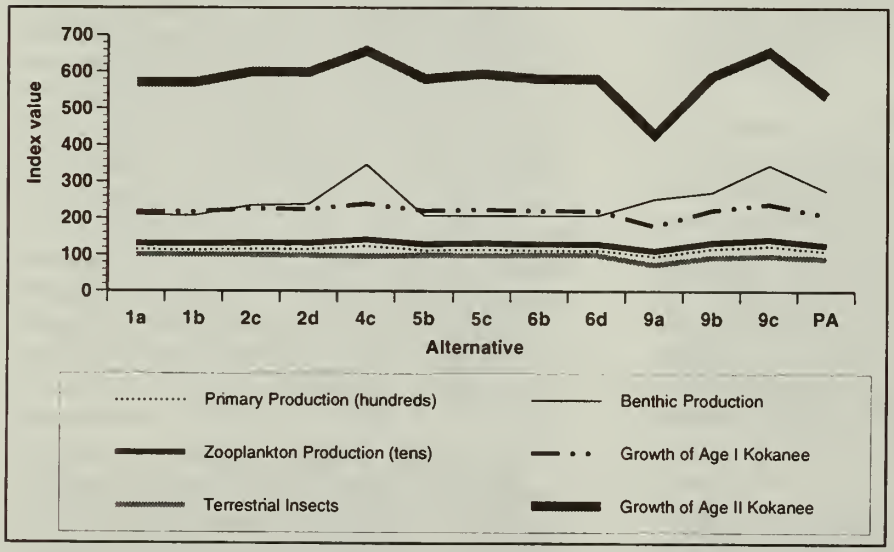


Figure 4-8. Comparison of index values representing aquatic production at Lake Koocanusa for median water years

SOS PA has moderate drawdown compared to other alternatives but also frequently does not refill, except during the highest flow years. The lack of refill influences modeled aquatic production, which was second only to SOS 9a for lowest predicted production for all parameters except benthic production.

Based on modeled results, SOSs 4c and 9c would provide the highest aquatic production in Lake Koocanusa of all SOSs. SOS 9a would have the lowest aquatic production of any alternative, by a substantial margin. The remaining alternatives were generally similar. SOSs 2c, 2d, and 9b all would have slightly higher production than the historical conditions, as represented by SOS 1a and 1b. SOSs 5 and 6 would be similar but slightly lower, and SOS PA would be second only to SOS 9c in having the lowest modeled aquatic production in most categories.

Kootenai River

Spawning of Kootenai River white sturgeon, listed as endangered under the ESA, is believed to be triggered by increasing flows and river temperatures in the spring and early summer (May through June), with peak spawning in June (Apperson and Anders, 1991). The exact flows required to trigging spawning are unknown. The last recorded successful production of a white sturgeon since Libby Dam was built occurred when spring flows were about 35 kcfs (1,000 cms) (Apperson 1991). Recently, spawning was documented when eggs were collected at flows of 20 kcfs (566 cms) (Marcuson 1994), and in 1994 at flows of 13 to 20 kcfs (368 to 566 cms). Biologists believe that flows of 20 to 25 kcfs (566 to 708 cms) at Bonners Ferry may be necessary for movement and spawning of fish. A range of target flows has been established in the Bonners Ferry Reach of the Kootenai River for May, June, and July, depending on whether the water year is wet, medium or dry. The highest June flow target during wet years has been set at 35 kcfs (1,000 cms). Flow recommendations during these months are intended to stimulate spawning and protect egg incubation and rearing of larval sturgeon. However, these flow targets are not solely designed to enhance white sturgeon. Other water factors that affect spawning, such as temperature and substrate composition, were also considered. Because of the uncertainty of the exact flows needed to produce successful spawning, the SOSs were evaluated by comparing 1) how closely they met the target flows for May, June, and July for three representative years (wet, medium, and dry); and 2) whether they produced average monthly flows of 20 and 35 kcfs (566 and 1,000 cms) in June, the primary spawning month (Figure 4-9).

Considering the three categories of flow evaluated, SOSs 1, 2, 5, and 6 produced fewer occurrences than other alternatives. The flow targets were generally met about 40 percent of the time for the average of 3 wet, medium, and dry years. Average June flows of 35 kcfs

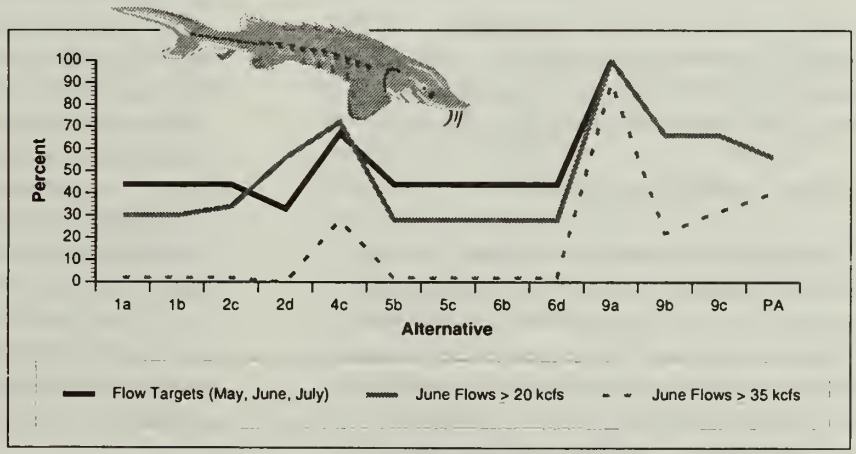


Figure 4-9. Percent of years that June average flows equal or exceed specified sturgeon flow levels for May, June, and July at Bonners Ferry

(1,000 cms) would occur less than 2 percent of the time with these alternatives. Flows of 20 kcfs (566 cms) would occur about 30 percent of the time for these alternatives except for SOS 2d when it occurs 56 percent of the time.

SOS 4c increases frequency of all flow over the previous SOSs. Overall, flow targets would be met 67 percent of the time. High June flow of 35 kcfs (1,000 cms), which stimulates spawning, would occur 28 percent of the time, and 20 kcfs (566 cms) flows would occur in 72 percent of the years.

SOSs 9a, 9b, 9c, and PA have the highest frequency of occurrence of most of the evaluated flows of all SOS alternatives. This is especially true for SOS 9a, which meets targeted flow and 20 kcfs (566 cms) flow all years, and the high spring flow category (35 kcfs [1,000 cms]) 90 percent of the years. With flow the major factor that limits spawning, spawning should be triggered in nearly all years under SOS 9a. The high June flows of 35 kcfs (1,000 cms) occur from 22 to 40 percent of the years for SOSs 9b, 9c, and PA, with PA having the greatest occurrence. The targeted flows and 20-kcfs (566-cms) June flows would occur from 56 to 66 percent, and 72 to 86 percent of the years, respectively. All of these alternatives would likely enhance white sturgeon spawning significantly over past operations.

SOS 9a would supply the greatest enhancement of white sturgeon in the Kootenai River, while SOSs 4c, 9b, 9c, and PA would also greatly improve spawning conditions.

Hungry Horse Reservoir

Hungry Horse Reservoir contains two fish species of special concern. Genetically pure strains of westslope cutthroat trout have been reduced to less than 10 percent of their historic range, making the relatively healthy population in Hungry Horse Reservoir a particularly valuable resource. Additionally, the reservoir contains a substantial population of bull trout, which are considered suitable for listing under the ESA. This population is apparently stable and one of the strongest known. The factors affecting fish populations in Hungry Horse Reservoir are essentially the same as those described for Libby Reservoir.

The hydrologic consequences of SOSs 1, 2, 5, 6, and 9a would all be essentially the same at Hungry Horse (Figure 4-10). The model shows that these alternatives would provide the lowest levels of aquatic productivity and fish growth. Slight variations in productivity relate mainly to the depth of the draft and refill probability during dry years. Among this group of options, water levels under SOS 9a would be the worst for resident fish.

SOSs 4c, 9b, 9c, and PA would substantially improve the production of prey and fish growth compared to the other SOSs. Of these alternatives, SOS 4c would provide the highest aquatic production in Hungry Horse Reservoir. These four alternatives have the least deep drafting and result in complete or near refill of the reservoir in all but the lowest flow conditions, enhancing aquatic production in the reservoir. Phytoplankton and zooplankton production would increase during the summer months because of a fuller reservoir, and moderated pool fluctuations would enhance the production of benthic organisms. Growth of trout in the reservoir would be enhanced by the increased concentrations of prey populations and larger volumes of warm water. Refill timing would also enhance access to spawning and rearing habitat in tributaries to the reservoir. The reservoir would have an average minimum elevation 31 feet (9.4 m) higher in normal water years under SOSs 4c, 9b, 9c, and PA than under SOS 1, and roughly 27 feet (8.2 m) higher in wet years. This difference in pool elevations provides for the predicted differences in growth and production in the reservoir. Hence, SOSs 4c, 9b, 9c, and PA have the greatest potential for preservation and/or enhancement of the resident westslope cutthroat trout and bull trout populations in the reservoir (Figure 4-10).

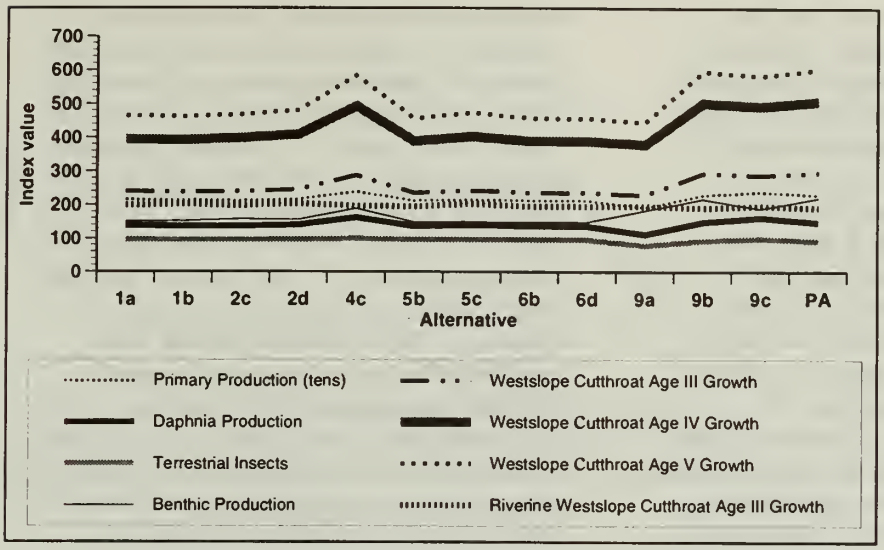


Figure 4-10. Comparison of index values representing aquatic production at Hungry Horse Reservoir for median water years

Flathead River

The primary factors affecting fish production in the Flathead River downstream of Hungry Horse Reservoir appear to be: 1) erosion of streambanks and subsequent introduction of sediment into the stream channel due to power peaking operations; 2) stranding of fish and desiccation of benthic organisms due to daily peaking; and 3) release of cold water into the river from the deeper waters of the reservoir, which reduces the growth of riverine fish and invertebrates. SOS 4c attempts to address the erosion and sedimentation problems by providing higher flows periodically in the spring to wash sediments from the streambed. This release of water was conceived, and would be implemented, as a short-term event (less than 1 month). The hydroregulation models could, however, only model this release as a month-long event; therefore, they do not provide sufficient information to assess whether sufficient flows would be released to benefit river habitat under SOS 4c or any other SOS.

The effect of cold-water releases on trout production in the river is not apparent in the modeled results. This is because it was assumed that a temperature control facility (which would allow for release of water from variable depths) would be installed on Hungry Horse Dam (construction plan to begin in 1996). The difference in the growth rate of westslope cutthroat trout varied little among alternatives. Without this facility, alternatives with high reservoir elevations (e.g., SOSs 4c and 9c) would have lower production as cold water would be released from the deep intake. As modeled, SOSs 9b and PA would have slightly lower trout production than other alternatives.

Lake Pend Oreille (Albeni Falls)

Lake Pend Oreille supports substantial fisheries for kokanee, rainbow trout, bull trout, cutthroat trout, and a variety of warm-water species including bass. Populations of kokanee and trout have been declining for 40 years. The decline is thought to be at least partially related to fluctuations in reservoir elevations, which affect spawning success. Unlike other storage reservoirs, Lake Pend Oreille is normally maintained at a relatively constant elevation. The annual fluctuation in water surface elevations ranges from approximately 7 to 12 feet (2.1 to 3.7 m). Nevertheless, spawning success of fish populations can be significantly affected by these fluctuations.

Kokanee that spawn in the reservoir are shore spawners. Drawdown more than 6 to 7 feet (1.8 to 2.1 m) from full pool can force these fish to spawn in sediment-laden gravel when elevations are reduced in September through November. Reservoir drawdowns in

November through May, after the fish have spawned, can also desiccate eggs. Because the trout species prey on young kokanee, declines in kokanee also reduce the feeding success of other resident fish. Variations in water elevation in spring and early summer can also affect the spawning success of warm-water species that spawn in shallow waters (such as bass). In fluctuating waters, the eggs can become desiccated and the young stranded in drying backwater pools. In addition, fall and early winter drawdowns can block access to tributary spawning grounds by river-spawning fish, such as bull trout and overwintering largemouth bass. The long-term decrease in fish abundance in the reservoir may have been further aggravated by the introduction of mysid shrimp, which feed on the same prey as kokanee.

SOS 4c is the only alternative that would substantially improve nearly all of the production categories (Figure 4-11). This alternative reduces drawdown most often to 7 feet (2.1 m) or less most years, with up to an 11-foot (3.4 m) drawdown occurring every sixth year. This would primarily benefit kokanee spawning and egg incubation, and cutthroat, bull trout and warm-water fish production. Because the kokanee production model was relatively insensitive to improvements in specific model parameters, including spawning and incubation factors, these improvements were included in Figure 4-12 as part of the kokanee production model to demonstrate the area where this alternative is most beneficial to this stock. The benefit to bull trout would be from increased kokanee production, which increases their food supply, and increased stream access for spawning. The warm-water species would benefit from improved spawning success by reducing egg desiccation and stranding. Warm-water species also would benefit from increased access to overwintering habitat. However, if stream access remains limited for bull trout from drawdown from any alternative in the late summer or fall, mitigation would be recommended to modify stream mouths to improve passage. The larger drawdown that would occur about every 6 years with this alternative would reduce the available winter habitat to all age groups of warm-water fish, and reduce spawning success of other species during those years.

The second category of alternatives, including SOSs 9a, 9b, and 9c, result in slight improvements in some resident fish parameters such as bull trout, warm-water fish, and spawning conditions for kokanee over historical conditions and other alternatives. All other alternatives, including SOS PA, result in lower resident fish production levels similar to existing conditions.

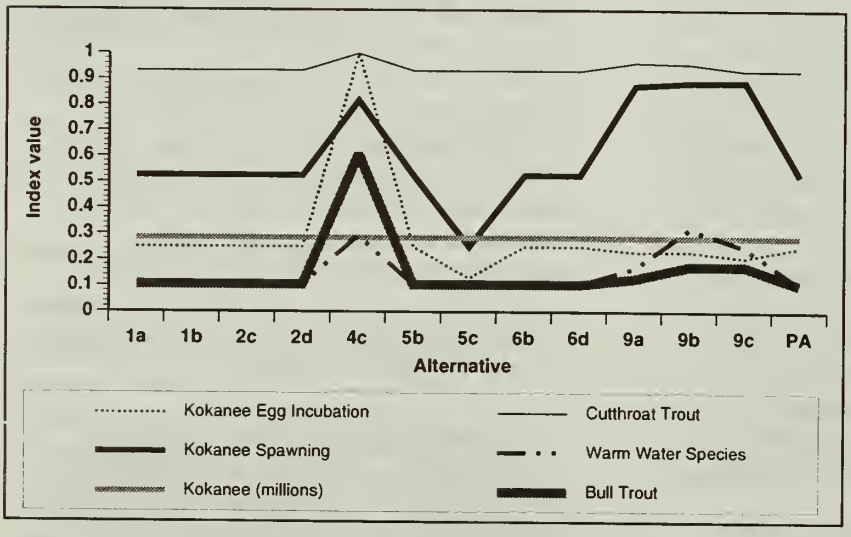


Figure 4-11. Comparison of 2-year index values for fish species in Lake Pend Oreille

Lake Roosevelt (Grand Coulee)

Key fish species in Lake Roosevelt include kokanee, walleye, rainbow trout, and smallmouth bass. Under existing conditions, all fish populations exhibit

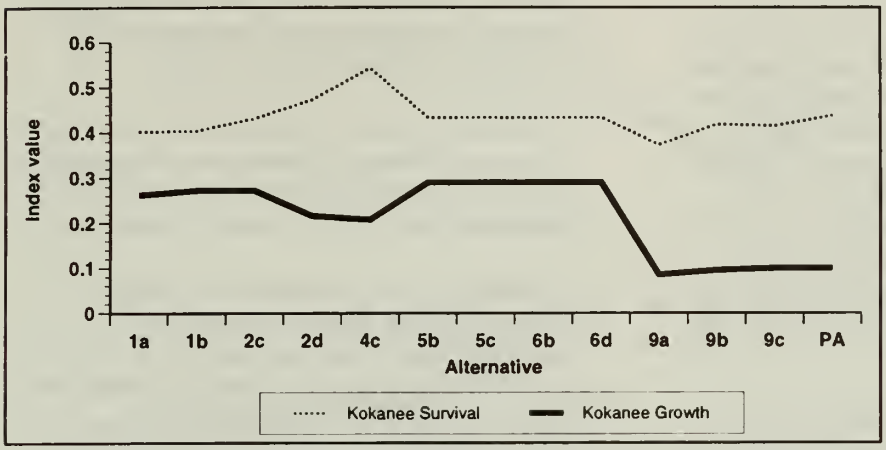


Figure 4-12. Comparison of 2-year index values for kokanee growth and survival in Lake Roosevelt

good growth and have fairly high catch rates relative to other Northwest waters. Fluctuations of the water surface elevation up to 82 feet (25 m), however, limit the natural reproduction of several fish species in the reservoir. During the annual winter-spring drafting, the retention time of water in the reservoir is reduced by 20 to 30 days. Nutrients entering the reservoir are quickly flushed through, becoming unavailable for phytoplankton production. Phytoplankton and zooplankton produced in the reservoir during this period are also flushed from the reservoir.

Typically, when the reservoir elevation and water retention time are high in the spring, zooplankton populations are also high, peaking in late summer. Low spring elevations tend to result in smaller populations of plankton that peak later in the year. Because kokanee, rainbow trout, and the young of other species rely upon zooplankton as a major food source, low spring elevations limit fish growth during the season. A minimum water retention time of 30 to 35 days in spring appears to be critical to reservoir productivity. The production of kokanee and other fish species is further reduced when young are flushed through the dam by drafting.

Spring drafts further affect fish production in the reservoir by reducing spawning success of several species, such as yellow perch (fed upon by walleye) and bass. The lower elevation drawdowns can strand eggs and young in drying shallows, resulting in their death.

The effects of the SOS alternatives were evaluated using a model for kokanee, a plankton feeder, under the assumption that SOSs that provide good conditions for kokanee would also provide good conditions for other fish species. Larger populations of zooplankton were assumed to result in better fish growth. Hence, the index of growth of kokanee was developed using estimates of zooplankton production during the summer growing season. The index of fish survival is related to the numbers of fish entrained during the spring drawdown, when water retention time is low. Figure 4-12 shows the effect of the SOS alternatives on kokanee survival and growth during 2-year flow recurrence intervals. These effects are described below.

Lake Roosevelt would be drafted in spring for extended times under both SOS 1 options, resulting in spring water retention times of less than 30 days in January through May for approximately 90 percent of the years examined. The drawdown would result in moderate levels of index survival during the short-term interval. Modeled zooplankton production, however, suggests low growth in the upper range of alternatives evaluated. In the short- and long-term, entrainment losses are high for SOS 1.

SOSs 2c and 2d would have very similar water retention times and spring drawdowns. Generally, these SOSs were estimated to have water retention times of less than 30 days for

January to May in 80 percent of the years examined. The short-term entrainment survival index particularly for SOS 2d is better than that under SOS 1, reflecting the somewhat improved water retention time. The long-term survival values are reduced from short term but SOS 2d remains one of the highest of all alternatives. The growth index is similar to SOS 1 for SOSs 2c and 2d. The short-term growth index for SOS 2d is reduced, probably reflecting the lower water surface elevation for some years compared to SOSs 1 and 2c.

SOS 4c would provide for improved water retention times that reduce entrainment of fish, but not zooplankton, during the short term. Hence, the entrainment survival index value is very high for this SOS, and the growth index value is moderately low compared to other SOSs. During infrequent (once every 10 years) flow events, survival and growth would be reduced because of sporadic increases of entrainment and lost zooplankton.

At Grand Coulee, operations under SOS 5 or 6 would be very similar to those under SOS 2c. As a result, the index values calculated for these SOSs are very close or identical to those described for SOS 2c.

Under SOS 9a increased flushing and low reservoir elevation during winter and the growing season would result in the lowest survival and growth in the short term. In the long term, like other alternatives, these index values decrease and this alternative consistently would have the lowest survival and growth of kokanee of any alternative.

SOSs 9b and 9c are similar but would be slightly improved over SOS 9a in the short term. SOS 9a would have survival in the lower range of alternatives and much lower growth than others. The lower growth is the result of increased spring flushing.

SOS PA is very similar to SOSs 9b and 9c in the short term but would have slightly higher survival. Over the long term, this alternative would experience decreases in growth and survival, but survival would become higher than any other alternative possibly because of fewer low-water conditions during the winter.

Generally, during infrequent flow years survival and growth of kokanee would be lower, and differences among alternatives would be slight except for SOS 9a, which is much lower.

SOSs 2d and 4c would provide the best protection against kokanee entrainment losses. The best growth is achieved under SOSs 1b, 2c, 5, and 6. Fish production conditions would be worst under SOS 9a, considering growth and environment.

SOS PA would provide moderate protection against fish entrainment for the short term and the best protection under infrequent flow conditions. Kokanee growth, as measured by zooplankton production, would be one of the lowest under all conditions.

Brownlee Reservoir

Key sportfish species in Brownlee Reservoir include crappie, channel catfish, smallmouth bass, and rainbow trout. These species were all included in the model used for impact analysis. The model evaluated food production in the reservoir and changes in water surface elevation that could affect fish spawning and egg development.

Brownlee elevations and outflow would change little among SOSs 1, 2, 4, 5, and 6 but more so for SOSs 9 and PA (Figure 4-13). Hence, the model predicts that food production, spawning success, and overall fish production vary little among most alternatives, except SOSs 9 and PA. The alternatives were much lower in overall production values. Production parameters were generally good for rainbow and channel catfish under most alternatives, but moderate to low for smallmouth bass and crappie. SOS 4c would have slightly higher production values for smallmouth bass and crappie than other alternatives probably because of reduced reservoir drawdown during spring spawning periods of these warm-water species.

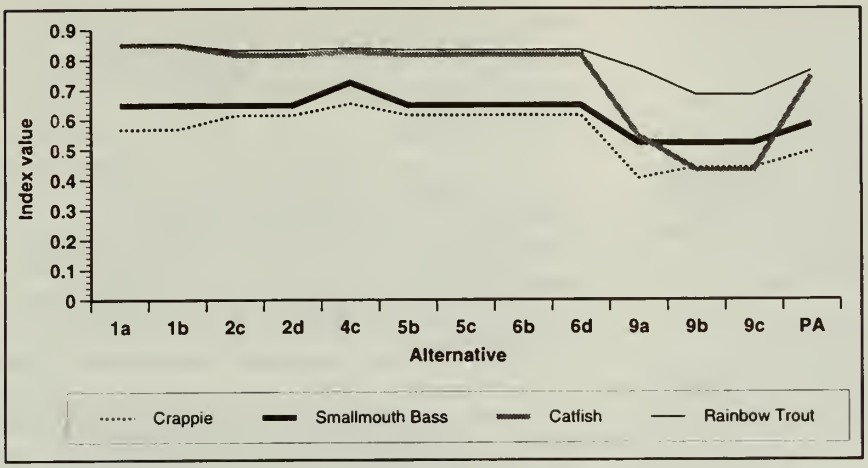


Figure 4-13. Comparison of 2-year index values for fish species in Brownlee Reservoir under the various alternatives

Channel catfish would fare better because reservoir fluctuations would be reduced in the summer when this species spawns. SOS 1 would have slightly higher overall production of rainbow trout and channel catfish than the other alternatives because more stable summer reservoir conditions. But, SOS 1 would experience slightly lower smallmouth bass and crappie production than SOS 4c. SOSs 2, 5 and 6 were near the highest production index levels of all alternatives.

SOSs 9 and PA had much lower overall production for most fish indexes species because of greater water level fluctuations during warm-water species' spawning periods. Of these SOSs 9b and 9c had the lowest values for all but crappie, which was lowest for 9a. SOS PA was the best of this group for all four stocks and only slightly worse than the current conditions for rainbow trout and channel catfish. The low values under SOS PA for crappie and smallmouth bass is probably because of the higher spring water level fluctuations.

Dworshak Reservoir

Dworshak Reservoir is a deep, relatively unproductive reservoir with a steep-sided shoreline. It has a maximum depth of about 636 feet (194 m) and is typically drafted up to 155 feet (47 m) in fall and winter, which reduces the surface area as much as 50 percent. Water retention time averages 10.2 months and ranges from 6 to 22 months. Primary sport species in the reservoir include kokanee, rainbow trout, cutthroat trout, bull trout, and smallmouth bass. Redside shiners are preyed upon by several fish species.

Cutthroat trout and bull trout spawn in the fall in tributaries to the reservoir. The fish model used to predict the effects of the SOSs on trout in the reservoir assumes that fish production is related to food production in the reservoir.

Shallow-water spawning habitat for smallmouth bass is limited in the reservoir, but the bass population appears to be healthy and growing. Spawning success of bass can be affected by decreases in pool elevation, potentially causing dewatering of nests from mid-May through mid-August. Increases in elevation can expose eggs to cold waters, causing fish to abandon nests or interrupting egg development. The model used in the evaluations estimated spawning success as it is affected by changes in reservoir elevation as well as food production (both plankton and shiners).

Kokanee mortality rates in the reservoir appear to be near 80 percent. Entrainment of fish through the dam may be at least partially responsible for this high mortality rate. Initial studies suggest that large numbers of fish are entrained with releases greater than 8 kcfs (240 cms). Low water levels may also limit access to spawning grounds in tributaries by kokanee. The kokanee model incorporates factors for entrainment, tributary access, food availability, fishing mortality, and adult habitat availability.

Both SOS 1 options would provide relatively good conditions for kokanee. SOS 1b would have slightly better conditions than SOS 1a, likely due to differences in entrainment rates. Predicted index values for bass and trout are slightly lower than the highest SOSs, with SOS 1b being better than SOS 1a. The lower values are likely due to limited food production compared to some of the other SOSs, and to increasing pool levels in June, which can interfere with egg development of the bass. Drawdown under this SOS inhibits shallow-water plant growth and inhibits spawning of redside shiner, a forage fish.

Reservoir drafts under SOS 2c are not as great as under SOS 1, but are greater under SOS 2d. Fluctuations in elevation and discharge occur more frequently under SOS 2d compared to SOS 2c. Deep drafts in excess of 100 feet (30.5 m) can be expected in wet and moderately wet years but are not as deep in normal to dry years. The pool would fail to refill in most years. Monthly discharge would be substantially increased in the summer. Increased flows would result in increased entrainment of kokanee and higher than SOS 1, potentially driving the population to such low levels that it could not rebound. Failure to refill the reservoir would reduce adult habitat and access to tributaries for spawning. Reproduction of bass might be affected by interruption of spawning due to inundation by cold water in June and dewatering of nests in July with SOS 2d having some of the lowest index levels of all SOS alternatives. Trout production under SOS 2 is predicted to be markedly lower than under SOS 1 because of the reduced food production. SOS 2d has one of the lowest trout production index values of all alternatives.

SOS 4c would generally provide excellent conditions for all fish species in the reservoir. Full-pool elevations during the summer rearing and spawning months would be expected in virtually all years under SOS 4c. The high pool would provide access to all spawning areas, and protect bass and shiner spawning and egg development. Zooplankton production would be enhanced. Because of high flows out of the reservoir, fish entrainment would be fairly high in most years and very high during wet years. This entrainment occurs more with SOS 1 but less than SOS 2.

SOS 4c has the highest smallmouth bass production of any alternative because the relatively stable spring and summer water levels increased the spawning success of smallmouth bass and redside shinner and increase overall food production.

Dworshak would typically fill in July under SOS 5. The reservoir would remain near full through August during wet years. In normal to dry years, however, pool elevations would be expected to decline during the summer. Predicted trout, kokanee, and smallmouth bass production is similar to (although slightly lower for most than) levels described for SOS 4c.

Fish production under SOS 6 would be very similar to that described for SOS 5. Food production would be somewhat better under SOS 6 than under SOS 5b but worse than 5c.

Moderate-to-deep drafting and moderate-to-high outflow would occur under SOS 9. Drafting under SOSs 9a and 9c is similar to SOS 2, but drafting under SOS 9b is higher. Mid- to late summer drawdown occurs for all SOS 9 options but is especially pronounced with SOS 9b, which is drafted deeper than SOS 9a or 9c to augment flows in the Snake River. SOS 9b is also less often refilled than SOS 9a or 9c.

SOS 9 is one of the worst alternatives for all fish stocks, with SOS 9b being the lowest of the three for all indexes. The food production index, which is a measure of bull and cutthroat trout production, is the lowest under SOS 9b. Probable high entrainment and reduced food production cause very low kokanee production, similar to SOS 2. Changing spring water levels and summer drawdown cause smallmouth bass production to be very low, similar to levels of the lowest alternatives.

SOS PA would have severe drawdown in the summer, up to 80 feet (24.4 m) below full pool

by the end of August. SOS PA would often result in pool levels of 80 to 120 feet (24.4 to 36.6 m) below full pool. The reservoir often would not completely refill. High outflow would also occur often during flow augmentation in the summer. This alternative would result in severe impacts to all species of resident fish in Dworshak Reservoir. The kokanee production index would be by far the lowest because of the increased entrainment, drawdown, and reduced food production. This alternative also would be one of the worst for smallmouth bass and trout. The increasing pool level in June would be detrimental to smallmouth spawning, and summer drawdown and high outflow would adversely affect both smallmouth bass and trout production by reducing food supply.

The long-term effect would be to keep production low within the system for all stocks.

Overall, SOSs 4c, 5c, and 6 are predicted to provide similarly high fish production in Dworshak Reservoir (Figure 4-14). Fish production would be worse under SOSs 2, 9, or PA.

Lower Granite Reservoir

Lower Granite is a run-of-river project that normally has water surface elevation fluctuations in the range of 5 feet (1.5 m). In recent years, however, the reservoir has been operated near MOP during the spring and summer to enhance outmigration of juvenile salmon. Key resident fish species in the reservoir are smallmouth bass, white sturgeon, and northern squawfish. All three species can be affected by changes in reservoir elevation, which can have substantial effects on spawning and rearing areas in the reservoir. The resident fish model incorporated estimates of the amount of suitable habitat available. In Lower Granite Reservoir, within-month variations in water elevation can have as much or more effect on rearing success as variations from month to month. Hence, the effects of the SOSs were evaluated assuming a range of within-month variations in water elevation. These effects are shown in Figure 4-15 and described below.

Under SOSs 1a and 1b, Lower Granite operations would reflect water level fluctuations within the normal range, from minimum pool of elevation 733 feet (223 m) to full pool at elevation 738 feet (225 m). Effects on resident fish habitat would depend upon daily and weekly cycling of the project and the resulting within-month variations in water elevation. The greater the within-month pool fluctuations, the greater the impacts.

SOSs 1a and 1b would have some of the highest index values for squawfish and sturgeon, and some of the lowest values for smallmouth bass. The higher values for sturgeon would result from more deep-water habitat. Squawfish would benefit from reservoir levels remaining higher, which would provide more suitable habitat than other alternatives. However, the sturgeon model does not consider the essential need for high-velocity water for spawning.

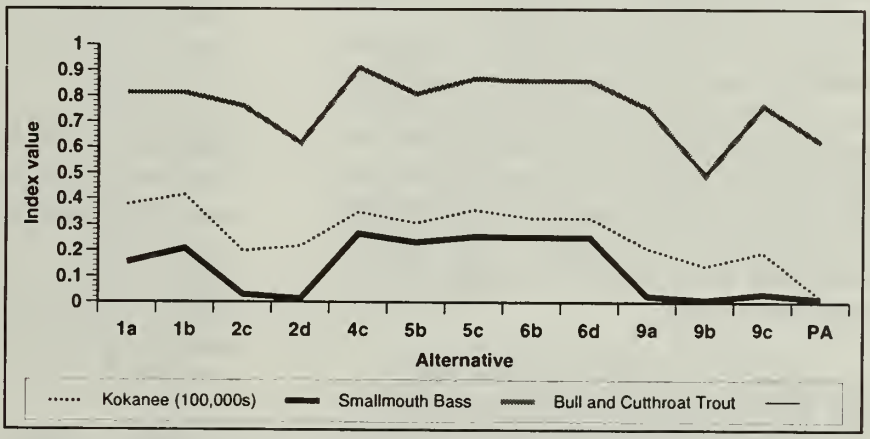


Figure 4-14. Comparison of 2-year index values for fish species in Dworshak Reservoir

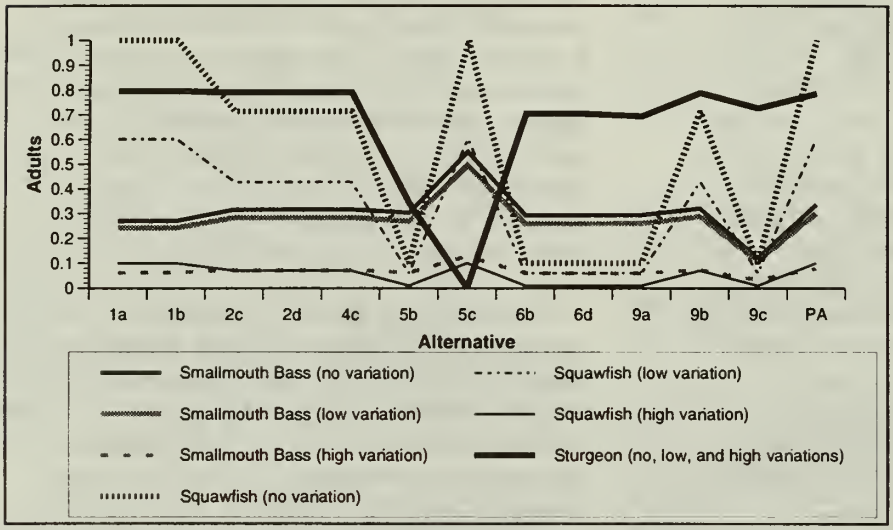


Figure 4-15. Comparison of 2-year index values for fish species at Lower Granite Reservoir

Water surface elevations under SOS 2 would be held within 1 foot (0.3 m) above MOP (733 feet [233 m]) in spring and summer, returning to normal elevations, as under SOS 1, during the rest of the year. The model indicates that smallmouth bass habitat would benefit from SOS 2. The slight decrease in water elevation under SOS 2 would normally be expected to decrease smallmouth bass habitat somewhat compared to SOS 1. Conversely, stabilized pool elevations would tend to ensure that spawning would occur in areas that are submerged throughout incubation. The net result would be a slight increase in smallmouth bass habitat over SOS 1. Sturgeon index values would remain high because deep-water habitat would remain unchanged, while squawfish habitat would be substantially reduced because of slight elevation fluctuations compared to SOS 1. The overall index values would be about mid-range of all alternatives evaluated.

Operations and water surface elevations under SOS 4c would be identical to those for SOS 2. Resident fish habitat conditions would consequently also be identical under all of these SOSs.

SOS 5b or 5c would result in the most significant changes in operations and fish production compared to current conditions. Under this alternative, Lower Granite would be drawn down by approximately 95 to 115 feet (29 to 35 m) to the original riverbed level by mid-April the first year. SOS 5b would maintain the low elevation through August, refilling in September each year, and this repeat of drawdown and refill would occur annually. The pool elevation could fluctuate up to 5 feet (1.5 m) during the drawdown period. SOS 5c would remain at the river bed level year-round with only natural river level fluctuations occurring.

SOS 5b would provide stable water levels during the egg development period that should be favorable to bass, with index values only slightly lower than SOS 2 or 4c. SOS 5c would result in stable smallmouth bass spawning and rearing habitat year-round, providing the best habitat of any SOS alternative. The resulting river environment is likely to improve both food supply and egg incubation. Assuming moderate fluctuations in reservoir level in the summer, SOS 5 would not appear to be good for northern squawfish because of degradation to fry rearing habitat. However, reduced reservoir elevations might provide an increase potential spawning habitat by providing additional high-velocity spawning areas, which are preferred by squawfish.

SOS 5c apparently would result in excellent conditions for northern squawfish because of the permanent establishment of high velocity habitat for spawning, resulting in the highest index

values. SOS 5, particularly SOS 5c, apparently would provide poor rearing habitat for sturgeon because of reduced deep-water habitat. The important high-velocity spawning habitat, which would be substantially increased with SOS 5, is not included in this model.

SOSs 6b and 6d include 4.5-month Lower Granite drawdowns that would be similar to SOS 5b. Under SOS 6, the depth of drawdown would be 33 feet (10 m), much less than under SOS 5. Because timing of drawdown and not depth would be the controlling factor, the effects of these SOSs would be likewise similar to SOS 5b.

SOSs 9a, 9b, and 9c as a group have divergent effects on resident fish production. SOS 9a and 9c both have drawdown of 33 feet (10 m), similar to SOS 6, but 9a is for 4.5 months and 9c for only 2 months. The result is some of the lowest production index values, especially for 9c, for northern squawfish and smallmouth bass. The longer drawdown period of SOS 9a allows for less habitat disruption, enabling smallmouth bass habitat to remain fairly stable and having moderate levels of production similar to SOSs 5b and 6. SOS 9c, with its mid-summer refill, disrupts fry rearing habitat, causing the lowest production index of any alternative for smallmouth bass. SOSs 9a and 9c are both poor for northern squawfish habitat, which is reduced because of the drawdown. These SOSs would be similar to SOSs 5b and 6. The reservoir level for SOS 9b is operated similar to SOS 2, with Lower Granite near MOP during the spring and summer. The result is higher smallmouth bass and northern squawfish index values than SOSs 9a and 9c because of the more stable water level and greater amount of suitable habitat, similar to SOS 2. Sturgeon habitat is only slightly reduced for SOS 9a and 9c because of reduced deep-water habitat, while SOS 9b is near the highest index value. The fluctuating water levels under SOSs 9a and 9c would likely have greater adverse effects than indicated in the model for sturgeon. The spill under SOSs 9b and 9c would likely increase nitrogen saturation that would be adverse to resident fish. This effect was not included in the models.

SOS PA would have reservoir levels operating similar to SOSs 2 and 9b, near MOP during the spring and summer and high summer spill similar to SOSs 9b and 9c. The index values for resident fish are in the upper range of those evaluated for all three stocks. The relatively stable reservoir level without large drawdown is apparently beneficial to northern squawfish and would have the highest values of all alternatives. Smallmouth bass would also have relatively high levels because of stable reservoir levels during spring spawning and summer rearing being similar to SOS 2 and 9b. White sturgeon index values would also remain high because deep-water habitat remains high. The important high-velocity spawning habitat is not included in the sturgeon model; this habitat would change little from current conditions. As with SOS 9, the high summer spill under SOS PA could be detrimental to resident fish from increased gas saturation levels that at times could be lethal to resident fish.

Deep-water habitat for sturgeon would not be significantly affected by any of the SOSs, except for SOSs 5b and 5c. Under these options, drawdown to natural river levels would reduce the amount of deep-water habitat. The model does not address the effects of flow on spawning of sturgeon. SOSs that substantially increase reservoir velocity during the April and July spawning period (primarily SOSs 5, 6, and 9c) might benefit sturgeon populations in the reservoir by improving spawning conditions. As discussed above, sturgeon-rearing habitat would decrease under SOS 5. Whether the benefit of increased flows on spawning success would be offset by reduced rearing area in the reservoirs is unknown.

Overall, SOS 9c would be the worst alternative for resident fish resources in Lower Granite Reservoir. SOSs 5b, 6b, 6d, and 9a are also expected to produce poor conditions for fish. All other SOSs would likely provide relatively good conditions for fish production.

John Day Pool (Lake Umatilla)

The key resident fish species in Lake Umatilla are smallmouth bass, northern squawfish, and walleye. The model evaluated the quantity of spawning, rearing, and overwintering habitat for smallmouth bass, rearing success of northern squawfish, and the effects of entrainment on walleye. Based on the model, there would be no significant differences among the SOSs for squawfish or walleye (Figure 4-16), but walleye entrainment would be slightly higher under SOS PA and the lowest under SOS 1a.

Predicted index values for smallmouth bass vary only slightly among SOSs, and all SOSs would provide for relatively good bass production, if reservoir fluctuations remain low.

The effects of water-level changes in the spring and summer, as modeled, suggest that SOSs 9a and 9c would have slightly more adverse effects on smallmouth bass compared to the other alternatives. SOS PA would have the least adverse effects. But, similar to the other two stocks modeled, differences among the alternatives would be slight for smallmouth bass.

However, SOSs 5, 6, 9a and PA, because of their drawdown to lower reservoir levels (elevation 257 feet [78.3]) in the spring and summer, are likely to have marked adverse effects to resident stocks that are not evaluated by the models. Drawdown to this level would reduce shallow-water habitat by about 6,000 acres [2,428 ha] (see Appendix K), which is important spawning and rearing habitat for most of resident stocks. Because drawdown would occur in the spring, yellow perch spawned eggs may be desiccated. It was not possible to model these effects, so the extent of the impact to these stocks can not be quantified. But it is likely that SOSs 5,6, 9a and PA would have similar adverse effects on resident stocks, and would be worse overall than other SOSs.

Box Canyon Reservoir

Box Canyon Reservoir is located on the Pend Oreille River below Albeni Falls Dam. The key resident fish species in this resevoir are yellow perch, pumpkinseed and largemouth bass. Spawning success of largemouth bass is thought to be affected by water level fluctuations during and after spawning and by the amount of flow passing through the reservoir during April and May. Optimum flow during May and June is between 40 and 45 kcfs (1,133 and 1,274 cms). All SOSs have flows exceeding this range during May and June. However, those SOSs with lower flows, while reducing short-term flow fluctuation, would provide the best habitat conditions for largemouth bass. Based on this flow criterion, alternatives that would supply flows closest to optimum include SOSs 1, 2, 5, and 6. All of these alternatives have similar

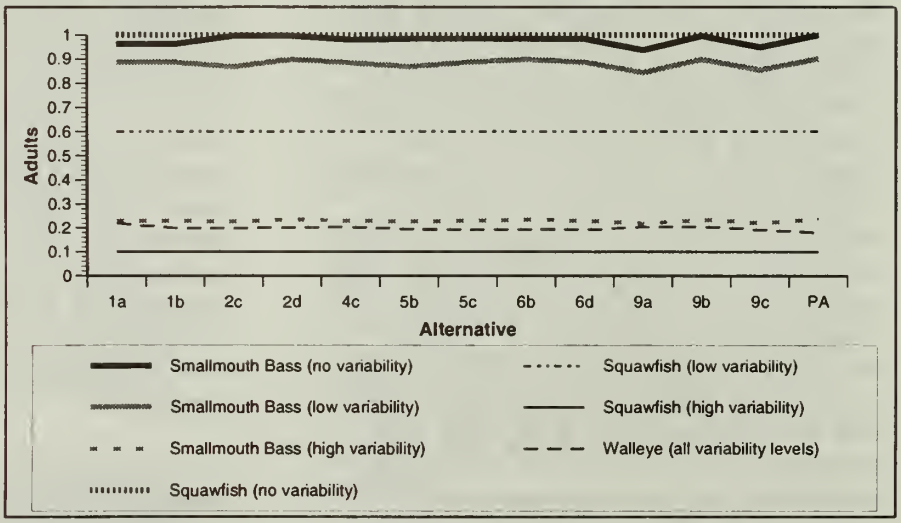


Figure 4-16. Comparison of 2-year index values for fish species at Lake Umatilla (John Day pool) assuming a range of variability in pool elevation

monthly flows, averaging 47 kcfs (1,331 cms) in May and 59 kcfs (1,671 cms) in June. SOSs 9c and 4c, which have May flows of 47 or 48 kcfs and June flows of 61 to 62 kcfs, would be slightly worse for spawning largemouth bass. SOSs PA and 9b have slightly higher flows, which may be worse for largemouth bass. It is expected that short-term flow fluctuations may be less for SOS PA than other alternatives, which should benefit largemouth bass spawning. SOS 9a would have the greatest average flows, 56 and 64 kcfs, during May and June. These flows are much higher than optimum spawning bass.

Non-modeled Resident Fish Populations

Lower Columbia fish populations that were not modeled would generally respond in a similar manner as described for John Day. The exception would be the adverse effects of drawdown that occur only in John Day Reservoir and not in McNary, The Dalles or Bonneville pools. Substantial increases in velocity under SOSs 5, 6, 9b, and PA might benefit spawning of native species, such as trout, sturgeon, and northern squawfish, present in both reservoirs and riverine habitats. The increased spill would increase dissolved gas concentrations that in turn could adversely affect resident fish in the lower Columbia under SOSs 2b, 9a, 9b, 9c, and PA, depending on duration of spill and exposure length of fish. Increased sediment effects on rearing habitat from SOSs 5 and 6 are likely to be minor in these reservoirs, except possibly in McNary during the first year of activity.

Fish in the lower Snake River pools would be expected to respond similarly to the fish in Lower Granite Reservoir. The effects on lower Snake River fish should mostly follow those shown for Lower Granite (Figure 4-15) except for SOS 6d. SOS 6d draws down Lower Granite only. Also, the cumulative effect of increased gas saturation would increase in a downstream direction, so that fish in the lower reservoirs would be subjected to higher gas levels than those of Lower Granite. This could possibly increase mortality during spring for those alternatives with higher spill (SOSs 2d, 9, and PA). The increased sediment load associated with drawdowns of SOSs 5, 6, 9a, and 9c, especially during the first year, could also diminish the quality of rearing habitat in the reservoirs. Sediment load is likely to also adversely affect zooplankton and other fish food sources. The overall potential effects of this increased sediment load would be likely to adversely affect resident fish populations. SOS 9c might be the worst for resident fish in the lower Snake, but SOSs 5b, 6b, and 9a would also create poor conditions; the others would generally produce good conditions.

Several other projects and river reaches in the Columbia River system were not modeled, and the distinctive differences in effects among SOS alternatives could not be determined. While it is known that changes in operations affect some of these projects and reaches, information was insufficient to determine how the SOS alternatives would affect the hydroregulations, reservoir and river fluctuations, or the fish populations. Those projects where information was insufficient to determine differences among the alternatives include: the Canadian projects (Kinbasket, Arrow, Kootenay Lake, and Duncan Lake), Clark Fork River (below Cabinet Gorge Dam), Pend Oreille River (below Albeni Falls Dam), and mid-Columbia River projects (reservoirs of Wells, Rocky Beach, Rock Island, Wanapum, and Priest Rapids), the Hanford Reach below Priest Rapids Dam, the Hells Canyon Reach, and the Columbia River below Bonneville. Projects where operations appear to be fairly independent of SOS alternatives and would, therefore, likely be affected the same for any alternative include Rufus Woods Reservoir, a run-of-river project below Grand Coulee Dam, and Flathead Lake, a modified lake in the upper Columbia River that appears to have similar hydroregulation and reservoir level independent of any SOS alternative.

The fish populations in river reaches (e.g., Hanford Reach, Hells Canyon, below Bonneville) are often primarily affected by hourly and daily flow fluctuations, which

influence adult spawning, juvenile and egg stranding and food supply. These hydrological changes among alternatives could not be modeled with available information, so predictions of project effects in these areas is not possible. However, it is unlikely that drastic changes from current hourly and daily flow fluctuations would occur among any of the alternatives because daily load demand, which usually controls daily discharge changes, is not likely to change markedly among the alternatives. In other words, such short-term fluctuations in flows result from load following, and would not be attributable to selection of an SOS.

Summary

None of the SOSs is consistently good or bad for resident fish populations in all reservoirs and river reaches in the Columbia River Basin (Table 4-11) (Appendix K, Resident Fish, presents informative comparisons). In many cases, detrimental changes in water management in one area would be offset by positive changes in another area. For instance, the beneficial higher pool elevations in spring and summer at Lake Koocanusa and Hungry Horse Reservoir would be offset to a degree by the transfer of flood control functions to Lake Roosevelt and the subsequent reduction in reservoir level during the spawning and incubation season.

Overall, SOS 4c would be good or neutral for resident fish populations throughout the region, and SOSs 5b and 9a would be the worst for fish production. SOSs 5c, 9c, and PA would have varied effects throughout the basin. SOSs 4c, 9a, 9b, 9c, and PA are expected to provide improvements in the probability of survival of the Kootenai white sturgeon. No other SOSs are likely to provide sufficient spawning opportunities to maintain the population. SOS 4 is the only alternative that would provide sufficient flows to support white sturgeon and benefits to resident fish regionwide.

Differences among SOS alternatives could not be determined for most unmodeled projects of the middle and upper Columbia, primarily because of lack of sufficient hydrological and biological information.

4.2.6 Wildlife

The Columbia River creates and maintains suitable conditions for a diversity of wildlife habitat. The open water, wetlands, islands, and shore (riparian) environments support animals and plants that would not otherwise survive in the surrounding area. Many other wildlife live in the adjacent mix of sagebrush steppe, agricultural land, or conifer forest, but they use river-dependent habitats for cover or food. These species may occur in non-riverine environments, but their numbers may increase where river habitats are available.

During the SOR scoping, people expressed concern about the impacts of river operations on wildlife and associated river and open-water environments. Such species include shorebirds and waterfowl, which nest on islands and feed on plants or animals in the river or adjacent wetlands and riparian lands. They also include non-game birds, which nest or forage in riparian trees or shrub thickets. Some of the species dependent on the river system represent major resources of Washington and Oregon, such as the hundreds of thousands of ducks that winter on Lake Umatilla (John Day pool). Concerns also focused on species not entirely dependent on riverine habitat, but whose numbers reflect its quality, for example, deer and elk.

Wildlife Impact Issues

To evaluate the effects of SOS alternatives, the Wildlife Work Group identified groups of species (see box) to represent the spectrum of wildlife resources influenced by system operations. One or more species of wildlife (or plant, in one instance) were selected to represent each category for evaluation purposes at each particular reservoir or reach of the river. For example, mallards and great blue herons were often selected as indicator species representing waterfowl and colonial nesting birds.

Table 4-11. Relative overall effect of the SOSs on resident fish production in the Columbia River[a/]

	1a	1b	2c	2d	4c	5b	5c	6b	6d	9a	9b	9c	PA
Koocanusa	--	--	--	-	++	--	-	--	--	--	-	++	-
Hungry Horse	--	--	--	--	++	--	--	--	--	--	0	++	-
Pend Oreille	-	-	-	-	++	-	--	-	-	-	-	-	-
Roosevelt	-	0	+	+	+	+	+	+	+	--	-	-	+
Dworshak	0	+	-	-	++	0	+	0	0	-	--	-	--
Brownlee	0	0	0	0	++	0	0	+	+	--	--	--	-
L. Granite	-	0	0	0	0	--	+	-	-	-	0	-	+
John Day	0	0	+	+	+	--	--	--	--	--	0	--	++
Other Snake R.	-	0	0	0	0	--	+	-	-	--	0	-	+
White Sturgeon	--	--	--	--	++	--	--	--	--	++	+	++	+
Overall	-	-	-	-	++	--	0	-	-	--	-	0	0

a/ Ranging from significantly positive (++) to significantly negative (--).

To evaluate how the various wildlife categories could be affected by changes in river operations, the work group identified important habitats and physical factors. These are aspects of the wildlife "support system" that respond to changes in the magnitude or timing of reservoir or river elevations. The work group analyzed five habitats in as much detail as available data permitted (see box), estimating acre changes at affected projects and reaches where possible. Other factors, such as human intrusion and fish productivity, were also considered in the evaluation. Chapter 3 of Appendix N, Wildlife, describes evaluation methodology in greater detail.

The abundance and quality of wetland and riparian habitat depend on water levels and timing. When dams were constructed, many acres of wetland and riparian vegetation were drowned and converted to open water. Some wetlands and riparian plants re-established along the new shoreline, but in some reaches of the Columbia River system, the new shoreline sloped much more steeply than the pre-dam shoreline, and the area of shallow water or saturated soils required for wetland establishment was much reduced compared to pre-dam conditions. More important than modified shoreline topography, however, were changes in the timing and magnitude of water level fluctuations brought about by regulated releases from the dams.

KEY HABITATS

- Emergent Wetland
- Submergent Wetland
- Riparian Zone
- Drawdown Zone
- Islands

Although it is difficult to predict accurately, the acreage of wetland and riparian habitats changes as water levels change. Daily fluctuations in water levels resulting from power peaking operations, and longer-term fluctuations

WILDLIFE CATEGORIES USED FOR EVALUATING IMPACTS

- Waterfowl
- Colonial Nesting Birds
- Shorebirds
- Non-game Birds
- Raptors
- Aquatic Furbearers
- Terrestrial Furbearers
- Big Game
- Reptiles and Amphibians
- Threatened/Endangered Species

resulting from seasonal drafts, create conditions generally inhospitable for wetland and riparian plants. Along much of the Columbia and Snake Rivers, lowering water levels for even a short time during the hot, dry summer can desiccate and kill shoreline plants, as well as small aquatic animals inhabiting the mud and shallow waters. Consequently, relatively little wetland habitat survives under current operating conditions. This is particularly true at storage projects, where water elevations fluctuate from day to day, month to month, and year to year. Emergent marsh and riparian habitat are most abundant where water level changes are dampened by backwaters, relatively reduced drafts, or active management of impoundments.

In addition to desiccation, periodic drafts from reservoirs accelerate erosion. Ledges of saturated substrates exposed as water levels recede can slough, or break up, as a result of wave action.

When water levels drop over a period of days or months, exposed sand and gravel create a barren drawdown zone. Wide drawdown zones typically ring the storage reservoirs of Lake Koocanusa (at Libby Dam), Hungry Horse, Lake Pend Oreille (Albeni Falls Dam), Lake Roosevelt (Grand Coulee Dam), and Dworshak. At Lake Roosevelt, for example, average water conditions expose approximately 23,000 acres (9,300 ha) of bare substrate. The width of exposed drawdown zone can greatly increase susceptibility of nesting waterfowl or denning furbearers to predators such as coyotes or raptors. It can also benefit shorebirds and other species that feed along the water/land interface, but on the whole, a barren drawdown zone decreases wildlife numbers and limits wildlife productivity at the storage projects.

Islands provide ground-nesting birds with protection from coyotes and other non-flying predators. Colonial ground-nesting species found in the lower Columbia River system include ring-billed and California gulls, and Forster's and Caspian terns. Large numbers of Canada geese nest on islands in the lower portion of the system, including about 350 pairs in the Umatilla National Wildlife Refuge. In some reaches, islands provide deer with fawning sites safe from predators. If water levels drop low enough, islands reconnect to the shore and lose their water barrier. If water levels drop after wildlife have selected an island for nesting or fawning, the ensuing predation on the young can be severe.

In addition to the timing and duration of water levels, system operations affect wildlife habitat by changing river velocity. Higher-velocity flows resuspend sediments and shift larger-sized stones and cobbles, sometimes removing established vegetation and depositing a new layer of sands and fine particles. Cottonwood and willow seeds require the resulting bare mineral soils for successful germination and survival. Although flow or river velocity no longer shapes the Columbia River valley landscape, it still maintains important habitat in the unimpounded Hanford Reach. Prior to damming, high spring flows, followed by gradually declining summer flows, exposed a cobble and stone substrate habitat that is now uncommon. Occurrences of persistent sepal yellow-cress, a member of the mustard family and a candidate for Federal listing as threatened or endangered, are believed restricted in Washington to the few areas of exposed cobble habitat remaining along the shores of the Hanford Reach and one locale below Bonneville Dam. This plant also occurs in other states.

The timing of high flows can directly affect wildlife productivity. For example, high flows occurring after shorebirds and waterfowl have selected nest sites can flood nests. Loss of one year's young can dramatically reduce numbers of waterfowl and shorebirds.

Effects of Alternatives

SOS 1 and Pre-ESA and SOS 2, Current Operations

Continuation of recent or current operations would cause little change in wildlife trends throughout the Columbia River system. Both SOS 1 (pre-ESA operations) and SOS 2 (current operations) would provide similar habitat conditions throughout the system. Large seasonal drafts from the storage projects would continue to restrict wetland area to current levels (Figure 4-17).

Compared to pre-ESA operations, current operations drop Lake Umatilla by about 1 foot (0.3 m) during the critical part of the growing season (April, May, and June). This area harbors some of the largest summer populations of waterfowl in the Oregon/Washington region. Some loss of marsh habitat fringing the upper edge of areas such as Paterson Slough would be expected, but new marsh may expand into bare sediments exposed at the water's edge. When fully implemented, current operations will desiccate roughly 735 acres (224 ha) of shallow water habitat including beds of aquatic plants, as well as some pond habitat. Under current operations, some of the small ponds hydrologically linked to Lake Umatilla dry up. With full implementation of the current operations plan, more ponds will be similarly affected. These ponds support western painted turtles and are used by mallards and other ducks for raising broods. Waterfowl populations breeding at various locales in Lake Umatilla might also lose nesting sites and experience slightly increased predation from mammals as a result of the shallower depths produced by SOS 2. These combined impacts associated with SOS 2 might slightly reduce long-term breeding duck and Canada goose numbers by from 5 to 33 percent at Lake Umatilla, compared to SOS 1 (Section 4.2.19, Appendix N, Wildlife).

Elsewhere in the system, effects of SOSs 1 and 2 on wildlife populations would be similar.

Expected Changes with Other Alternatives

The Wildlife Work Group considered the effects of other SOS alternatives on all of the projects and reaches of the Columbia River system. At some projects, all SOSs produced identical simulated water levels and flows. At others, simulated hydrological data varied so little among alternatives or from continuation of

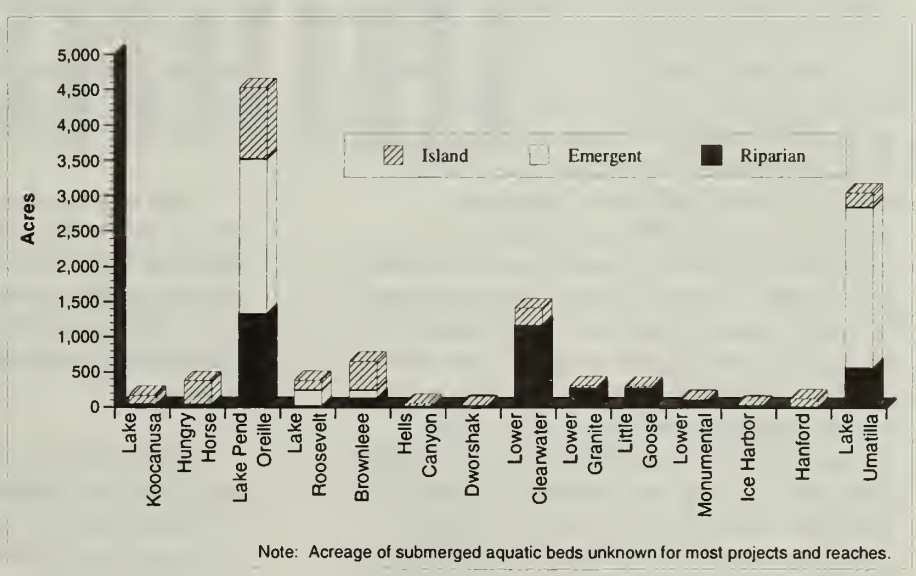


Figure 4-17. Current distribution of water-dependent habitats in principal affected areas of the Columbia River System

current operations that no differential effects on wildlife were considered likely. The work group focused primarily on projects and reaches where wildlife resources were considered sensitive to change, depending on the operational strategy selected. After detailed analyses, potential changes in wildlife resources were identified at 14 areas. Effects at these 14 geographical areas provide the basis for the evaluation presented below. Appendix N provides more detailed analyses of effects at each of the 14 areas, plus the other reaches and projects evaluated.

SOS 4, Stable Storage Project Operation

This strategy attempts to stabilize water level fluctuations at the storage projects, perhaps the single most important factor affecting wildlife resources over much of the Columbia River system. Of all alternatives, only SOSs 4c and 9b would markedly improve the abundance of water-dependent habitat (Figures 4-18 and 4-19). Areas of emergent marsh and riparian habitat would be expected to increase by more than 1,100 acres (445 ha) at Lake Pend Oreille, and by much smaller amounts at Hungry Horse (less than 50 acres [20 ha]) and Lake Koocanusa (about 10 acres [4 ha]). The large projected increase in wetland area at Lake Pend Oreille derives from dropping the maximum summer pool elevation 2.5 feet (0.8 m), coupled with providing relatively stable water levels during the growing season. Wetland and riparian plants would colonize the 2.5 feet (0.8 m) (vertical drop) of exposed sediments, benefiting essentially all categories of wildlife. Of particular importance at Lake Pend Oreille are large flocks of migratory and resident waterfowl, big game, ospreys, and bald eagles, which have recently nested along the shore. Osprey and eagles would benefit primarily from increased fish productivity associated with the stable storage operation. Lake Pend Oreille is a major spring and fall stop for waterfowl migrating along the Pacific Flyway. Fall and winter surveys conducted by the Idaho Department of Fish and Game (IDFG) indicate that numbers of duck and Canada geese peak each year in November, at an estimated 24,000 ducks and 2,200 geese. Early winter counts of redhead ducks have ranged as high as 17,000, which IDFG estimates constitutes almost 98 percent of the statewide count and approximately 20 percent of the total Pacific Flyway population of this species. The degree to which wildlife populations would increase is difficult to predict, but at both Lake Pend Oreille and Lake Koocanusa increases could range between 5 and 33 percent. Greater percentage increases might occur at Hungry Horse Reservoir, where recent large drafts have further reduced densities of most species dependent on aquatic or wetland habitats (Appendix N, Sections 4.3.1 through 4.3.8).

At Brownlee Reservoir, SOS 4c would raise February and March pool elevations. Higher pools would decrease the incidence of land-bridging of islands used for nesting, and benefit Canada geese and colonial nesting birds such as killdeer and American avocet.

The stable storage strategy would reduce the full pool elevation and spring drawdown at Lake Roosevelt, reducing the area of barren drawdown zone and providing opportunity for wetland expansion into the drawdown zone. Aquatic vegetation and benthic invertebrates might also increase in shallow water areas in response to lesser spring drawdowns. Additional wetland habitat and more productive shallow water habitat would benefit essentially all categories of wildlife.

Higher spring flows prior to nest initiation should reduce the incidence of nest flooding along the Hanford Reach, benefiting waterfowl, colonial nesting birds, and shorebirds. The higher late spring flows would also improve brooding and foraging habitat in sloughs and backwaters.

SOS 4c would provide the same water level regime at Lake Umatilla as occurred under SOS 1. Compared to no action, slightly more acreage of shallow water habitat, including some aquatic vegetation, would be maintained. The higher summer pool would maintain open water in the small ponds located within Irrigon

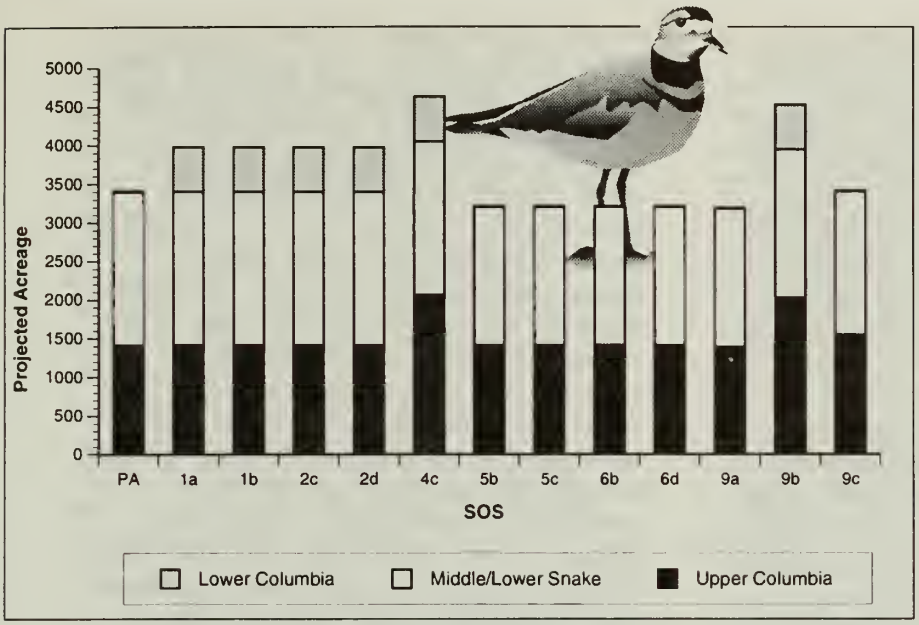


Figure 4-18. Quantity of riparian habitat under SOSs at principal affected areas of the Columbia River System

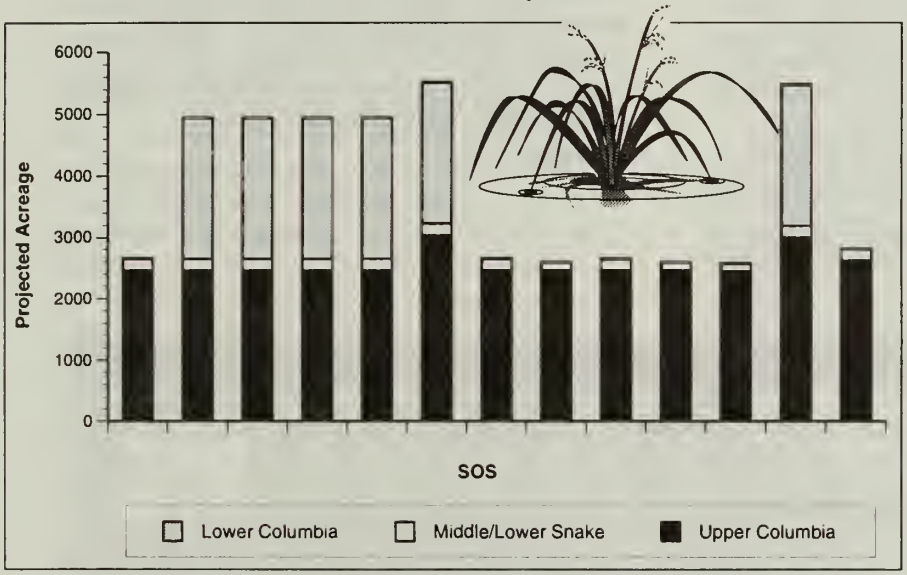


Figure 4-19. Quantity of emergent marsh habitat under SOSs at principal affected areas of the Columbia River System

Wildlife Management Area and other areas that are hydrologically linked with the Columbia River. Waterfowl productivity would, therefore, be slightly greater than under SOS 2c.

SOS 4c would have little or no effects on wildlife resources associated with Hell's Canyon Reach, lower Clearwater Reach, or lower Snake projects.

SOS 5, Natural River, and SOS 6, Fixed Drawdown

These strategies would affect wildlife resources of the Columbia River system similarly. They would decrease wildlife habitat in the lower Columbia (primarily on Lake Umatilla) and lower to middle Snake reaches, but would not cause significant differences from current operations in the upper Columbia region (Figures 4-18 and 4-19).

These strategies would annually lower water levels in Lake Umatilla to a minimum elevation of 257 feet (78.3 m) for 4 months (May through August), compared with recent (pre-ESA) operations which maintained the water level at elevation 263.5 feet (80.3 m) during May and June, and at elevation 266.5 feet (81.2 m) during July and August. SOSs 5 and 6 would, similar to SOS 1 and 2, continue to restore Lake Umatilla to between 266 and 267 feet (81.1 and 81.4 m) by the end of September. The summer drafts produced by these strategies would desiccate the entire 2,100 acres (850 ha) of existing extensive emergent marsh and riparian habitat including highly productive areas at Paterson Slough, McCormack Slough, Willow

Creek Wildlife Management Area (WMA), and Irrigon WMA. Another 6,000 acres (2,430 ha) of shallow water, supporting mud-dwelling animals and aquatic plants, would be de-watered. Few of these animals and plants would survive until fall, when the water level at Lake Umatilla would return to 266 to 267 feet (81.1 to 81.4 m) elevation. The return of the water level in the fall to 266 feet (81.1 m) would flood and kill any emergent plants colonizing the lower edge of the drawdown zone. Large losses of shallow-water, emergent marsh, riparian and pond habitats would substantially reduce breeding populations of ducks, Canada geese, colonial nesting gulls and terns, and western pond turtles. Reductions in wildlife might exceed 50 percent for representative species such as Canada geese, great blue heron, and yellow warbler (Table A-24 and Section 4.2.20, Appendix N, Wildlife). Loss of aquatic vegetation and shallow water benthic communities could create a serious food shortage for the hundreds of thousands of waterfowl that stopover during fall migration. The large flocks of wintering Canada geese and mallards would be relatively unaffected, as long as irrigation is not affected and irrigated croplands near the river continue to produce waste grain. Wintering diving ducks would decline as a result of decreased abundance of benthic organisms, a principal winter food. Raptors, aquatic furbearers such as river otters, and amphibians would also decline with lost habitat.

The natural river and fixed drawdown strategies would significantly degrade wildlife resources associated with the lower Snake projects; essentially all categories of wildlife, with the exception of non-game birds, would suffer from habitat loss. SOSs 5b and 6b would draw water levels down at all four projects by approximately 100 and 35 feet (30.5 and 11 m), respectively. The drawdowns would extend from April through August, desiccating wetlands, aquatic plants, and mud-dwelling organisms, and re-connecting islands to the shore. SOSs 5b and 6b would return water levels to within 3 to 5 feet (0.9 to 1.5 m) of full pool by September, which might maintain riparian vegetation for some years. The smaller drawdown resulting from SOS 6b (about 35 feet [11 m]) might retain riparian plants for an extended time. Even an annual drawdown of 35 feet (11 m) during the growing season, however, would preclude occurrence of moist soil required for successful germination and survival of cottonwood and willow seeds. Under both options, riparian habitat would gradually convert to upland vegetation as willows and cottonwoods failed to regenerate. The width of barren drawdown zone ringing the water's edge at middle/lower Snake projects would increase substantially, compared to SOS 2c or other strategies such as SOS 4c (Figure 4-20). The greater width of drawdown zone subjects nesting ducks, geese, and shorebirds to greater predation.

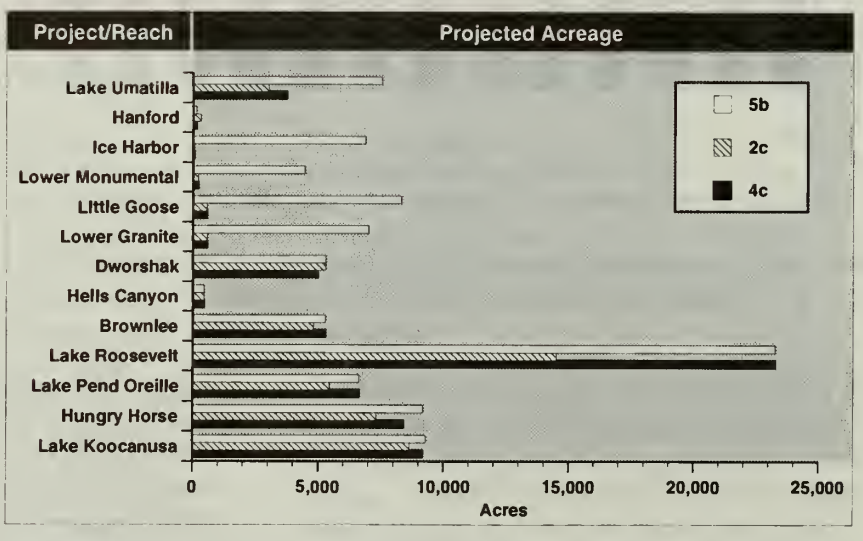


Figure 4-20. Quantity of drawdown zone projected for stable storage, natural river, and continued current operations at affected projects and reaches: SOSs 2c, 4c, 5b

Under SOSs 5b and 6b, wildlife resources in the lower and middle Snake River would suffer from the combined effects of desiccation of submerged aquatic plants and mud-dwelling fauna, land-bridging of islands, gradual loss of riparian vegetation, and increased predation associated with an extensive drawdown zone. Populations of waterfowl (Canada geese, mallards), colonial nesting birds, shorebirds, furbearers (beaver and otter) and amphibians could decline to 50 percent of current populations or even less. Over time, raptor occurrence along the lower Snake could also decline as riparian trees used for perching die without replacement. (Table A-21 and Section 4.2.17, Appendix N, Wildlife).

SOS 5c would implement a permanent 100-foot (30.5-m) drawdown at all four projects along the lower Snake River. The short-term impacts would be similar to those described above for SOS 5b; riparian habitat might disappear more quickly without a return to near full pool during non-growing season months. Over many years, however, natural-river operation associated with SOS 5c would allow riparian and some wetland habitats to reestablish. The more stable water levels resulting from natural-river operation would provide conditions suitable for colonization by emergent and riparian plants. The extent and timing of habitat establishment and rebound in wildlife would greatly depend on suitability of sediments for plant growth and topography of shoreline.

Effects of SOS 6d would be identical to SOS 6b, except restricted to Lower Granite Reservoir. Water levels at Little Goose, Lower Monumental and Ice Harbor projects would be identical to those resulting from no action (SOS 2c).

SOS 9, Settlement Discussion

Effects of SOS 9 vary widely depending on the option (Figures 4-18 and 4-19). SOS 9a, the DFOP, would eliminate wetland and riparian habitat at Lake Umatilla and at the lower Snake River projects as described for SOSs 5b and 6b. Water levels resulting from SOSs 9a, 5b and 6b would be similar at these areas. Declines in most categories of wildlife could exceed 50 percent at Lake Umatilla, including Canada geese, ducks and colonial nesting birds. SOS 9a would also adversely affect various categories of wildlife at Lake Koocanusa, Brownlee and the Hells Canyon reach of the Snake River; colonial nesting birds, non-game birds, and aquatic furbearers would decrease in all three of these areas.

Wildlife dependent on aquatic vegetation or sensitive to human intrusion would likely increase at Lake Pend Oreille if SOS 9a were implemented. Higher winter lake levels would enhance aquatic beds and increase densities of benthic invertebrates and fish, which provide prey to waterfowl, shorebirds, aquatic furbearers and other species. Effects of SOS 9a on wildlife at other projects within the Columbia River system would be either negligible or a mix of beneficial and adverse effects.

SOS 9b, adaptive management, would create about the same amount of additional wetland and riparian habitat at Lake Pend Oreille as the stable storage strategy would (Figures 4-18 and 4-19), increasing waterfowl and other categories of wildlife by 6 to 30 percent. Lake Pend Oreille is an important stopover point for waterfowl migrating along the Pacific Flyway. Similar to stable storage, SOS 9b would lower Lake Pend Oreille during summer months, favoring expansion of marsh and riparian habitat and the wildlife these habitats support. Unlike SOS 4c (stable storage), SOS 9b would not improve conditions at Lake Koocanusa or Hungry Horse, but would maintain wildlife populations at these two projects at levels expected from SOS 2c. SOS 9b would reduce shorebird and aquatic furbearer populations at Brownlee Reservoir by 6 to 30 percent. At John Day (Lake Umatilla), SOS 9b would provide water levels similar to SOS 2c, and thus reducing shallow water and pond habitat compared to recent (pre-ESA) acreage. As described for SOS 2c, this would reduce the important waterfowl populations at Lake Umatilla by 6 to 30 percent.

SOS 9c, a balanced impacts operation, would eliminate wetland habitat at the John Day project as described above for SOSs 5, 6, and 9a. Acreage of wetland and riparian habitat in the lower Snake projects would decline, but not as much as under SOS 9a. Drawdowns at the lower Snake River projects would be implemented earlier in the year under SOS 9c and for slightly shorter duration (March through June) compared to SOS 9a. SOS 9c would operate Libby Dam and Hungry Horse Dam projects under IRCs, which would create more stable reservoir levels and would generally improve wetland habitat. Elsewhere in the system, SOS 9c would not affect wildlife resources differently than SOS 2c.

SOS PA, Preferred Alternative

SOS PA would lower Lake Umatilla to 257 feet (78.3 m), as would SOSs 5, 6, 9a, and 9c. This magnitude of change in lake elevation would desiccate marsh and aquatic plants, benthic organisms, and eventually riparian vegetation. Ponds adjacent to the lake, mostly in the Irrigon Wildlife Management Area (WMA) and sheltered backwaters, would dry up. Habitat losses would be severe, as they would also be for the SOSs 5, 6, 9a, and 9c. Unlike the other options, however, SOS PA would maintain water levels at Lake Umatilla within 5 feet (1.5 m) of the 257-foot (78-m) elevation. After 1 to 5 years of relatively stable water levels, riparian, emergent and aquatic vegetation should re-establish along the new shoreline, and benthic organisms and aquatic plants should colonize the new areas of shallow water. The extent and timing of re-establishment is difficult to predict, depending greatly on the suitability of exposed substrates and shoreline topography.

Initially, impacts on wildlife resources at Lake Umatilla would be severe. Breeding waterfowl, primarily Canada geese and mallards, would decline by greater than 50 percent. Many important nesting islands used by geese would become land-bridged; loss of protective marsh and riparian plant cover would subject goose brooding areas to increased predation. The de-watering of McCormack Slough, Patterson Slough, Irrigon WMA and other sites would reduce mallard and other duck reproduction. Currently, total duck brood production on the Umatilla NWR approximates 2,000 ducklings; lowering the reservoir to 257 feet (78 m) would decrease duck production 50 to 80 percent. Diving ducks would suffer greater declines because they nest in emergent marsh near open water, and require aquatic plants for brood rearing.

In 1 to 5 years following implementation of SOS PA, goose and duck production would increase as habitat re-establishes. The extent to which marsh, aquatic bed and pond habitat would rebound, which is currently unknown, would largely determine the future numbers of breeding waterfowl at Lake Umatilla.

The important wintering habitat for geese at Lake Umatilla would probably not be affected by SOS PA, assuming irrigation practices are not altered. Wintering waterfowl feed primarily on waste grains in adjacent irrigated farm lands. Wintering mallards might be significantly affected by loss of protected backwater wetlands and sheltered open water, which they use for winter cover. Diving ducks, which do not feed on agricultural lands, would likely disappear immediately following implementation of SOS PA. Numbers of wintering diving ducks would increase over 1 to 5 years following implementation, as benthic productivity increases.

The lowered lake level would land-bridge or reduce the water barrier protecting islands which currently provide sites for colonial nesting birds; the thousands of ring-billed and California gulls and other birds that currently use these islands might relocate to new islands exposed by reduced lake elevations, if and when the new islands became adequately vegetated. Island habitat currently used for nesting might be restorable if sufficiently deep-water barriers can be dredged.

Non-game birds such as downy woodpeckers, yellow warblers, and red-winged blackbirds would incur substantial losses as riparian

vegetation succumbed to droughty soils. Populations of these species would recover over time, as riparian plants re-established along the new shoreline.

Beavers and otters would be severely affected by exposure of dens and loss of riparian and backwater habitat for foraging. Recovery for beavers could require 15 to 25 years, depending on the time required for growth of willow and alder. Otters might recover more quickly if macrobenthos rebound following establishment of the new pool level.

The ponds inhabited by western painted turtles at the Irrigon WMA and Umatilla NWR would likely dry up. Some turtles would likely pioneer into newly formed ponds and/or backwaters, but the net result of SOS PA would likely be a significant reduction in western painted turtles at Lake Umatilla.

Additional information about likely changes in wildlife resources at Lake Umatilla under SOS PA is presented in Appendix N, Wildlife. Efforts to replace lost pond and backwater habitat would be hampered by the abundance of porous soils, which are not easily impounded, in the area adjacent to Lake Umatilla. Control of carp, a nuisance fish that seriously interferes with establishment of aquatic vegetation, might be more difficult under conditions created by the new topography and open water configurations. These factors and others indicate that replacement of waterfowl and other wildlife habitat at the John Day Project would be costly and not necessarily entirely successful.

Effects of SOS PA at other projects in the Columbia River system would differ relatively little from those of SOS 2. At Lake Roosevelt, the rapidity of spring and summer drawdowns would stress emergent, submerged and riparian vegetation, leading to reduced numbers of waterfowl, colonial nesting birds, non-game birds and amphibians.

Threatened or Endangered Species

The Wildlife Work Group evaluated possible effects on bald eagles and, at the Hanford Reach, on persistent sepal yellow-cress, because these species are rare and closely tied to the health of Columbia River system habitat. The bald eagle is listed by the USFWS as threatened in Washington and Oregon, and endangered in Idaho and Montana. Persistent sepal yellow-cress is a candidate species that has been proposed for listing. Possible effects on the threatened grizzly bear, endangered peregrine falcon, and endangered Macfarlanes' four o'clock were also examined on a preliminary basis at projects where occurrence of these species indicated possible impact. Comparison of SOS alternatives based on possible effects on the grizzly bear (Hungry Horse Reservoir) yielded results identical to those based on effects on the bald eagle. No SOS alternatives were considered likely to affect the peregrine falcon (Brownlee Reservoir, Hells Canyon) or Macfarlanes' four o'clock (Brownlee Reservoir) any differently. The endangered gray wolf may occur in the vicinity of projects located within the upper Columbia River system, but population changes for this species will primarily reflect factors other than Columbia River system operations.

The number of projects where listed wildlife might benefit or decline are summarized for each alternative in Figure 4-21. Potential impacts generally relate to the effects of each alternative on emergent marsh and riparian habitat. Expansion of wetlands into the narrow zone of exposed sediments produced by flow augmentation at Lake Koocanusa, for example, would provide more foraging area for eagles.

Stable storage operation would allow wetland expansion into exposed sediments at Lakes Koocanusa and Pend Oreille. SOS 4 would also reduce water level fluctuations at Hungry Horse sufficient to favor some establishment of marsh and riparian vegetation. As with flow augmentation, SOS 4 would produce relatively high flows in the lower Clearwater reach, favoring larger trees used for perching.

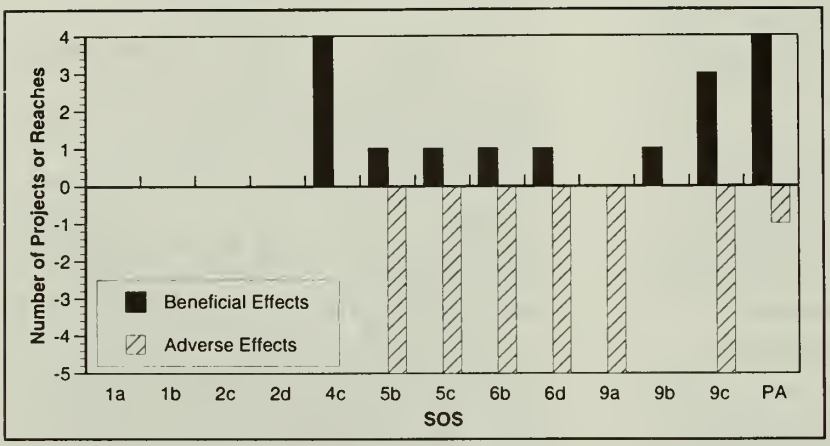


Figure 4-21. Number of projects or reaches with beneficial or adverse effects on Federally listed wildlife

SOSs 5 and 6 would maintain perching trees for eagles along the lower Clearwater reach, but would desiccate marsh and riparian habitat at the four lower Snake River projects and at John Day pool.

SOSs 9a and 9c would also prevent regeneration of riparian perch and roost trees at the four projects along the lower Snake River. In time, eagle foraging opportunities would diminish. SOS 9b would increase emergent marsh and aquatic beds at Lake Pend Oreille, with consequential increases in benthic organisms and fish; an increase in fish productivity should enhance foraging for bald eagles.

SOS PA implements the recommendations of the NMFS and USFWS Biological Opinions issued in March 1995 to avoid jeopardizing the continued existence of anadromous fish and other listed species, including plants and wildlife, in the Columbia River system. However, possible effects on bald eagles at John Day were not presented, and a biological assessment describing these has been prepared. From its own review of SOS PA, the Wildlife Work Group determined that this alternative would likely decrease bald eagle numbers in the vicinity of Lake Umatilla as a result of a decrease in the wintering waterfowl population and lost riparian habitat. Modification of irrigation facilities to maintain existing crop rotation patterns should mitigate impacts to wintering waterfowl. The decrease in numbers would not be substantial but probably greater than 6 percent (see Appendix N, Wildlife). In time, riparian habitat would likely re-establish along the new shoreline of Lake Umatilla, but this process might take 20 to 40 years. SOS PA would have no immediate beneficial effects on listed wildlife.

4.2.7 Cultural Resources

This section discusses direct and indirect impacts on historic and cultural properties that are typically associated with river system operations. Certain SOSs would involve the modification of structures such as spillways, dam embankments, and fish passage facilities, potentially causing direct impacts to historic or cultural properties. These structural elements are not considered in the SOR. Instead, they are addressed in the Corps' SCS. The following summary of direct and indirect impacts is based on the complete report on cultural resource studies provided in Appendix D.

Cultural Resources Impact Issues

Changing water levels and flows can cause wave action, inundation, and exposure of reservoir drawdown zones, all of which can affect cultural resources. System operations can also cause indirect impacts to historic properties as a result of changes in the human use and aesthetics of the shore and drawdown zones.

Impacts within the reservoir pool occur most often to non-structural archeological deposits, since initial reservoir construction and filling usually removed or damaged above-ground or structural cultural resources such as historic architecture. Direct impacts to archeological deposits resulting from reservoir shoreline fluctuations occur differently in each of three reservoir zones: 1) the littoral (exposed beach), 2) wave-impact, and 3) inundation zones (Figure 4-22).

Exposed archeological deposits within the littoral zone are subject to direct impacts that are mechanical, human, and animal in origin. Because inundation removes vegetation, wind and water (runoff) erosion deflates archeological sites in this zone. Deflation is the removal of the archeological soils, leaving heavier items and artifacts in place. Water running over unvegetated slopes also causes erosional rills and gullies and moves artifacts. The movement of artifacts and site features within or away from a site decreases its scientific integrity and value because it becomes more difficult to reconstruct the site's original features and placement of artifacts.

The littoral zone is also subject to repeated cycles of wetting and drying, which can cause organic deposits, such as bone, and some artifacts, such as ceramics, to deteriorate. In certain soils, rapid drawdown can cause mass wasting (e.g., slumping or landslides) of slopes in or above the reservoir. This occurs as water rapidly vacates the pores between soil particles, causing the soil to lose cohesion. Progressive soil slumps on beach cut-banks form erosional fronts that can slowly advance landward. Over time, this can result in the loss of large areas of bank.

Wind- and powerboat-generated wave action erodes and deflates archeological sites. It may also stimulate geomorphological changes that can destroy intact archeological deposits. These changes can include slumping, scouring, terracing, and piping (see the Glossary for definitions of these terms).

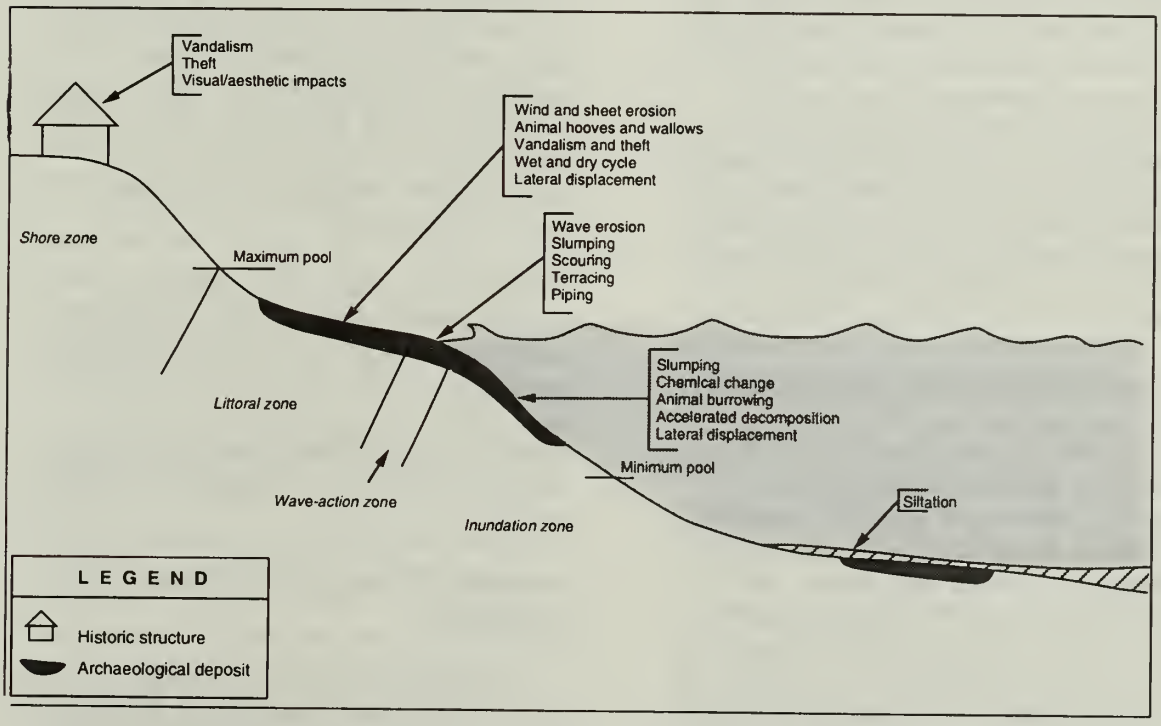


Figure 4-22. Reservoir impact zones and potential impacts on historic and cultural properties

Direct impacts on archeological deposits that occur underwater include erosion, chemical change, and accelerated decomposition (Lenihan et al., 1981). Underwater currents can cause slumping or displace materials and artifacts already brought to the surface by wind- and water-caused erosion. For example, drawdowns at Kettle Falls in Lake Roosevelt have revealed that underwater eddies have caused pothole erosion of archeological sites. Reservoir water dissolves organic materials and ceramics, and changes chemical attributes, such as pH, phosphate, and nitrogen levels of deposits. Aquatic organisms such as burrowing clams can disturb archeological deposits by moving artifacts as they burrow. An accumulation of organic acids accelerates the decomposition of organic materials and ceramics.

Indirect impacts to historic and cultural properties due to system operating strategies involve changes in the human use of the shore and littoral zones. For example, reservoir operations affect the attractiveness of the reservoir for recreation, and thereby influence the number of people visiting these zones. The devegetation and deflation of archeological sites in the littoral zone, furthermore, make them more visible to the public. When more people are present and archeological sites are more visible, there is a greater likelihood of vandalism and artifact theft. Archeological sites in the devegetated littoral zone also are susceptible to disturbance, artifact displacement, and erosion from cattle trampling and wallowing and the operation of off-road vehicles on reservoir beaches.

Land management actions not related to system operations can also affect human activities at the reservoirs, and different uses can have different effects on archeological and historic sites near system reservoirs. Decisions to develop or permit camping, summer homes, hiking trails, or off-road vehicle uses, for example, may all lead to increased impacts on historic and archeological sites from human-caused erosion, vandalism, and artifact theft. A comprehensive analysis must, therefore, consider the effects of land management actions that affect projects in the SOR study area as well as system operations.

System operating strategies that change land uses might also change the integrity of "feeling" or association of a historic or cultural property. For example, change in nearby recreational uses might adversely affect a traditional cultural property such as a Native American ritual site, by increasing sights and sounds incompatible with ritual use. Reservoir drawdown might destroy the visual integrity of a historic site or traditional cultural property by introducing an element that is inconsistent with its historic or cultural character.

Effects of the Alternatives

All of the SOSs would cause adverse effects to cultural resources, and some of these effects would be more dramatic than others. Reservoir sites that have been covered by siltation, for example, are to some extent protected from erosion and vandalism. At the same time, the siltation may have caused chemical changes in the soils, and also reduced access to these sites for scientific study. Some sites in vulnerable locations in the reservoir drawdown zone have already been eroded or deflated beyond significance, while others contain intact deposits. Recreational use of the reservoir shoreline has led to vandalism at some sites above the operating pools, while other sites remain relatively inaccessible.

The relative effects of the SOSs on the known cultural resources can be estimated by measuring the length of time a given operation would cause shoreline erosion and exposure of these properties. The potential for a given alternative to cause geomorphological changes that would affect historic properties can also be estimated.

Shoreline Erosion, Site Exposure, and Inundation

To assess each alternative's potential to cause archeological shoreline erosion and drawdown zone exposure, the Cultural Resources Work

Group developed a site impact computer simulation model. This model simulates the movement of the reservoir shorelines over a 50-year period during which water volumes would be the same as actual water volumes between 1929 and 1978. For each alternative, it calculates the number of days in the 50-year period on which wave erosion, site exposure in a drawdown zone, and inundation would occur for each known archeological site. The simulation results are thus general rates of ongoing impact. Because reservoir elevations and patterns of shoreline movement differ significantly between alternatives, these rates of impact also differ significantly between alternatives.

The simulation is based on month-to-month changes in elevation as predicted by the ROSE hydroregulation models. To simulate shoreline wave erosion potential, it calculates the number of days in the month that the reservoir shoreline would be within the site boundary, based on the site's upper and lower elevation limits and the change in the reservoir elevation from the previous month. To simulate site exposure potential, the model calculates the number of days in the month that the reservoir shoreline would be below the site's upper boundary, also based on shoreline transgression from the previous month. To simulate inundation, the model calculates the number of days in the month that the reservoir shoreline would be above the site's upper boundary. The model then calculates overall shoreline erosion, drawdown zone exposure, and inundation scores for each alternative. The model represents these as the average number of days per year when a given effect would occur and as the average percentage of time that the effect would occur.

The simulation uses archeological site data from the known sites only. It should be kept in mind that archeological survey can never be considered complete. Archeological survey of the operating pool is relatively complete for some projects, including Libby, Albeni Falls, Chief Joseph, and the four lower Snake River projects. Data is relatively incomplete and of poor quality for Grand Coulee, though a project is currently ongoing to add to the survey coverage. Recent surveys have greatly improved the data from Hungry Horse and Dworshak. The lower Columbia projects had little or only cursory survey before the dams were built. Subsequent surveys have filled in some of these gaps, but the data are sparse. These are run-of-river projects, however, and except for John Day, do not vary in elevation among alternatives. The simulation results, therefore, are valid only for portions of the reservoirs that have been surveyed.

The simulation study helped highlight general patterns of effect on cultural resources. For example, the average rates of shoreline erosion for some reservoirs under some alternatives are somewhat lower in general than expected. Shoreline erosion rates are moderately high or high (shoreline erosion occurring 40 to 80 percent of the time) only for Albeni Falls and Dworshak. For many reservoirs, including Libby and the lower Snake projects, the average rate of shoreline erosion is low (shoreline erosion occurring less than 20 percent of the time) for all alternatives. This does not mean, however, that reservoir operation impact on the sites is low. It only means that the impact is taking place more slowly than might have been expected.

Another result of the simulation study is that there are large differences in simulated rates of impact among reservoirs. The rates of shoreline erosion and site exposure are both high or very high at Albeni Falls, for example, and low or very low at the lower Snake River reservoirs for most alternatives. These patterns have to do with the distribution of the known sites in relation to the reservoir operating zones.

The simulation study also indicates that site exposure is particularly a problem at the storage reservoirs. Exposure rates at Albeni Falls, Hungry Horse, and Dworshak are all predicted to be high to very high (known sites exposed, on average, more than 60 percent of the time). Actual rates of impact will depend on the local topography, soil conditions, and the extent of recreational use, but the simulation indicates that rapid site deterioration may be taking place.

The simulation study predicts that SOSs 1a, 1b, and 2d would be very similar to the baseline condition (2c) in their overall rates of shoreline erosion and site exposure (Figures 4-23 and 4-24; Table 4-12). SOS 4 would increase the rate of shoreline erosion at the same time that it would slow the rate of site exposure. This indicates that the two kinds of impacts vary inversely. When reservoir shorelines are high, site exposure decreases while shoreline erosion tends to increase. This is because the known sites tend to be disproportionately located high in the reservoir pool.

SOS 5 would show the opposite pattern. Since this alternative involves deep drawdowns at the lower Snake River projects and greater pool fluctuation at the storage reservoirs, it would increase the rate of site exposure while lowering the rate of shoreline erosion. The more the shoreline moves, the less time it will spend attacking any given archeological site.

According to the simulation model, SOSs 5c and 9a would cause the greatest overall increase in the rates of shoreline erosion and site

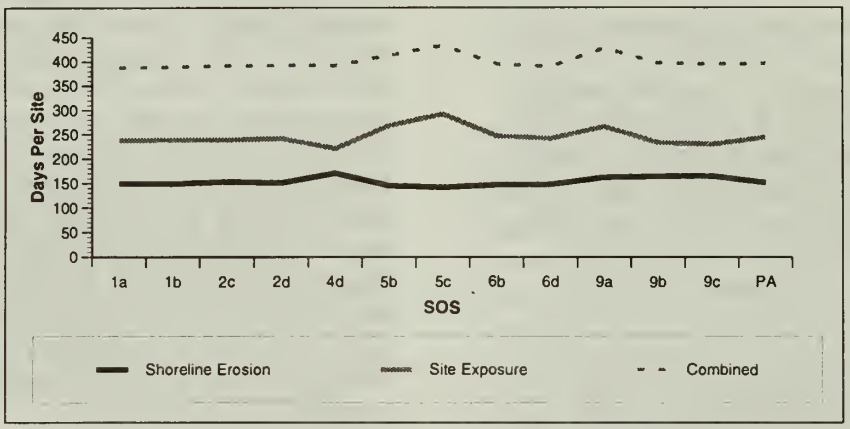


Figure 4-23. Average days per year that archaeological sites would experience shoreline erosion and site exposure

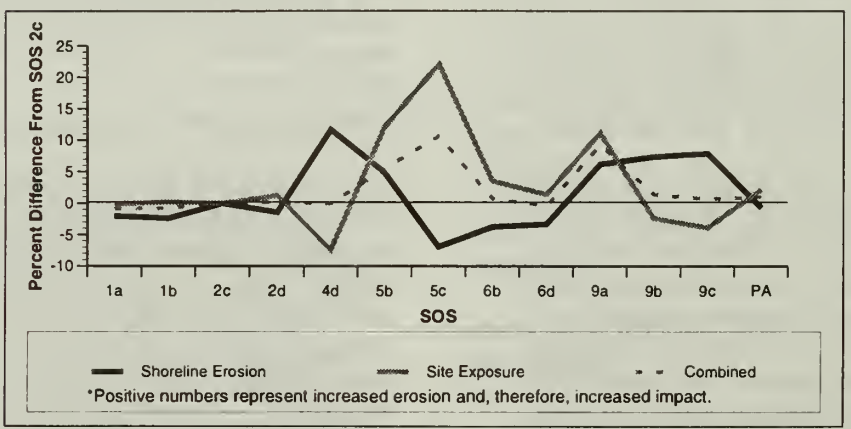


Figure 4-24. Percent difference from SOS 2c in historic property shoreline erosion and site exposure*

Table 4-12. Comparison of archaeological site shoreline erosion, site exposure, and inundation by SOS

SOS	Shoreline erosion			Site exposure			Inundation			Shoreline and exposure combined		
	Site-Days per 50-Year Model Period	Site-Days per Year	Percent Difference from SOS 2c	Site-Days per 50-Year Model Period	Average Site-Days per Year	Percent Difference from SOS 2c	Site-Days per 50-Year Model Period	Average Site-Days per Year	Percent Difference from SOS 2c	Site-Days per 50-Year Model Period	Average Site-Days per Year	Percent Difference from SOS 2c
1a	9,995,358	150	-2.0	15,892,549	238	-0.1	14,111,917	212	0.2	25,887,907	388	-0.9
1b	9,949,051	149	-2.4	15,954,048	239	0.2	14,050,418	211	-0.3	25,903,099	389	-0.8
2c	10,195,966	153	0.0	15,916,362	239	0.0	14,088,104	211	0.0	26,112,328	392	0.0
2d	10,051,816	151	-1.4	16,113,565	242	1.2	13,890,901	208	-1.4	26,165,380	393	0.2
4c	11,389,874	171	11.7	14,731,722	221	-7.4	15,272,744	229	8.4	26,121,596	392	0.0
5b	9,693,683	145	-4.9	17,846,256	268	12.1	12,157,210	182	-13.7	27,539,940	413	5.5
5c	9,489,138	142	-6.9	19,430,007	292	22.1	10,574,460	159	-24.9	28,919,144	434	10.7
6b	9,819,781	147	-3.7	16,493,818	247	3.6	13,510,648	203	-4.1	26,313,600	395	0.8
6d	9,858,071	148	-3.3	16,144,321	242	1.4	13,860,145	208	-1.6	26,002,392	390	-0.4
9a	10,825,025	162	6.2	17,706,861	266	11.2	12,297,605	185	-12.7	28,531,885	428	9.3
9b	10,948,532	164	7.4	15,528,805	233	-2.4	14,475,661	217	2.8	26,477,338	397	1.4
9c	11,006,151	165	7.9	15,300,437	230	-3.9	14,704,029	221	4.4	26,306,589	395	0.7
PA	10,121,952	152	-0.7	16,264,098	244	2.2	13,740,368	206	-2.5	26,386,049	396	1.0

exposure at the known sites combined, compared with the baseline condition. SOS 5c, however, would do so by greatly increasing rates of site exposure while slowing down the overall rate of shoreline erosion. One interesting aspect of this is that SOS 5c involves permanent drawdown at the four lower Snake River projects. The site exposure that this would cause would be mitigated by the fact that, under these conditions, the drawdown zone at these projects would eventually revegetate. This would provide some protection to archeological deposits and restore their accessibility. In other words, SOS 5c might be seen as an overall improvement in terms of impacts to cultural resources. SOS 5b, on the other hand, would involve drawing down the lower Snake River projects annually and then refilling them. SOS 9a would increase the rates of both shoreline erosion and site exposure compared to the baseline. The preferred alternative would not differ significantly from the baseline condition, according to the simulation.

Geomorphic Change

The Cultural Resources Work Group also analyzed the potential effects of reservoir operation on cultural resources by looking at the ways in which various features of system operation could accelerate erosion and change to the landforms on which cultural resources are located. This analysis took into account geomorphic processes such as land slumping that were not included directly in the simulation model. It also considered effects on the entire reservoir pool at each project. The simulation model, on the other hand, examined only impacts to the known historic properties. Since cultural resources surveys are incomplete, the geomorphic model provided a way to account for the effects on unrecorded sites. The simulation and geomorphic models are thus complementary approaches to impacts analysis.

The following discusses the potential effects of the system operational features on cultural resources through sedimentation and erosion.

Flow Augmentation—Augmenting flows increases water velocity through the reservoirs. Depending upon the rate of flow and the volume of additional water, such increases can be sufficiently large to increase erosive cutting at reservoir shorelines, particularly on peninsulas and embayments. Currents of 4 feet per second (0.3 m per second) can increase shoreline erosion by 30 percent in light soils such as those that occur on the Columbia Plateau.

Some level of flow augmentation would occur under every option except SOS 1b. SOS 1a includes the original Water Budget flow augmentation. SOSs 2, 9, and PA incorporate substantial flow augmentation in addition to the Water Budget.

New Reservoir Levels—The construction of a dam and reservoir upsets the dynamic equilibrium of the river on which the dam is built. As soon as the reservoir fills, the shoreline begins to erode and sediment collects on the reservoir sideslopes. As time passes, erosion rates decrease as the reservoir reaches a new equilibrium state. When reservoir operation changes, a new erosional cycle begins. Shoreline waves begin to cut deeper benches at new stable levels. The benches undermine steeper slopes above the benches, which lead to landsliding and slumping that, in turn, may affect cultural resources. If new reservoir levels are considerably lower, this can lead to narrower pools through which water travels faster, causing increased bank erosion.

Rapid Drawdown—Rapid drawdowns (greater than 2 feet [0.6 m] per day) can dramatically accelerate ongoing processes of soil creep, landsliding, and mass wasting. This occurs as water becomes trapped in the pores between soil particles, then exerts pressure on surrounding soil particles during drawdown, causing an unstable soil mass. This can cause slumping and sliding, affecting archeological deposits located nearby.

Rapid Pool Fluctuation—Reservoir fluctuations of more than 5 feet (1.5 m) per day (including both raising and lowering of the pool)

can increase erosion within the reservoir and stream channels downstream. As with rapid drawdown, this condition can cause slope failures and affect archeological sites.

Natural River Operations—Operating reservoirs at near natural river levels is a special case of operation at new reservoir levels. This feature leaves the largest possible area open to erosion and slope failure that could affect cultural resources. It combines the effects of flow augmentation, rapid drawdown, and new reservoir levels. Natural river operation is a feature of SOS 5 and the lower Snake River reservoirs only. With SOS 5b, the lower Snake reservoirs would draw down to natural river level and refill annually, exposing large areas to erosive forces. With SOS 5c, the drawdowns would take place at one time, and would be permanent, however, so that the former reservoir sideslopes would no longer be subject to erosive forces due to pool operation.

Geomorphic Comparison of the Alternatives—The most significant increases in sedimentation and erosion would occur with SOS 5, natural river operation, and SOSs 6 and 9, deep drawdown strategies (except 9b). Certain alternatives, such as SOSs 2d, 4c, and 9b, could cause significant slope failures that may affect cultural resources at Dworshak and Grand Coulee. These strategies feature hydropower flows combined with flow augmentation with target spill levels that may lead to short-term cyclic drawdown and refill over a range of a few feet. This can cause bank slumping in loose, unconsolidated soils such as the glacial tills in the storage reservoirs at the upper reaches of the basin.

SOSs 1 and 2c should cause the lowest rates of ongoing adverse effect on landforms and the cultural resources located on them. These strategies have been in effect for some time, and shorelines have to some extent reached an equilibrium condition due to armoring effects. These alternatives represent the least amount of change from the current situation. In contrast, SOSs 2d, 6, and 9 would create new minimum levels for some reservoirs. For example, under SOS 6, the lower Snake River projects (Lower Granite only under 6d) would begin drawdowns to new minimum pools located below the existing minima. This would lead to the creation of new wave-cut benches at these levels, which would dramatically increase erosion at any archeological sites located at these levels.

The SOS 5 options would draw the lower Snake reservoirs down to natural river level. This would lead to the maximum possible exposure of unvegetated sediments in the drawdown zone and would consequently lead to potential erosion of landforms containing archeological sites over a large area. SOS 5b would annually draw down these four projects to natural river level for 4.5 months. Under SOS 5c, however, the drawdown would be permanent. The drawdown zone would thus have the opportunity to revegetate, affording some protection for cultural resources from erosion and sedimentation.

Summary of Effects

Because the simulation study and geomorphic analysis are complementary approaches to comparing the effects of the alternatives, combining their results provides a comprehensive view of the system's effects. This combined analysis shows that SOSs 5c, 2c, 1a, 1b, and PA would be the most beneficial in terms of impacts to cultural resources. These alternatives would either maintain the current ongoing rate of impact, or would improve it in some way. SOSs 9a, 5b, 4c, 9c, 9b, 6b, 6d, and 2d would be the least beneficial. These alternatives would increase the ongoing rate of impact to cultural resources.

SOS 1—The SOS 1 options would probably cause a slight decrease in the rate of ongoing impacts to cultural resources of system operation. The simulation model predicts slightly reduced shoreline erosion and site exposure for SOS 1a, compared with the baseline. The geomorphic analysis shows that returning to operation under SOS 1a would involve returning the shoreline zone to areas likely to have reached erosional equilibrium

during the time period when the system operated according to SOS 1a.

SOS 2—SOS 2 would also not cause very much change from current operations and so would not accelerate the rates of ongoing impact to cultural resources. The simulation model uses SOS 2c as the baseline condition and so predicts no change in ongoing impact rates for SOS 2c, and only insignificant changes for SOS 2d. The geomorphic analysis predicts that SOS 2d would change reservoir levels at John Day and the lower Snake River projects, leading to accelerated erosion of landforms.

SOS 4—The simulation study results show some change in ongoing effects for SOS 4c as compared to current conditions. It would accelerate shoreline erosion at known cultural resources sites, while simultaneously slowing down the rate of drawdown zone exposure at these sites. According to the geomorphic analysis, rapid drawdowns at John Day and Dworshak in the fall months could accelerate slope failures on steeper slopes at these reservoirs. Otherwise, SOS 4c would cause less exposure of landforms to erosive processes than other alternatives because it would maintain high pool levels at the storage reservoirs for a longer period of time in the summer. The known archeological sites, however, are disproportionately located in the high pool shoreline areas at the storage reservoirs. These sites, particularly at Albeni Falls, would experience accelerated erosion.

SOS 5—SOS 5 represents a large departure from current operations. SOS 5b would draw down the lower Snake River projects to natural river level for part of the year and would thus involve repeatedly inundating and exposing all of the archeological sites in these reservoirs. SOS 5c would involve permanent drawdown to natural river level. According to the simulation model, both would dramatically increase average site exposure rates while decreasing the rate of shoreline erosion. According to the geomorphic model, both would expose large areas to erosion. SOS 5c, however, should be considered the most beneficial for cultural resources because the drawdown to natural river level would be permanent. Therefore, access to archeological sites in the reservoirs would be restored. The drawdown zones would revegetate, affording some additional protection from erosion.

SOS 6—SOS 6, with its new reservoir minima at the lower Snake River projects, would increase erosion and sedimentation. According to the simulation model, it would increase the rate of site exposure and decrease the rate of shoreline erosion, though by small amounts in either case.

SOS 9—SOS 9a is unique among the alternatives in that it would increase the rates of both shoreline exposure and site erosion at the known sites, according to the simulation model. SOS 9b and 9c, by contrast, are similar to SOS 4c in that they would increase the rate of shoreline erosion, but also decrease the rate of site exposure. The geomorphic analysis also predicts that SOS 9a would cause an acceleration of erosion and sedimentation because it would involve drawdowns to new minima at the lower Snake River projects and John Day as well as increased flow velocities and pool fluctuations.

SOS PA—SOS PA would not cause major changes in the rates of ongoing impact to cultural resources. There would be some increases in shoreline erosion at the lower Snake River reservoirs and at John Day because of flow augmentation and new minimum water levels. Throughout the study, the Cultural Resources Work Group has attempted to consider and evaluate additional factors relating to cultural resources impacts. A key question has involved the significance of the affected resources. Within the legal and regulatory framework of cultural resource management, answers to the significance question come from determinations of eligibility and nominations for the National Register of Historic Places. Unfortunately, not all of the cultural resources in the Columbia River system have been inventoried and evaluated. Consequently, analysis based on the limited existing information must be interpreted very carefully

because the existing data may not reliably represent the full range of all cultural resources. A more detailed analysis of the effects of the SOS alternatives would require complete archeological inventories of all reservoirs; evaluations of the eligibility of their historic properties for nomination to the National Register; and information about the susceptibility of cultural sites to reservoir exposure and wave erosion effects, based on their soils, slopes and locations in the landscape.

The lead agencies have formerly initiated the National Historic Preservation Act (NHPA) Section 106 consultation process. Section 106 requires Federal agencies to evaluate the effects of their actions on historic, archeological, and cultural resources, and to provide the Advisory Council on Historic Preservation with the opportunity to comment on the proposed actions. The SOR agencies will develop an interagency agreement, based upon a statement of shared principles and commitments, that will identify specific agency roles, responsibilities, and commitments for budget allocations necessary to meet cultural resources requirements for Section 106 and 110 compliance. Based on the SOR impact analysis, the lead agencies will also develop cultural resources implementation plans for specific projects or river reaches; these plans will outline the steps to be taken to fulfill the interagency agreement, as part of the NHPA Section 110 consultation process. For some projects, treatment for mitigation will be according to an existing memorandum of agreement or programmatic agreement (see Appendix D, Chapter 6 for further discussion).

Traditional Cultural Properties

Information submitted by the tribes within the region indicates that the Columbia River system has significant, ongoing, adverse effects upon traditional cultural properties valued by Native Americans. Some of these effects involve aquatic and terrestrial resources associated with a free-flowing river system that were diminished or lost with development of the dam and reservoir system. Other adverse effects occurred through inundation of ceremonial grounds, sacred sites, important plants and life forms, fishing sites, social and political gathering areas, unique landforms, and other features important to the traditional way of life of the Indian peoples. Some traditional cultural properties were not inundated and remain accessible, but their integrity and value has been diminished through project-related landscape changes and the management of project lands for recreation and other public purposes. For example, some vision quest sites are still accessible, but have lost their traditional context and feeling because the original riverine landscape has been significantly modified.

Based on the nature of these effects, the adverse impacts of the system on traditional cultural properties have occurred and will continue primarily as a result of the construction and continued presence of the dams and reservoirs. The variable effects of system operations on these resources are somewhat limited. In assessing the effects of the 13 SOSs on traditional cultural properties, an important distinction is that the SOSs would vary the physical characteristics of the water flowing through the system, but they would not directly change the structures of the system or the management of project lands. The SOSs therefore would primarily affect resources in the water (principally fish), or resources that would benefit from or be harmed by changes in water levels. In addition, a significant potential effect would be for changes in water levels to expose traditional cultural properties that now are normally inundated.

Given the ways in which system operations can affect tradional cultural properties, comparison of the SOSs on this basis is partially subsumed in the previous assessments for anadromous fish, resident fish, and wildlife (Sections 4.2.4, 4.2.5, amd 4.2.6, respectively; see also Section 4.2.8). The traditional cultural significance of these natural resources is very high. Based on the information submitted by a few of the tribes, the SOR agencies conclude that the lower river treaty tribes in particular would view an SOS that would benefit anadromous fish as being protective of one important dimension of traditional cultural properties. For the upriver tribes in areas where anadromous fish are not present, the SOR agencies have concluded that this dimension of

traditional cultural properties would depend primarily on SOS effects on resident fish and wildlife.

Aside from the biological dimension, SOS effects that would result through exposure of cultural sites would generally be based on the depth, duration, and geographic extent of reservoir drafting. In the case of storage reservoirs, seasonal drafting under current or past operations has probably exposed and provided tribal access to some traditional cultural properties on an intermittent basis. Access to these areas is considered a positive effect by at least some of the tribes. This type of effect would continue under all 13 SOSs, with relatively minor incremental differences among the SOSs. In general, however, any benefits from increased access to inundated sites at storage reservoirs would likely be at least partially offset by less desirable conditions for resident fish.

The greatest potential for change in operations effects through exposure of and access to cultural sites applies to mainstem reservoirs at which drawdown has been considered. The CTUIR, for example, reported that nearly 1,500 known sites of particular cultural significance to the Umatilla tribes have been inundated by the eight lower Columbia and Snake River dams, and that many more such sites may exist but have not yet been identified (see Appendix D, Section 4.6). Natural river or drawdown operations for one or more of these projects would (in conjunction with appropriate land management and resource protection) restore access to numerous culturally significant sites and expand opportunities for the tribes to actively practice their culture. Based on the characteristics of the 13 SOS alternatives, The SOR agencies conclude that SOS 5c would be the most beneficial by this impact measure, as it would provide year-round access to all sites inundated by the four lower Snake River pools (approximately 660 sites in the CTUIR inventory), and to sites around the upper margin of the John Day pool (if any exist in this zone). SOS 5b would allow access to the same sites, but for only about half of the year. SOSs 6b, 9a, and 9c would expose cultural sites in the upper one-third (by elevation) of the lower Snake River pools on a seasonal basis,and therefore would allow use of a considerably smaller and unknown number of sites. SOS 6d would have the same type of effect, but limited to the Lower Granite pool.

The CTUIR and the Spokane Tribe have specifically indicated that access to culturally significant sites and resources, and opportunities to practice their culture, are very important factors in how they view system operations and the effects of the SOSs. Other tribes have expressed or probably hold similar views with respect to the places and resources that have special significance for them.

4.2.8 Native Americans

The purpose of this section is to identify and discuss potential consequences of system operations on Native American resources and interests. In many ways, this is a non-traditional impact assessment; while some of the resources of interest to Native Americans are tangible physical or biological features, others include considerations such as spiritual and cultural attributes of the resources. The following material attempts to identify SOR-related issues of interest to Native Americans and characterize the effects of the SOS alternatives on Indian resources and concerns.

Native American Impact Issues

Coordination with the tribes to date has indicated that, in general, issues that particularly concern tribes with respect to the SOR include treaty rights, impacts on fishing, and the protection of graves and cultural resource sites. While these may be the key concerns, a wide range of other resources and issues is of interest to the Indians of the basin. Some of these interests are best described through prior tribal expressions of their views of the SOR.

Many Native Americans from the basin's tribes traditionally have centered their lives around the Columbia River and depended on its resources, such as salmon and transportation. Some quotations from the April 1993 edition of the SOR newsletter, *Streamline*, illustrate how some Native Americans view the river:

Shoshone-Bannock Tribes: The Shoshone-Bannock Tribes believe that the entire Columbia River system is culturally significant, not just individual "sites" within the system. The preservation of the free-flowing rivers and associated riparian ecosystems should be included in the cultural resources elements analyzed.

Fred Ike, Sr. and Johnson Meninick, staff, Yakama Indian Nation Cultural Program: The Yakama Nation has a vested interest in the river basin, which is our homeland. It is important that the SOR recognize Tribal sovereignty. Our interests are more than fishing rights; we are concerned about preserving a seasonal round of life that is the focus of people up and down the river. We want to preserve a traditional way of life connected to the river and the resources of the river.

Many of the tribes are extensively involved in fish and wildlife management, and the SOR agencies have received a number of comments from tribal representatives concerning these resources. Specific concerns or requests included use of the empirical life-cycle model for anadromous fish being developed by the state agencies and tribes; managing water in upstream reservoirs more for the benefit of resident fish and wildlife; and protecting existing investments in fish and wildlife mitigation. Tribal representatives have also expressed concern over exposure of cultural resource sites at the reservoirs, the overall approach to the cultural resources assessment, and the development of management plans to monitor and protect affected cultural resources. As indicated in Section 2.2.1, the tribes are concerned about a broad range of features of the natural environment. They believe that this more expansive definition of cultural resources and values should be considered throughout the SOR analysis. This issue is discussed further in Appendix D.

In addition to these issues, tribal rights and resources described in Section 2.2.3 represent significant issues for the SOR. There are several Indian reservations that abut projects within the SOR study area and that conceivably could be directly affected by system operations. The tribes have treaty fishing rights that are of interest, both directly through possible influence on fishing sites, and indirectly through potential effects on fish resources. Generally, for example, upper Columbia-Snake River tribes (e.g., Colville, Kalispel, Kootenai, Coeur d'Alene, and Spokane Tribes) are very concerned about the status of resident fish; lower Columbia-Snake River tribes (Warm Springs, Umatilla, Yakama, and Nez Perce) have greater concern for anadromous fish. Similar circumstances may apply to off-reservation hunting and gathering rights. Finally, as representatives of the United States, the Federal agencies have obligations to uphold their Indian trust responsibilities, and deal with the tribes on a government-to-government basis.

Effects of Alternatives

Generally, key Native American interests—principally, access to and protection of natural and cultural resources sites—would be adversely affected by all of the SOS alternatives, with few exceptions. All the SOSs would continue the existing pattern of soil erosion, mass wasting, and exposure of cultural resources to damage, looting, and vandalism. These impacts are discussed in Section 4.2.7, Cultural Resources, and more extensively in Appendix D. Other effects (e.g., the potential for interference with fishing, hunting, and gathering rights) are considered in this section. The effects of the SOS alternatives on anadromous fish, resident fish, and wildlife are dealt with extensively in Appendices C, K, and N, respectively.

Eleven of the affected Indian tribes have so far agreed to contract with the SOR agencies to provide independent reports on the effects of the dam operations: the Confederated Tribes and Bands of the Yakama Indian Nation, the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Burns Paiute Tribe, the Confederated Tribes of the Warm Springs Reservation, the Colvillc Confederated Tribes, the Kalispel Indian Community, the Coeur d'Alene Tribe, the Kootenai Tribe of

Idaho, and the Mid-Columbia Council. Contracts with the Shoshone-Bannock, Shoshone-Paiute, and Burns-Paiute Tribes will soon be in place to likewise ensure their continued and future participation. Additionally, the Confederated Tribes of the Umatilla Indian Reservation submitted to the SOR agencies and to the Secretaries of Defense, Energy, and the Interior, a communication "not to be considered as technical comments" but as comments to address "broadly defined tribal concerns and inadequacies related to the SOR process" (CTUIR, 1994). This communication was published in the Draft EIS. Much of the documentation submitted since by the tribes through their contracts has been included as Exhibits 1 through 9 of this Final EIS. Additional material submitted by the tribes is provided in Appendix D, Cultural Resources.

The following discussion is based on the submittals from these tribes (also represented among exhibits) and on analyses reported elsewhere in Section 4.2 that address the effects of the SOSs on resource areas of great importance to Native Americans. This discussion specifically addresses Indian trust assets as well as other resources of interest to Native Americans. The conclusions stated in the discussion of impacts do not necessarily represent the views of the affected tribes. The submittals reviewed by the SOR agencies were largely of a general nature, not specific to the SOSs.

SOS 1 and SOS 2, Pre-ESA Operations and Current Operations

Returning to operations prior to enactment of measures to benefit anadromous fish (SOS 1) would continue shoreline erosion and mass wasting with resulting negative effects on natural and cultural resources. Down-river Indian tribes would face diminished populations of salmon (Burns Paiute Tribe, 1994), which for those tribes are critical to fulfillment of their treaty fishing rights and to the basis of their cultural and spiritual existence. This alternative also would result in a decline in resident fish populations, limiting the Federal government's ability to meet its trust responsibilities for both resident and anadromous fish. Returning to pre-ESA conditions could further diminish the way of life for those practicing traditional lifestyles. Although SOS 2 would improve salmon survival somewhat over pre-ESA operations, other adverse effects resulting from SOS 1 operations (e.g., shoreline erosion, mass wasting, decline in resident fish populations) would prevail with SOS 2.

SOS 4, Stable Storage Project Operations

The goal of this SOS, to benefit resident fish and wildlife, would also benefit Native American cultural interests at some locations. Stabilizing water level fluctuations at storage projects generally would improve conditions for resident fish and improve wetland and riparian habitat available for waterfowl, big game, and other wildlife. However, such action could negatively affect wildlife at Lake Roosevelt and on the Hanford Reach and the lower Clearwater River, where spring flow augmentation could reduce wetland vegetation available for foraging and nesting. Anadromous fish survival would be about the same as under current conditions, continuing to limit the supply available to meet Indian fishing treaty expectations and Federal government trust responsibilities. Setting new seasonal pool levels at upper Columbia storage reservoirs could increase or cause new damage by exposure to looting and erosion of traditional use sites and areas. Erosion and mass wasting of traditional use areas would continue.

SOS 5 and SOS 6, Natural River Operations and Fixed Drawdown

While benefiting Snake River anadromous fish stocks by moving them faster downstream, SOS 5 would result in increased damage to virtually every other resource of interest to Native Americans. Resident fish spawning and egg development on the lower Snake River projects would be adversely affected by either option for natural river operations, reducing the availability of this trust resource. Wildlife resources would be reduced due to desiccation of vegetation and habitat critical to their survival.

Thus, hunting and gathering opportunities would be diminished by this operating strategy. Severe drawdown would result in bank destabilization of traditional use sites. Impacts under SOS 6 would be similar to those from SOS 5, except they would be limited under Option 6d to the Lower Granite area. Effects of storage reservoir operatios on resident fish and wildlife in the upriver areas would be similar to those of SOS 1.

SOS 9, Settlement Discussion Alternatives

The SOS 9 options would appear to have some benefit for anadromous fish trust assets, compared with current conditions. Impacts on wildlife habitat affecting hunting rights and on vegetation conditions affecting gathering would vary from reservoir to reservoir. Drawdowns below current minimum pool at the lower Snake projects and to minimum pool at John Day under SOSs 9a and 9c would result in some desiccation of riparian vegetation and would accelerate erosion of traditional use sites in the drawdown zones. SOS 9c incorporates IRCs or similar features for some of the storage projects, and therefore would offer improved conditions for resident fish and wildlife in some locations. SOSs 9a and 9b would variously increase storage reservoir elevation fluctuations for some projects, thereby worsening conditions for resident fish.

SOS PA, Preferred Alternative

The preferred alternative would benefit the recovery of anadromous fish stocks. Fish migration flow augmentation water would reduce wetland vegetation at Lake Roosevelt, on the Hanford Reach, and on the lower Clearwater somewhat. This would cause some reduction of favorable wildlife habitat. Drafting storage reservoirs for flow augmentation would have some adverse impacts on resident fish, although summer draft limits included in SOS PA are intended to afford some protection to resident fish.

Summary

All tribes that submitted comments on the SOS alternatives generally felt that all SOSs would continue the overall decline of resources associated with their traditional way of life. Since they view the entire Columbia River as an integrated whole, for which impacts anywhere affect the entire river and basin, they believe that all SOS alternatives would impair the cultural environment of the Native Americans who reside in and use the Columbia River Basin. All strategies would continue to diminish hunting, fishing, and gathering capabilities and to damage cultural resource sites. The eleven tribes that provided evaluations expressed the view that it would be increasingly difficult for the U.S. government to meet treaty and trust responsibilities so tied to these issues. This, in turn, would reduce Native American access to important resources and eliminate habitat for some resources (Yakama Indian Nation, 1994).

All eleven tribes expressed the concern that their sovereignty is compromised by failure of the SOR agencies to afford the tribes what they consider a meaningful role in decisionmaking over anadromous and resident fish, and by the lack of trust responsibility for their rights and resources (CTUIR, 1994; Yakama Nation, 1994). Finally, based on the tribal submittals and informal input received during various coordination activities, there appears to be general agreement among all the tribes that additional monitoring must be provided at cultural resource sites and that enforcement of existing Federal and state laws protecting cultural resources (that is, cultural resources as broadly defined by the tribes) must be improved.

4.2.9 Aesthetics

Reservoir operations, primarily drafting, can have significant aesthetic impacts on adjacent lands. These impacts result from a number of factors, including increased shoreline visibility and contrast, erosion, changes in recreational facilities, reduction in the size of embayments and seep lakes, changes in water characteristics, and production of dust and odors. A decrease in

aesthetic quality at a project can affect recreational use and have social and economic consequences for visitors and residents.

Aesthetic Impact Issues

Changes in the aesthetic qualities of reservoirs and river reaches can be attributed to changes in specific physical factors. These factors are discussed in general terms below and then are related to the SOS alternatives. Aesthetic issues and projected impacts are addressed in more detail in Appendix J, Recreation.

Shoreline Contrast

Shoreline contrast (the visual effect of exposed shorelines caused by reservoir drafting) is generally more of a concern at reservoirs, particularly storage reservoirs, than on free-flowing river reaches. In fact, some shoreline contrast along river reaches and natural lakes is often natural and appealing. The aesthetic impact of reservoir drafting depends on the amount of shoreline exposed, the color and textural contrast between shoreline and adjacent uplands, and the number of people viewing the affected shorelines. As reservoir levels decrease, the demarcation between the water and land becomes more distinct. Shoreline contrast tends to increase with the vertical and horizontal distances between full pool and the current reservoir level. Visual contrast is also higher if the exposed shoreline materials are light in color and differ markedly from, for example, the dark background created by forested uplands adjacent to the reservoir. Other visual elements of reservoir drafting include floating debris (such as logs) left on the shoreline and exposed stumps.

Erosion

Fluctuating reservoir levels can cause landslides and erosion along reservoir shores. Scarring from erosion and landslides increases visual contrast makes landscapes unattractive. Shoreline facilities that are built on surficial sediments may be subject to undercutting and even collapse with fluctuating reservoir levels. Erosion is generally less of an aesthetic concern on free-flowing river reaches, where dynamic natural processes are expected.

Facility Impacts

Reservoir drafting can expose waterside facilities such as beaches, swimming areas, boat ramps, docks, and marinas, leaving them unusable and unsightly. Recreational facilities at the run-of-river projects typically depend on irrigation for park landscaping. Operating these reservoirs at elevations below irrigation intakes could reduce or eliminate the ability to irrigate lawns and plantings. The aesthetic quality of these facilities would be diminished by withered or dead landscaping.

Seep Lakes and Embayments

Seep lakes are water bodies separated from reservoirs by railroad and highway embankments, but hydrologically connected to the reservoirs by culverts and/or groundwater interaction. Embayments are backwater areas connected to reservoirs by open channels. These features are common at the run-of-river projects. Both are connected to the reservoirs hydrologically and, without water replenishment, their size and water quality can be reduced. Possible visual impacts include exposure of bottom material and damage to nearby wetland areas.

Water Characteristics

Changes in reservoir levels can affect the physical and visual characteristics of water in several ways. When water levels in reservoirs are lowered, the remaining water flows at a higher velocity and picks up additional sediment, which in turn leads to increased turbidity. Erosion of reservoir sediments exposed by drafting has the same effect. Increases in turbidity can decrease water clarity and change its color.

Reservoir drafting also changes water motion. As the reservoir recedes, shallow areas and the far reaches of the reservoir become



Lake Koocanusa (Marners Haven Marina) at low and full pool

exposed and the extent of slack water is reduced. Water velocity increases at the head of the reservoir, giving these areas a more riverine character. Tributary streams entering the reservoir re-establish channels in the exposed lake bed. As a result, decreased reservoir size is accompanied by a decrease in slack water and a corresponding increase in river and stream areas with a moving or free-flowing character.

The quantity of water in a river can affect its aesthetic quality. Different viewers have different perceptions about the relationship between quantity of river flow and the aesthetic quality of the river environment. The Recreation Work Group assumed that flows similar to historic flows would be acceptable to most viewers.

Dust and Odors

Reservoir drafting exposes shorelines and lake bottoms to the effects of wind. Fine sediments dry out and are carried off by the wind, which can be a nuisance to nearby residents and recreationists. Odors can be created in areas where organic material is exposed as a result of drafting. The extent of odor impacts depends upon the amount of organic material exposed, the amount of shoreline exposed, the wind direction, and the proximity to areas frequented by people.

Effects of Alternatives

Most of the SOS alternatives would vary little from SOS 1a (historic conditions) or SOS 2c (no action) in terms of physical changes in water levels. Other alternatives would cause

significant changes in reservoir elevations and the resulting shoreline exposure would affect the aesthetic environment of some projects. Most of these changes would occur during the spring or summer, generally the times of year when recreational use and highway travel are greatest. These aesthetic effects in most cases represent incremental changes to impacts that regularly result from existing operating patterns, rather than the introduction of new types of impacts. In addition, the aesthetic impacts of any SOS would occur within landscapes already substantively modified by human activity (such as logging, railroads and highways, residential and recreational development, transmission lines, and dams). Such modifications are apparent in virtually all parts of the study area.

The average annual vertical shoreline exposure (the difference between the average pool elevation and the full-pool elevation) can be used as an overall indicator of the aesthetic effects of SOSs on reservoirs. However, shoreline exposure measurements are somewhat skewed because these measurements are annual averages, and do not reflect seasonal variations. For example, under some of the SOSs, storage reservoir pools are lowered during the winter and kept near full pool during the summer. In these cases, the average amount of annual vertical shoreline exposure does not reflect the aesthetic condition during the time of year when most visitation would occur. Nevertheless, average annual measurements of vertical shoreline exposure do allow comparisons among the SOSs and indicate the relative impacts the SOSs would have on aesthetic quality.

Table 4-13 indicates that compared to the other SOSs, SOS 4c would expose the least amount of shoreline at most of the storage projects. The average vertical shoreline exposure at Libby would be 35 feet (10.7 m), at Hungry Horse 24 feet (7.3 m), at Dworshak 33 feet (10 m), at Grand Coulee 12 feet (3.7 m), and at Albeni Falls SOS 5 feet (1.5 m). SOS 9a would expose the most shoreline at Libby (83 feet [25.3 m]), Hungry Horse (83 feet [25.3]), and Grand Coulee (26 feet [7.9 m]). At Albeni Falls, SOS 6b would result in the most shoreline exposure (6 feet [1.8 m]) of any of the SOSs. At Dworshak, SOS 9b would expose the most (80 feet [24.3 m]).

The average annual vertical shoreline exposure at the run-of-river projects would vary considerably by SOS. SOS 5 would expose the greatest amount of shoreline (from 46 to 112 feet [14.0 to 34.2 m]) at run-of-river projects of any of the SOSs. Some SOSs, such as SOSs 6b, 9a, and 9c, would expose from 8 to 28 vertical feet (2.4 to 8.5 m) of shoreline. The other SOSs would not expose much shoreline at the lower Snake River projects or John Day. At the John Day project, SOS PA would expose the greatest amount of shoreline, while SOSs 5c, 6b, 9a, and 9c would expose between 3 and 5 feet (0.9 to 1.5 m).

4.2.10 Recreation

The 14 projects and 5 river reaches addressed in this EIS have varying degrees of local, regional, or national recreational significance. They support recreational activities that are dependent on, or are enhanced by, nearby lakes or rivers. Some of the more popular activities, such as boating, fishing, and swimming, require developed facilities that allow access to the water. Use of the facilities depends on adequate water levels in reservoirs and adequate instream flows for river reaches.

The SOS alternatives would result in lake elevation and river flow patterns that would affect recreational facilities and influence visitation at those facilities. The recreation analysis indicated that, systemwide, there would be insignificant to moderate differences among the alternatives in terms of total visitation. However, visitation at some projects and river reaches would vary significantly among the SOSs. In addition, operations that would benefit certain projects or areas of the system, in some cases, would worsen conditions for recreation in other areas.

The following material summarizes the results of the recreation analysis. The discussion addresses the ways in which recreation could be

Table 4-13. Average annual vertical shoreline exposure (in feet)[a/, b/]

	Representative SOS Alternatives									
	1a	2c	4c	5b	5c	6b	9a	9b	9c	PA
Storage Projects										
Libby	59	57	35	61	61	61	83	49	35	55
Hungry Horse	60	57	24	61	61	61	83	29	24	29
Albeni Falls	6	6	5	6	6	6	5	3	4	6
Grand Coulee	19	16	11	16	16	16	26	16	16	13
Dworshak	51	46	33	46	39	40	50	80	61	66
Run-of-River Projects[c/]										
Lower Granite	3.6	3.3	0.6	55.4	112	12.4	14.1	0.8	10.1	1.2
Little Goose	1.8	2.7	0.9	55.3	112.2	13.1	15	1.2	10.3	1.1
Lower Monumental	1.3	1.7	0.4	52.1	106.7	28.4	14.3	0.5	10.4	0.5
Ice Harbor	1.3	1.7	0.4	45.7	95.7	13.7	14.3	0.5	8.4	0.5
John Day	3.6	4.6	1.1	1.9	4.9	4.3	3	0.4	5.3	8

a/ Based on the difference between the full-pool elevation and the average end-of-month reservoir elevation for a given SOS.
b/ 1 foot = 0.3048 m.
c/ Elevations would not vary among SOSs for Chief Joseph, McNary, The Dalles, and Bonneville.

affected, the physical effects on recreation facilities, potential changes in recreation visitation, and apparent tradeoffs associated with different operations. Appendix J, Recreation, contains details on methods and results for the analysis. The impact results that are presented here are based on operational effects without mitigation; visitation effects could be reduced if the potential mitigation measures discussed in Section 4.3.3 were implemented.

Recreation Impact Issues

Operation of the Columbia River system directly affects the suitability of storage reservoirs, run-of-river reservoirs, and controlled downstream river reaches for recreation uses. System operations result in variable reservoir pool elevations and downstream flows that influence recreation by affecting:

- the usability of recreation facilities
- fish habitat and fishing success
- wildlife habitat and hunting or wildlife viewing success
- geophysical characteristics and recreational safety
- water quality parameters influencing recreation
- aesthetics

These types of effects from the SOSs are described quantitatively and qualitatively in Appendix J, Recreation, and are summarized in the following section.

Project visitors can be expected to adjust their participation in water-dependent and water-related recreation activities, either positively or negatively, in response to these physical recreation impacts. The primary measurement of the effects of an alternative on recreation in the Columbia River system is visitation. Impact assessment models were developed to estimate participation in terms of annual recreation days for key recreational activities at 14 Federal projects and two downstream river reaches under each alternative SOS. Appendix J describes the models and their results. The results are summarized below.

Physical Effects

The most important physical recreation impact is the effect of operations on water-based recreation facilities. Fixed water-based facilities, such as boat ramps, swimming beaches, and moorage facilities, have very specific ranges of elevation in which they can function. These facilities become less usable as pool elevations and flows decline (or if flows are too high), eventually reaching a point where access to the water is severely constrained or precluded. Some floating facilities, such as docks, can be relocated as pool elevations drop. Moving facilities can be difficult, however, and it is often not practical to move them because pool elevations fluctuate frequently or rapidly.

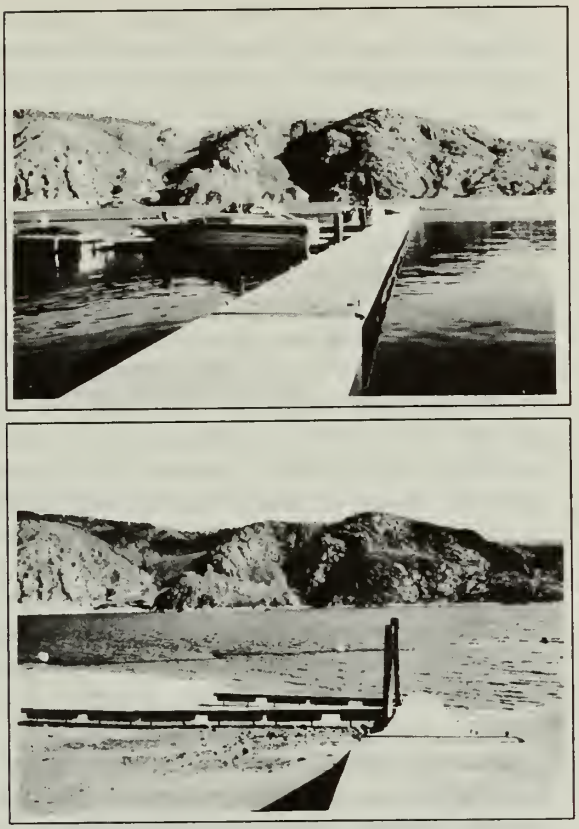
Pool levels at the run-of-river projects fluctuate on a daily and weekly basis. Daily fluctuations typically vary between 0.5 and 2 feet (0.2 and 0.6 m), and weekly fluctuations by as much as 5 feet (1.5 m). Project recreational facilities have generally been designed to function over these normal operating ranges. The use of some facilities can be impaired at the low end of normal operating ranges. Low pool levels can also increase shoaling at moorage facilities and entrance channels, and wind and wave erosion, accentuated by low pool elevations, can damage banks and the toes of boat ramps.

Pool elevations outside the normal range at run-of-river projects would have more acute effects on recreational facilities. Nearly all developed facilities would become unusable at pool elevations more than a few feet below the normal range. Low pool elevations can expose rocks, tree stumps, shoals, and other objects that pose hazards to boaters, wind surfers, waterskiers, and other water users. Increased water velocity can be dangerous to swimmers and watercraft operators. Drawdown outside of normal operating ranges can also dry out intakes for irrigation systems used to maintain lawns and plantings at some recreation sites.

For recreational facilities to be used at storage reservoirs, pool elevations must be sufficiently high when there is a demand for the facilities. Developed swimming areas tend to be the most sensitive to reservoir elevations, as they typically can be used only over the top 5 to 10 feet (1.5 to 3 m) of a normal operating pool. Most storage reservoirs have one or more boat ramps designed to be used over a wide range of elevations and functional for longer periods. While boat access to the water may be physically possible at very low elevations, using such ramps becomes difficult and time-consuming.

Use of land-based facilities can also be diminished by operations, particularly at storage reservoirs. Visitors participating in land-based activities often seek recreation sites close to the water. Large drawdowns leave camping, picnicking and other land-based facilities visually and physically separated from the water, reducing the quality of recreational experiences and demand for recreation sites.

Changes in flows resulting from system operations can also affect recreation suitability in downstream river reaches. Generally, the recreational use of rivers is optimized by maintaining stable flows within a preferred range. Although the river is usable at flows greater or less than preferred, fluctuations outside of the preferred range make floating more difficult and hazardous and reduce the quality of the experience. The optimum range of flows varies by river reach and, in some cases, by recreation activity.



Dewatered boat ramp, before and after (Grand Coulee—Spring Canyon Recreation Area)

While the primary emphasis of this analysis is on pool elevations and river flows and their associated effects on recreation facilities, there are several other types of physical effects on recreation that can be significant. Water levels can reduce or improve fish and wildlife population numbers, which in turn influences opportunities for fishing, hunting, and wildlife viewing. Low pool elevations can expose rocks, tree stumps, and other objects that can pose hazards for water recreationists. Increased water velocity can increase risks to swimmers and water craft operators. System operations can influence turbidity and other water quality parameters that are noticeable to recreationists. Finally, the aesthetic impacts discussed in Section 4.2.9 also often become adverse physical effects for recreationists. Appendix J, Recreation, provides a more detailed discussion of the various physical effects on recreation for each SOS.

Visitation

Numerous factors determine how flows and elevations influence recreational participation. One important factor is how sensitive various user groups are to water levels. A study of Hungry Horse Reservoir found that 43 percent of the recreational users surveyed had no preference as to lake level and as long as they could still participate in recreational activities after adjusting their activities to be compatible with reservoir conditions (Ben-Zvi, 1990). Many recreationists participate in more than one activity, and some no doubt switch activities or locations depending upon water levels. If reservoirs are drawn down severely, it is likely that more people would decide to participate in land-based recreational activities.

Abt Associates (1978) found that on most reservoirs in the Columbia River Basin, most recreationists are fairly insensitive to moderate reductions in water elevation as long as water facilities are still available. Ben-Zvi's research at Hungry Horse Reservoir supported that premise, as it found that the most common reason recreationists decided not to visit a reservoir was because they could not launch their boats (Ben-Zvi, 1990).

At some point, water levels and resource quality may decline to where demand for specific activities may drop to zero. Recreationists can: (1) accept the lower quality of the resource and continue to use it, (2) decide to recreate less frequently or not at all, or (3) travel to a different site (Corps, 1980). If the change in resource quality is temporary, users may change the timing of their use by scheduling a trip to a reservoir earlier or later than they would under normal circumstances. To some extent, if use drops at a given reservoir due to low water levels in May, it may shift to later months when water elevations have returned to higher levels.

In addition to water levels and resource quality, weather and other climatic conditions can have a significant influence on recreational activities and use levels (see also Section 3.3.7 and Appendix J). Even if pool elevations are conducive to certain activities, weather conditions might cause recreationists to choose not to participate in certain activities, or to choose substitute activities.

Recreationists frequently participate in several activities while at one recreation site. Campers often visit a particular lake because they are attracted by its boating and fishing opportunities. A change in operations that eliminated the use of boat ramps could result in a decrease in the other activities if recreationists avoided sites where they could not participate in their primary activity. In this case, visitation at the affected site would decrease and likely be shifted to nearby sites with usable facilities. On the other hand, the recreationists could still use the site but substitute other activities for their primary activity.

Effects of Alternatives

This section discusses the physical effects of the SOS alternatives relative to the operating ranges of recreation facilities and river recreation uses. The flow and elevation patterns that characterize the physical conditions drive the analysis of recreational visitation. The visitation levels for the different SOS alternatives are the key value measure for the recreation analysis.

Physical Effects on Facilities

The following material discusses the expected physical conditions at the projects and river reaches across the range of SOS alternatives. Effects for each SOS are presented in comparison to SOS 1a, representing the historic operating conditions with which most visitors are familiar, and the no-action conditions represented by SOS 2c. The discussion is highly generalized because there are many aspects of physical characteristics that influence recreational use. Each project or river reach has different types of facilities and/or activities, each of which responds in different ways to physical conditions. For a given reservoir or river reach, each SOS would result in elevation or flow patterns that vary considerably both during the year and from year to year as water conditions change.

This discussion attempts to summarize the range of variability in physical conditions for each geographic component of the study, based on the elevation and flow characteristics from the hydroregulation model. The complexity of the hydrologic and facility characteristics generally limits the discussion to average conditions and key times of the year. This focus admittedly overlooks much variability in physical conditions that can be quite significant for recreation. The reader should review Appendix J and the hydroregulation results in Appendix A for more comprehensive and in-depth information on the physical characteristics for recreation at each project and river reach.

Libby—Seasonal reservoir fluctuations at Libby result in low pool elevations of between 100 and 160 feet (30.5 and 48 m) below full pool (elevation 2,459 feet [749.5 m]). Lake Koocanusa has typically been full by the end of July and remained so through the end of August. By the end of September, the pool has historically been lowered to about elevation 2,450 feet (746.8 m).

Boat ramps and moorage facilities function over a wide range of elevations. All but two of the project's 11 boat launching and mooring facilities are operable down to 15 feet (4.6 m) below full pool. Six are operable down to 35 feet (11 m) below full pool (elevation 2,424 feet [738.8 m]), and three at 50 feet (15.2 m) below full pool. Two boat ramps remain usable down to elevation 2,310 feet (704.1 m), which is 149 feet (45.4 m) below full pool. Three of the project's five developed beaches are functional only within 5 feet (1.5 m) of full pool, and the other two are functional down to slightly lower elevations.

SOSs 4c and 9c would be the best for recreation in an average water year. The pool

level would rise to within 6 feet (1.8 m) of full pool by the end of June, and stay at that level through the end of August. These alternatives would improve boating compared to SOS 2c because facilities such as floating and fixed docks would be able to operate due to the high-pool elevations.

During average water years with SOSs 1 and 2, pool elevations by the end of May would be approximately 20 feet (6.1 m) below full pool. By the end of July, the reservoir level would rise to within 10 feet (3.1 m) of full pool and remain there through the end of August. Boat ramps would continue to be usable, but the use of some swimming beaches and boating facilities (particularly on the Canadian side of the lake) would be more difficult. SOSs 5 and 6 would be similar to SOSs 1 and 2, but would refill slightly more slowly and would reach slightly higher elevations in July and August.

SOS 9a would be the worst SOS for recreation at Libby. The end-of-June pool elevation would be 64 feet (19.5 m) below full pool, and would be lowered an additional 5 feet (1.5 m) by the end of August. Although most boat ramps on the American side of the lake operate down to 80 feet (24.4 m) below full pool, most other facilities on the lake would not be usable in the summer during average water years.

SOS 9b would fill to within 23 feet (7.0 m) of full pool by the end of June, and would not get any higher than 17 feet (5.2 m) below full pool for the rest of the summer. Impacts to recreation facilities would be similar to those of SOS 9a.

SOS PA would refill to within 35 feet (10.7 m) of full pool by the end of June, and then reach an elevation approximately 23 feet (7.0 m) below full pool in July and August. Impacts to recreation facilities would be similar to those of SOS 9a.

Kootenai River—The volume and timing of releases from Libby Dam greatly influence recreation on the Kootenai River. The primary concern with releases is the effect of flows on fishing success and the ability to float the river for fishing access. Normal minimum discharge from Libby is 4 kcfs (113.3 cms), although the flow is sometimes reduced to 3 kcfs (85 cms). Between May 1 and September 15, operators attempt to keep flows below 8 kcfs (227 cms) from early morning to after sunset to benefit anglers. The optimal flow for bank fishing is between 4 and 8 kcfs. Optimal flows for other river uses, such as boating (and fishing from boats), canoeing, and rafting, range from approximately 8 to 14 kcfs (227 to 397 cms). The optimum flow in terms of accommodating the greatest number of water-related activities is approximately 8 kcfs. Stable flows are important for all types of water-related activities, particularly fishing. In addition, stabilized short-term flows would improve habitat for fish, which would in turn lead to improved fishing experiences and increased visitation.

SOSs 1, 2, 5, and 6 would produce flows that would be fairly stable and within or close to the optimal range for recreation during the summer of average water years. SOSs 4c, 9a, and 9b would produce flows of 17 to 19.7 kcfs during June and July, which would be greater than the optimal or acceptable flow range. SOS PA would produce flows near the optimal range throughout the summer except for June when flows would be as high as 21 kcfs. SOS 9a would produce the greatest summer flows, with flows of 26.8 and 21.2 kcfs in June and July, respectively.

Hungry Horse—Annual drafts at Hungry Horse range as low as 3,336 feet (1,016 m) and affect the use of recreational facilities. Ideally, Hungry Horse reaches full pool (elevation 3,560 feet [1,085 m]) by early July and is kept near full pool through Labor Day to allow use of the project's recreational facilities. Lowering the reservoir 5 feet (1.5 m) renders some swimming beaches unusable. Only 5 of the 11 boat ramps are usable at 20 feet (6.1 m) below full pool. When the pool is drafted to elevation 3,483 feet (1,062 m), the only facility that functions is the Abbot Bay boat ramp.

With SOS 1a or 2c, Hungry Horse would be expected to fill within 2 feet (0.6 m) of full pool by July in 62 and 54 percent of the water years, respectively. There would be a 74 and 78 percent chance the reservoir would refill to an elevation of at least 3,540 feet (1,079 m) in July. Expected summer pool elevations in low water years would be below the minimum that would allow any boat ramps to function. During high water years, the pool would be full in July and August. Operations and elevations for SOSs 2d, 5, and 6 would be essentially the same as under SOS 1a or 2c. With these SOSs, 6 of the 11 boat ramps would be operable during average water years. During low water years, only 1 would be operable and during high water years, all 11 would be.

SOSs 4c, 9, and PA are the only alternatives that would result in summer pool elevations significantly different from those under SOS 1a or 2c. SOSs 4c and 9c would establish high pool elevations through the summer. The reservoir would refill to within 2 feet (0.6 m) of full by the end of June in 82 percent of the water years, and would remain near full pool through the summer with SOS 4c, and within 5 feet (1.5 m) of full 98 to 94 percent of the time in July and August with SOS 9c.

SOS 9a would be the worst alternative for recreation at Hungry Horse. During average water years the pool would come to within 10 feet (3.0 m) of full from 22 to 4 percent of the water years between June and August.

SOSs 9b and PA would refill to within 2 feet (0.6 m) of full by the end of June 20 percent and 30 percent of water years, respectively. The probability of the pool remaining within 10 feet (3.0 m) of full by the end of August would be 20 and 4 percent, respectively.

Columbia River in Canada—There are few formal water-oriented recreational facilities (two docks and three boat ramps) on the free-flowing reach of the Columbia River in Canada. Releases from the Hugh Keenleyside and Brilliant projects control flows on the upper Columbia and influence both the accessibility of facilities and the types of activities that can occur on the river. Flows between 71 kcfs (2,200 cms) and 99.3 kcfs (2,800 cms) are considered optimal for general recreational use of the river. Optimal flows for swimming are considered to be between 78 kcfs (2,200 cms) and 99.3 kcfs (2,800 cms).

During average water years flows associated with SOSs 1, 2c, 5, 6 and 9 would generally be within the optimal range for river recreation. No boat ramps, boat docks, or swim beaches would be affected.

SOSs 2d, 9b, 9c and PA, on the other hand, would exceed optimum flows during June and/or July, and would have impacts to varying degrees on recreational facilities. Swimming beaches, in particular, would be affected by the high flows and would not be usable during June and July. SOS 2d would produce the highest flows (106 to 107 kcfs [29.9 to 30.2 cms]), while SOSs 9b, 9c, and PA would result in June and July flows between approximately 101 and 109 kcfs (28.5 to 30.7 cms).

Albeni Falls—Recreational facilities at Lake Pend Oreille were designed to be operational during the summer, when the pool has traditionally been maintained at a high elevation. Most of the facilities function from full pool (elevation 2,062.5 feet [629 m]) down to approximately 11.5 feet (3.5 m) below full. This relatively narrow functional range for a storage reservoir is due to the limited draft capability at Albeni Falls and reliable historical operation near full pool during the recreation season.

All SOS alternatives, except SOSs 4c, 9a, and 9b would produce average pool elevations of 2,062.5 feet (629 m) from June through the end of August during all water years.

SOS 4c would result in average August pool elevations during all years of 2,060 feet (628 m), which would be 2 feet (0.6 m) below optimal and would affect the use of recreational facilities. During low water years, the pool

would be kept at the 2,060-foot (628-m) elevation the entire summer.

SOS 9b would keep pool levels from approximately 1 to 2 feet (0.3 to 0.6 m) below full pool during the summer which would affect some recreational facilities. SOS 9a would keep the pool 4 to 7 feet (1.2 to 2.1 m) below full pool and would result in many or most recreational facilities not being usable.

Grand Coulee—Some recreational facilities at Grand Coulee, such as boat ramps, are usable throughout much of the reservoir's annual drawdowns. Developed swimming beaches and some moorage facilities function only, or function best, within 5 feet (1.5 m) of the full pool elevation of 1,290 feet (393 m). The pool has typically been kept within 5 feet (1.5 m) of full pool during the summer. Seven of the 14 boat ramps are functional to at least an elevation of 1,240 feet (378 m). However, at that elevation, other facilities such as swimming beaches and some docks will be dry.

Under SOS 1a or SOS 2c, the chances of Grand Coulee refilling by the end of July would be approximately 95 percent. As a result, all water-based recreational facilities would be fully operational throughout the summer. Pool elevations during low and high water years would be very similar to those of average water years.

SOSs 1b, 2d, 4c, 5, and 6 would result in pool elevations that would be similar to SOSs 1a and 2c. Summer pool elevations under SOSs 9a, 9b, 9c, and PA would be lower. These four options would draft the reservoir in July and/or August to augment river flows. As a result, end-of-August pool elevations with SOS 9c and PA would be approximately 8.5 feet (0.3 m) lower than the end-of-August elevation of SOS 2c. The end of August pool elevations with SOSs 9b and 9c would be approximately 40 and 19 feet (12.2 and 5.8 m) lower.

Chief Joseph—Recreational facilities at Chief Joseph are functional from a full pool elevation of 954 feet (291 m), to elevation 950 feet (290 m). All SOSs would maintain an average pool elevation of 953.2 feet (290 m) during all water years. As a result, no SOS would significantly change conditions for recreational facilities at Chief Joseph.

Mid-Columbia River—The five mid-Columbia PUD projects (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) offer an assortment of developed and dispersed recreational facilities. There are 15 facilities with boat launches and 11 facilities with boat moorage spaces. All of these projects are currently maintained at a relatively stable pool elevation, and all facilities are functional over the normal operating range for the respective project. Some Rock Island project recreational facilities near Wenatchee can be flooded during high spring lows, however.

None of the SOS alternatives would result in elevations outside the normal range, but there would be some shifting of flow patterns in some cases. For example, under SOS 4c, the peak monthly average flow would shift from May to June and would increase relative to SOS 1a or 2c. Flow patterns under these operations would likely add to existing reported problems with high flows at some recreation facilities near Wenatchee, but it is not expected that this would measurably change participation rates. SOSs 1, 2, 5, and 6 would all continue historical flow patterns on the mid-Columbia reach.

SOS 9a would have the highest flows during the summer recreation season of any of the SOSs. June flows would exceed acceptable levels (25 kcfs) approximately 50 percent of water years. July flows would be at the high end of the acceptable range over 90 percent of water years and within the desirable range approximately 10 percent of the water years. During August, flows would be in the upper end of the acceptable range, but would never fall within the desirable range.

SOSs 9b, 9c, and PA are similar and would produce acceptable to desirable flows during the entire summer. Flows would be relatively high

in June, and then would be very stable and within the desirable range for July and August.

Flow patterns projected for the mid-Columbia projects would also generally apply to the Hanford Reach downstream. While there might be some redistribution of monthly flows compared to current operations, all of the SOS alternatives would continue to meet the requirements of the Vernita Bar Agreement (which specifies flows downstream from Priest Rapids). Under those conditions, there would be no significant effect on recreation conditions or suitability in the Hanford Reach.

Brownlee—Optimum pool elevations at Brownlee for swimming beaches and all boat ramps are in the upper 5 feet (1.5 m) of the pool, ranging from approximately 2,072 to 2,077 feet (632.0 to 633.5 m). Four of Brownlee's six ramps are operable when the pool elevation falls 10 feet (3 m) below full pool.

Under SOS 1, pool elevations within 10 feet of full pool (2,067 feet [630.4 m]) would occur in 48 percent of water years during May, 100 percent in June, 82 percent in July, and 68 percent in August. In representative low (1941) and high (1976) water years, pool elevations are predicted to remain within 10 feet (3.0 m) of full during the primary recreation use season.

SOSs 2, 4c, 5, and 6 have essentially identical hydrological characteristics. Average elevations would generally be higher than SOS 1 in all prime recreational use months. In May, pool elevations would remain within 10 feet (3.0 m) of full pool (2,077 feet [633.5 m]) in 56 percent of water years. Elevations would be within 10 foot (3.0 m) of full (2,067 feet [630.4 m]) in all water years during June, July, and August.

Middle Snake River: Hells Canyon—Flows in the Hells Canyon reach are controlled by releases from Brownlee Reservoir. Recreational use of the river is largely by private and commercial floaters and jet boat operators, and the prime season is from June through August. Flows of 10 to 15 kcfs (283 to 425 cms) are considered ideal for float boat and jetboat activity. Flows of 8 to 10 kcfs (227 to 283 cms) and 15 to 25 kcfs (425 to 708 cms; 30 kcfs [850 cms] for jet boats) are considered the acceptable low and high range of flows for river recreation. Flows of between 10 and 15 kcfs (283 and 425 cms) are considered most desirable. Fluctuations in flow (particularly rapid fluctuations) can change the river level, which may cause navigational and safety hazards and erode beaches.

In general, SOS 1a would provide stable, relatively high flows during all types of water years, which would benefit recreation. The Brownlee operation follows essentially the same plan under SOSs 2, 4c, 5, and 6. These SOSs operation would result in a wider range of desirable flows during the prime recreation season than SOS 1a, but would average slightly less (8.5 kcfs [239.7 cms]) than desirable in August.

Dworshak—Most recreational facilities at Dworshak cannot operate over the annual fluctuation of up to 155 feet (47.2 m). Developed swimming beaches can only be used to elevation 1,595 feet (486.2 m), which is within 5 feet (1.5 m) of full pool (elevation 1,600 feet [487.7 m]). All six boat ramps are functional above elevation 1,577 feet (480.7 m) (23 feet [7 m] below full pool). The Big Eddy ramp is functional down to the minimum elevation of 1,445 feet (440.4 m). Some moorage docks can partially function down to elevation 1,505 feet (458.7 m), but an elevation of above 1,590 feet (484.6 m) is considered necessary for the docks to be fully functional. Because most visitation occurs during June, July, and August, operators have attempted to keep the pool above elevation 1,590 feet (484.6 m) through the summer.

Under SOS 1a, Dworshak would be within 2 feet of full pool by the end of July in 62 percent of the water years. In 78 percent of the years, the pool would reach an elevation of at least 1,590 feet (484.6 m) by the end of July, which would allow use of all recreational facilities

except developed swimming beaches. During low water years, pool elevations would range from about 1,567 feet (477.6 m) in June, down to 1,538 feet (468.8 m) at the end of August. As a result, the only developed facility that would be functional during the summer would be the Big Eddy ramp. During high water years, the pool elevation would be high enough to allow use of all developed facilities the entire summer.

Under SOSs 2c, 2d, and 9c, recreational facilities would be less usable than under SOS 1a. Dworshak would refill to within 2 feet of full pool by the end of July in 0 percent of water years and to the 1,590-foot (484.6-m) elevation in approximately 22 percent of the water years. During low and high water years, summer pool elevations would have essentially the same impacts on recreational facilities as SOS 1a.

SOSs 1b and 9a would have similar impacts on access to recreational facilities. Based on the hydroregulation model, these SOSs would reach full pool by the end of July in approximately 82 and 52 percent of the water years.

SOSs 4c, 5, 6 would produce the highest summer pool elevations of all of the SOSs. With these SOSs, there would be an 80 percent probability of refill to within 10 feet (3 m) of full pool during average water years.

SOSs 9b and PA would result in the lowest summer pool elevations of all the SOSs. During average water years, SOS 9b would refill to within 10 feet of full pool approximately 2 percent of the water years, and under SOS PA Dworshak would have 0 percent probability of refilling.

Clearwater River—Releases from Dworshak influence flows on the North Fork of the Clearwater River, and to a lesser extent, on the mainstem. Releases from Dworshak have been used to enhance steelhead fishing on the main system during the prime season (from November through February). Optimum mainstem flows for fishing are considered to be between 3 and 7 kcfs (85 and 198 cms).

Steelhead fishing between November and February has traditionally been the dominant recreational activity on the Clearwater River. In recent years, however, natural resource managers are reporting that steelhead fishing now accounts for slightly less than 50 percent of the total recreational use on the Clearwater. Slightly over 50 percent of the total recreational use of the river is now devoted to summer river activities such as trout fishing, innertubing, and swimming. While the importance of both steelhead and summer river recreation is acknowledged, the primary focus of the analysis of the impacts of the SOSs on recreation will be on winter steelhead fishing.

Optimum flows for steelhead fishing range between 3 kcfs and 7 kcfs (85 to 198 cms) and occur between November and February. SOSs 2c, 2d, 4c, 5, 9a, 9b, 9c, and PA would have low probabilities (from 12 to 40 percent) of providing optimum average monthly flows from November through February.

SOSs 1a, 1b, and 6 would have somewhat greater probabilities of reaching optimal flows during that period. The probabilities of optimum flow in February would range from 42 to 47 percent.

Lower Snake River—Recreational facilities at the four lower Snake River projects are designed to function within 5 feet (1.5 m) of full pool. When pools reach this level, some ramps, moorage facilities, and almost all developed swimming beaches become difficult to use due to shallow water, shoaling, and/or the distance required to travel from the normal shore to the water. Some facilities (primarily boat ramps) can function at elevations more than 5 feet (1.5 m) below full pool, but the use of most facilities is eliminated or compromised. Pool elevations can fluctuate between 0.5 and 2 feet (0.02 and 0.6 m) daily, which can make some facilities easier or more difficult to use at different times of the day.

Under SOS 1a, the projects would operate within their normal range, with an average elevation near full. Under SOSs 2, 4, 9b, and

9c, the lower Snake River pools would operate within 1 foot (0.3 m) above MOP generally from mid-April through July (SOSs 9b and 9c would operate from early April through late August). At this low end of the normal operating range, daily and weekly pool fluctuations would make use of some facilities difficult.

SOS 5b would result in a 4.5-month drawdown at the lower Snake River projects to natural river levels that would be well below the minimum required for the use of recreation facilities. Developed recreational facilities at all four projects would not be usable during the summer.

SOS 5c would operate the four projects at natural river levels all year. No existing developed recreational facilities would be usable.

SOS 6b would draw down the four lower Snake projects 33 feet (10.1 m) below full pool for 4.5 months. As with SOS 5, existing recreational facilities would not be usable during the late spring and summer (from mid-April to the end of August). SOS 6d would draw Lower Granite down 33 feet (10.1 m) below full pool for 4.5 months. The other lower Snake River projects would not be affected by SOS 6b. No existing developed recreational facilities at Lower Granite would be usable during the summer.

SOS 9a would also draw the lower Snake project down 33 feet (10.1 m) but from early April through late August. It would essentially have the same effects on recreational facilities as 6b, but for 1.5 months longer.

Lower Columbia River—The recreational facilities at the lower Columbia River projects are designed to function over a range of pool elevations varying from 5 feet (1.5 m) (McNary and The Dalles) to 8 feet (2.4 m) (John Day) below full pool. The pool elevations on the lower Columbia projects fluctuate daily and weekly. Daily pool fluctuations normally range from 0.5 to 1 foot (0.15 to 0.30 m), but can fluctuate as much as from 2 to 3 feet (0.6 to 0.9 m). Pool elevations from July through October have typically been kept higher than at other times of the year to benefit a number of resources, including recreation.

All of the SOSs would maintain the normal summer operating range at McNary, The Dalles, and Bonneville. As a result, there would be no effect on the accessibility of recreational facilities at either project as a result of pool elevation.

In addition to pool elevation, the velocity of water traveling through the projects influences recreation. Although flows vary throughout the year, optimal summer flow velocity for recreation is between 150 and 250 kcfs (4,200 and 7,050 cms). Natural flows peak in May and June, then decline rapidly over the summer. During all water years, the high spring flows associated with SOSs 9a and 9b could affect some facilities at McNary, The Dalles, and Bonneville. High flows could erode reservoir banks near some facilities, such as ramps, and would make using the facilities dangerous.

Recreational facilities at the John Day project would be more affected by some of the SOSs than any of the other lower Columbia River projects. Under SOS 1 or 4, the effects on recreational facilities at John Day would be minimal. SOSs 2, 9b, and 9c would establish an average summer pool elevation (elevation 262.5 feet [80 m]) that would be at the low end of the normal operating range.

SOSs 5, 6, 9a, and PA would have more of an influence on recreational facilities. These strategies would involve drawing the John Day pool down to minimum operating pool (elevation 257 feet [78.3 m]), resulting in significant impacts on project facilities and their use. This operation would occur from May through August under SOS 5 or 6, April through August under SOS 9a, and year-round under SOS PA. SOSs 5, 6, 9a, and PA would significantly reduce the usability of recreation facilities at Lake Umatilla during the entire peak recreation season, and all year in the case of SOS PA.

Recreation along the free-flowing Columbia River below Bonneville Dam is influenced by flow velocity and river elevation. Annual flows and river elevations vary considerably throughout the peak summer recreation season. After peaking in April and staying high through June at between 300 to 400 kcfs (8,400 to 11,200 cms), flows typically decline to 75 to 100 kcfs (2,100 to 2,800 cms) by the end of August. Optimal flows for recreation are considered to be between 150 and 250 kcfs (4,200 and 7,000 cms).

Flows with SOSs 1, 2, 4c, 5, and 6 are generally similar. June and July flows with these SOSs during average water years would be within the optimum range between 42 and 58 percent of the years (during July SOS 4c would be in the range in June 34 percent of the water years). By August when flows would decrease, the optimum flows would be achieved between 6 and 10 percent of the years.

SOS 9a would be the best SOS for recreation. Flows would be within the optimal range 70 percent of the average water years in July, and 100 percent of the years in August. SOSs 9b, 9c, and PA would be similar in terms of optimal flows in June (30 to 42 percent of the time) and July (52 to 64 percent of the time). In August SOS 9b would be in the optimal range 52 percent of the water years, and SOSs 9c and PA would be 28 and 38 percent, respectively.

Estimated Visitation Effects

Recreation Impact Assessment Models

The Impact Assessment Models (IAMs) developed by the RWG and used to estimate the quantitative impacts of the alternative SOSs on recreation visitation for the Draft EIS have been replaced in this Final EIS. As early as 1991, the RWG had concluded that the validity of the break-point curves that formed the basis for the IAMs was questioned because evidence of users' actual response to changes in lake elevations and streamflows was absent. Although the lake elevation (streamflow)/activity relationships may approximate reality, for the most part, they are not based upon empirical user behavioral response (demand) curves. Other important limitations of the Draft EIS modeling approach were: (1) it did not correlate visitation to fishing and hunting success as it may be influenced by the effects of alternative SOSs on fish and wildlife populations; and (2) it does not address shifts in participation across substitutes in the region under the alternative SOSs.

To remedy these concerns, the RWG determined that recreation user surveys should be conducted at a number of Federal projects to enhance the predictability and credibility of the SOR recreation IAMs applied in the Draft EIS. To this end, a comprehensive study plan was developed to improve upon the Draft EIS analytical tools and to accomplish the following objectives for the Final EIS: 1) implement visitor use surveys throughout the Columbia River Basin; 2) apply a Contingent Valuation Method (CVM) to elicit the public's participation and economic valuation response to changes in lake elevations and/or streamflows; 3) estimate contingent evaluation and participation user responses to alternative hydrologic conditions; and 4) develop a simulation model that will statistically predict changes in recreation demand and social welfare values under various hydrological (pool levels and streamflow rates), substitution, resource quality, and social, demographic, and economic conditions in the basin.

A survey of Columbia River Basin recreationists was carried out in fall 1993 and designed to provide data needed for developing the revised models. The statistical estimation tasks and development of a basinwide simulation demand model were subsequently completed and the results incorporated into the Final EIS. The simulation modeling results predict changes in recreation participation for the final set of SOSs and replace the quantitative estimates that were provided in the Draft EIS. Appendix J, Chapter 3 describes the conceptual framework of the model development, while Appendix J-1 provides a detailed technical description. Chapter 4 of Appendix J presents the quantitative estimates of changes in trip-taking

behavior resulting from changes in the alternative operating alternatives (SOSs). The monetized non-market value of these changes in visitation to Federal hydro projects are presented in Appendix O (Economic and Social Impacts).

The systemwide visitation estimates in the Final EIS are greater than those used for the Draft EIS. There are several reasons for the changes, one of which is the use of the new IAMs models discussed above. The other reason is that visitation numbers for the Mid-Columbia PUD projects are being used in the Final EIS and were not used in the Draft EIS. By adding the Mid-Columbia PUD projects, 1,482,000 recreation days are added to the systemwide total for all SOSs.

Changes In Visitation

Table 4-14 displays the estimated visitation at each project or river reach for selected SOSs, based on average water conditions over the 50-year simulation period. The SOSs for which results are included in the table are representative of similar options that are not shown. Complete details are provided in Appendix J. The recreation models estimated that systemwide visitation for the No Action Alternative (S0S 2c) would average about 18,043,600 recreation days over the 50-year period of record. The model results indicated lower visitation under most other SOSs, although some alternatives generated slightly higher visitation estimates compared to SOS 2c.

The highest estimate of average visitation is 18,305,600 under SOS 1b, or 262,000 recreation days more than the corresponding figure for SOS 2c. In other words, the model estimates suggest that, over the long term, operation according to SOS 1b would maximize recreational use of the system. Visitation estimates for SOSs 1a, 2d, and 4c are also higher than the average figure for SOS 2c. They range from about 18,305,600 for SOS 1b to 18,057,300 for SOS 2d. The SOS 1b result is similar to the estimated aggregate visitation under SOS 1a, while the SOS 2d estimate is approximately 13,800 recreation days higher than the SOS 2c figure.

At the other extreme, the minimum estimated visitation level is about 15,970,600 recreation days for SOS 5c. The latter figure is 2,073,200 recreation days lower than the estimate for SOS 2c. The average-condition model results for SOSs 6b, 6d, 9c, and PA range from 16,886,400 (6b) to 17,152,800 (9c), or from 1,157,200 to 890,800 recreation days below expected visitation with SOS 2c. The visitation estimate for SOS 9a, at 15,986,000, is also lower than for SOS 2c. The SOS 9b visitation estimate is greater (17,631,000) than many SOSs, but less than SOS 2c.

Table 4-14 indicates the relative differences in projected recreation participation as a result of the SOSs, compared to the baseline (SOS 2c). These differences are displayed graphically in Figure 4-25. These relative differences represent expected departures from baseline conditions that would likely occur, all other factors being equal, if a given SOS were implemented. They reflect long-term average conditions and should not be interpreted as definitive changes from existing or recent visitation that would occur immediately upon implementation of an SOS.

Changes compared to SOS 2c range from about 1.5 percent above (SOS 1b) to 11.5 percent below (under SOS 5c) the estimated visitation for SOS 2c. In absolute terms, the difference between the maximum and minimum estimates is approximately 2,319,600 recreation days, or about 13 percent of the expected total of 18,043,600 recreation days for SOS 2c. This difference represents a rather narrow band of potential outcomes, and suggests that aggregate systemwide visitation is not highly sensitive to change with the types of operational measures included under the SOS alternatives. However, recreational suitability and visitation at individual areas within the system can be quite sensitive to operational changes, as indicated in the discussion of tradeoffs below. Some of the SOSs would have significant impacts to visitation at some projects.

The visitation estimates in Table 4-14 apply specifically to average water years. While not

Table 4-14. Estimated annual recreation days for an average water year, by project and SOS (in thousands) Page 1 of 2

Project/River Reach	SOS 1a	1b	2c	2d	4c	5b	5c
Libby	604.6	603.8	607.2	605.0	619.9	602.9	602.9
Kootenai River	34.3	34.9	35.6	35.1	34.0	35.0	35.0
Hungry Horse	128.3	125.7	129.3	128.6	152.6	126.5	128.5
Albeni Falls	1215.9	1216.9	1222.5	1222.5	1183.1	1217.8	1217.8
Columbia River, Canada	40.7	41.5	41.6	37.2	40.4	41.5	41.5
Grand Coulee	1631.0	1637.2	1670.1	1662.8	1661.5	1665.9	1665.9
Chief Joseph	47.9	47.9	47.9	47.9	47.9	47.9	47.9
Mid-Columbia PUD	1482.0	1482.0	1482.0	1482.0	1482.0	1482.0	1482.0
Snake River Hells Canyon	43.5	43.5	43.5	43.5	43.5	43.5	43.5
Dworshak	182.7	185.6	201.4	159.7	207.6	213.7	226.9
Clearwater River	109.1	105.3	128.2	198.9	147.3	126.7	141.6
Lower Granite	1653.9	1687.1	1662.7	1662.7	1649.8	859.3	652.3
Little Goose	244.8	244.9	240.4	240.4	239.6	92.7	71.1
Lower Monumental	140.0	140.1	137.6	137.6	136.7	57.6	44.1
Ice Harbor	525.7	525.9	514.7	514.7	507.0	164.1	127.3
McNary	2747.5	2747.5	2747.5	2747.5	2747.5	2747.5	2747.5
John Day	2860.0	2860.0	2555.4	2555.4	2760.0	2121.0	2121.0
The Dalles	1411.3	1411.3	1411.3	1411.3	1411.3	1411.3	1411.3
Bonneville	3164.6	3164.6	3164.6	3164.6	3164.6	3164.6	3164.6
System Total	18267.7	18305.6	18043.6	18057.3	18236.3	16221.5	15970.6
Changes in Visitation Relative To:							
SOS 1a Total	0.0	37.9	-224.2	-210.4	178.9	-1835.9	-2297.1
Percent	0.0	0.2	-1.2	-1.2	1.0	-10.0	-12.6
SOS 2c Total	224.2	262.1	0.0	13.8	192.7	-1822.1	-2072.9
Percent	1.2	1.5	0.0	0.1	1.1	-10.1	-11.5
SOS PA Total	1338.5	1376.5	1114.4	1128.1	1307.1	-707.7	-958.5
Percent	7.9	8.1	6.6	6.7	7.7	-4.2	-5.7

Table 4-14. Estimated annual recreation days for an average water year, by project and SOS (in thousands) Page 2 of 2

Project/River Reach	SOS 6b	6d	9a	9b	9c	PA
Libby	602.9	602.9	546.2	596.8	618.4	601.6
Kootenai River	35.0	35.0	14.3	28.9	33.9	25.0
Hungry Horse	126.5	126.5	91.0	135.4	152.6	133.5
Albeni Falls	1217.8	1217.8	1001.1	1148.0	1187.9	1243.2
Columbia River, Canada	41.5	41.5	40.7	39.4	40.2	39.1
Grand Coulee	1665.9	1665.9	1257.2	1482.1	1570.7	1612.8
Chief Joseph	47.9	47.9	47.9	47.9	47.9	47.9
Mid-Columbia PUD	1482.0	1482.0	1482.0	1482.0	1482.0	1482.0
Snake River Hells Canyon	43.5	43.5	43.5	43.5	43.5	43.5
Dworshak	198.9	198.9	180.4	133.2	183.1	149.6
Clearwater River	133.9	133.9	136.2	135.3	143.3	151.3
Lower Granite	1250.0	1250.0	1175.3	1618.3	1485.5	1673.5
Little Goose	164.4	240.4	151.9	233.1	203.3	242.7
Lower Monumental	96.5	137.6	89.4	133.4	119.3	138.8
Ice Harbor	335.3	514.7	301.6	494.8	449.6	519.2
McNary	2747.5	2747.5	2747.5	2747.5	2747.5	2747.5
John Day	2121.0	2121.0	2103.8	2555.4	2068.3	1502.1
The Dalles	1411.3	1411.3	1411.3	1411.3	1411.3	1411.3
Bonneville	3164.6	3164.6	3164.6	3164.6	3164.6	3164.6
System Total	16886.4	17182.9	15986.0	17631.0	17152.8	16929.2
Changes in Visitation Relative To:						
SOS 1a Total	-1381.4	-1084.9	-2281.8	-636.7	-1114.9	-1338.5
Percent	-7.6	-5.9	-12.5	-3.5	-6.1	-7.3
SOS2c Total	-1157.2	-860.7	-2057.6	-412.6	-890.7	-1114.4
Percent	-6.4	-4.8	-11.4	-2.3	-4.9	-6.2
SOS PA Total	-42.8	253.7	-943.2	701.8	223.6	0.0
Percent	-0.3	1.5	-5.6	4.1	1.3	0.0



Figure 4-25. Estimated systemwide recreational use for representative SOS options (average water conditions)

shown, visitation figures for low and high water years are very similar to, or somewhat higher than, corresponding figures for average water years. Changes in visitation during low and high water years compared to average water years would generally not be great—usually between 0 and 5 percent, although in some cases it would be as much as 15 percent.

Key Tradeoffs

The systemwide visitation estimates in Table 4-14 reflect a mixture of positive and negative effects on recreation under the various SOS alternatives. The following discussion highlights some key tradeoffs in systemwide visitation and among the different portions of the system that are responsible for the results indicated in the table. For a more detailed account of effects at individual projects, please see Appendix J.

The systemwide visitation patterns, particularly the narrow range across the SOS alternatives, are largely determined by the distribution of existing use and potential operational measures. The four lower Columbia River projects are the most heavily used portion of the system for recreation. The operation of three of these projects (Bonneville, The Dalles, and McNary) would remain the same under all SOSs, while significant operational changes would occur at John Day with SOSs 5, 6, 9a, 9c, and PA. Consequently, a large portion of the systemwide visitation total would be relatively unaffected by most SOSs. Similarly, operations would change little or not at all at Albeni Falls and the lower Snake River projects

under most SOSs. In short, changes in system operations only affect a small portion of systemwide visitation.

Several of the alternatives, particularly SOS 4c, would result in high pool elevations at storage reservoirs during the prime summer recreation season. As a result, visitation at these reservoirs would be higher than under SOS 2c.

Visitation numbers for the storage reservoirs would also be higher than the baseline condition in some other cases. For example, visitation at Dworshak would be higher under SOSs 5a and 5b compared to SOS 2c. Despite these increases at Dworshak, there would be a significant systemwide decrease in visitation because of the impacts of drawdowns on the more heavily used lower Snake River projects and John Day. Visitation during average water years at Dworshak under SOS 2c is estimated at 201,400 recreation days. By contrast, Lower Granite alone would receive 1,662,700 recreation days under SOS 2c. Under SOSs 4c and 5, the comparatively small increases in visitation at Dworshak would be more than offset by decreases at the lower Snake River projects and John Day, resulting in a net systemwide loss in recreation days. There would be similar tradeoffs between storage reservoirs and run-of-river projects under other alternatives.

Aside from systemwide patterns, there are some other tendencies in the impact results that apply more to specific projects or types of resources. For example, SOSs 5 and 6 would decrease recreation at some run-of-river projects, but would have neutral or positive effects on recreation at the storage reservoirs.

The model results also indicate there can be localized tradeoffs near the storage reservoirs. Operations that would improve recreational conditions and thus visitation at storage reservoirs could also affect visitation at downstream river reaches. At Libby, for example, holding water during the summer would maintain high pool elevations but result in low outflows into the Kootenai River. As a result, recreation at the reservoir would benefit, but visitation along the Kootenai River would decrease due to lower flows. At Dworshak, on the other hand, holding water in the summer would help recreation on the Clearwater River. Flow releases from late fall through early spring would be particularly beneficial to steelhead anglers, the largest group of recreationists using the Clearwater.

Visitation at most storage reservoirs under SOS 4c would slightly increase or stay essentially the same as under SOS 2c. At Albeni Falls and Grand Coulee, however, estimated visitation for SOS 4c would be less than under SOS 2c. Although the pool level at Albeni Falls would be stable, which would likely benefit resident fish and wildlife, it would be from approximately 1 to 2.5 feet (0.3 to 0.8 m) below full pool in July and August. This level would be too low for many of the fixed-access recreational facilities on Lake Pend Oreille. The negative effects for recreation in this case reflect only the effects of pool elevation on recreation facilities and access to water. The Recreation Work Group and local users consulted for the analysis believe that SOS 4c would benefit kokanee and other resident fish sufficiently to increase fishing success and demand. The resulting increase in fishing use, which is not reflected in the model results, could offset the negative use effects based on the elevation change.

Although there is not a great deal of difference among the SOSs in terms of impacts on systemwide recreation, Table 4-14 indicates there would be significant impacts on recreation at specific projects. Changes in visitation at projects that receive the most use would affect the greatest number of recreationists and have the greatest impacts systemwide. A sizeable change at projects such as the lower Snake River projects, John Day, or Grand Coulee would affect many more people than an equivalent change at a project that receives fewer visitors, such as Hungry Horse. Nevertheless, considerations such as the local economic significance of a recreation resource must be factored into any evaluation and comparison of the effects of the SOSs on recreation.

4.2.11 Flood Control

Flood control is one of the authorized purposes of six of the 14 Federal projects in the SOR study area. Construction and operation of these and related projects in Canada have dramatically reduced the damage caused by floods on the Columbia River system. Assessing changes to the current level of local and systemwide flood protection is an important aspect of the SOR, and each alternative was evaluated to determine how it would affect the amount of property damage that currently occurs each year. Compared to SOS 2c, implementing most of the other SOS alternatives would not change average annual property losses. Changes from SOS 2c conditions ranged from a $27,000 increase in losses under SOS 9b to an increase of $459,000 under SOS 9c. Complete details of the analysis are reported in Appendix E, Flood Control and Appendix O, Economic and Social Impacts.

Flood Control Impact Issues

Flood damage has historically occurred in many areas of the Columbia River system, but some of these areas are no longer subject to flooding because they are protected by various flood control measures. The Tri-Cities area for example has a high degree of flood protection from levees; because the SOSs evaluated in the Final EIS would produce only minor changes in the maximum level of flow and stage, the Tri-Cities area was not included in the specific analysis of flood control impacts. The flood control analysis addressed expected flood damages in the following regions and locations (termed damage centers):

- Upper Columbia region—includes the following damage centers and control points: Libby Dam to Kootenay Lake (Bonners Ferry, Idaho gage); Columbia Falls to Flathead Lake (Columbia Falls, Montana gage); Flathead Lake shoreline (Somers, Montana gage); Kerr Dam to Thompson Falls (Polson, Montana gage); Pend Oreille Lake shoreline (Newport, Washington gage;, and Albeni Falls to Cusick (gage near Hope, Idaho)

- Clearwater River region—includes Clearwater River reach between Dworshak Dam and the city of Lewiston (Spalding, Idaho gage)

- Lower Columbia region—includes the area between Bonneville Dam and Columbia RM 40 (The Dalles, Oregon gage).

Since the 1970s, when the Columbia River Treaty storage projects were completed and the Columbia River Treaty Flood Control Plan was instituted, overall system flooding has been largely brought under control. Major levee systems have also been instrumental in reducing local flooding. This relative security from flooding is naturally important to those who live and work in areas that would be subject to more frequent or severe flooding if the projects were operated with less regard to flood control.

Section 3.2.1 explained that the objective of the Columbia River system flood control operation is to capture enough runoff in the primary flood control season—May through July—to keep downstream flows from reaching dangerously high levels. To do this effectively, the water level in the reservoirs must be low enough at the beginning of the flood control season—which occurs at the end of April—to provide ample storage space for the flood season runoff.

The six Federal projects that include flood control as an authorized purpose are: Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak, and John Day. The first five are major storage projects that are typically operated for flood control; John Day has allocated flood control storage but is operated in a manner similar to run-of-river projects. Just over half of the system's total flood storage of 39.7 MAF (49 billion m^3) is provided by storage dams in Canada, including Mica, Keenleyside, and

Duncan; operation of the Canadian storage projects is the single biggest factor affecting system flood control. None of the SOS alternatives would alter Canadian project operations.

Flood control on the Columbia River system is designed to handle both local and system flooding. Local flood control operations focus on areas immediately surrounding and downstream of the storage reservoirs. The objective of system flood control operations is to reduce peak flows on the lower Columbia. Controlling flooding on the lower Columbia requires the coordinated operation of Hungry Horse, Libby, Grand Coulee, and Dworshak in the United States and Mica, Keenleyside, and Duncan in Canada.

The Flood Control Work Group studied two means by which the SOS alternatives might affect local or system flood control. First, the level of each flood control reservoir at the beginning of the flood season affects its flood storage capacity. If the reservoir level is too high at the beginning of the flood season, the reservoir would not be able to absorb all its inflow, and the excess water would add to high downstream flows. On the other hand, reservoirs that begin the flood season at lower levels would have greater than normal flood storage capacity. The second type of effect stems from how outflow from the reservoir is managed. Alternatives that involve large releases from storage projects in certain seasons could contribute to flows that could be too high for the downstream flood control structures. The Flood Control Work Group determined that only the first type of effect (storage capacity limited by high reservoir levels at the beginning of the flood season) had the potential for any discernible impact on flooding. None of the SOSs called for seasonal storage releases that were high enough to increase downstream flooding.

Flood control operations are currently based on the use of runoff forecasts, outflow estimates, and reservoir rule curves. Each year, runoff forecasts are made beginning in January, predicting the amount of runoff anticipated from approximately April through August. Outflow estimates indicate the expected amount of outflow during the reservoir refill period. The flood control rule curves define reservoir flood control operations that strike the appropriate balance between inflow, outflow, and reservoir storage space.

Use of the flood control rule curves is intended to ensure that downstream flows and water elevations do not exceed a certain critical point. For the SOR analysis, the Flood Control Work Group selected several stream gage locations (referred to as control points) to indicate how each alternative would perform its flood control function. At each control point, a given flow or water level (called stage) defines the point above which damage begins to occur in the associated river reach (Table 4-15).

Project operators develop frequency curves indicating the probability that a peak flow or river stage will occur. The coordinates of any point on the frequency curve indicate, on average, how rare that particular peak flow is, or the probability that it will be exceeded in any year. SOR strategies that raise the frequency curve at one or more storage projects indicate increased flooding and increased damages to property.

Effects of Alternatives

None of the SOS alternatives would have a dramatic impact on flood control, partly because none would affect operations at the Canadian storage projects. The storage provided at Mica, Keenleyside, and Duncan is the single biggest factor in system flood control. Some of the strategies, however, would be somewhat less protective than others. SOSs 9c and SOS 4c would have the greatest effects on flood damage, because they would base some storage reservoir operations on integrated rule curves (IRCs) rather than flood control rule curves. In these cases, the affected reservoir's capacity for storing upstream runoff in the spring would be reduced in order to maintain higher reservoir elevations to benefit resident fish.

Table 4-15. Columbia River system flood control points and flow or stage above which damage begins to occur

Region/River Reach	Gage Location	Stage (water level)[a/,b/]	Flow[a/,c/]
Upper Columbia Region			
Kootenai River, Libby Dam to Kootenay Lake	Bonners Ferry, ID	1,766.5 feet	
Columbia River, Arrow Lakes and Brilliant Dam to U.S. border	Birchbank, BC		225 kcfs
Flathead River, Columbia Falls to Flathead Lake	Columbia Falls, MT		52 kcfs
Flathead Lake shoreline	Somers, MT	2,893.1 feet	
Flathead River, Kerr Dam to Thompson Falls	Polson, MT		28 kcfs
Lake Pend Oreille shoreline (Albeni Falls Dam)	near Hope, ID	2,062.5 feet	
Pend Oreille River, Albeni Falls Dam to Columbia River	Newport, WA		85 kcfs
Clearwater Region			
Clearwater River, Dworshak Dam to Lower Granite Dam	Spalding, ID		112 kcfs
Lower Columbia Region			
Columbia River, Bonneville Dam to RM 40	The Dalles, OR		450 kcfs

a/ At each location, the point at which damage begins to occur is defined either by stage or by flow.
b/ 1 foot = 0.3048 m.
c/ 1 cfs = 28 cms.

The results of the flood control analysis are summarized below. The initial discussion addresses total annual flood damages, in dollars, by SOS for all areas of the Columbia River system. This discussion is followed by a brief summary of the results for the upper Columbia, Clearwater, and lower Columbia portions of the study area.

Total System Damages

Table 4-16 shows the projected average annual flood damages by SOS and location for each alternative after it is implemented. Total estimated flood damages for the entire system under the No Action Alternative (SOS 2c) are about $3.3 million annually. For the worst-case alternative (SOS 9c), the damages would

Table 4-16. Average annual flood damages[a/]

SOS	Damages by Region (thousands of dollars)			
	Upper Columbia	Clearwater	Lower Columbia	Total Damages
1a	$3,274.7	$10.3	$0	$3,285.0
1b	3,274.7	10.3	0	3,285.0
2c	3,274.7	10.3	0	3,285.0
2d	3,274.7	10.3	0	3,285.0
4c	3,718.8	10.3	0	3,729.1
5b	3,274.7	10.3	0	3,285.0
5c	3,274.7	10.3	0	3,285.0
6b	3,274.7	10.3	0	3,285.0
6d	3,274.7	10.3	0	3,285.0
9a	3,532.2	10.3	0	3,542.5
9b	3,302.1	10.3	0	3,312.4
9c	3,733.5	10.3	0	3,743.8
PA	3,497.5	10.3	0	3,507.8

a/ Results are average annual damages, in 1992 dollars, assuming 100 years of operation under each alternative. Because damages are expected to be the same over the entire period of the analysis, the average annual damages would be the same using a 3.0 percent or a 7.75 percent discount rate.

increase by nearly $0.5 million to over $3.7 million. Stable storage operations would also have relatively high flood damages, with SOS 4c showing an increase of over $0.4 million. SOSs 9a, 9b, and PA show smaller variance from baseline (SOS 2c) conditions, while SOSs 1, 2d, 5, and 6 would have the same level of flood damage costs as SOS 2c. Figure 4-26 displays the total annual flood damages for each option compared to SOS 2c, based on the results presented in Table 4-16.

These variances in damages might be overstated. The models used to estimate flows, stages, and subsequent flood damages are based on monthly averages. In some cases, modeling monthly averages might not adequately capture the true expected effects. At several dams (including Hungry Horse, Dworshak, Libby, Kerr, and Albeni Falls), there is considerably more flexibility in the daily management of releases than is represented by the model. Because of this additional flexibility, flood damages might be less than indicated by the model.

Upper Columbia Region

Of the three regions in the study area, the upper Columbia region is the only one for which there is measurable variation in estimated flood damages from different SOSs.

Within the upper Columbia region, the Columbia Falls damage center would experience the greatest absolute amount of flood damage under any alternative (see Appendix E for details). Damage estimates for Columbia Falls under SOSs 4c and 9c range from 21 to 73 percent higher than the estimate for SOS 2c. Residential and commercial properties adjacent to Kalispell account for approximately 60 percent of the damages. Agricultural damages would occur both upstream and downstream of Kalispell.

Flood damages for the Flathead Lake, Kerr Dam to Thompson Falls, and Lake Pend Oreille damage centers are included in the upper Columbia estimate shown in Table 4-16. As noted above, the stage and flow forecasts for

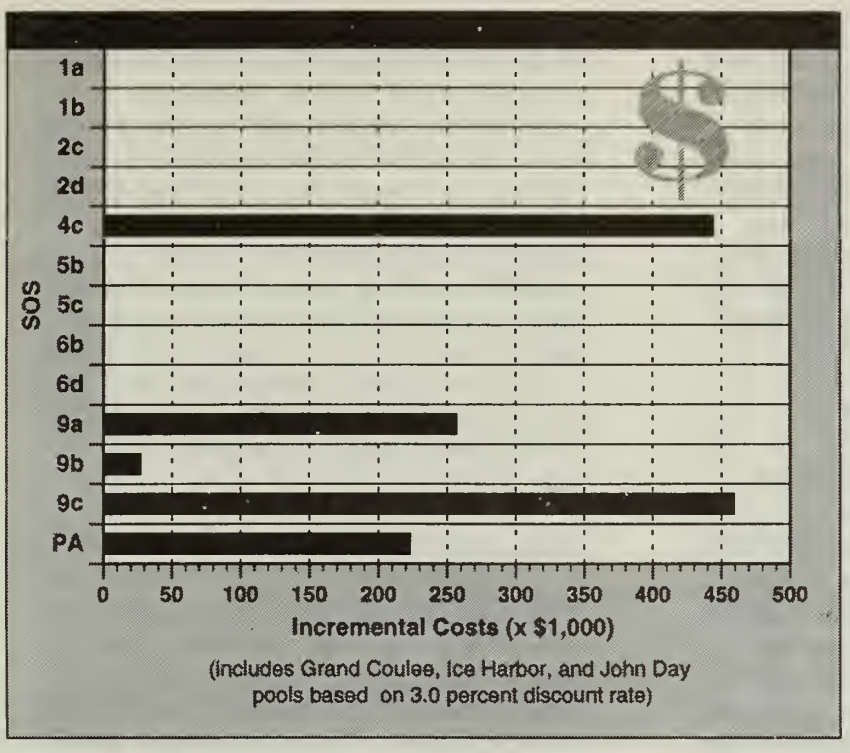


Figure 4-26. Flood control costs relative to SOS 2c

Flathead and Pend Oreille Lakes are thought to be higher than would actually occur. Daily real-time regulation would tend to reduce flows and stages below those predicted by the model.

Erosion losses of waterfront land and dock damage represent the majority of potential flood damages along Flathead Lake. In all the other areas, damages would mostly be to agricultural lands.

The Albeni Falls to Cusick reach of the Pend Oreille River would account for about 30 percent of all upper Columbia region damages under most SOSs, and the estimates for this damage center vary little among the alternatives. Damage estimates for Lake Pend Oreille are also very similar in most cases, but they are noticeably higher under SOS 4c and SOS 9c. The Kootenai River reach below Libby Dam generally accounts for the lowest damage total among the upper Columbia damage centers.

Clearwater River Region

The levees near Lewiston completely protect the highly developed industrial, commercial, and residential property in that area. No SOS would result in a discharge that exceeds the safe carrying capacity of the levees. All flood damages estimated for this region would occur upstream of Lewiston.

That upstream reach is essentially undeveloped. There are approximately 240 single-family residences, mostly at either end of the flood plain, with agricultural and undeveloped land in between. A system of roads, railroads, and bridges is also found in the area. All of the SOS alternatives analyzed for the Final EIS would produce the same level of annualized flood damages in this area, estimated at $10,300.

Lower Columbia Region

Levees provide property protection in the developed areas along the lower Columbia. While the frequency curves for The Dalles show high flows under some of the alternatives, a flood of sufficient magnitude to overtop the levees is unlikely. The area is prone to nuisance flooding at flows above 200 kcfs (5,600 cms), but little economic damage is expected until flows approach 450 kcfs (12,600 cms). This nuisance flooding is caused by high Columbia River flows coupled with high tides. In this situation, interior runoff (runoff behind the levees) is not able to drain into the Columbia.

A comparison of levee heights within the area to the elevation of a flood expected to occur only once in 500 years indicates that the levee height would exceed the water level by a minimum of 3 feet (0.9 m) under all SOSs.

Consequently, the SOR Economic Analysis Group attributed no flood damages to the lower Columbia region for all SOSs (see Appendix O). While there would be no direct impacts on flooding in this area, these actions might conflict with the original design criteria of the levees. Even though projected peak flows would be within maximum levee height, structural stress on the levees could occur. Repeated stress over time could weaken the levees and make them unable to hold back future flood waters.

4.2.12 Navigation

Water transportation is a key element in Columbia River Basin economic growth. Continuing improvements to the Columbia-Snake River navigation infrastructure have yielded economic benefits to cities and communities along the shoreline, and to the surrounding region. Manufacturers and commodity and agricultural producers have come to rely on the inexpensive, reliable, and easily accessible water transportation system that has developed. Other navigation uses of the river include Dworshak Reservoir log transport, which depends on specific reservoir elevations, plus recreational boat traffic and other uses such as small ferry operations.

Operations that involve deep drawdowns of the Snake River projects or that simulate natural river conditions are those most likely to restrict river navigation and result in significant economic consequences. Flow enhancement measures that increase river velocity could also have some negative effect on barge movements, water recreation traffic, and other navigation uses. Some of the SOS alternatives would result in minor net cost savings for navigation. The following material is summarized from detailed information presented in Appendix H, Navigation and Appendix O, Economic and Social Impacts.

Navigation Impact Issues

Commercial users and those who maintain and operate the waterway have been the focus of SOR public involvement and agency coordination relating to navigation. While there are numerous other groups who benefit from maintaining a safe waterway, commercial navigation is a Congressionally authorized use of the waterway. The continued operation of the waterway is a necessity for 6 barge companies and 54 port facilities, and is important to the shippers who have chosen the waterway as a cost-effective way to transport commodities to buyers. Effects on large commercial navigation interests along the river are similar to the effects on other users, such as recreationists. The juvenile fish transportation program (see Section 3.3.3) is also a significant navigation use of the waterway.

Shallow-Draft Navigation

Most of the potential impacts to navigation would occur on the shallow-draft navigation channel, particularly on the lower Snake River upstream to Lewiston. Operating strategies that involve drawdown of one or more lower Snake River projects (SOSs 5, 6, 9a, and 9c) would prevent access to the locks at Ice Harbor, Lower Monumental, Little Goose, and/or Lower Granite Dams, making them unusable at certain times of the year. Drawdown actions would occur mostly during the spring or spring and summer, and could overlap with a period of relatively high navigation activity, for both commercial shipments and the barging of juvenile salmon and steelhead (see Section 4.2.4 for discussion of effects on fish transportation).

Normal seasonal flows of grain and other commodities would be altered if barge service were interrupted. Shippers would have to reschedule shipments, store commodities, and/or use trucks or railways to avoid major disruptions in the delivery of products to final destinations. In addition, existing activities at affected lower Snake River ports could shift to other ports in response to the interruption of service and changes in commodity movements.

A secondary, relatively minor, shallow-draft navigation issue applies to any operation that would significantly increase river velocities in the inland waterway. Increased stream velocity

attendant with flow enhancement measures could impair navigability at certain locations along the river where physical constraints now exist. Physical difficulties in navigating constricted areas could entail delays or require changes in locking procedures.

The effects of increased stream velocity would be most pronounced at the Ice Harbor Cut, downstream from Ice Harbor Dam, and just below Lower Monumental Dam. In these areas, high flows (generally above 150 kcfs [4,200 cms] at Lower Monumental and above 100 kcfs [2,800 cms] at Ice Harbor) require that barging operations be modified. Current operations place several barges together for transit. In areas with increased stream velocities, however, tows would have to be broken up into smaller groups, resulting in more trips, increased transit time and operating costs, and possibly less-safe operating conditions. The potential costs of this effect are expected to be minor, however, and were not estimated.

Deep-Draft Navigation

During the screening phase of the SOR, concern arose over potential impacts on deep-draft commercial navigation on the lower Columbia River that might be associated with Snake River drawdowns. This issue related to whether refill of the Snake River projects during late summer and fall, at the low point of the Snake and Columbia Rivers' natural hydrograph, would be sufficient to affect river stages in the deep-draft channel from Portland-Vancouver to the Columbia River mouth.

Dworshak Logging Operations

One authorized use of the Dworshak pool consists of rafting logs across the pool to a transfer area near the dam. Logs are cut from the North Fork of the Clearwater River drainage, dumped from trucks into the Dworshak pool, and then towed in rafts to a loading area where the logs are transferred onto trucks. Staging areas have been developed for several pool elevations so that timber operations can continue during periods of normal drawdown. During periods of significant drawdown, the pool becomes unusable for log rafting.

Other Commercial Uses

There are currently two ferry operations on Lake Roosevelt (one at Keller and the other at Gifford) that provide key travel routes across the 150-mile-long (250-km-long) reservoir. They are the only crossing points between Grand Coulee Dam and Kettle Falls, near the northern end of the reservoir. The navigation analysis addressed the issue of whether service on these ferries would potentially be affected by severe drawdowns.

Effects of Alternatives

Shallow-Draft Navigation

The SOR Navigation Work Group determined the physical impacts to navigation that would result from the SOS alternatives. Using these results as inputs, the Economic Analysis Group then analyzed economic impacts to shallow-draft commercial navigation with a system transportation model developed to simulate transportation responses under different operating scenarios, and to measure transportation costs under each scenario. The model determines the least-cost transportation mode and calculates transportation costs, including storage and handling costs.

It considers rerouting commodities and using alternative transport modes, such as trucking grain to river elevators located on McNary pool, and/or shipping directly by rail to export elevators on the lower Columbia River or Puget Sound. The model thereby determines the minimum cost combination for handling and transporting commodities given the duration and magnitude of river impairments. In some cases, for grain shipments from Montana, North Dakota, and a few counties in Idaho, the shift away from barge transportation would be permanent. However, shipments of most

commodities would return to their normal patterns when pools are operated within their normal ranges.

Shallow-draft navigation would be affected most by SOSs 5b, 5c, 6b, 9a, and 9c. SOS 6d involves drawdown and navigation closure at Lower Granite only. These actions would interrupt navigation on the lower Snake River for variable periods including year-round (SOS 5c), 7 months beginning in February (SOS 5b) and ending in September, 4.5 months between April and August/September (SOSs 6b, 6d, and 9a) and 2.5 months between April and June (SOS 9c).

Total annual gross costs for commodity shipments on the Columbia-Snake River system under SOSs 1, 2, 4, 9b, and PA are estimated at approximately $414.4 million. Under SOSs 5b, 5c, 6b, 6d, 9a, and 9c, total annual shipping costs would increase. The smallest increase would be under SOS 6d, for which shallow-draft costs are estimated to increase by $2.1 million on an annualized basis (discounted at 3.0 percent). SOSs 9c, 9a, 6b, and 5b would increase annual shallow-draft costs by $7.4 to $13.6 million. The largest projected increase in shipping costs is $37.5 million for SOS 5c.

The transportation-related costs associated with other potential drawdown impacts have been treated as implementation costs and have not been included in the annual operating costs. These include possible impacts to waterfront structures, impacts due to increased stream velocities, and impacts on alternative transportation systems, such as roads and railroads.

Deep-Draft Navigation

The Navigation Work Group assessed the potential influence of Snake River drawdown actions (SOSs 5b, 5c, 6b, 9a, and 9c) on river stages within the authorized lower Columbia River deep-draft navigation channel. They used tidal data and discharge data from the hydroregulation model to identify potential effects on river stages for each drawdown option relative to current operations. The work group compared the percentage of time that river stages would be within a specific interval during August, September, and October, the months of concern due to low natural flows. River stages relate to the length of the refill period after drawdown.

The analysis showed that the effects of refill operations on river stage at key locations (Vancouver, Kalama, and Wauna) during these critical months would not be extreme under average water conditions. However, multi-dam drawdowns produced noticeable effects in stage at Portland and Vancouver in September. Differences in stage intervals between the drawdown/refill scenarios and the base condition would be such that the physical impact on deep-draft vessel operations would be negligible. Waterborne commerce on the deep-draft channel would not be significantly affected by any of the drawdown plans.

Dworshak Logging Operations

The impacts on Dworshak logging operations are minor and somewhat variable among SOSs. Many of the alternatives would result in actual cost savings (a benefit), or only slight increases in cost, to the operators at Dworshak. For example, SOS 4c would reduce Dworshak logging operation costs by $228,000 per year (at a 3.0 percent discount rate) compared to SOS 2c. SOSs 1, 5, 6, 9a, and 9c would also result in cost savings (benefits) relative to SOS 2c. The only alternatives that would produce a negative impact for Dworshak timber interests are SOSs 2d, PA, and 9b, which would increase annual log transport costs by about $93,000, $120,000, and $173,000, respectively. All alternatives that provide a stable high elevation at Dworshak, or delayed the drafting of the lake for flow augmentation or refill of the lower Snake River dams, were beneficial to this authorized use of the project. In many cases, these alternatives result in increased costs for other forms of transportation.

Lake Roosevelt Ferries

The Keller ferry is able to use an alternate docking and loading facility when Lake Roosevelt is drafted to low elevations. Therefore, the analysis indicated that none of the SOSs would impair the operation of the Keller ferry.

The Gifford ferry becomes inoperable when the Lake Roosevelt elevation drops by more than 72 feet (22 m), or to below elevation 1,218 feet (375 m). The analysis indicated that compared to SOS 2c, SOSs 9b and 9c would result in a slight increase in impacts to the Gifford ferry. During these service interruptions, regular users of the Gifford ferry would have to use alternative travel routes, go to alternative destinations, or cross Lake Roosevelt less frequently. The most likely alternative route would be to travel via State Route 20 to the north of Gifford and Inchelium, which would add approximately 45 miles (72 km) to the trip. The economic costs of the interruption of ferry service have not been estimated, but are not expected to be large.

Total Navigation Costs

The total navigation costs entered into the analysis of direct economic impacts include the shallow-draft navigation costs and the Dworshak log transport costs. The former component accounts for virtually all of the total navigation costs. Compared to SOS 2c and using a 3.0 percent discount rate, total navigation costs for the other SOS alternatives would range from $0.1 million lower (SOS 1a or 1b) to $37.4 million higher (SOS 5c; see Figure 4-27). Total navigation costs for SOSs 1a, 1b, and 4c would be slightly lower than for SOS 2c, because of improved log transport conditions for Dworshak. SOSs 9b and PA would have slightly higher total navigation costs than SOS 2c, because of somewhat worse log transport conditions. The remaining SOSs include mainstem drawdown provisions and would have significantly higher total navigation costs.

4.2.13 Power

The 14 Federal projects under review in this EIS account for 57 percent of the Pacific Northwest's total electric capability, and 97 percent of the Federal system's hydroelectric capability. In project scoping, the importance of hydropower and its indispensability to the regional economy were common themes. With the exceptions of SOSs 1a and 1b, adopting any of the system operating strategies other than the No Action Alternative (SOS 2c) would reduce hydropower production and increase the cost of the power system to Northwest ratepayers. SOS 9a would have the greatest impact, increasing total net system power generation costs by an annual average of $236 million assuming a 3 percent discount rate. Average annual

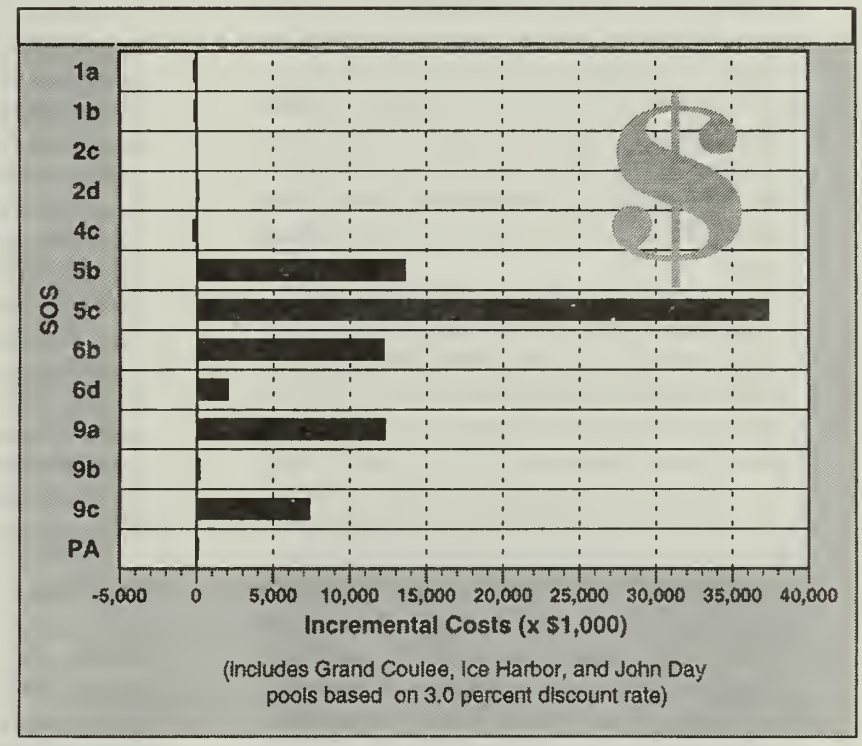


Figure 4-27. Net navigation costs

hydropower generation under SOS 9a would decrease by 6.6 percent. (Appendix I, Power, and Appendix O, Economic and Social Impacts, provide a complete report on this analysis.)

Power Impact Issues

The hydropower system currently provides many products and services, including firm and nonfirm energy, capacity (both peak and sustained), daily load-following capability, system reliability, and other attributes that contribute to the efficiency of the regional power system. Northwest residents are interested in keeping the system reliable and economical. In conducting its study for the Draft EIS, the Power Work Group assumed that BPA would cover any deficits that would result from changing system operations, so that an adequate supply of power would always be available to meet demand. For the Final EIS, the Power Work Group assumed that, at a minimum, regional utilities would strive to maintain a probability of failing to meet load equivalent to 1 day in 20 years. This is because utilities currently are relying to an unprecedented extent on spot market purchases to meet indigenous demand. The cost of supplying that power under most of the alternatives analyzed is higher than under the No Action Alternative. The economic impact of limiting power production in order to promote other river uses concerns some people; others want continued low-cost, reliable power.

Sections 3.1.3 and 3.3.6 included a description of how storage projects and run-of-the-river projects operate, how the system's firm and nonfirm energy sales are made, and how the system's generating capacity is affected by how the reservoirs are managed. Changing system hydropower operations affects the capability of the regional power system to meet its objectives in a variety of ways. The first is in its ability to generate energy, and the costs of generating that energy. The second is in its ability to provide capacity, and the associated costs. Changes in the regional power system's ability to provide both energy and capacity, and the costs of providing these products, are at the core of the power system impact analysis.

Energy

One of the hydrosystem factors that varies among the SOSs is the relative proportion of firm and nonfirm energy produced. Firm energy is energy that could be produced in the critical period (the worst historical water conditions—see Glossary); it is very dependable because there is usually enough water to produce that much energy (currently about 12,700 average megawatts [aMW]), year in and year out. Nonfirm energy is produced when water conditions are better than critical. Nonfirm energy (currently about 4,000 aMW) is less useful for meeting Pacific Northwest loads because the amount that can be generated varies from year to year. Because of its usefulness and dependability, firm energy can be sold at higher prices than nonfirm energy. Alternatives that produce relatively less firm energy and more nonfirm energy make it more costly to provide a dependable supply of power to the consumer.

In terms of firm energy production, some of the SOSs would severely restrict the system's flexibility because they restrict the use of the storage reservoirs. In such cases, the hydrosystem has little ability to retain water in storage for later release in times of power need. It would have to generate power when the water is coming down the river, usually in response to a requirement from some other use, such as providing water flows for anadromous fish. This would severely restrict the ability of the system to generate firm energy when most needed, and instead produces more of the less-valuable nonfirm energy. In extreme cases, when flow would exceed the capacity of the turbines, water would be spilled over the dam and produce no energy at all.

Capacity

The same water management strategies that restrict firm energy production also tend to restrict capacity, particularly sustained capacity. Any restriction on the ability to draft and store

water, and the rates at which this takes place, affects the system's sustained capacity.

Thus, reservoir drawdowns and changes in flow patterns would result in lost power generation, either through forced shutdowns of powerhouses, spilling water that exceeds the capacity of the turbines, or shifting power generation from a time when it is needed to a time when it is not particularly needed. Such changes in hydroelectric generation would represent an economic cost to the region, and could translate into increased power rates. These changes could also result in an economic cost to the Pacific Southwest, because lost nonfirm power normally exported to the Southwest would require replacement with higher cost energy.

Costs of System Changes

For each SOS, the Power Work Group calculated how much it would cost to operate the entire Pacific Northwest power system if that alternative were applied under conditions identical to the 50 water years spanning September 1928 through August 1978. This calculated cost consists of capital costs for new resources plus operating costs for all resources (including any energy purchases from outside the region), less revenues from sales out of the region. The Power Work Group summed the results for each alternative under all water conditions and calculated the average annual expected cost, producing estimates that indicate the relative cost of satisfying energy demand under each alternative across the range of hydrologic conditions.

Changes in the cost of providing sustained capacity (energy for 10 hours a day, 5 days a week) and instantaneous capacity (1-hour peak loads) were also evaluated. The sum of changes in the cost of the system's ability to provide capacity and energy gives the impact on the power system as a result of each SOS.

Resource Acquisition Philosophy

The efficiency of the power system has been a product of traditional "firm planning" methods in which resource needs were guaranteed by the acquisition of firm resources within the control of the region's utilities. For the Draft EIS, the work group used two resource acquisition philosophies to analyze the cost of each SOS. In the combustion turbine (CT) case, a resource with characteristics similar to a combustion turbine would be acquired to meet load in months when there is a deficit; that is, when the expected demand for energy exceeds the supply. In the purchases case, no resources would be acquired because it was assumed that energy would be available for purchase to cover any deficits. All deficits would be covered by purchasing energy on the short-term spot market.

At present, competition is forcing utilities to lower prices at the expense of reliability. Few, if any, Northwest utilities can afford to maintain the level of reliability suggested by the strictest interpretation of firm planning. Utilities are relying on the lower-cost spot market for purchases to meet indigenous loads to an unprecedented extent. This will continue until 1) reliability will decline to a point where the utilities decide acquisition of firm resources in the Pacific Northwest is needed, or 2) resource acquisitions will become competitive with the purchase market. How far utilities are willing to allow reliability levels to drop is unclear. No clear enforceable standards exist, and methods for assessing system reliability are in their infancy in the Northwest.

Additionally, costs of combustion turbines have fallen dramatically since the publication of the Draft EIS. This is due to three factors: historically low natural gas prices, decreases in hardware costs, and increases in CT operating efficiency.

In light of these developments, a new resource acquisition philosophy was adopted for the Final EIS. This philosophy was based on the assumption that, at a minimum, regional utilities would strive to maintain a probability of failing to meet load equivalent of 1 day in 20 years. This level of reliability is common to all alternatives including the No Action Alternative.

Therefore, the resource acquisition philosophy applied to the analysis in the Final EIS purports that it would be impossible to site, license, and construct CTs by 1995, the earliest SOS implementation date. Consequently, the analysis for that operating year was based on the assumption that all power needs would be met by spot market purchases. For the analysis of later operating years, an attempt was made to optimize the choice of CTs versus purchases after sufficient CTs were constructed to meet the reliability standard of 1 day equivalent energy outage in 20 years.

Effects of Alternatives

The work group compared the alternatives in terms of their effects on energy and capacity, and the cost of satisfying the region's total power demands. The potential implication for retail power rates is briefly explored as well. Projected generation, cost, and rate impacts are summarized below, based on the more detailed information reported in Appendices I and O.

Generation

Table 4-17 indicates that only the alternatives representing past actions (SOS 1) would produce more energy, on average, than the No Action Alternative (SOS 2c). All the other alternatives would produce between 0.1 and 6.6 percent less energy than the No Action Alternative. SOSs 5b, 5c, and 9a would cause the most substantial loss in total average annual generation. In the case of SOS 5b or 5c, turbines would be taken out of service or head would be severely reduced. SOS 9a couples large amounts of spill with drawdown of the lower Snake plants. The decreases in generation under these three alternatives would range from 828 aMW under SOS 5b to 1,095 aMW under the worst alternative, SOS 9a. For SOS PA, most of the 307-MW reduction in average annual generation is due to large amounts of spill for anadromous fish.

Energy and Capacity Costs

For the Draft EIS, total system costs, including replacement for both energy and capacity, were estimated following both the purchases and CT replacement strategies. This approach was in line with the resource acquisition philosophy presented in the Draft EIS. However, due to the change in resource acquisition philosophy for the Final EIS, the analysis of combined energy and capacity costs has been changed accordingly.

Therefore, average annual net system cost for each SOS was based on each SOS's combined management of spot market purchases and CTs designed to ensure maintenance of the reliability standard of 1 day equivalent energy outage in 20 years. The combined energy and capacity costs were calculated for loads and resources that existed in the 1995 to 1996 operating year (OY 1996) and for the loads and resources that existed in the 2003 to 2004 operating year (OY 2004). Results for intermediate years were determined by interpolation. Results for years past 2004 were assumed to stay constant.

Additionally, several SOSs have different implementation years. For example, SOS 2c has an implementation date of 1995 while SOS 5b would be implemented in 2010, furthest into the future compared to SOS 2c. In light of the different implementation dates, average annual net system costs were assessed using two discount rates: a 3 percent or "real" interest rate and a 7.75 percent rate, the Federal discount rate for fiscal year 1995. This approach was taken to better capture changes in cost relationships among SOSs. SOSs with a longer lead-time would experience a more significant reduction in cost structure under a higher discount rate. All of the alternatives other than the past (SOS 1) operating strategies would increase the cost of operating the regional power system. Therefore, flexibility of the system would be enhanced under SOS 1 and reduced under all other alternatives. Large energy deficits would occur in a number of months, requiring CTs or out-of-region purchases to make up the difference.

Table 4-18 indicates that increases in the cost of operating the system could be substantial.

Table 4-17. Average annual hydropower generation by SOS, compared to SOS 2c

SOS	Total Generation (aMW)	Change from SOS 2c	
		(aMW)	(percent)
1a	16,909	138	0.8
1b	17,080	309	1.8
2c	16,771	0	0.0
2d	16,737	-34	-0.2
4c	16,752	-19	-0.1
5b	15,943	-828	-4.9
5c	15,826	-945	-5.6
6b	16,494	-277	-1.7
6d	16,682	-89	-0.5
9a	15,676	-1,095	-6.6
9b	16,130	-641	-3.8
9c	16,042	-729	-4.4
PA	16,464	-307	-1.8

Annual net system cost increases range up to $236 million or 25 percent under SOS 9a, assuming a 3 percent discount rate, and up to $207 million or 22 percent under SOS 9b assuming a 7.75 percent discount rate. As shown, incorporating the effects of implementation timing and discounting future costs at different rates has some effect on the economics of the various SOSs. Using the 7.75 percent discount rate, some of the SOSs that have longer lead-times (SOSs 5b, 9a, and 9c) showed substantially lower cost increases than when their costs were discounted at 3 percent. The reasons for the large increases in operating costs include the following:

- Under stable storage project operations, such as SOS 4, water stored in reservoirs would not be as available for power generation. In certain months of lower-runoff years, particularly in August and September, additional energy from CTs or purchase of spot-market energy would be needed to make up for energy deficits.
- Under SOS 5, drawdown of the lower Snake reservoirs to natural river levels would eliminate hydroelectric generation at these projects because they would need to be drafted below the minimum level necessary for turbine operation.
- SOS 5 or 6 would incur a substantial capital cost before the reservoirs could be safely drawn down. These additional costs, annualized over the planning period, were included in the analysis as part of the cost of operating the power system.
- Under SOS 9, drawdowns and/or large amounts of spill would result in reduced hydropower generation. Sizable amounts of replacement energy, CTs, or spot-market purchases would be necessary to augment energy deficits.
- Under SOS PA, fall/winter water storage and spring/summer flow releases would both increase, reducing system operating efficiency.

Table 4-18. Annual net system replacement power cost by SOS, compared to SOS 2c ($1,000,000)[a/]

SOS	3 Percent Discount Rate		7.75 Percent Discount Rate	
	$ Change from SOS 2c	% Change from SOS 2c	$ Change from SOS 2c	% Change from SOS 2c
1a	-38	-4	-36	-4
1b	-72	-8	-66	-7
2c	0	0	0	0
2d	24	3	24	3
4c	85	9	81	8
5b	85	9	44	5
5c	167	17	132	14
6b	35	4	23	2
6d	17	2	14	1
9a	236	25	153	16
9b	213	22	207	22
9c	138	14	90	9
PA	126	13	108	11

a/ Results are annual averages, in 1993 dollars, of system generation and capacity costs for the 100 years following implementation of each alternative, but do not include implementation costs.

Rate Impacts

Fortunately for the region's ratepayers, the wholesale and retail costs of purchasing electricity would not be expected to change as a result of the replacement power costs associated with changing system operations. In previous years, salmon-related power system costs have been incorporated within wholesale electric rate increases adopted by BPA. Recently, however, BPA announced proposed power rates that would go into effect October 1, 1996 and that represent a reduction in average costs from the current rates that were set in 1993. The new rates would be available as 2-year or 5-year flat options, with no provisions for escalation or interim rate adjustments. This rate proposal reflects BPA's commitment to remain competitive. Therefore, based on its recently announced intentions concerning wholesale rates, BPA would be expected to reduce other costs to offset any increases in generation cost resulting from adoption of an SOS.

Nevertheless, during the preparation of the Draft EIS the Economic Analysis Group selectively analyzed the changes in wholesale rates that would result from increased system costs, and then took into account the fact that higher rates would induce some customers to reduce their demand. For illustration purposes, this analysis was repeated for the Final EIS. It showed that the highest cost alternative (SOS 9a) would be expected to reduce estimated demand by about 1 percent. This reduced demand would in turn reduce the cost of satisfying total demand. Including these demand effects, the net power replacement costs estimated for the SOS alternatives (at a discount rate of 3 percent) would correspond to net average regional rate changes ranging from about -1 percent to 4 percent under historical cost-recovery conditions.

The reduced system power costs for SOSs 1a and 1b would normally allow small rate reductions, while the potential 4-percent rate increase applies to SOS 9a. An average rate increase of 2 percent was estimated for SOS PA. Again, these estimates reflect how regional retail rates might change if power impact costs were recovered through rates, which appears unlikely.

4.2.14 Irrigation

The waters of the Columbia River system irrigate more than 7.3 million acres (2.95 million ha) of land in the Columbia River Basin, including British Columbia. This irrigation water makes possible the production of crops ranging from relatively low-valued hay and irrigated pasture to very specialized fruit and vegetable crops that provide a high return per acre. Maintaining this important sector of the Northwest economy is a vital issue to many people.

Of the 14 Federal projects under review in this EIS, three—Grand Coulee, Ice Harbor, and John Day—support irrigation that could be affected by the SOS alternatives. Other projects either do not supply significant irrigation withdrawals or would not experience changing water levels that would affect irrigation. Several of the alternatives would have a very minor effect on irrigators at Grand Coulee in most years, slightly decreasing or increasing pumping costs. One alterative—SOS 9a—could have a much more serious impact during certain months of critical water years, when irrigation deliveries may not be fully met.

Four strategies—SOS 5, SOS 6, SOS 9, and SOS PA—would affect irrigation pumping cost to differing degrees at Ice Harbor, John Day or both. This is because of drawdowns at Ice Harbor and John Day during pumping season for SOSs 5, 6, 9a, and 9c, as well as year-round drawdown of John Day under SOS PA.

Irrigation Impact Issues

During public scoping for the SOR, the Federal agencies received many comments on the use of water for agricultural production. These ranged from numerous comments expressing strong support for existing levels of irrigation use to suggestions by a few that water used for irrigated agriculture in the Pacific Northwest should be reduced, or given a lower priority than other uses. Other comments expressed interest in keeping the price of water resources fair for all users.

Because of the importance of agricultural irrigation to the economy of the Columbia River Basin, the SOR irrigation analysis focused on determining the cost of maintaining the status quo with regard to water deliveries. The analysis was conducted within the context of additional cost to irrigators, although it is possible that the increased cost could be borne by taxpayers through Congressional approval of mitigation for irrigation impacts. In this case, increased pumping costs represent both the best proxy for irrigation impacts and the potential mitigation costs. Thus, most of the analysis is based on assumptions that cropping patterns would remain the same as current conditions and that none of the land would go out of production due to any of the alternative operating strategies. An exception to this general rule is SOS 9a; it could cause some acreage near Grand Coulee to lose irrigation water in critical water years. The SOR agencies concluded that attempting to predict indirect irrigation impacts at the other affected projects, such as changes in cropping patterns or acreage in production, would be highly speculative and inappropriate.

With the exception of SOS 9a, none of the alternatives would affect the amount of water available to irrigators. However, the alternatives that would change the water level of Grand Coulee, Ice Harbor, and/or John Day pools during the irrigation season would affect irrigators by changing the cost of maintaining their water deliveries. Irrigation water in the Columbia River Basin is pumped up out of the reservoirs and into distribution systems located on the surrounding plateaus. At all three pools, irrigators would have to pay higher annual operating costs under any alternatives that lower the pool during the irrigation season. More

electrical energy would be needed to raise water from the lower elevation and maintain pressure over a greater distance. At Grand Coulee, some alternatives would raise the water level during the irrigation season, which would lower the pumping cost paid by irrigators. At the Ice Harbor and John Day pools, some users would have to modify intakes and pumps so that the intake would reach the lower water level and the pump capacity would be adequate to raise water from a lower elevation.

SOS 9a would reduce the delivery of water to irrigators at Grand Coulee in critical water years only. This would occur, not because there would not be enough water, but because the unusually low lake level would reduce the efficiency of the pumps to where they could not keep up with the demand for water.

Effects of Alternatives

The effects of the SOS alternatives on irrigation pumping costs are summarized below, based on the corresponding results provided in Appendix F. Most alternatives would either increase or decrease costs at Grand Coulee only slightly, compared to the No Action Alternative (SOS 2c), from an annual savings of $18,400 to an added annual cost of $34,900.

SOSs 5, 6, 9a, 9c, and PA would have significant effects on irrigators in non-critical water years. Those effects would fall on irrigators at the John Day and Ice Harbor pools. Proposed reservoir drawdowns would result in increased pumping costs and electric power costs due to greater lift requirement, as well as increased capital and maintenance costs associated with pumping plant modification.

Because the SOS options have different implementation dates, pumping costs were discounted to 1995, year 1 of the analysis. Two discount rates were used, 3.0 percent or the "real" interest rate, and 7.75 percent or the Federal discount rate. In performing this analysis, this approach was taken to better capture changes in pumping cost relationships among SOSs resulting primarily from capital costs associated with plan modification. SOSs with capital costs and longer lead-time would experience a more significant change in pumping cost structure under a higher discount rate.

Grand Coulee

At Grand Coulee, an extensive system of irrigation pumping plants, canals, and laterals; storage reservoirs; and drainage facilities has been constructed to serve nearly 600,000 irrigated acres (243,000 ha). Water is delivered by a pumping plant located on the south side of Lake Roosevelt and immediately upstream of Grand Coulee Dam. The pumping plant lifts water approximately 300 feet (91 m) from Lake Roosevelt to Banks Lake, an offstream reservoir with an active storage capacity of 715 KAF (882 million m^3). Several irrigation districts use the water in Banks Lake to supply local irrigators.

Operations that would lower the level of Lake Roosevelt would increase pumping costs because additional electrical energy would be needed to run the pumps and raise the water more than the current average lift of 300 feet (91 m). Individual irrigators would have to cover the higher pumping costs by paying higher rates to their irrigation districts.

The annual irrigation pumping requirement at Grand Coulee is 959,254 megawatt-hours and the repayment cost to pump the water is $911,300 under SOS 2c (Table 4-19). The other operating strategies would have a relatively minor effect on irrigation pumping costs at Grand Coulee; SOS 9a would have the greatest negative impact. With an annual pumping cost of $946,200, SOS 9a would increase costs just $34,900 (3.8 percent) over SOS 2c in non-critical water years. Some alternatives would reduce costs slightly compared to SOS 2c; the greatest savings would be afforded by SOS 4c, saving $18,400 annually.

SOS 9a would have an additional cost in critical water years. During spring and summer, SOS 9a would draft Lake Roosevelt to unprecedented levels. Because the efficiency of the pumping units decreases as the level of Lake

Table 4-19. Change in annual irrigation pumping costs at Grand Coulee

SOS	Pump Modification Required	Implementation Date	Change in Annual Pumping Cost Compared to No Action Alternative 3%	7.75%
1a	no	1995	9,000	9,000
1b	no	1995	8,900	8,900
2c	no	1995	0	0
2d	no	1995	-3,300	-3,300
4c	no	1995	-18,400	-18,400
5b	no	2010	0	0
5c	no	2000	0	0
6b	no	2005	0	0
6d	no	2000	0	0
9a	no	2005	34,900	34,900
9b	no	1995	5,400	5,400
9c	no	2005	6,000	6,000
PA	no	1998	-2,800	-2,800

Roosevelt goes down, pumping from Lake Roosevelt to Banks Lake would not be able to keep up with peak demand. Consequently, deliveries from Banks Lake could not be fully met, and some acres would not receive their full allotment of irrigation water in some months of critical water years. Additionally, during critical water periods, pumping units would be operating for extended periods of time resulting in increased operations and maintenance costs. However, this cost was not evaluated for alternative SOS 9a.

Assessment of pumping costs under the two discount rates did not differ because it was assumed that no capital outlays for pumping plant modifications would be necessary under any alternative including SOS 9a. Consequently, pumping costs are strictly a function of annual megawatt hours of pumping needed to meet annual irrigation demand under each alterative.

Ice Harbor

Since the construction of Ice Harbor Dam in the early 1960s, private interests have developed irrigated lands adjacent to the reservoir in Franklin County (north side) and Walla Walla County (south side), both in Washington. The irrigated lands were privately developed and funded, and include both small farms and large corporate operations. The Corps has identified 13 pumpers irrigating 36,389 acres (14,726 ha) from the Ice Harbor pool. Reservoir level fluctuations at Ice Harbor are currently kept to a narrow range between elevations 437 and 440 feet (133 and 134 m).

SOS alternatives that would lower the Ice Harbor pool during the irrigation season would cause an increase in annual pumping costs because irrigators would have to pay for pumping plant modifications and the increased energy costs associated with the additional pumping lift. Using the estimated increased pumping cost as the measure of the impact was a change from the farm income methodology used in the Draft EIS analysis.

SOS 5b/c and SOS 6a/b would draw down Ice Harbor to 343 feet (104 m) and 407 feet (124 m), respectively, during all or part of the irrigation season. SOS 9a would operate 33 feet (10 m) below full pool between April 1 and August 31, while SOS 9c would operate 35 to 45 feet (10.6 to 13.6 m) below full pool between April 1 and June 15 to meet Lower Granite flow targets. Capital costs for pump modifications would be required under all five options. These alternatives would also require irrigators to spend more on annual pump operation, including increased power costs due to greater lift requirements.

If SOS 5, 6, 9a or 9c is implemented, compared to the No Action Alternative (SOS 2c), annual irrigation pumping cost to irrigators drawing from the Ice Harbor pool would increase by $1.4 million (SOS 6b) to $3.2 million (SOS 5c), using a 3 percent or "real" discount rate (Table 4-20).

John Day

Like the Ice Harbor pool, the John Day pool is surrounded by private irrigation developments, ranging from small farms to large corporate concerns. The Corps has identified 24 pumpers irrigating 139,500 acres (46,463 ha) from this pool. Prior to 1992, the operating pool normally fluctuated between 265 feet (80.7 m) and 268 feet (81.6 m) during the irrigation season. John Day has generally been operated between elevations 262.5 feet (80.0 m) and 265 feet (80.7 m) from May through August during the past 2 years, as in SOS 2c. SOS alternatives that would lower the John Day pool during the irrigation season would increase irrigators' pumping costs by increasing their costs for pump modifications and operations.

All options for SOS 5 or 6 would draw John Day down to elevation 257 feet (78.3 m) from May through August. SOS 9a or 9c would draw down John Day to elevation 257 feet (78.3 m) from April through August while SOS PA would draw it down year round. Pump modifications would be required under all seven options (SOSs 5b, 5c, 6b, 6d, 9a, 9c, and PA) and operating costs would increase due to the increase in pumping head.

If SOS 5, 6, 9a, 9c or PA is implemented, compared to the No Action Alternative (SOS 2c), annual irrigation pumping cost to irrigators drawing from John Day would increase by $0.95 million (SOS 9a) to $1.54 million (SOS PA), using a 3 percent or "real" discount rate (see Table 4-21).

Summary

The combined irrigation cost changes for all three affected areas, relative to SOS 2c, are shown in Figure 4-28 and Table 4-22. Overall, the SOS with the greatest impact on irrigators would be SOS 5c, which would increase irrigators' pumping costs by nearly $4.5 million annually (using a 3.0 percent discount rate). In this case, all of the impact would fall on irrigators at the Ice Harbor and John Day pools, with Ice Harbor accounting for 70 percent of the total change and John Day 30 percent. Comparing the pumping cost results for SOSs 9a and 9c with those for SOS 6b indicates that the duration of these drawdown operations (2 months versus 4.5 months) would have little influence on the level of impact.

4.2.15 Municipal and Industrial Water Supply

Municipal, industrial, and other miscellaneous water supply diversions from the Columbia River system amount to only about 2 percent of the total withdrawals in the region. Issues related to municipal and industrial water use on the Columbia River system focus on the

Table 4-20. Change in annual irrigation pumping costs at Ice Harbor

SOS	Pump Modification Required	Implementation Date	Change in Annual Pumping Cost Compared to SOS 2c @ 3% ($000)	@ 7.75% ($000)
1a	no	1995	0	0
1b	no	1995	0	0
2c	no	1995	0	0
2d	no	1995	0	0
4c	no	1995	0	0
5b	yes	2010	2,305.4	1,443.8
5c	yes	2000	3,164.7	3,072.9
6b	yes	2005	1,377.4	1,080.9
6d	no	2000	0	0
9a	yes	2005	1,378.1	1,081.3
9b	no	1995	0	0
9c	yes	2005	1,427.6	1,126.2
PA	no	1998	0	0

Table 4-21. Change in annual irrigation pumping costs at John Day

SOS	Pump Modification Required	Implementation Date	Change in Annual Pumping Cost Compared to SOS 2c @ 3% ($000)	@ 7.75% ($000)
1a	no	1995	0	0
1b	no	1995	0	0
2c	no	1995	0	0
2d	no	1995	0	0
4c	no	1995	0	0
5b	yes	2010	1,013.8	650.7
5c	yes	2000	1,375.0	1,373.0
6b	yes	2005	1,181.1	945.2
6d	yes	2000	1,375.0	1,373.0
9a	yes	2005	945.9	748.4
9b	no	1995	0	0
9c	yes	2005	1,213.2	966.1
PA	yes	1998	1,540.2	1,663.7

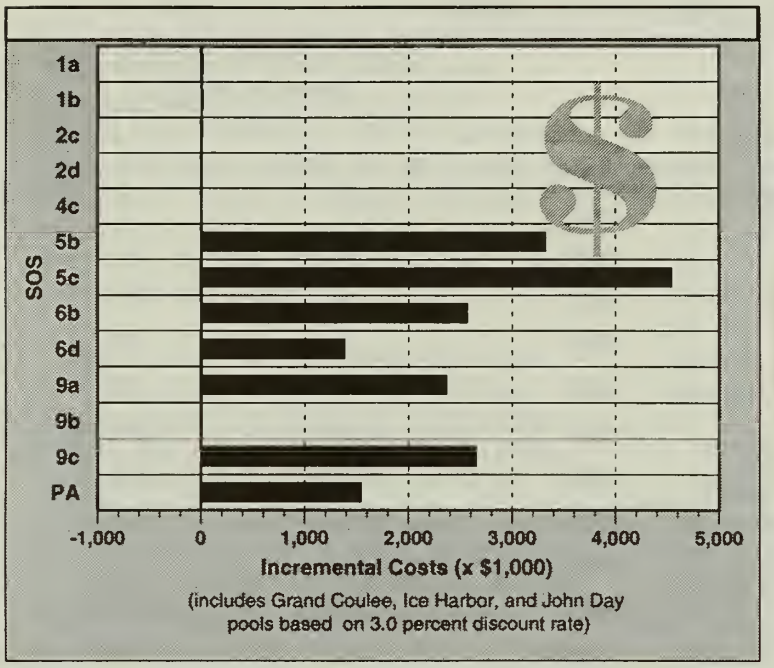


Figure 4-28. Combined incremental irrigation costs relative to SOS 2c.

assurance of an adequate water supply now and in the future; the cost of modifying and operating equipment to provide that water supply to users; and the quality of the water diverted by these users. Because withdrawals for municipal, industrial, and other miscellaneous uses constitute such a small fraction of total system water, all alternatives provide an adequate water supply. SOSs 5, 6, 9a, 9c and PA, however, would require additional expenditures on the part of water users to modify pumps, pay higher annual operating expenses, or make other adjustments to accommodate lower pool levels. The following information on these water supply impacts is based on the study results documented in Appendix F, Irrigation/Municipal and Industrial Water Supply.

Water Supply Impact Issues

Municipal, industrial, and other miscellaneous water use of the Columbia River system constitutes a small component of water use that is nonetheless vitally important to recipients of the water supply. These water users include two groups: those who pump directly from the river system (some of whom would be affected by any of the SOS alternatives), and those who do not pump directly from the system, but whose water supply would be affected in other ways by one or more of the alternatives.

Several municipal, industrial, and miscellaneous water users pump water directly from the system pools but would not be affected by any of the SOS alternatives. These include, for example, the cities of Kennewick, Richland, and Pasco that withdraw water from the McNary pool. McNary pool elevations would not be changed measurably by any of the alternatives, so the means and cost of water supply withdrawal would not be affected.

Other water users pump water directly from system pools that would be affected by one or more of the SOS alternatives. The alternatives that include drawdowns of Lower Granite, Lower Monumental, Little Goose, Ice Harbor, and/or John Day Reservoirs would affect these water users in two ways. First, some users would have to modify intakes and pumps so that the intake would reach the lower water level and the pump would be capable of raising water from a lower elevation. Second, all users would pay higher annual operation and maintenance costs, including higher energy costs. More electricity would be needed to raise water from the lower elevation and maintain pressure over a greater distance. These are essentially the same types of impacts that would affect irrigation pumping plants, as discussed in Section 4.2.14.

The Irrigation/Municipal and Industrial (M&I) Water Supply Work Group inventoried

Table 4-22. Combined increase in costs to irrigators at Grand Coulee, Ice Harbor, and John Day pools ($000)[a/]

	3 percent discount rate				7.75 percent discount rate			
SOS	Grand Coulee[b/]	Ice Harbor	John Day	Total	Grand Coulee	Ice Harbor	John Day	Total
1a	9.0	0	0	9.0	9.0	0	0	9.0
1b	8.9	0	0	8.9	8.9	0	0	8.9
2c	0	0	0	0	0	0	0	0
2d	-3.3	0	0	-3.3	-3.3	0	0	-3.3
4c	-18.4	0	0	-18.4	-18.4	0	0	-18.4
5b	0	2,305.4	1,013.8	3,319.2	0	1,443.8	650.7	2,094.5
5c	0	3,164.7	1,375.0	4,539.7	0	3,072.9	1,373.0	4,445.9
6b	0	1,377.4	1,181.0	2,558.5	0	1,080.9	945.2	2,026.1
6d	0	0	1,375.0	1,375.0	0	0	1,373.0	1,373.0
9a	34.9	1,378.1	945.9	2,358.9	34.9	1,081.3	748.4	1864.6
9b	5.4	0	0	5.4	5.4	0	0	5.4
9c	6.0	1,427.6	1,213.2	2,646.8	6.0	1,126.2	966.1	2,098.3
PA	-2.8	0	1,540.2	1,537.4	-2.8	0	1,663.7	1,660.9

Source: Appendix F, Chapter 5, Tables 2, 3, and 4.
a/ All values are annual averages, in 1992 dollars, for the 100 years following implementation of each alternative.
b/ Negative numbers denote a savings to irrigators.

nonagricultural water withdrawals that might be affected by SOS alternatives. The number of potentially affected pumps includes nine on the Lower Granite pool, two on Lower Monumental, two on Little Goose, three on Ice Harbor, and seven on John Day. The users of these potentially affected pumps are a sand and gravel company, Whitman County Parks, a Clarkston golf course, the Corps of Engineers (wildlife areas), Washington State Parks, Idaho State Parks, fish hatcheries at Umatilla and Irrigon, the City of Boardman water supply, the City of Umatilla sewage treatment outlet, individual groundwater wells, dredging at Umatilla River mouth, and an aluminum company.

Additionally, municipal and industrial water users and several small tract irrigators could be slightly affected by changes in operations at Grand Coulee. Any costs associated with these changes would be very minor, and the effects were not included in this analysis.

Changes in water quality associated with system operations could have an indirect impact on M&I water supplies. This primarily relates to possible increases in turbidity caused by changes in sediment transport patterns. The alternatives involving lower Snake River drawdowns, particularly SOS 5, would erode large volumes of sediment from the lower Snake River and could transport much of the fine sediment downstream. Significant increases in turbidity could require additional water supply treatment costs. The potential for this impact would be greatest at McNary pool. Please see Sections 4.2.1, Earth Resources, and 4.2.2, Water Quality, for additional discussion of sedimentation and turbidity.

Users that are not pumping water directly from the system but could be affected by some of the SOS alternatives include a variety of municipal, industrial, and miscellaneous groundwater uses located near the John Day

pool. SOSs 5, 6, 9a, 9c, and PA requiring drawdown of the John Day pool to elevation 257 feet (78.3 m), might necessitate the following responses to maintain these existing uses:

- Modifying groundwater wells affected by a lower groundwater table (additional discussion of groundwater effects can be found in Section 4.2.1),
- Extending the pipeline for the City of Umatilla's sewage treatment outfall,
- Dredging the Umatilla River to prevent blockage by sedimentation, and
- Covering a gas pipeline that would be exposed by the drawdown.

In addition to water withdrawals for municipal and industrial supplies, uses of the river system for wastewater discharge could be affected by some of the SOS alternatives. The SOR agencies have to date identified one such case, in which the Potlatch Corporation effluent discharge facility at Lewiston would need to be modified to accommodate drawdown of Lower Granite Reservoir (as in SOS 5, 6, or 9a).

Effects of Alternatives

Under SOSs 1, 2, and 4, there would be sufficient water in the system to satisfy current and expected future demands for water supply. Existing pumps and other facilities would continue to operate as they do currently, requiring routine maintenance and periodic replacement as components reach the end of their useful lives.

The reservoir drawdowns associated with SOSs 5, 6, 9a, 9c, and PA would increase average annual M&I pumping costs. Because the SOS options have different implementation dates, pumping costs were discounted to 1995, year 1 of the analysis. Two discount rates were used, 3 percent or the "real" interest rate, and 7.75 percent or the Federal discount rate. This approach was taken to better capture changes in pumping cost relationships among SOSs. SOSs with a longer lead-time would experience a more significant change in pumping cost structure under a higher discount rate.

Average annual pumping costs would increase from $3.3 million (SOS 5b) to $4.5 million (SOS 5c) under a 3 percent discount rate, and $2.1 million (SOS 5b) to $4.6 million (SOS PA) under a 7.75 percent discount rate (Table 4-23). These costs include the amortized value of modifying pumping plants and other facilities as well as increased annual operating and maintenance costs. The costs associated with lowering the John Day pool account for over 80 percent of the total costs for each option. Figure 4-29 shows the incremental impacts, by SOS, on M&I water users.

4.2.16 Economics

Management of the Columbia River system has the potential to affect virtually every resident of the Pacific Northwest, and many people outside the area, both directly and indirectly. Commercial and sport fishing interests, irrigators, producers who ship cargo on the river, people who use the river for recreation, and recipients of the river's vast hydroelectric resources are among those who are directly affected by the way the system is managed. Others are indirectly affected, such as when an increase in shipping costs increases the cost to consumers who buy the shipped goods.

While all of these elements are affected by Columbia River system operations, satisfying the region's demand for power and the loss of recreation benefits dominate discussion of economic impacts for most of the SOS alternatives. Where alternatives reduce the amount of hydropower generation, the lost power must be replaced by other, more costly resources. Changes in the cost of operating the total Northwest power system account for more than half of the net change in measurable economic costs associated with SOSs 2d, 4c, 5c, 9a, 9b, 9c, and PA. Loss of recreation benefits make up a significant share of the increased cost

Table 4-23. Increased annual pumping cost—M&I Pumpers[1/2/3/]

SOS	Pump Modification Required	Implementation Date	Annual Equivalent Value @ 3% $000	Annual Equivalent Value @ 7.75% $000
1a	no	1995	0	0
1b	no	1995	0	0
2c	no	1995	0	0
2d	no	1995	0	0
4c	no	1995	0	0
5b	yes	2010	3,256.9	2,111.0
5c	yes	2000	4,520.1	4,483.8
6b	yes	2005	3,617.3	2,921.6
6d	yes	2000	4,126.2	4,100.5
9a	yes	2005	3,616.0	2,920.6
9b	no	1995	0	0
9c	yes	2005	3,662.5	2,957.8
PA	yes	1998	4,273.4	4,670.3

1/ See Appendix F, Exhibit A for derivation of increased pumping costs.
2/ Impacts on Grand Coulee M&I pumpers considered insignificant.
3/ Annual cost includes amortization of pump modification cost, plus increased operation, maintenance, and pumping power cost.

of SOSs 5, 6, 9, and PA. Reductions in anadromous fish benefits and increases in shallow-draft transportation costs are also large for some alternatives.

Only SOS 1 would have lower economic costs than the No Action Alternative, SOS 2c. Valued at a 3.0 percent discount rate, total annual system costs would be $42.5 million lower than SOS 2c under SOS 1a, and $79.9 million lower under SOS 1b. All other SOS alternatives would be more expensive. The net increase in costs compared to SOS 2c ranges from $28.9 million annually under SOS 2d to $399.5 million annually under SOS 9a. This summary of the economic analysis is based on the methods and results reported in detail in Appendix O, Economic and Social Impacts.

Economic Impact Issues

The SOR Economic Analysis Group determined the economic impact of various operating strategies for eight elements: anadromous fish, irrigation, M&I water use, flood control, navigation and other water transportation, power, recreation, and construction activity associated with implementing each alternative. Not all of the values attributable to the Columbia River system are fully or accurately reflected in the economic

analysis reported here, however. Some reasons for this are:

1) There are limitations in the techniques available to apply certain economic theories, so that some values, such as the value people place on saving an endangered salmon species, are not counted in the analysis.

2) There were limitations of time and money associated with preparing the analysis. Simplifying assumptions were used to keep the analysis from becoming too detailed, and these simplifying assumptions obscure some of the changes that would take place. For example, even though more sophisticated methods are available for estimating the value of each recreation activity at each site, the analysis assumes a uniform average value for each type of recreation activity across the entire Columbia River system.

3) There are limitations to some of the models used in the analysis, and to the ways in which the models were applied. For example, the flood damages analysis used results from a streamflow regulation model that predicts flooding based on average monthly flows. This tends to predict higher flows and stages than would actually occur. A model that made predictions based on average daily flows would provide a more accurate picture of expected flood damages because it would incorporate more finely tuned responses on the part of reservoir managers.

Despite these limitations, the SOR agencies believe that the analysis is sufficiently complete to be used in identifying the primary economic effects of the alternatives and differentiating among them.

The following descriptions indicate how the SOR agencies measured direct economic impacts in each area of interest, and how these results were applied to estimate indirect or regional economic impacts.

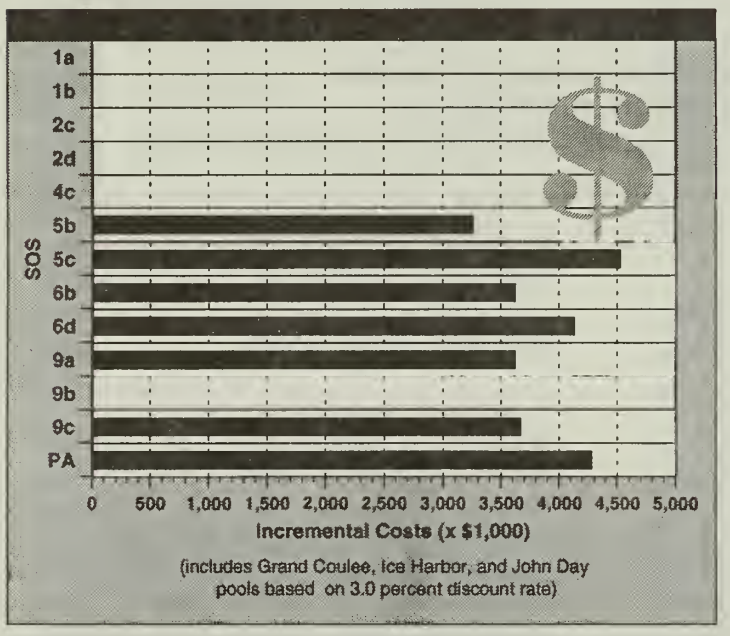


Figure 4-29. Combined incremental municipal and industrial water supply costs relative to SOS 2c

Anadromous Fish

The analysis of direct economic impacts to Pacific Northwest anadromous fisheries included four components: 1) the commercial ocean and in-river fisheries, 2) the commercial Indian fishery, 3) the ocean and lower Columbia River sport fisheries, and 4) the mid-Columbia and Snake River sport fisheries.

The direct economic impact of alternative system operations on commercial fishers is the change in net income. The change in income is a function of changes in the number of fish harvested, the expenditures to catch these fish, and the price received for the fish. The indirect impacts stem from the changes in expenditures for a

fishing operation and the change in net income retained by commercial operators.

The direct impacts of alternative system operations on recreational anglers are the change in angler days, the change in consumer surplus realized by anglers, and changes in expenditures made by anglers. The indirect impacts stem from the changes in expenditures.

Irrigation and Municipal and Industrial Water Use

Direct economic impacts to irrigators and M&I water users include two components: 1) pump or other facility modification costs, and 2) energy and other operating costs. Modifications to pumps and other facilities paid for by private owners would have a direct impact on the net income of the operation for which the facilities are required. In the case of irrigated agriculture, producers could withhold or delay investment in other farm activities in order to meet the modification expenses, or could borrow money. In either case, net farm incomes and farm household disposable income would decrease.

The indirect economic impacts associated with the annualized costs of the pump or facility modifications would depend in large part on whether these costs were paid by the public sector or by the facility owners. If the costs were paid by the public sector in the form of regional electric ratepayers, then the modification costs would likely be translated into higher electricity rates with a subsequent decline in individual household discretionary incomes in the region. If the costs were paid by the public simply as taxpayers, then any associated secondary impacts would be an increase in regional income.

Flood Control

Assessment of impacts on flood control is based on expected flood damages that would result from each SOS. Direct economic impacts are a function of the value of property at risk of flooding and the predicted frequency and stage of flooding.

Navigation

Alternative Columbia River system operations could affect transportation of commodities, primarily by forcing shifts from barges to other transportation modes. Direct economic impacts of such shifts would include increased transportation costs, additional storage and handling costs, and incremental increases in capacity investments required to enable commodities diverted from the Columbia River system to reach their final destination. The added transportation costs are the direct impacts which drive the indirect impact analysis.

Some alternatives also affect other enterprises such as log transport on Dworshak Reservoir and small ferry systems. Direct economic impacts include changes in operating costs and revenues.

Power

The direct impacts of the SOS alternatives on the regional power system are measured as the cost of producing power to meet system demand, a concept that accounts for the change in resource mix required to meet anticipated regional loads. It includes the consumer-demand response to higher energy costs. Systems analysis and decision models were used to evaluate the direct power impacts of the SOSs.

Generally, the models evaluated the effects of the strategies on power supply, incremental energy costs, and consumer demand. The ability of the regional power system to supply both capacity and energy would be affected by the SOS. This would, in turn, modify the least-cost resource mix necessary to meet regional electricity demands. Changes to the resource mix resulting from a decrease in system hydropower generation would cause average wholesale power rates to increase. As power rates adjust upward, regional consumers would use less electricity. This would lead to continued rounds of adjustments to the resource

mix, electricity prices, and consumer demand until a supply-demand balance is achieved.

Potential wholesale rate changes are measured for the region's major power consumers, including public and private utilities and BPA's direct service customers (DSIs).

Recreation

Recreation activities affected by system operations include boating, waterskiing, windsurfing, sport fishing, swimming, hunting, wildlife viewing, camping, and picnicking. Potential direct economic impacts include changes in visitor use, and the consumer surplus associated with this use. Indirect impacts would stem from changes in expenditures made by visitors.

Construction Activities

Some of the SOS alternatives depend on future construction activities to modify projects and/or mitigate for the effects of the operations on the direct river users. Construction activities might include modification of irrigation pumping stations, additions to on-farm grain storage, improvements to boat ramps and moorages, dam modifications, and the development of new power stations. Expenditures for these construction activities would generate positive short-term indirect impacts in the regional economy. These effects are different from direct SOS economic impacts in that they could be expected to last only through the duration of the construction activity, perhaps a few months to a few years. The indirect effects associated with the SOS alternatives would continue along with the direct impacts, in many cases reflecting permanent changes in regional economic activity.

Indirect Economic Effects

Through their influence on river uses, river operations affect the demand for local goods and services and thereby the output levels in many related industries. Changes in operations would likely affect industry input requirements and the distribution of regional output to local and export markets. Labor requirements could change, increasing or decreasing the availability of regional jobs. Personal income could rise or fall depending on the job impacts. The regional trade balance could shift as the availability of local commodities is affected by changes in production levels.

The most common indicators of these changes in regional economic activity, or indirect economic effects, are adjustments in regional employment and earnings. These are the measures from regional input-output models which best describe the change in the economic well-being for the local population. Employment is measured as the total number of jobs and includes both full-time and part-time workers. Earnings, or income, is measured as wage and salary income paid to employees plus income earned by business owners and sole-proprietorships. These indirect or regional economic impacts of the SOS alternatives were estimated using IMPLAN regional, state and sub-regional models.

Effects of Alternatives

Direct Economic Effects

Table 4-24 indicates, at a 3 percent discount rate for those elements that were analyzed, the difference in average annual costs and benefits associated with each SOS alternative compared to SOS 2c. Table 4-25 shows the same information calculated at a 7.75 percent discount rate.

Some elements are commonly defined as benefits, such as recreation and the commercial and recreational value of anadromous fish. For elements defined as benefits, the best alternatives are those with the highest positive dollar values (increases in benefits) or lowest negative values (reductions in benefits).

Other elements are commonly defined as costs, such as the cost of operating M&I water systems, the cost of transporting goods on the river, the cost of operating the power system,

Table 4-24. Direct economic impacts by alternative compared to SOS 2c, at 3.0 percent discount rate ($1,000)[a/]

	Elements Defined as Benefits		Elements Defined as Costs							
SOS Alternative	Recreation Benefit	Anadromous Fish Comm/Rec Benefit[b/]	Irrigation Cost	M&I Water Cost	Shallow Draft Transportation Cost	Dworshak Reservoir Log Trucking Cost	Net System Generation Cost[c/]	Flood Damages Cost	Implementation Cost[d/]	Total Annual System Cost
1a	4,691	(330)	9	0	0	(112)	(38,000)	0	0	(42,464)
1b	7,941	(180)	9	0	0	(120)	(72,000)	0	0	(79,872)
2c	0	0	0	0	0	0	0	0	0	0
2d	(5,015)	160	(3)	0	0	93	24,000	0	0	28,945
4c	4,171	160	(18)	0	0	(228)	85,000	444	0	80,867
5b	(66,280)	(6,370)	3,319	3,257	13,631	(51)	85,000	0	88,560	266,367
5c	(89,792)	(8,660)	4,540	4,520	37,534	(171)	167,000	0	24,600	336,475
6b	(49,057)	(11,120)	2,558	3,617	12,314	(120)	35,000	0	31,565	145,112
6d	(39,812)	(5,500)	1,375	4,126	2,146	(141)	17,000	0	7,760	77,577
9a	(96,871)	(16,710)	2,359	3,616	12,314	(42)	236,000	257	31,434	399,520
9b	(35,418)	(3,350)	5	0	0	173	213,000	27	0	251,974
9c	(37,925)	(11,490)	2,647	3,662	7,359	(5)	138,000	459	31,666	233,203
PA	(26,441)	50	1,537	4,273	(26)	120	126,000	223	5,922	164,440

a/ All costs and benefits are annual averages, in 1992 dollars, for the 100 years following implementation of each alternative.
b/ Value based on "high" values for fish and "optimistic" values for SOSs 6b, 6d, 9a, and 9c. Optimistic values reflect a 25% increase in FGE with drawdown.
c/ Net system generation cost reflects some reduction in consumer demand in response to higher electricity prices.
d/ Implementation costs are for dam modifications associated with SOSs 5, 6, 9a, 9c, and PA.

Table 4-25. Direct economic impacts by alternative compared to SOS 2c, at 7.75 percent discount rate ($1,000)[a/]

SOS Alternative	Elements Defined as Benefits: Recreation Benefit	Elements Defined as Benefits: Anadromous Fish Comm/Rec Benefit[b/]	Elements Defined as Costs: Irrigation Cost	M&I Water Cost	Shallow Draft Transportation Cost	Dworshak Reservoir Log Trucking Cost	Net System Generation Cost[c/]	Flood Damages Cost	Implementation Cost[d/]	Total Annual System Cost
1a	4,691	(330)	9	0	0	(112)	(36,000)	0	0	(40,464)
1b	7,941	(200)	9	0	0	(120)	(66,000)	0	0	(73,852)
2c	0	0	0	0	0	0	0	0	0	0
2d	(5,015)	170	(3)	0	0	93	24,000	0	0	28,935
4c	4,171	110	(18)	0	0	(228)	81,000	444	0	76,917
5b	(34,728)	(3,430)	2,094	2,111	6,966	(27)	44,000	0	154,462	247,764
5c	(72,284)	(7,030)	4,446	4,484	30,173	(138)	132,000	0	44,891	295,170
6b	(31,835)	(6,920)	2,026	2,922	7,945	(78)	23,000	0	56,793	131,363
6d	(32,049)	(4,760)	1,373	4,100	1,688	(114)	14,000	0	12,592	70,449
9a	(62,863)	(10,220)	1,865	2,921	7,945	(27)	153,000	257	56,611	295,655
9b	(35,418)	(2,990)	5	0	0	173	207,000	27	0	245,613
9c	(24,611)	(7,140)	2,098	2,958	4,730	(4)	90,000	459	56,915	188,907
PA	(23,211)	40	1,661	4,670	(169)	105	108,000	223	9,196	146,857

a/ All costs and benefits are annual averages, in 1992 dollars, for the 100 years following implementation of each alternative.
b/ Value based on "high" values for fish and "optimistic" values for SOSs 6b, 6d, 9a, and 9c. Optimistic values reflect a 25% increase in FGE with drawdown.
c/ Reflects some reduction in consumer demand in response to higher electricity prices.
d/ Implementation costs are for dam modifications associated with SOSs 5, 6, 9a, 9c, and PA.

and damages resulting from flooding. For elements defined as costs, the best alternatives are those with the highest negative values (reductions in costs) or lowest positive values (increases in costs).

Table 4-24 indicates that, compared to SOS 2c, the net annual system cost at a 3 percent discount rate ranges from a $79.9 million lower cost associated with SOS 1b to a $399.5 million higher cost under SOS 9a. Table 4-25 indicates a similar range when calculated at a 7.75 percent discount rate: from a $73.9 million lower cost under SOS 1b to a $295.7 million higher cost under SOS 9a. The Table 4-24 results are displayed graphically in Figure 4-30.

The cost of operating the power system is generally the largest element of any change. Even small percentage changes in the cost of generating electricity overwhelm many changes in the other elements.

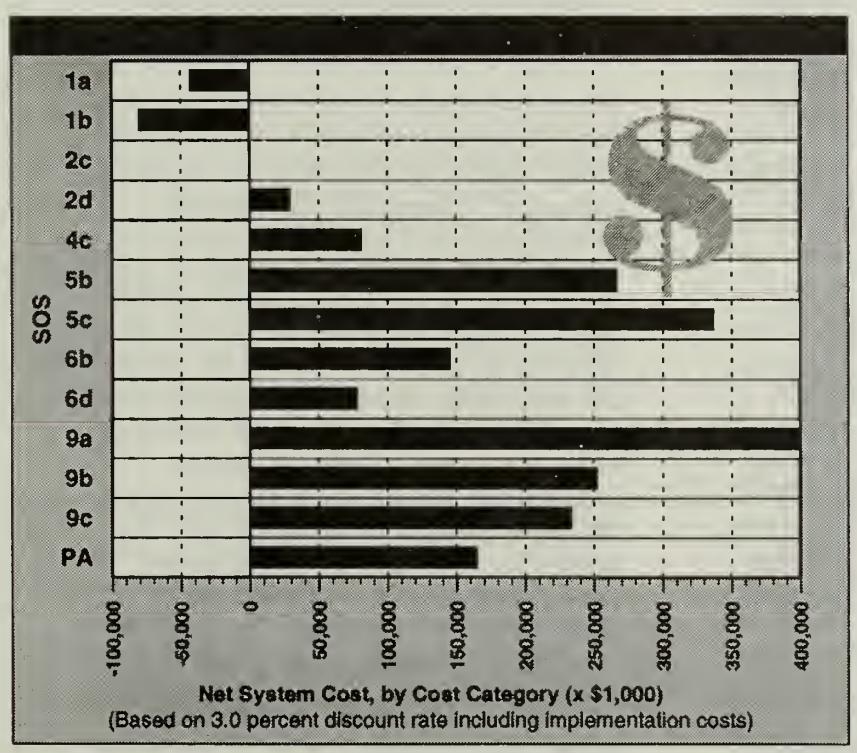


Figure 4-30. Aggregate net system operation costs relative to SOS 2c

For example, at a 3.0 percent discount rate, implementing SOS PA would increase average annual system generation costs by $126.0 million compared to SOS 2c. The next largest economic impact would be on the benefits associated with recreation, which would be reduced by $26.4 million annually. On the plus side, the economic benefit to commercial and sport fisheries associated with anadromous fish would equal only $50,000 annually. In terms of aggregate measured economic impact, the power system cost clearly predominates.

System generation costs are not as dominant under SOS 5, where they account for 31 to 50 percent of the estimated net costs, or under SOS 6, where they account for 21 to 24 percent of the estimated net costs.

There are several factors that account for the difference:

- SOS 6 has a relatively small impact on system generation costs compared to the other alternatives.
- SOSs 5, 6, and 9 would substantially reduce recreation benefits and the commercial and recreational values of anadromous fish compared to most of the other alternatives. This is especially true of SOSs 5c and 9a for recreation and SOS 9a for anadromous fish. Drawing down the pools at several reservoirs would reduce sport fishing and other recreational uses.
- SOSs 5 and 6, particularly SOS 5c, would substantially increase transportation costs. Reservoir drawdowns would prevent use of the locks, requiring the use of more expensive transport modes.

- SOSs 5 and 6 would adversely affect irrigators and M&I water users. Drawing down the pools at Ice Harbor and John Day would cause irrigators and M&I water users to invest in new pumping equipment or to make other facility changes that would increase their costs.

SOSs 9a and 5c would increase net system costs by the greatest amount ($399.5 million and $336.5 million, respectively) relative to SOS 2c. Most of that effect would be accounted for by the increase in system generation costs, although losses in recreational benefits and the sport and commercial value of anadromous fish would also be substantial.

Indirect Economic Effects

Sections 4.11 and 5.5 of Appendix O, Economic and Social Impacts, provide a detailed assessment of projected indirect economic effects at the regional, state, and subregional levels. Given the scale of the region and the complexity of this multi-level analysis, the following discussion summarizes indirect economic impacts at the regional level for all resource categories. The reader is referred to Appendix O for information pertaining to specific resource types or individual states or subregions within the Pacific Northwest.

Regional economic impacts related to all resource activities likely to be affected by implementation of the SOSs were evaluated for the Pacific Northwest region using a set of IMPLAN regional analysis models. This analysis was conducted for all 13 of the SOSs, covering the entire range of the different operations reflected in the SOS alternatives. These impacts provide an indication of the net effect of the adjustments in river operations on regional employment and income.

Employment—The total employment impacts for the Pacific Northwest that are likely to result from the alternative river operations were estimated by modeling the employment influences of the direct economic effects reported previously in Section 4.2.16. Expected changes in regional employment range from a net increase of over 2,000 jobs annually under SOS 1b to a loss of approximately 9,450 jobs annually under SOS 9a (see Table 4-26). SOS PA would result in a decrease in regional employment estimated at about 4,000 jobs. Only 2 of the 12 alternatives evaluated (SOSs 1a and 1b) would result in a net increase in regional employment. Virtually all of the job impacts would occur as a result of the power generation and cost aspects of the SOS alternatives. Under each of the SOS alternatives, Washington accounts for over one-half of the regional job impacts, ranging from a net increase of nearly 1,500 jobs with SOS 1b to a loss of nearly 6,600 jobs for SOS 9a. Employment impacts in Oregon ranged from a net increase of nearly 800 jobs under SOS 1b to a loss of over 3,300 jobs under SOS 9a. Net job impacts in Idaho and Montana are about one-half and one-fifth the levels measured for Oregon, respectively. Once again, the net effect of the SOS alternatives on state-level employment was dominated by the impact of the operations strategies on the regional power system.

Income—The effects of the SOS alternatives on Pacific Northwest regional income include the direct economic changes along with the indirect and induced changes that result from the interdependencies which exist throughout the regional economy. Expected changes in regional income range from a net increase of over $56 million annually under SOS 1b to a loss of over $260 million annually under SOS 9a. As with the employment impacts, all alternatives other than SOSs 1a and 1b would result in decreases in regional income. The model analysis indicated that SOS PA would decrease regional income by about $113 million per year. The distribution of changes in regional income among the states is consistent with the distribution of the employment impacts, with Washington accounting for the largest share of the income impacts.

4.2.17 Social Impacts

Currently, uncertainty is the most significant social impact occurring throughout the Pacific

Table 4-26. Summary of regional employment impacts, compared to SOS 2c.

SOS	Andromous Fish	Irrigation	Navigation	Power	Recreation	Power Purchases	Total
1a	-5	0	2	1,505	60	-526	1,036
1b	-6	0	2	3,016	63	-1,055	2,021
2d	0	0	-2	-886	0	310	-578
2c	0	0	0	0	0	0	0
4c	1	0	5	-3,443	42	1,204	-2,191
5b	-114	-434	158	-5,265	-281	1,841	-4,095
5c	-246	-437	94	-9,271	-318	2,693	-7,486
6b	-388	-347	-132	-1,854	-191	648	-2,264
6d	-144	-261	-26	-769	-153	269	-1,083
9a	-557	-335	-133	-12,509	-290	4,373	-9,451
9b	-82	0	-4	-8,519	-36	2,978	5,662
9c	-394	-356	-17	-7,317	-152	2,558	-5,678
PA	-6	-259	-2	-5,419	-237	1,895	-4,029

Northwest. Because the current operation of the Columbia River is subject to change and the future operation is unknown, individuals and economic entities are experiencing stress because they are unable to make decisions for their short- or long-term futures. It was pointed out during public meetings held in May 1994 on the *System Configuration Study and Lower Snake River Biological Drawdown Test Draft Environmental Impact Statement* at Lewiston, Idaho that economic investments are being withheld, which is affecting economic growth which in turn creates stress for individuals, families, and business interests. The stress of uncertainty will continue until decisions for the future operation of the Columbia River are made.

Overall changes in employment and income would be relatively minor from regional and sub-regional perspectives (see Appendix O, Section 5.6). SOSs 5b, 5c, 9a, 9b, 9c, and PA would have the largest impacts on regional employment and income. SOS 9a would have the largest impact, with regional job losses of 9,450 and a decrease in income of $260 million. These changes are less than 0.25 percent of total regional employment and income.

The largest relative changes in employment and income would occur in mid-Columbia and lower Snake subregions. The largest net change in employment and income in the mid-Columbia subregion would occur with SOS PA, a loss of 1,040 jobs and a decrease in income of $28 million (less than a 1 percent decrease in total subregion employment and income). The largest net change in employment and income in the lower Snake subregion would occur with SOS 5c, a loss of 3,800 jobs and a decrease in income of $79 million (about 5 percent of total subregional employment and income).

Employment and income in the Mid-Columbia subregion focus communities of the Tri-Cities in Washington and the Umatilla/Morrow Counties area in Oregon would generally be positively affected by increases in grain transportation costs and negatively affected by increased pumping costs for irrigation and M&I water supplies, increased power costs, lower levels of anadromous fish harvest, and reduced levels of reservoir recreation activity. The communities are likely to experience relatively short-term positive increases in regional employment and income during the construction periods for project modifications and pump modifications of

irrigation and M&I water supplies. The construction activities associated with pump and project modifications would likely cause the greatest social impact to the Mid-Columbia focus communities. While providing an increase in employment, there would potentially be transitional impacts on local infrastructure and services resulting from the short-term influx of construction workers and their families.

The focus communities of Lewiston, Orofino, and the Nez Perce Reservation in Idaho and Clarkston, Washington, in the lower Snake subregion would experience negative employment and income changes associated with declining levels of anadromous fish harvest, increased grain transportation costs, increased power costs, declining levels of reservoir recreation activity. Decreases in navigation employment and income associated with the drawdown alternatives would occur in Lewiston/Clarkston. Orofino and the Nez Perce Reservation would be primarily affected by loss of employment associated with declines in recreation activity and anadromous fish harvests. All of the communities would be affected by increasing power costs. Lewiston and Clarkston would likely experience short-term increases in employment and income from the construction activities associated with pump and project modifications. Dam modification construction in this subregion would cause the greatest social impact in the Lewiston/Clarkston area. While providing an increase in construction-related employment, there would potentially be transitional impacts on local infrastructure and services resulting from the short-term influx of construction workers and their families.

The Upper Columbia subregion would be most affected by net changes in employment and income associated with SOS 9a, a loss of nearly 700 jobs and a decrease of $18 million in regional income (approximately 0.5 percent of regional employment and income). These changes would be associated primarily with reductions in anadromous fish harvests, increased power costs, and lower levels of reservoir recreation activity. The region would experience positive changes to employment and income due to declining costs for grain transportation. The focus communities of Grand Coulee/Coulee Dam and the Colville and Spokane Reservation in Washington would be primarily affected by reduced levels of recreation activity at Lake Roosevelt.

The focus communities of Astoria and Portland in the West Coast and Portland subregions, respectively, would be primarily affected by increasing regional power costs, although the impacts are not expected to be significant. Additional employment and income effects associated with declining anadromous fish harvests would also occur. In both subregions the expected impacts would be greatest with SOS 9a. Employment and income losses in the Portland subregion under this scenario would include 1,500 jobs and $52 million (0.25 percent of regional employment and income). In the West Coast subregion employment losses under SOS 9a would reach nearly 1,025 jobs with associated income losses of $26 million (approximately 0.75 percent of regional employment and income). In May 1994, the Pacific Coast area was declared an Economic Disaster Area because of the decline in the fishery. Employment and income impacts to the focus community of Astoria, Oregon, would be negative which would add to the decline.

The Northeast subregion would be most affected by the net changes in employment and income associated with SOS 9a, an annual loss of 1,125 jobs and an decline in income of $28 million (0.5 percent of total subregion employment and income). Positive job and income effects would be associated with decreased costs for grain transportation while negative impacts would result from increased regional power costs. Minor declines would also be associated with some decrease in reservoir recreation. The focus communities of Libby, Flathead Lake, and the Flathead Reservation in Montana and Bonners Ferry and the Kootenai Reservation in Idaho would be primarily affected by increased regional power costs. The Montana communities would also be minimally affected by changing levels of recreation activities at Hungry Horse Reservoir.

While overall impacts are generally minor (with the exception of the potential impacts of dam modification construction), the individuals who lose jobs would be the most adversely affected group. Losing a job and having to look for another is very stressful to the individual and the family. Some individuals might have to leave their current location to obtain employment, which could mean an unwanted change in lifestyle.

4.3 SUMMARY COMPARISON OF SOS ALTERNATIVES

Section 4.3 is the "heart of the EIS" (as termed by CEQ [40 CFR 1502.14]) with respect to the SOS decision. It compares the environmental impacts of the SOS alternatives, defining the issues and providing a clear basis for choice among the options.

The text of Section 4.3 is based on Table 4-27, which is a master table comparing the key attributes of the SOS alternatives. The table presents selected value measures for each resource or subject area by alternative. The following discussion highlights key observations and conclusions from the table and the supporting analysis. Chapter 8 describes how the agencies have approached overall comparison and evaluation of the SOS alternatives and identification of a preferred alternative.

4.3.1 Summary of Effects by SOS

SOS 1–Pre-ESA Operation

Returning to river operations before they were modified by the 1990 Salmon Summit and the ESA to benefit anadromous fish would differ little from current operations except for power and recreation. SOS 1b would save $72 million annually, compared to today, in system power generating costs. SOS 1a would save $38 million. Both SOS 1 options could help to maintain or reduce today's wholesale power rates. Likewise, recreation would realize the greatest benefits under this operating strategy since recreation facilities were designed and built around traditional project operations. SOS 1b would provide more recreation benefits than any other alternative, an increase in average annual benefits of $7.9 million over today.

The effects of SOS 1 on anadromous fish would be much like existing conditions, although the study found this alternative had lower rates of successful juvenile passage and adults returning to spawn than most of the other alternatives. The analysis showed water temperature problems in the lower Snake River would occur in the summer, with temperatures exceeding the 63°F (17°C) value measure up to 79 days per year. The operations around the reservoirs that occur today, such as normal drafting for power generation, would continue with the same effects on resident fish, wildlife, erosion, aesthetics, cultural resources, and Indian trust assets. Navigation, irrigation, and M&I water supply uses would experience normal favorable conditions.

SOS 2–Current Operations

As might be expected, introducing flow improvements to benefit migrating anadromous fish diminishes the effectiveness of the system for traditional river uses. Both SOS 2 options would be more expensive than SOS 1 for power generation. This is because flow augmentation in the spring and summer requires storing water in the winter, a time when it would ordinarily be used to generate electricity. For anadromous fish, juvenile survival rates were studied for fish traveling in-river to the ocean and for fish transported under the Corps' Juvenile Fish Transportation Program. In the study, transportation emerged as the most important factor for juvenile fish survival over the next 5 to 10 years. Under SOS 2, the survival rates for juvenile passage and adult returns generally fell in the middle range of all the alternatives.

More frequent lowering of water levels in the storage projects than under SOS 1 would decrease the chance of refill, which would worsen conditions for resident fish and could reduce recreational use somewhat (1 percent less than SOS 1a). Because SOS 2d calls for additional water releases at Libby Dam to

Table 4-27. Environmental comparison of SOS alternatives—1

Resource/ Subject Area	SOS 1 Pre-ESA Operation	SOS 2 Current Operations	SOS 4 Stable Storage Project Operation
Earth	• Continued moderate-to-severe erosion and mass wasting on storage project shorelines. • Minor erosion and mass wasting on run-of-river project shorelines. • Sediment accumulation in all reservoirs at historical rates; redistribution in storage reservoirs. • Seasonal groundwater fluctuations near storage reservoirs; no known significant effects on wells.	• Continued moderate-to-severe erosion and mass wasting at storage reservoirs but at less than historical rates. • Minor erosion and mass wasting at run-of-river projects, similar to historical conditions. • Sedimentation patterns similar for historical patterns • Groundwater fluctuations less than historical conditions with no net effects on water supply.	• Major decrease in erosion, mass wasting, and sedimentation at Libby and Hungry Horse. • Slight decrease in erosion and mass wasting at Albeni Falls, Grand Coulee, and Dworshak. • Groundwater fluctuations within historical limits except at Libby and Hungry Horse, where groundwater fluctuations would decrease moderately. Slight decrease in fluctuations near Albeni Falls, Grand Coulee, and Dworshak.
Water	• 83 to 93 days per year with temperature exceeding 63°F at The Dalles, 66 to 79 days at Lower Granite, and 63 to 75 days at Priest Rapids. • Up to 83 days per year exceeding 110 percent total dissolved gas (TDG) standard at Ice Harbor, 100 days at The Dalles. • Sediment conditions similar to SOS 2.	• 83 to 94 days per year with temperature exceeding 63°F at The Dalles, 67 to 84 days at Lower Granite, and 67 to 77 days at Priest Rapids. • Up to 61 days exceeding TDG standard at Ice Harbor (22 days less than SOS 1), 101 days at The Dalles. • No exceedance of 25 mg/l silt level, no significant sediment transport.	• 83 to 90 days per year with temperature exceeding 63°F at The Dalles, 74 to 80 days at Lower Granite, and 64 to 70 days at Priest Rapids. • Up to 61 days exceeding TDG standard at Ice Harbor (same as SOS 2), 92 days at The Dalles. • Sediment conditions similar to SOS 2.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—1

SOS 5 Natural River Operation	SOS 6 Fixed Drawdown	SOS 9 Settlement Discussion Alternatives	SOS PA Preferred Alternative
• Minor increase in erosion, mass wasting, sedimentation, and groundwater fluctuation at Dworshak. Same as SOS 2c for other storage reservoirs. • Major increase in erosion, mass wasting, and water table lowering at the four lower Snake reservoirs (decreasing to background after 5 to 15 years for SOS 5c); also damage to embankments and shoreline structures. • Major increase in sedimentation at McNary. • Slight increase in erosion and mass wasting at John Day, with slight lowering of spring-summer water table.	• Same as SOS 5 for storage projects. • Large increase in erosion, mass wasting, and sedimentation on the four lower Snake projects (SOS 6b) or Lower Granite only (SOS 6d), although only about 1/3 as much as SOS 5b. • Moderate decrease in water table during drawdown along the lower Snake reservoirs. • Moderate increase in sedimentation at McNary. Same as SOS 5b for John Day. Same as SOS 2 for other run-of-river projects.	• Moderate decrease in erosion, mass wasting, and sedimentation at Libby and Hungry Horse (all options). • Moderate increase in erosion, mass wasting, and sedimentation at Dworshak (9a and 9b) and Brownlee (all SOSs). • Slight decrease in erosion, mass wasting, and sedimentation at Grand Coulee. • Major increase in mass wasting, erosion, sedimentation, and groundwater fluctuations on the four lower Snake River Projects (SOSs 9a and 9c). • Effects at John Day same as SOS 5 (SOSs 9a and 9c) or as under current operation (SOS 9b).	• Moderate decrease in erosion, mass wasting, sedimentation, and groundwater fluctuations at Libby and Hungry Horse. Moderate increase in these effects at Dworshak. At John Day, temporary increase in erosion and mass wasting, and permanent lowering of water table near the reservoir. • All other projects would continue to experience conditions within historical ranges.
• 83 to 94 days per year with temperature exceeding 63°F at The Dalles, 58 to 76 days at Lower Granite, and 58 to 85 days at Priest Rapids. • Up to 2 days exceeding TDG standard at Ice Harbor (59 less than SOS 2), 83 days at The Dalles. • Maximum silt concentrations, exceeding 25 mg/l up to 36 percent of the time in the first year, 25 percent of time long-term. • Lead and DDT in sediments transported downstream to McNary, large increase in exceedance levels. • Prolonged reservoir bank erosion for SOS 5c would continually load lower Snake with sediments.	• 83 to 93 days per year with temperature exceeding 63°F at The Dalles, 61 to 81 days at Lower Granite, and 67 to 72 days at Priest Rapids. • Up to 65 days exceeding TDG standard at Ice Harbor (4 more than SOS 2), 102 days at The Dalles. • Major sediment transport, but 1/4 to 2/3 of SOS 5b. Maximum concentrations exceed 25 mg/l 24 percent of time in first year, 5 percent long-term. • Lead and DDT in sediments transported elsewhere in lower Snake pools.	• The worst SOS for water temperature. Consistently high number of exceedance days in the lower and mid-Columbia and Snake rivers. 87 to 95 days per year with temperature exceeding 63°F at The Dalles, 79 to 86 days at Lower Granite, and 71 to 80 days at Priest Rapids. • Overall worst SOS for gas supersaturation. Days exceeding 110 percent standard at Ice Harbor would be 91 more than No Action Alternative. At The Dalles there would be 82 more days. • SOS 9a and SOS 9c sediment transport would be similar to SOS 6b. SOS 9b would be similar to SOS 2.	• Overall, SOS PA water temperatures are not significantly different from SOS 2. 87 to 92 days per year with temperature exceeding 63°F at The Dalles, 69 to 78 days at Lower Granite, and 67 to 77 days at Priest Rapids. • High exceedance of 110 percent gas saturation standard at The Dalles, up to 77 days more than SOS 2c, but about average in mid-Columbia and lower Snake. • Sediment transport similar to SOS 2.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—2

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Air	• Dust emissions at Lower Granite (SOS 1a), Libby, and John Day could result in PM_{10} concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Lowest criteria and total air pollutant emissions from thermal power plants generating replacement electricity for the year 2004.	• Dust emissions at Libby could result in PM_{10} concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Low dust emissions would result in small concentrations for all wind speeds at Lower Granite and John Day. • Lowest total air pollutant emissions from thermal power plants generating replacement electricity for the year 2004.	• Dust emissions at Libby could result in PM_{10} concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Low emissions will result in small concentrations for all wind speeds at Lower Granite.
Anadromous Fish	• Relatively moderate passage survival and adult escapement for most salmon and steelhead, differences from existing conditions would be slight.	• Similar juvenile in-river passage survival and adult escapement for most stocks, which represent existing conditions without transportation. Passage survival and adult escapement in the middle range of alternatives. • With transport, one of higher juvenile passage survivals (SOS 2d) for most transport hypotheses.	• Nearly the same as existing conditions for juvenile in-river passage survival with transport, and adult production for most stocks.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—2

SOS 5	SOS 6	SOS 9	SOS PA
• Highest dust emission rates for the lower Snake reservoirs. • Dust emissions at Lower Granite and John Day could result in PM_{10} concentrations greater than AAQS for maximum 1-hour wind speeds at locations immediately adjacent to the emission source. • Dust emissions at Libby could result in PM_{10} concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Contaminated sediments could result in airborne concentrations greater than ASILs for locations adjacent to source of sediments in drawdown reservoirs. • Highest criteria and total air pollutant emissions from thermal power plants generating replacement electricity for the year 2004.	• Dust emissions at Lower Granite and John Day could result in PM_{10} concentrations greater than AAQS for maximum 1-hour wind speeds at locations immediately adjacent to the emission source. • Dust emissions at Libby could result in PM_{10} concentrations greater than AAQS for fastest-mile winds at locations immed iately adjacent to the emission source.	• Dust emissions at Lower Granite and John Day could result in PM_{10} concentrations greater than AAQS for maximum 1-hour wind speed at locations immediately adjacent to the emission source for SOS 9a and 9c. • Dust emissions at Libby would result in PM_{10} concentrations greater than AAQS for fastest-mile winds at locations immed iately adjacent to the emission source. • Highest criteria and total air pollutant emissions from thermal power plants generating replacement electricity for the year 1996.	• Low dust emissions would result in small concentrations for all wind speeds at Lower Granite and John Day. • Lowest criteria air pollutant emissions from thermal power plants generating replacement electricity for the year 2004.
• Highest modeled in-river passage survival for Snake River stocks. • With transport, depending on passage and transport model used, survival of Snake River spring and summer chinook–low to high; steelhead–medium; fall chinook–low. • Other salmon and steelhead stocks similar to existing conditions. • Based on one or two transport migrant models, adult production was considerably lower than existing conditions for all Snake River stocks except summer chinook, which was the highest of any alternative. • Drawdown first year would cause significant adverse effects to Snake River stocks, primarily rearing fall chinook, from high suspended sediment load and reduced food supply. Adverse effects would be reduced (5b) or eliminated (5c) in later years.	SOS 6b: • Some of the higher or lower in-river passage survivals for Snake River stocks; other stocks' in-river survival similar to existing. • With transport, depending on hypotheses, usually one of lowest Snake River spring chinook passage survivals. Usually low passage survival for other Snake River stocks even with optimistic assumptions. Passage survival of Snake River spring and summer chinook is slightly higher without transport for one of the transport hypotheses. • Possible adverse effects on adult passage success on the Snake River, particularly for spring and summer chinook, from new untested adult passage facilities.	• Some of the highest in-river survivals of the lower river Deschutes spring chinook, while similar to other SOS alternatives for Rock Creek steelhead survival. • Slightly higher in-river survival, particularly 9a, for the mid-Columbia stocks. Survival improved with transport (SOS 9b and 9c), but with slightly lower overall survival than most other alternatives for most transport models. • SOSs 9a and 9c similar to 6b for in-river effects, having in-river survival higher and lower than most SOSs depending on dam passage assumptions for Snake River stocks, except fall chinook under 9c, which was the lowest of any alternative. • SOS 9c had higher overall Snake River survival with transport, for most transport hypotheses, under optimistic dam passage conditions resulting in relatively high survival, while pessimistic passage assumptions resulted in low survival for all transport hypotheses.	• Snake River in-river survival in the middle range of alternatives, similar to SOS 2. Transport resulted in significant improvement in survival, except one transport hypothesis which had survival similar to in-river. Among the highest alternatives for Snake River stocks for overall survival based on most transport hypotheses. • In-river survival of mid-Columbia and lower Columbia stocks similar to most other alternatives, in the mid-to-upper range for most stocks. Since transport does not occur for Wenatchee steelhead or Methow spring chinook with this alternative overall survival would be slightly less than alternatives with transport based on assumed transport survival. However, with transport, Methow summer and Hanford fall chinook have overall survival in the high range of all SOS alternative.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—3

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Anadromous Fish *continued*			
Resident Fish	• Variable conditions among reservoirs and species; some key populations declining. • Production in run-of-river projects limited somewhat by pool fluctuations. • Production in storage projects significantly limited by annual drafting, and by failure to refill in low-runoff years.	• Similar to SOS 1. • Poorer conditions for Dworshak kokanee, bull trout, and smallmouth bass. • Improved conditions for Koocanusa kokanee.	• Best SOS overall for resident fish except Kootenai River sturgeon; conditions generally the same as or better than SOSs 1, 2, 5, 6 or PA. • Improved conditions primarily at Lake Pend Oreille, Koocanusa, Hungry Horse, and Dworshak. • Moderately improved conditions for Kootenai River sturgeon through enhanced flow during spawning.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—3

SOS 5	SOS 6	SOS 9	SOS PA
• Possible adverse effects to other anadromous stocks including lamprey and American shad from reduced rearing habitat quality and quantity and from stranding, but overall population effects very small. • Benefits highly speculative due to experimental nature of	SOS 6d: • Snake River spring and summer chinook and steelhead in-river passage survival higher or lower and fall similar to most other SOSs, depending on dam passage assumptions. • Snake River stock survival generally is much higher with transport than without for two of three transport hypotheses. For the third transport model, survival is only slightly lower than in-river survival for spring and summer chinook. General: • American shad passage possibly impeded, particularly with SOS 6b. • Increased suspended sediment and reduced rearing habitat could adversely affect rearing fall chinook, American shad and lamprey, particularly for 6b. • Benefits speculative due to experimental nature of actions, particularly for 6b.	• SOS 9b has slightly higher in-river survival of Snake River spring and summer chinook, and lower survival for fall chinook and Dworshak steelhead than existing conditions. Inclusion of transport resulted in overall survival of Snake stocks being slightly lower than existing conditions except for fall chinook which is much lower. Overall survival generally improved with transport, except for one of three transport models, where values were slightly less than in-river survival (spring and summer chinook). • Adult production of Snake stocks was typically very low based on transport models, except for 9b which was moderately low relative to existing conditions. The two mid-Columbia stocks were also lower than most, particularly 9a, which has no transport. • General effects on American shad, lamprey, rearing fall chinook habitat from drawdown of 9a and 9c similar to 6b. • Benefits of 9a and 9c are speculative due to the experimental nature of these actions.	• Adult production for all six stocks evaluated was in the upper range of all SOS alternatives, based on transport model survival hypotheses used.
• Generally poor in most areas; some reservoirs having improved conditions, particularly for SOS 5c. • Significantly worse conditions at lower Snake River Projects (5b only), and at John Day (SOSs 5b and 5c). • Improved conditions at Roosevelt and Dworshak (SOSs 5b and 5c) and the lower Snake River projects (SOS 5c).	• Conditions generally the same as SOS 5, but not as severe. • Under SOSs 6b and 6d, conditions worse at Lower Granite and John Day.	• SOS 9 contains some of the worst and best resident fish conditions of all SOSs, with all providing, at a minimum, acceptable flows for Kootenai River sturgeon • SOS 9a has some of the worst resident fish conditions in most areas, but best conditions for Kootenai River sturgeon, particularly poor resident fish conditions, occur in Koocanusa, Hungry Horse, Roosevelt, and John Day. • SOS 9b is generally good in many areas including Hungry Horse, Pend Oreille, Lower Granite, and John Day, but very poor for Brownlee and Dworshak. • SOS 9c has resident fish conditions both high and low; high quality conditions occurring in Koocanusa and Hungry Horse and very good conditions for Kootenai sturgeon; poor conditions occur in Brownlee and lower Snake River region.	• Overall conditions are better than many other alternatives for resident fish under SOS PA. • Resident fish conditions are slightly better in Lake Roosevelt, Lower Granite, and other lower Snake projects; substantial improvements for Kootenai River sturgeon and John Day. • Conditions somewhat worse in some areas, primarily Dworshak.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—4

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Wildlife	• Wildlife resources largely unchanged from current conditions. Downward trends might continue.	• Long-term downward trend of wildlife resources. • Productivity of nesting waterfowl at John Day slightly reduced as a result of lowered water levels compared to historical levels.	• Greatest systemwide wildlife benefits provided. • More than 1,100 acres of shoreline at Lake Pend Oreille suitable for reestablishment of marsh and riparian habitat exposed. • Wildlife populations moderately increase over existing conditions at Libby and Hungry Horse. • SOS 4c would reduce spring drawdown at Grand Coulee and increase wetland habitat for most categories of wildlife. • Higher February and March pools at Brownlee would decrease landbridging of islands used for nesting by Canada geese and colonial nesting birds.
Cultural Resources	• Ongoing shoreline erosion and exposure of archaeological sites, largely at the same rate as current conditions. Some additional erosion and bank sloughing due to hydropower operations under SOS 1b may occur.	• Ongoing shoreline erosion and exposure of archaeological sites largely at the same rate as current conditions. Increase in bank sloughing due to flow augmentation may affect archaeological sites under SOS 2d.	• Very high rates of shoreline erosion at archaeological sites in storage reservoirs, particularly Albeni Falls. Concomitant decrease in exposure of archaeological sites to vandalism and erosion due to higher pools at these reservoirs.
Native Americans	• Continued shoreline erosion and mass wasting of lands used for hunting and gathering. • Reduced salmon populations jeopardize treaty fish rights. • Limited ability of Federal government to meet trust responsibilities because of diminished resident and anadromous fish populations. • Diminished traditional Indian way of life dependent on salmon and seasonal round.	• Similar to SOS 1 except for improved salmon survival.	• Improved conditions for resident fish and wildlife trust assets at most storage projects. • Possible negative impacts on wildlife at Grand Coulee, Hanford Reach, and lower Clearwater River. • Conditions for salmon same as SOS 2, continuing decline of populations and further jeopardizing treaty rights. • Continued erosion and mass wasting of traditional-use areas.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—4

SOS 5	SOS 6	SOS 9	SOS PA
• Greatest loss of wildlife resources at Lower Snake and John Day projects of all SOSs. • Desiccation of submerged aquatic vegetation and mud-dwelling animals, and increased reconnection of submerged islands to the shore. • Greatest decline in waterfowl, shorebirds, aquatic furbearers, and all other categories of wildlife are expected. • Lowering of John Day reservoir would totally dry up existing marsh and riparian habitat, eliminating breeding activity of existing waterfowl and colonial nesting bird populations and significantly reducing reptile and other categories of wildlife. • SOS 5c would restore natural river flows to the four lower Snake projects and allow for long-term restoration of wetland and riparian habitat desiccated at time of initial drawdown.	• SOS 6b same as SOS 5b. SOS 6d same as SOS 6b except adverse effects at lower Snake projects would be limited to Lower Granite.	• SOS 9a would desiccate wetland, riparian, backwater and pond habitats at John Day with large reductions in waterfowl, colonial nesting birds, non-game birds, aquatic furbearers, reptiles and other wildlife; decreased numbers of colonial nesting birds and other wildlife at Libby, Hungry Horse and Brownlee; increased wetland and wildlife at Albeni Falls. • SOS 9b would provide benefits to wildlife similar to SOS 4, but no improvement for wildlife at Libby or Hungry Horse. • SOS 9c would desiccate habitat at John Day similar to SOS 9a; increased wetland at Libby and Hungry Horse; loss of emergent wetland at lower Snake projects	• Would desiccate wetland, riparian, backwater and pond habitats at John Day, similar to SOS 5b, with large reductions in waterfowl, colonial nesting birds, non-game birds, aquatic furbearers, reptiles and other wildlife; relatively stable water levels at John Day would provide opportunity for restoring some if not all lost habitat, over long term; reduction in numbers of waterfowl, colonial nesting birds, nongame birds and amphibians at Grand Coulee; possible adverse effects on shorebirds and cobble habitat at Hanford Reach, but benefits waterfowl and colonial nesting birds.
• Dramatic increase in the amount of time that archaeological sites are exposed in a drawdown zone at the lower Snake River projects because of drawdowns to natural river level. Less shoreline erosion would take place at these projects. Permanent drawdowns under SOS 5c, however, would restore access to more than 200 archaeological sites and would lead to protective revegetation.	• Exposure of archaeological sites in the drawdown zone would increase at the lower Snake projects, but not as dramatically as with SOS 5. Only Lower Granite would be affected under SOS 6d. There would be a corresponding small improvement in rate of shoreline erosion impact at these reservoirs.	• Damage to archaeological sites due to both shoreline erosion and exposure of archaeological sites in the drawdown zones would increase. There would be increased bank sloughing due to flow augmentation under SOSs 9a and 9b. Site exposure would increase at the lower Snake projects under SOSs 9a and 9c, at Libby, Grand Coulee, and Hungry Horse under SOS 9a, and at Dworshak under SOS 9b due to drawdowns.	• Ongoing shoreline erosion and exposure of archaeological sites would change little overall from current conditions. Exposure of archaeological sites in the drawdown zone would increase at Dworshak and John Day. The amount of time shoreline waves could affect John Day sites would decrease.
• Improved survival of anadromous fish, benefiting treaty right. • Damage to most other Indian resource interests: resident fish, wildlife, destabilization of traditional-use areas, at least in the short term. • Overall benefit to cultural and traditional-use sites with long-term recovery under SOS 5c.	• Similar to SOS 5 except effects limited to Lower Granite under SOS 6d.	• Positive effects on anadromous fish trust assets compared to SOS 2. • Varied impacts on wildlife and vegetation from reservoir to reservoir. • Desiccation of riparian vegetation and erosion of traditional-use sites in lower Snake River and John Day drawdown zones under SOS 9a or 9c.	• Improved migration conditions for anadromous fish, benefitting recovery and treaty rights. • Reduced wetland vegetation and wildlife habitat at Grand Coulee, Hanford Reach, and lower Clearwater River. • Some adverse impacts on resident fish trust assets at storage reservoirs.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—5

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Aesthetics	• Minimal shoreline exposure at run-of-river projects. • Late winter, early spring drawdowns expose significant amounts of shoreline at storage projects.	• Minimal shoreline exposure at run-of-river projects. • Late winter, early spring drawdowns expose significant amounts of shoreline at storage projects; slight decrease compared to SOS 1.	• Minimum shoreline exposure at run-of-river projects. • Best SOS for aesthetic quality of storage projects.
Recreation	• Total systemwide visitation: SOS 1a–18,267,700, SOS 1b–18,305,600. • McNary, Bonneville, and John Day estimated to each receive between 2.7 and 3.2 million recreation days. • The Dalles, Lower Granite, Grand Coulee, and Lake Pend Oreille estimated to each receive between 1.2 and 1.6 million recreation days. • Ice Harbor, Libby, Hungry Horse, Little Goose, Lower Monumental, Dworshak, and Clearwater River estimated to receive between 109,000 and 525,000 recreation days. • The Snake River, Hells Canyon, the Canadian Columbia River, Chief Joseph, and the Kootenai River expected to receive between 34,000 and 48,000 recreation days. • Systemwide visitation up to 262,000 recreation days or 1.5 percent (SOS 1b) more than SOS 2c. • Annual benefit increase of $4.7 million (SOS 1a) to $7.9 million (SOS 1b) compared to SOS 2c, using a 3 percent discount rate.	• Total systemwide visitation: SOS 2c–18,043,600, SOS 2d–18,057,300. • McNary, Bonneville, and John Day estimated to each receive between 2.6 and 3.2 million recreation days. • The Dalles, Lower Granite, Grand Coulee, and Lake Pend Oreille estimated to each receive between 1.2 and 1.7 million recreation days. • Ice Harbor, Libby, Hungry Horse, Dworshak, Clearwater River, Little Goose, and Lower Monumental estimated to receive between 129,000 and 607,000 recreation days. • Kootenai River, Columbia River in Canada, Chief Joseph, Snake River, and Hells Canyon expected to receive between 35,000 and 48,000 recreation days. • Systemwide visitation up to 225,000 recreation days (1.2 percent) less than under typical historic conditions (SOS 1a). • Annual average benefit reduction of $5.0 million (SOS 2d) compared to SOS 2c, using a 3 percent discount rate.	• Total systemwide visitation: SOS 4c–18,236,300. • Generally, slight increase in visitation at storage reservoirs, except Lake Pend Oreille and Clearwater River. • Slight decrease in visitation at Little Goose. • Systemwide visitation up to 193,000 recreation days or 1.0 percent more than SOS 2c. • Annual benefits increase by $4.2 million compared to SOS 2c, using a 3 percent discount rate.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—5

SOS 5	SOS 6	SOS 9	SOS PA
• Significant amount of exposed shoreline at lower Snake and John Day projects for 4-1/2 months (SOS 5b) or permanent natural river operation (SOS 5c). SOS 5b worst for aesthetic quality at Snake and Columbia run-of-river projects. Possible long-term aesthetic recovery on lower Snake under SOS 5c. • No or minor aesthetic impacts to other run-of-river projects. • No incremental aesthetic impacts to storage projects.	• Significant amount of exposed shoreline at lower Snake River projects under SOS 6b (less than SOS 5), or only at Lower Granite under SOS 6d. • Similar to SOS 5 for other run-of-river (including John Day) and storage projects.	• Significant shoreline exposure at lower Snake River projects and John Day under SOSs 9a and 9c, similar to SOS 6. • Minimal shoreline exposure at run-of-river projects under SOS 9b. • SOS9a would have greatest shoreline exposure among all SOSs for Libby, Hungry Horse, and Grand Coulee. • Greatest shoreline exposure at Dworshak under SOS 9b; exposure at other storage projects under SOS 9b same as or less than SOS 2c. • For SOS 9c, shoreline exposure at storage reservoirs same as SOS 4c, except for large increase at Dworshak.	• Permanent significant shoreline exposure at John Day. • Minimal shoreline exposure at other run-of-river projects. • Shoreline exposure at Libby, Albeni Falls, and Grand Coulee comparable to SOS 2c. • Significant increase in shoreline exposure at Dworshak, comparable to SOS 9c. • Significant decrease in shoreline exposure at Hungry Horse, similar to SOSs 4c, 9b, and 9c.
• Total systemwide visitation: SOS 5b–16,221,500, SOS 5c–15,970,600. • Significant decrease in visitation at lower Snake projects and John Day. • Systemwide visitation as much as 2,073,000 recreation days or 11.5 percent (SOS 5c) less than SOS 2c. • Annual benefits decrease by as much as $89.8 million (SOS 5c) compared to SOS 2c, using a 3 percent discount rate.	• Total systemwide visitation: SOS 6b–16,886,400, SOS 6d–17,182,900. • Significant decrease in visitation at lower Snake projects and John Day. • Systemwide visitation up to 1,157,000 recreation days or 6.4 percent (SOS 6b) less than SOS 2c. • Annual benefits decrease by as much as $49.1 million (SOS 6b) compared to SOS 2c, using a 3 percent discount rate.	• Total systemwide visitation: SOS 9a–15,986,400, SOS 9b–17,631,000, SOS 9c–17,152,800. • SOS 9a and 9c similar to SOS 6b, with significant decrease in visitation at lower Snake projects and John Day. • SOS 9b similar to SOS 2c for run-of-river projects, but with decrease in visitation at storage projects, except for Hungry Horse. • Systemwide visitation up to 2,057,600 days or 11.4 percent (SOS 9a) less than SOS 2c. • Annual benefits decrease by $37.9 million (SOS 9c) to $96.9 million (SOS 9a), using a 3 percent discount rate.	• Total systemwide visitation: 16,929,200. • Significant increase in visitation at Clearwater River, slight increase at Lake Pend Oreille, Lower Granite, and Hungry Horse. • Significant decrease in visitation at Kootenai River, Dworshak, John Day; slight to moderate decrease at Libby and Grand Coulee. • Systemwide visitation: 1,114,000 days or 6.2 percent less than SOS 2c. • Annual benefits decrease by $26.4 million, using a 3 percent discount rate.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—6

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Flood Control	• Flooding risk in lower Columbia reach unchanged from current conditions. • Upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages under SOS 1a or 1b the same as with SOS 2c.	• Flooding risk in lower Columbia reach unchanged from current conditions. • Upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages under SOS 2d the same as with SOS 2c.	• Upper Columbia region accounts for virtually all flood damages. • With many reservoirs kept full later in the season, an increase in flood risk would occur in most upper Columbia and Clearwater reaches. • Higher flood risks at Columbia Falls compared to SOS 2c. • Flooding in lower Columbia reach unchanged from current conditions. • Average annual flood damages $0.4 million more than SOS 2c and among highest of all SOSs, using a 3 percent discount rate.
Navigation	• Normal conditions for deep-draft navigation on Columbia River and shallow-draft navigation on Columbia-Snake Inland Waterway. • Annual shallow-draft navigation costs average the same as under SOS 2c. • Improved conditions for Dworshak log transport; annual transport costs average $0.1 million less than under SOS 2c, using a 3 percent discount rate. • Total net annual navigation costs about $0.1 million less than SOS 2c, using a 3 percent discount rate. • Normal conditions for Lake Roosevelt ferry operations	• Normal conditions for deep-draft and shallow-draft navigation for SOS 2c. • Annual shallow-draft navigation costs average the same under SOSs 2c and 2d. • Shorter operating season for Dworshak log transport; annual transport costs average $0.1 million more (SOS 2d) than under SOS 2c, using a 3 percent discount rate.	• Normal conditions for deep-draft and shallow-draft navigation. • Annual shallow-draft navigation costs average the same as under SOS 2c. • Improved operating conditions for Dworshak log transport under SOS 4c; annual transport costs average $0.2 million less than SOS 2c. • Total net annual navigation costs about $0.2 million less than SOS 2c, using a 3 percent discount rate. • Normal conditions for Lake Roosevelt ferry operations.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—6

SOS 5	SOS 6	SOS 9	SOS PA
• Flood risk in all areas similar to SOS 2c; upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages the same as with SOS 2c.	• Flood risk in all areas similar to SOS 2c; upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages the same as with SOS 2c.	• Flood risk in lower Columbia and Clearwater areas unchanged from current conditions. • Upper Columbia regions account for virtually all flood damages. • Average annual flood damages range from just over $27,000 more than SOS 2c (SOS 9b) to nearly $0.5 million more than SOS 2c (SOS 9c), using a 3 percent discount rate.	• Flood risk in lower Columbia and Clearwater areas unchanged from current conditions. • Upper Columbia regions account for virtually all flood damages. • Average annual flood damages $0.2 million more than SOS 2c, using a 3 percent discount rate.
• No shallow-draft navigation on lower Snake for about 6 months (SOS 5b) or permanently (SOS 5c). • Annual shallow-draft navigation costs average $13.6 million (SOS 5b) to $37.5 million (SOS 5c) more than under SOS 2c. • Improved Dworshak log transport conditions; annual transport costs average up to $0.2 million less than for SOS 2c. • No impacts to deep-draft navigation or Lake Roosevelt ferries. • Total net annual navigation costs $13.6 million (SOS 5b) to $37.4 million (SOS 5c) more than SOS 2c, using 3 percent discount rate.	• No shallow-draft navigation on lower Snake for 6 months (SOS 6b), or on Lower Granite only for 6 months (SOS 6d). • Annual shallow-draft navigation costs $2.1 million (SOS 6d) to $12.3 million (SOS 6b) more than under SOS 2c. • Dworshak annual log transport costs average $0.1 million less than SOS 2c. • No impacts to deep-draft navigation or Lake Roosevelt ferries. • Total net annual navigation costs $2.0 million (SOS 6d) to $12.2 million (SOS 6b) more than SOS 2c.	• No shallow-draft navigation on lower Snake for 6 months (SOS 9a) or 3 months (SOS 9c); probable delays at locks under SOS 9b. • Annual shallow-draft navigation costs range from the same as SOS 2c (SOS 9b) to $12.3 million more than SOS 2c (SOS 9a). • Slightly improved conditions for Dworshak log transport under SOS 9a, 9c; worse conditions for SOS 9b. • Compared to SOS 2c, annual log transport costs about the same for SOS 9a, 9c, $0.2 million more for SOS 9b. • No impacts to deep-draft navigation. • Slight impacts to Gifford ferry under SOS 9b, 9c. • Total net annual navigation costs $0.2 million (SOS 9b), $7.4 million (SOS 9b) or $12.3 million (SOS 9a) more than SOS 2c, using a 3 percent discount rate.	• Normal conditions for deep-draft and shallow-draft navigation. • Annual shallow-draft navigation costs nearly the same as SOS 2c. • Shorter operating season for Dworshak log transport, annual costs average $0.1 million more than under SOS 2c. • No impacts to deep-draft navigation or Lake Roosevelt ferries. • Total net annual navigation costs $0.1 million more than SOS 2c.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—7

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Power	• SOS 1b is the least expensive alternative for satisfying regional energy needs. • Energy production would be at its highest and load-shaping capability would be maximized. • Annual system generation costs (at 3 percent discount rate) $72 million (SOS 1b) to $38 million (SOS 1a) less than SOS 2c. • Wholesale rates comparable to today's level.	• Flow augmentation in the spring and summer slightly reduces system efficiency compared to SOS 1b. • Annual system generation cost (at 3 percent discount rate) $24 million higher under SOS 2d compared to SOS 2c. • Wholesale rates at today's level.	• Stable storage project operation would slightly reduce average annual generation compared to SOS 2c and enlarge the mismatch between flows and generation needs. • Annual system generation costs $85 million (at 3 percent discount rate) more than SOS 2c. • Wholesale rates comparable to today's level.
Irrigation	• All irrigation needs served; irrigators incur routine expenses to operate and maintain pumps. • Minor increase in annual pumping costs at Grand Coulee, compared to SOS 2c ($9,000).	• All irrigation needs served; irrigators incur routine expenses to operate and maintain pumps. • Under SOS 2d, irrigators would experience minor savings in annual pumping costs at Grand Coulee, compared to SOS 2c ($3,300).	• All irrigation needs served; irrigators incur routine expenses to operate and maintain pumps. • Minor savings in annual pumping costs at Grand Coulee ($18,400).

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—7

SOS 5	SOS 6	SOS 9	SOS PA
• Natural river operation would eliminate the system's load-shaping capability and reduce average annual energy by taking turbines out of service. • Annual system generation costs (at 3 percent discount rate) for SOS 5b and SOS 5c about $85 million and $167 million, respectively, more than SOS 2c. • Wholesale rates comparable to today's level.	• Generation effects similar to SOS 5, particularly under SOS 6b. • Annual system generation costs (at 3 percent discount rate) for SOS 6d and SOS 6b about $17 million and $35 million, respectively, more than SOS 2c. • Wholesale rates comparable to today's level.	• Drawdown (with SOS 9a or 9c) and large amounts of spill would reduce average annual hydropower generation compared to SOS 2c). • Annual system generation costs (at 3 percent discount rate), $138 million (SOS 9c), $236 million (SOS 9a), and $213 million (SOS 9b) more than SOS 2c. • Wholesale rates comparable to today's level.	• Increased water storage in fall and winter and increased spill during spring and summer would mismatch flow and generation needs. Average annual hydropower generation would fall compared to SOS 2c. • Annual system generation costs (at 3 percent discount rate) about $126 million more than SOS 2c. • Wholesale rates comparable to today's level.
• Drawdowns at Ice Harbor and John Day require irrigators to modify pumps and increase operating expenses. • Annual irrigation pumping costs at Ice Harbor increase by $2.3 million (SOS 5b) or $3.2 million (SOS 5c) compared to SOS 2c using a 3 percent discount rate. • Annual irrigation pumping costs at John Day increase by $1.0 million (SOS 5b) or $1.4 million (SOS 5c) compared to SOS 2c, using a 3 percent discount rate.	• Drawdown at Ice Harbor (SOS 6b) and John Day (SOS 6b and 6d) would require irrigators to modify pumps and increase operating expenses. • Annual irrigation pumping costs at Ice Harbor increase by $1.4 million (SOS 6b) compared to SOS 2c, using a 3 percent discount rate. • Annual irrigation pumping costs at John Day increase by $1.2 million (SOS 6b) and $1.4 million (SOS 6d) compared to SOS 2c, using a 3 percent discount rate.	• Irrigators incur a minor increase in pumping costs at Grand Coulee, ranging from $5,400 (SOS 9b) to $34,900 (SOS 9a), using a 3 percent discount rate. • Under SOS 9b, all Ice Harbor and John Day irrigators' needs are served; irrigators incur routine expenses to operate and maintain pumps. • Under SOSs 9a and 9c, drawdowns at Ice Harbor and John Day require irrigators to modify pumps and increase operating expenses. • Annual irrigation pumping costs at Ice Harbor increase by $1.4 million (SOSs 9a and 9c) compared to SOS 2c, using a 3 percent discount rate. • Annual irrigation pumping costs at John Day increase by $0.9 million (SOS 9a) or $1.2 million (SOS 9c) compared to SOS 2c, using a 3 percent discount rate.	• Minor savings in pumping costs at Grand Coulee ($2,800). • No change in pumping costs or conditions at Ice Harbor, compared to SOS 2c. • Year-round drawdown at John Day would result in a $1.5 million increase in irrigation pumping costs compared to SOS 2c, using a 3 percent discount rate.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—8

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Municipal and Industrial Water Supply	• Pumps and other facilities continue to operate, requiring routine maintenance.	• Pumps and other facilities continue to operate, requiring routine maintenance.	• Pumps and other facilities continue to operate, requiring routine maintenance.
Economics	• Most efficient SOS, from national economic development (NED) perspective. • Balance of total annual system costs from all measurable resources $42.5 million (SOS 1a) to $79.9 million (SOS 1b) less than SOS 2c, using a 3 percent discount rate. • Regional employment 2,000 jobs more than under SOS 2c, regional income $56 million higher annually.	• Baseline system costs and benefits for recreation, flood damages, irrigation, M&I water supply, navigation, power generation, and commercial and recreational use of anadromous fish. • Total annual system cost from all measurable resources $28.9 million more under SOS 2d than with SOS 2c, using a 3 percent discount rate. • Regional employment and income at baseline levels.	• Increased costs primarily for flood control and power, with increased benefits for recreation. • Total annual system cost of all measurable resources is $80.9 million higher than SOS 2c, using a 3 percent discount rate. • Regional employment about 2,200 jobs less than SOS 2c; annual regional income $61 million less.
Social	• Recent historical patterns of social stresses related to influences of river operations on employment and income. • Possible decrease in social impacts relative to SOS 2c from increased employment and income, with largest potential change in Puget Sound subregion.	• Baseline levels of social stresses related to influences of river operations on employment and income. • Key social impact is uncertainty of economic future for river user communities.	• Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts generally distributed across region through power system effects.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—8

SOS 5	SOS 6	SOS 9	SOS PA
• Drawdowns of lower Snake and John Day pools require water users to modify pumps and/or make other changes to facilities. • Average annual costs increased by $3.3 million (SOS 5b) or $4.5 million (SOS 5c) compared to SOS 2c, using a 3 percent discount rate.	• Drawdowns of lower Snake and John Day pools require water users to modify pumps and/or make other changes to facilities. • Average annual costs increased by $3.6 million (SOS 6b) or $4.1 million (SOS 6d) compared to SOS 2c, using a 3 percent discount rate.	• Pumps and other facilities continue to operate, requiring routine maintenance under 9b. • Drawdowns of lower Snake and John Day pools under SOS 9a or 9c require water users to modify pumps and/or make other changes to facilities. • Average annual costs increase by $3.6 million (SOS 9a) or $3.7 million (SOS 9c) compared to SOS 2c, using a 3 percent discount rate.	• Drawdown of John Day pool requires water users to modify pumps and/or make other changes to facilities. • Average annual costs increase by $4.3 million (SOS PA) compared to SOS 2c, using a 3 percent discount rate.
• Increased costs or reduced benefits for almost all elements, particularly recreation, anadromous fish, irrigation, M&I water supply, navigation, and power. • Average annual implementation cost $88.6 million (SOS 5b) to $24.6 million (SOS 5c) more than under SOS 2c, using 3 percent discount rate. • Total annual system cost from all measurable resources, including implementation cost, from $266.3 million (SOS 5b) to $336.5 million (SOS 5c) higher than SOS 2c, using 3 percent discount rate. • Regional employment up to about 7,500 jobs less than under SOS 2c, regional income $199 million less per year.	• Increased costs or reduced benefits for almost all elements, particularly recreation, anadromous fish, navigation, and power. • Average annual implementation cost $7.8 million (SOS 6d) to $31.6 million (SOS 6b) more than under SOS 2c, using 3 percent discount rate. • Total annual system cost from all measurable resources, including implementation cost, from $77.6 million (SOS 6d) to $145.1 million (SOS 6b) higher than SOS 2c, using a 3 percent discount rate. • Regional employment up to 2,300 jobs less than SOS 2c; annual regional income up to $59 million less.	• Increased costs or reduced benefits primarily for recreation (SOS 9a/b/c), anadromous fish (SOS 9a/b) and power (SOS 9a/b/c). • Average annual implementation cost (at 3 percent discount rate) $31.4 million (SOS 9a) or $31.7 million (SOS 9c) more than under SOS 2c. • Total annual system cost from all measurable resources, including implementation cost, from $233.2 million (SOS 9c) to $399.5 million (SOS 9a) higher than SOS 2c, using a 3 percent discount rate. • Regional employment up to 9,450 jobs less than SOS 2c, annual regional income up to $260 million less.	• Increased costs or reduced benefits primarily for recreation, M&I water supply, and power. • Average annual implementation cost (at 3 percent discount rate) $5.9 million more than under SOS 2c. • Total annual system cost from all measurable resources, including implementation cost, $164.4 million higher than SOS 2c, using a 3 percent discount rate. • Regional employment about 4,000 jobs less than SOS 2c, annual regional income $113 million less.
• Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Snake and Columbia River subregions.	• Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Snake and Columbia River subregions, particularly the Lewiston-Clarkston area under SOS 6d.	• Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Snake and Columbia River subregions, especially under SOS 9a or 9c.	• Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Columbia River subregion.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

benefit Kootenai River white sturgeon, this option would improve conditions for this ESA-listed species.

Water temperature conditions under SOS 2 parallel those for SOS 1, although exceedances of the dissolved gas standard would be somewhat less. Conditions for erosion, air quality, cultural resources, flood control, navigation, irrigation, and M&I water supply would be very similar to those under SOS 1a. Indian treaty rights and trust assets would benefit from improved salmon survival.

SOS 4–Stable Storage Project Operation

The purpose of keeping upstream storage reservoirs as full as possible for as long as possible is to benefit resident fish, wildlife, and recreation. And, in fact, SOS 4c is the only strategy that would significantly improve projected conditions for wildlife. Significant increases in wildlife habitat at Lake Pend Oreille could be expected, with habitat increases also occurring at Lake Koocanusa (Libby), Hungry Horse and Grand Coulee.

This is the best strategy for resident fish. Improved conditions would occur primarily at Lake Pend Oreille, Libby, Hungry Horse, and Dworshak. Conditions for Kootenai River white sturgeon would also improve moderately.

Despite its intention to enhance recreation, SOS 4c would increase systemwide visitation by 1 percent. This minor increase is due to greater benefits to upstream storage projects (Libby, Hungry Horse, and Dworshak), while more people currently visit downstream sites, several of which would be adversely affected by SOS 4. Annual recreation benefits were predicted to increase up to $4.2 million as a result of this strategy.

Survival rates for juvenile passage and adult returns would be about the same under SOS 4 as they are today for most stocks. Average annual power generation would decrease under SOS 4c, increasing the costs of operating the hydro system by $85 million per year.

The operations required at storage reservoirs would increase the chance of flooding in the Flathead River drainage and elsewhere in the upper Columbia reaches. Average annual flood damage could increase by $0.4 million.

Stable storage elevations also provide the best strategy for air quality and for maintaining the visual attractiveness of the reservoirs.

SOS 5–Natural River Operation

Making in-river fish migration more closely resemble conditions before the dams were built is the only strategy that has the potential for providing in-river survival rates for Snake River salmon equal to or greater than current rates achieved through fish transportation programs. The exception is fall chinook, which must be transported to maintain its already low numbers. Study models showed barging fall chinook provides greater survival rates for this stock than for any other in the basin. Overall, SOS 5 achieved the highest modeled in-river passage survival for Snake River stocks. However, barging of juvenile fall chinook from the Snake River would not be possible with this operation.

Survival rates for non-ESA salmon stocks and steelhead would be similar to those of today, except for Hanford Reach fall chinook and Methow River summer chinook, whose survival rates would decline without transportation. Survival rates for returning adults follow the same trends.

While none of the strategies would uniformly improve water quality, SOS 5 would provide the best long-term results. In the first 5 to 10 years of this operation, large amounts of sediment would be moved from the drawn-down lower Snake River reservoirs, creating a problem for fish, especially rearing fall chinook. The sediments would eventually dissipate, however, and SOS 5 would provide flows from upstream projects to keep water temperatures cooler than other alternatives. The lack of spill in SOS 5 would also keep dissolved gas saturation at more reasonable levels.

Building the river bypass structures called for in SOS 5 would cost as much as $4.1 billion and take as long as 17 years. Annualized over the period of analysis, implementation costs would be $88.6 million per year under SOS 5b and $24.6 million per year under SOS 5c.

While benefiting anadromous fish, this strategy could have severe consequences for most other river uses. Seasonal lower Snake River drawdowns (SOS 5b) would cause significant adverse impacts on resident fish in these reservoirs, although resident fish conditions would improve with the permanent natural river operation of SOS 5c. SOS 5b and SOS 6 (discussed below) would create lake-like conditions for resident fish for 8 to 10 months and river-like conditions for the rest of the year. In general, this abrupt switch in habitat would disrupt their habitat, spawning, and food supply.

Both SOS 5 and SOS 6 would initially destroy much wildlife habitat in the lower Columbia (Lake Umatilla) and lower Snake reaches. More than half the wildlife—waterfowl, shorebirds, aquatic furbearers, and others—near Lake Umatilla and in the lower Snake reaches could be lost because much emergent marsh and riparian habitat would dry up. Under SOS 5c however, permanently restoring natural river flows to the four lower Snake projects would allow for some long-term restoration of riparian and wetland habitat. The rebound in habitat and wildlife would depend on the suitability of sediments for plant growth and topography of the shoreline.

SOS 5 would eliminate power generation at several projects. Annual power system costs would increase by $85 million under SOS 5b or $167 million under SOS 5c.

Lower water levels at Ice Harbor and/or John Day pools during the irrigation season under this strategy would increase annual operating costs for irrigators, by as much as $4.5 million annually under SOS 5c. The drawdowns of the lower Snake and John Day pools under SOS 5 and SOS 6 would also require municipal and industrial water users to modify their pumps and facilities, at an annual cost of about $4.5 million under SOS 5c or $3.3 million under SOS 5b.

Erosion would increase dramatically at the four lower Snake River dams as large areas of shoreline are exposed each year after initial drawdown, although the rate of erosion would decrease to background levels after the initial years under SOS 5c. Cultural resource sites at these projects would suffer major damage; 96 percent of these sites would be affected. However, SOS 5c would restore access to more than 200 sites.

SOS 5b would interrupt navigation during the spring and summer, while SOS 5c would permanently eliminate shallow-draft navigation on the lower Snake River. Activities at lower Snake River ports would shift to other locations on a seasonal or year-round basis. Annual shallow-draft transportation costs would increase by $13.6 (SOS 5b) or $37.5 million (SOS 5c) over SOS 2c.

SOS 5c (with permanent natural river drawdown) presents the worst scenario for recreation, an 11.5 percent drop in recreational visitors systemwide. This would translate into a loss of $89.8 million in recreation-related benefits. Recreational visits at the lower Snake projects could drop by up to 75 percent. John Day's visitor levels could drop over 20 percent if the project is drawn down as proposed in SOS. 5

SOS 6–Fixed Drawdown

This strategy calls for less severe drawdown of lower Snake River projects than SOS 5—33 feet (10 m) compared to 100 feet (30.5 m)—but the effects would be similar.

The anadromous fish analysis used optimistic and pessimistic scenarios for fish survival during such drawdowns. Under SOS 6, the models usually yielded generally low juvenile survival rates, even with optimistic assumptions. Some of the in-river passage results for SOS 6 were

comparatively high. SOS 6b also might have adverse effects on adult passage success.

Except at Lower Granite, the fish ladders at the four lower Snake River dams would not function at the proposed levels, requiring modifications. The analysis of adult returns assumed that this redesign had been done and would provide adult survival rates similar to juvenile downstream passage rates. Under these scenarios, adult returns decreased because of the overall decrease in juvenile downstream survival.

Problems for other river uses would generally be similar to but not as severe as those under SOS 5. Resident fish and wildlife would suffer as a result of drawdowns, as described under SOS 5. Cultural resources would not be as badly affected because drawdowns would not be as low, exposing less area each year; damage at the lower Snake projects would still be extensive. Erosion would increase, about one-third as much as under SOS 5.

SOS 6 would eliminate some power generation, but it would have less effect on load shaping than several of the other alternatives. SOS 6 would be a comparatively low-cost way to operate the hydroelectric system after SOSs 1 and 2. Total system generation cost would increase by $17 million (SOS 6d) or $35 million (SOS 6b).

Irrigation would also suffer under SOS 6, with increased costs of $2.6 million (SOS 6b) or $1.4 million (SOS 6d) annually. Most of this would fall on irrigators who rely on water from the Ice Harbor and John Day pools, particularly for SOS 6d and John Day. Municipal and industrial water supply costs could go up $3.6 million or $4.1 million annually under SOS 6.

SOS 9–Settlement Discussion Alternatives

The three SOS alternatives that were derived from the Marsh process settlement discussions during 1994 incorporate varying themes for operation of the system, and therefore would have effects that would differ considerably among the projects and resources. SOSs 9a and 9c have several similarities, as they both incorporate fixed drawdown of the four lower Snake River projects and operation of John Day at MOP. As a result, the impacts from these two alternatives would be similar in many respects to those of SOS 6b. SOS 9a or 9c would provide relatively high in-river survival for juvenile anadromous fish, while SOS 9b would also improve conditions somewhat over current conditions.

SOS 9 options, particularly SOS 9a, would provide the worst conditions among all of the alternatives for several resources. These include water quality, with consistently high exceedances of temperature and dissolved gas standards; resident fish, with particularly poor conditions at Libby, Hungry Horse, Grand Coulee, and John Day; aesthetics; and recreation, with the largest decreases in visitation and benefits at several of the projects. However, SOS 9b would generally improve conditions for resident fish, and would provide wildlife benefits similar to those for SOS 4c.

Irrigation, navigation, and M&I water supplies would be disrupted and experience increased costs under SOS 9a or 9c. The costs to these resources would generally be comparable to those for SOS 6b. Flood damage costs would also be increased from current conditions under SOS 9a or 9c. SOS 9b would generally have little or minimal impact on this group of river uses, although it would be one of the more expensive alternatives in terms of power; SOS 9b would increase system power generation cost by $213 million compared to SOS 2c.

SOS PA–Preferred Alternative

SOS PA reflects the recommendations of the 1995 NMFS and USFWS Biological Opinions with respect to listed salmon and Kootenai River white sturgeon. This alternative is comparable to other non-drawdown alternatives in terms of juvenile salmon survival (with transport). Its overall survival results for Snake River stocks were among the higher of the alternatives. This

would also represent an improvement for Indian treaty fishing rights and trust assets. SOS PA would also provide substantial improvement in conditions for Kootenai River sturgeon.

The effects of SOS PA on other resources would be mixed. It would result in comparatively high dissolved gas exceedances on the lower Columbia River, although exceedances on the mid-Columbia and lower Snake would be about average. The most significant consequence for wildlife would be the loss of large areas of wetland, riparian, backwater and pond habitats at John Day as a result of year round operation at MOP. However, the permanent nature of this operation would provide the opportunity for restoring some lost habitat over the long term. Recreation visitation would decrease by about 6 percent compared to SOS 2c. Total system generation cost would increase by $126 million per year under SOS PA.

Irrigation and M&I water supply costs would increase significantly under SOS PA, as a result of operating John Day at MOP year round. These cost increases would be comparable to those for SOS 6d, amounting to about $1.5 million and $4.3 million annually, respectively. SOS PA would have minor to minimal changes, or offsetting positive and negative effects, for navigation, flood control, erosion, air quality, and aesthetics.

4.3.2 Key Relationships Among Resources

Complementary Resource Needs

As might be expected, the original uses of the Federal projects analyzed in the SOR—power, flood control, navigation, and in some instances irrigation—generally have complementary system needs. These uses represent the primary multiple-purpose objectives for which the projects were originally authorized, and their needs have long been integrated into system operations. Those river uses that were built up around traditional project operations—recreation, water supply, water quality—and, to some extent, resident fish, wildlife, air quality, cultural resources, and aesthetics also tend to complement traditional use needs. For example, navigation, irrigation, and M&I water supply have complementary requirements for river levels sufficient to accommodate barges and water intake pumps.

Water quality needs complement those of anadromous and some resident fish. High levels of gas supersaturation in the water can cause gas bubble disease and threaten fish survival. Excessive sediment in the water creates problems for rearing fish. Anadromous fish need cooler water temperatures. Warmer temperatures increase overall predation of downstream migrants, a cause of mortality equal to or greater than that caused by passage at dams, and can delay upstream passage of adult fish.

Recreation, resident fish, wildlife, aesthetics, erosion protection, and air quality all complement each other because of their need for relatively high reservoir levels (and/or reduced fluctuations) at certain times of the year for optimum conditions. In season, recreation needs include reservoir levels high enough to allow full use of existing boat ramps, swimming beaches, and moorage facilities. Resident fish require water levels high enough to allow spawning and support food growth. In addition, these water levels need to be maintained after spawning so that redds (nests) are not dried out. Wildlife require water levels that enable them to avoid exposure to predators and to maintain habitat conditions. The visual attractiveness of reservoirs is improved if they are kept full and less land is exposed. Full reservoirs minimize nuisance dust from exposed land, reduce the area exposed to erosion, and help to moderate water temperatures. Cultural resources can suffer erosion damage and vandalism if they are exposed by lower water levels.

Federal agencies have a trust responsibility to consider and protect the interests of Native Americans. To a degree, the needs of Native Americans dovetail with the needs of cultural resources, anadromous fish, resident fish, and wildlife. There is strong tribal interest in

cultural resource management. Indian treaty rights are directly tied to the health and welfare of resident and anadromous fish, as well as other resources. And, fishing and hunting are an integral part of the traditional way of life for Native Americans associated with the river.

Competing Resource Needs

The ESA listings require the Federal operating agencies to develop operating plans that will not further jeopardize threatened or endangered stocks. This essentially means that the need to recover threatened or endangered salmon, has taken precedence over other considerations. As resource needs are examined, it becomes readily apparent that the recovery of endangered runs of wild salmon on the Snake River competes to some degree against almost every other river use.

Many of the SOS alternatives address the need for salmon recovery actions by attempting to increase river velocities during juvenile salmon migration periods. Depending on the SOS, this increased velocity would be accomplished either through flow augmentation, using additional water releases from upstream projects, or through drawdown of one or more run-of-river projects.

SOSs with significant levels of flow augmentation involve a degree of inherent tradeoff or competition between upstream and downstream resources. In general, the effects of flow augmentation typically include diminished conditions for resident fish, wildlife, and recreation at affected storage reservoirs, which are located in the upstream portions of the basin. Flow augmentation benefits anadromous fish that use the downstream reaches of the system for migration. But reliance on flow augmentation to aid salmon recovery would mean the effects of other potential actions (primarily drawdowns) that are detrimental to river uses in the downstream areas could be avoided.

The other primary operational tool to increase river velocity is drawdown. SOSs 5, 6, 9a, and 9c employ this action to speed flows and enhance juvenile fish migration. These alternatives would provide benefits to anadromous fish migrating in-river, but would have significant adverse effects on a number of other resources in the downstream portions of the system (primarily the lower Snake River reach). While storage reservoirs would not be totally unaffected by these alternatives, drawdown would generally be used in place of flow augmentation.

The effect of variations in water level on spawning success for resident fish has a greater influence on fish production than any other factor. Drawdown would degrade shallow-water spawning and rearing habitat for most resident fish species in the SOR reservoirs.

Lower pool elevations on the four lower Snake projects also would compete with water levels required for recreation, navigation, irrigation, wildlife, cultural resources, and air quality. Fixed water-based facilities, such as boat ramps, swimming beaches, and moorage facilities, can function in only very specific ranges of elevation (within 5 feet [1.5 m] of full pool at the lower Snake projects). Likewise, navigation, irrigation, and water supply pumps on the lower Snake River require water depths within the normal operating range. Cultural resource protection, visual quality, erosion protection, and air quality would be diminished as a result of exposure from severe drawdowns.

The SOS analyses also indicated one other prominent general pattern among the distribution of effects. SOSs 2 through PA are all intended to benefit either anadromous fish or the fish, wildlife, and recreational resources at the upstream storage reservoirs. These alternatives would accomplish their objectives to varying degrees, and all would result in increased system power costs relative to SOS 1. In addition, the economic analysis indicated that power was the dominant factor among the system operating costs that could be quantified. These observations highlight one of the fundamental tradeoff relationships inherent and unavoidable in evaluating system operations.

4.3.3 Mitigation for SOS Alternatives

This section outlines NEPA and regulatory guidance on mitigation, describes possible measures to mitigate impacts on system resources resulting from various SOS options, and addresses agencies' mitigation policies.

Council on Environmental Quality Guidance on Mitigation

The Council on Environmental Quality (CEQ) requires agencies, in preparing EISs, to address appropriate mitigation measures not already included in the proposed action or alternatives (40 CFR 1502.14 and 1502.16). Mitigation can include: (a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments.

For any proposed action that would adversely affect the environment (either significantly or insignificantly), a range of mitigation measures must be considered and developed. Each adverse impact discussed in the EIS must have accompanying mitigation measures proposed, even if the impacts by themselves would not be considered significant (46 FR 18031). All reasonable mitigation measures, even if they are outside the jurisdiction of lead or cooperating agencies, must be identified. Agencies with jurisdiction would be notified of potential measures (46 FR 18031). To ensure that environmental effects of a proposed action are fairly assessed, the potential mitigation measures must also be discussed. Therefore, the EIS and the Record of Decision will provide information regarding implementation plans, responsible agencies, and the likelihood that mitigation will be accomplished.

Potential Mitigation Options

This section summarizes potential mitigation options that have been identified to date by the SOR work groups. The material is organized by resource or subject area, and is presented in the same order used in Section 4.2.

The measures identified are potential options that could be used to mitigate impacts. These measures have not yet been recommended, proposed, or adopted as mitigation for the consequences of river system operations. Proper consideration of mitigation requires that a full range of measures be identified (including, where appropriate, alternative means to mitigate the same impact), along with the cost of the measures and their effectiveness in reducing the level of impact. The SOR agencies will evaluate the potential mitigation options presented in the Final EIS, and will identify measures that they have adopted in the Record(s) of Decision. Recommended mitigation measures will be justified on critical habitat-based analyses conducted according to agency requirements.

In determining appropriate mitigation measures to implement, the SOR agencies will consider the extent to which mitigation for hydrosystem impacts is already occurring or planned through the NPPC's Fish and Wildlife Program and ongoing efforts by the Federal agencies. Fish and Wildlife Program activities undertaken to date have included extensive actions to increase fish and wildlife populations and replace habitat lost through construction of the Federal dams (effects that pertain to the existence of the dams, and not to their operation). The amended Program also includes a number of measures intended to mitigate some of the operational effects that have been occurring for some time and are discussed in this EIS. In determining mitigation for the selected SOS, the responsibility of the SOR agencies is to identify measures that correspond specifically to the incremental operational impacts of the selected SOS, and that do not address construction-related impacts or duplicate actions that are already planned through other regional processes.

The incremental operational impacts of SOS PA would be concentrated at the John Day project, and the status of mitigation for John Day impacts warrants specific discussion. Consistent with NMFS' 1995 Biological Opinion, SOS PA provides that John Day will be operated at MOP year-round. The Biological Opinion specifically states that this operation will begin by March 1996, or the earliest possible date after appropriate mitigation measures are assured. The Biological Opinion recognizes that, without additional authority, the Corps can not completely mitigate for impacts that may be caused by operation at MOP. The Corps can not assure mitigation until all mitigation measures have been identified and the appropriate authority needed to implement those measures has been enacted by Congress. Therefore, mitigation for the impacts of operating John Day at MOP (and the operation itself) will depend upon further action and documentation beyond the Record(s) of Decision for the SOS.

As noted in Section 4.3.2, competing needs among resources indicate that the ability to mitigate some impacts will be limited. SOS-induced impacts to fish and wildlife will be mitigated to the extent justified, although implementation of some alternatives would result in different levels of environmental impacts and associated mitigation.

Earth Resources

All of the SOS alternatives involve continued operation of the dams on the Columbia River system, which would continue significant erosion, mass wasting, and sedimentation caused by construction of the dams. In general, potential mitigation measures would be designed to stabilize the shorelines, a feat more easily accomplished on run-of-river projects than storage projects.

Implementation of a yearly landslide and erosion monitoring program is a mitigation measure that could apply to all reservoirs. Monitoring programs could not only predict where new slides might occur, but also give operating agencies a chance to acquire property and/or establish setbacks before the slides occur. With all alternatives, adding rock walls to critical areas, such as active landslides, could protect the toes of slides from waves and buttress them from future movement. In addition, diverse combinations of biotechnical (such as willow wattling) and mechanical stabilization methods exist for mitigating severely eroded areas. Shoreline revegetation/ stabilization programs could also effectively mitigate some of the effects from any of the alternatives.

Under SOSs 5, 6, 9a, and 9c, slope protection would likely be needed on the upstream side of each embankment of the dams. Riprap or grouted geotextile blankets could be extended from current wave protection zones to the lowest parts of the dam on all four lower Snake reservoirs. This type of mitigation would presumably be incorporated, as good engineering design, in the construction of dam modifications. Structural measures undertaken to allow operations under SOSs 5, 6, 9a, and 9c will be determined through the Corps' SCS.

Additional possible treatments include a variety of wave dissipation structures, including log booms, pontoons, log mats, and A-frame booms. Other off-shore, non-floating breakwaters are made of stacked sand- or concrete-filled bags, stone structures, and gabions (rock-filled mesh boxes). These methods have all been used to control shoreline erosion, although they can have limited applicability, depending upon the location and physical conditions.

Water Quality

Potential mitigation measures were identified for water temperature, total dissolved gases, sediment, and other pollutants. These options

and their intended effects are summarized as follows:

Water Temperature:

- Careful selection of release ports, at storage projects that currently have multi-level intakes, could improve downstream temperature conditions during thermal stratification periods.
- Selective withdrawal facilities could be constructed at storage projects that currently lack this temperature control capability.
- Underwater dams could be constructed within reservoirs to trap cool water.
- In cases where project discharges tend to be too cold for aquatic life, pumping from the reservoir surface could reduce the temperature of water released from the project.

Gas Supersaturation:

- Dissolved gas levels could be reduced somewhat by carefully monitoring flows and spill levels and attempting to distribute spills to projects with flip lips.
- More flip lips could be constructed and existing flip lips could be modified.
- Power exchanges or related techniques might be able to more closely match power system load and high flow periods.

Sediment Transport:

- Slower reservoir drafting and faster refilling could be prescribed to reduce bank erosion.
- Sediment deposition at the confluence of the Snake and Columbia Rivers resulting from lower Snake reservoir drawdowns may require dredging of navigation channels.

In addition to mitigation measures, the Water Quality Work Group identified extensive information needs for water quality. These needs included continued monitoring (real-time and periodic) and analysis of whole river dynamics and processes, and further assessment of the source, cause, transport, fate, and effects of water pollution in the system. In addition to the parameters specifically addressed in the SOR model analysis, one objective of monitoring would be to detect any potential effects of system operations on the ability of point-source dischargers to comply with the terms of their NPDES permits.

Air Quality

Dust-control measures could theoretically be used to mitigate the air quality effects of the SOSs. Dust-control measures would be intended to decrease the amount of dust generated when reservoir sediments are exposed. Such mitigation could include seeding or planting vegetation along shorelines so that less shoreline is exposed, or erecting wind barriers along the shoreline in the primary wind direction. These types of measures, if effective, would provide long-term mitigation following the initial construction effort. Alternatively, shorter-term but recurring or ongoing measures could be considered. For example, dust is typically controlled at construction sites by periodically spraying water on roads and disturbed surfaces. Restricting use of all-terrain vehicles (ATVs) or other vehicles on exposed reservoir sediments would also decrease dust, because this would prevent or reduce disturbance of the crust on the sediments.

Dust-control measures have been successfully applied to small-scale projects, but not to projects the size of a typical SOR reservoir. For the large reservoirs in the Columbia River System, comprehensive application of these measures would likely be too costly. The technical success of measures such as seeding would also be questionable, while wind barriers would have aesthetic drawbacks and technical limitations. Restricting vehicle use along shorelines during drawdown periods would be difficult to implement and enforce.

While comprehensive use of dust-control measures in all areas of significant shoreline exposure throughout the system would not be feasible, it might be practicable to reduce reservoir dust emissions on a localized basis. The SOR agencies can monitor particulate conditions near the system reservoirs as the selected SOS is implemented, and attempt to determine whether and where reservoir drafting is contributing noticeably to particulate concentrations in populated areas. If the agencies determine that to be the case, they can evaluate whether control measures in the immediate vicinity of areas of concern would likely be effective.

Overall, the need for and applicability of air quality mitigation measures would vary significantly among the SOS alternatives. The analysis of potential PM_{10} emissions demonstrated that one of the primary concerns would be as a result of natural river or drawdown operations at one or more mainstem run-of-river reservoirs. With the partial exception of operating John Day near MOP, SOS PA does not include such operational features so the air quality concerns related to mainstem drawdown would generally not apply. In the case of John Day, the potential exposure of existing shallow-water areas would be mitigated somewhat by the 3 to 5 feet (0.9 to 1.5 m) of pool fluctuation above MOP. Monitoring of particulate conditions at John Day would be appropriate, but the depth of drawdown proposed should not be sufficient to create significant dust problems.

The other primary concern from the air quality analysis involves normal seasonal drafting of the storage reservoirs. A significant degree of seasonal drafting is unavoidable if the storage reservoirs are to fulfill their storage functions. However, the fall and winter storage operations incorporated in SOS PA would generally serve to maintain or reduce the degree of storage reservoir drafting compared to existing or historical operations. In addition, SOS PA includes limits on the depth of storage reservoir drafting in the summer. While these features were not specified to counter air quality concerns, the summer draft limits will serve to mitigate air quality impacts at the storage reservoirs during the most critical portion of the operating year (because weather conditions are generally drier and more people are present during the summer). Continuation of the Corps' air quality monitoring program at Libby will help the SOR agencies develop more specific assessments of air quality concerns at system reservoirs.

Resident Fish

The Resident Fish Work Group identified possible mitigation measures on a project-by-project basis applicable to SOS PA. These measures are summarized below.

Koocanusa and Kootenai River—Current mitigation for the reservoir operations include lake stocking, hatchery operations and a selective water withdrawal to regulate downstream temperatures. Future mitigation will include habitat enhancement in tributaries and off-site fisheries improvements. For the Kootenai River endangered white sturgeon several mitigation actions are being considered. These include goals to meet flow targets based on an Integrated Rule Curve during May, June, and July, considering available water designed to enhance sturgeon spawning while balancing needs of other regional aquatic resource needs. While SOS PA does enhance sturgeon flows, they do not always meet these flow targets. Hatchery operations are being considered for this stock. The use of spillway flows to meet flow targets should be minimized to reduce harmful gas supersaturation in the river. Flow releases during critically low-flow years to enhance salmon smolts should be shaped to benefit sturgeon.

Hungry Horse—Mitigation measures will be implemented under current ongoing mitigation programs adopted by the NPPC in 1992 and the Excessive Drawdown Mitigation Program begun in 1994. These measures include fish passage at human-caused barriers and reconstruction of spawning and rearing areas to increase natural recruitment of juvenile fish and shoreline

revegetation. However none of these measures will completely mitigate for project operations under SOS PA. The primary mitigation objective for the Flathead River is to install and operate a selective withdrawal structure on Hungry Horse Dam to control discharge temperatures. The Resident Fish Work Group has not identified additional mitigation options beyond the current program.

Pend Oreille, Brownlee, and Lower Granite—Mitigation measures may include, but are not limited to, habitat enhancement in tributary streams, fish passage improvements at migration barriers, off-site fisheries improvements, project site selection and monitoring, and operation strategies which maintain full and stable reservoir elevations.

Lake Roosevelt—Potential mitigation measures include stream and riparian zone improvements, benthic invertebrate structure placement, and sonic avoidance mechanisms. Stream and riparian improvements would create more useable shoreline and tributary habitat for fish population use, thereby potentially decreasing entrainment numbers.

Riparian improvements and benthic invertebrate structure placement would increase the number of terrestrial and benthic insects within the reservoir, which would create an alternate food source. Sonic avoidance structures in the forebay might decrease the number of salmonids congregating in the area and lead to entrainment reductions.

Additionally, monitoring systems could be set up to aid in determining effects that could not be predicted based on current models and data. Mitigation measures should focus on on-site development; however, in the event that on-site mitigation is not possible, off-site mitigation could occur on the Spokane and Colville Indian Reservations.

Dworshak—Potential mitigation measures include revegetating the drawdown zone in areas of more gently sloping banks. Aerial photography and a digitized reservoir contour map could aid in the identification of suitable areas. Shoreline revegetation could partly offset the food and habitat deficits caused by pool level fluctuations.

Small subimpoundments near full pool elevation would also provide a permanently wetted, relatively stable environment to promote the production of aquatic and semi-aquatic vegetation. This vegetation would provide food and substrate for aquatic insect production and would also provide a nursery area for forage fish. The subimpoundments would also partly offset the food and habitat deficits caused by pool-level fluctuations. Both of the programs mentioned above would require monitoring to ensure effective results. Additional water from Snake River above Hell's Canyon and/or lower pool levels in the lower Snake River would reduce the drawdown requirements for Dworshak. Reducing prescribed releases for flood control and power production would also reduce Dworshak drawdown requirements.

John Day—Leaving the pool level to MOP year round would allow aquatic vegetation to establish in just below the new drawdown zone within 3 to 5 years, enhancing the aquatic food base, and improving habitat conditions for resident fish. Habitat and population surveys will need to be conducted to determine the extent of habitat that may be established at the new lower reservoir elevation of 257 feet (78.3 m) with SOS PA. Current bathymetric information is necessary before the type, quality, and size of expected future habitat can be determined.

Wildlife

Generic mitigation options include land purchases, development of additional habitats to replace affected habitats in adjacent or other locations, development of springs, artificial cover, perennial grass seedings, and habitat restoration using irrigation seepage.

Because considerable uncertainty exists concerning the actual magnitude of effects of SOS PA on wildlife habitats, the Wildlife Work Group recommends monitoring and follow-up

studies. These efforts would determine actual effects and might result in additional mitigation being determined to be necessary. To more efficiently design mitigation and monitoring programs, the Wildlife Work Group recommends developing an effective quantitative modeling technique that more accurately predicts the degree of impacts in system-wide wildlife populations and wildlife habitats from changes in system-wide river operations. Recommended monitoring efforts and comprehensive studies include:

- Joint U.S./Canadian system-wide inventories of plant and animal populations and long-term population trends in each of the physiographic regions affected by system-wide river operations.
- Identification of effects of daily fluctuations at each SOR project and reach.
- Identification and monitoring of effects of system-wide streamflows on quality and abundance of water-dependent wildlife habitat.
- Bathymetric mapping of selected reaches and projects, as necessary to design habitat restoration projects and predict drawdown impacts.
- Development of quantitative evaluation measure(s) or ecosystem health indicators that display the magnitude of system-wide impacts on wildlife values.
- Monitoring and analysis of system-wide streamflow and reservoir elevation data to assess the adequacy of (SOS hydroregulation) average end-of-month reservoir elevations and monthly streamflow averages to model wildlife impacts.
- Monitoring and analysis of long-term plant and animal responses to system-wide operational changes through use of photopoints, air photographs, satellite (LandSat) data and documentation of data on regional GIS and other available environmental data base digital information systems, as necessary to facilitate evaluation and understanding of long-term physical changes to habitats and population indicator species.
- Identification and evaluation of cumulative effects of river operations, including the rate of wetland and riparian habitat conversions and recreation, benthic invertebrate, and resident and anadromous fish effects on wildlife resources.
- Monitoring the effectiveness and costs of site-specific mitigation measures.
- Evaluation of the impacts from mitigation. Coordinate the development of site-specific mitigation projects through the NPPC's existing Fish and Wildlife Program.

For site-specific mitigation, the Wildlife Workgroup determined a general ratio of 3:1 for system-wide habitat acreage replacement purposes. This ratio will increase, however, in areas with special circumstances that are significant to wildlife, and for locations identified through public comment as pertaining to regional importance for wildlife. The most significant example of this exception is at the John Day pool. Existing wildlife values at the John Day pool are considered among the highest in the Pacific Northwest because of the great extent of wetland habitat that is supported in an otherwise desert environment. Significant concentrations of waterfowl associated with the nationally important "Pacific Flyway" use this area primarily for wintering purposes. Because SOS PA would result in significant wetland habitat losses and critically impact existing migratory waterfowl populations, the John Day Project interagency team recommends a range from 4:1 to 8:1 or as necessary to replace existing habitat conditions.

Based on currently available information and assumptions used in the EIS analyses, mitigation measures for individual projects in addition to monitoring/investigation include the following:

- Libby Project—Identify and acquire 432 acres of off-site wetland/riparian cover types including habitats for: nesting waterfowl, aquatic and terrestrial furbearers, bald eagles and ospreys, big game, reptiles, and amphibians.

- Hungry Horse Project—Facilitate the on-going efforts to re-vegetate exposed mudflats in the vicinity of Spotted Bear. This will require continued coordination among USBR, USFS and Montana FWP.

- Clearwater River—Acquire/mange 690 acres riparian habitat upstream of the Clearwater project to replace high priority riparian habitat presently managed under the Lower Columbia Basin Wildlife Mitigation Plan.

- Lower Snake Projects, Including McNary Project Mitigation for SOS PA—Acquire/manage up to 1,288 acres of riparian and 152 acres of emergent wetlands to replace high-priority riparian and wetland habitat areas and target species currently managed under the Lower Columbia Basin Wildlife Mitigation Plan and which will be affected by changes to existing irrigation practices. Riparian forest and scrub-shrub wetlands that were not compensated under the initial mitigation program for the lower Snake River should be the focus of mitigation acquisitions.

- John Day Project Mitigation for SOS PA—Wildlife values at the John Day pool are considered among the highest in the Pacific Northwest because of the great extent of wetland habitats that are supported in an otherwise desert environment. Significant waterfowl concentrations associated with the nationally important "Pacific Flyway" use this area primarily for wintering. SOS PA results in changes to existing irrigation practices and significantly impacts water availability for existing emergent marsh/riparian habitats. The following habitat replacement and on-site mitigation recommendations are recommended (off-site measures are identified in Appendix N, wildlife:

1. Habitat Replacement

Mitigation Summary:	4:1	8:1
Emergent Marsh/Riparian	11,416	22,832
Shallow Water	2,264	4,528
Total	13,680	27,360

Mitigation acreage acquired must be provided permanent protection, full restoration of habitat quality (to the level that was lost as a result of SOS PA), and long-term operations and maintenance budgets.

2. On-Site Mitigation

Willow Creek:

- Dredge silted areas
- Levee creek on both sides to eliminate silt deposits
- Fill embayment with dredge material to elevation that encourages riparian/emergent marsh development.
- Pump required water to maintain pond levels within the wetland

Additional mitigation actions immediately adjacent to John Day pool include:

- Construct dikes to form protected backwaters and control carp, pump water to maintain existing backwater areas, and dredge and/or deposit dredged materials to form emergent marsh, riparian, and shallow-water habitat. The feasibility of these actions is currently being determined. These proposed actions could significantly reduce the off-project requirement for mitigation lands if they are feasible and cost-efficient.

McCormack Slough:
Option #1
- Pump to maintain water levels within slough
- Add silt liner to hold water as practical and dependent on economic feasibility

Option #2
- Dredge to elevation 256 to 254 (approximately 4 to 6 feet deep). This action would generate approximately 2.5 million cubic yards of dredged material. Where this material can be placed without further affecting environment, costs and cultural resources are outstanding questions. The estimated dredge material far exceeds levee material requirements.

Long Walk
Option #1 Standard Design Levees
- Construct levees of standard design, riprap to elevation 265.
- Construct inlet upstream at elevation 263.5. The inlet would be placed at this elevation to allow for gradual filling during flood events and to prevent overtopping and introduction of carp and to decrease erosion of existing levees.

Option #2 Sheet Pile Dikes
- Construct inlet upstream at elevation 263.5. The inlet would be placed at this elevation to allow for gradual filling during flood events and to prevent overtopping and introduction of carp and to decrease erosion of existing levees. No pumping required

Option #3 Combination of Options 1 and 2.

Paterson Slough
- Construct standard levees, riprap to elevation 265.
- Excavate to provide levee materials.
- Construct inlet upstream at elevation 263.5

Irrigon
Option #1
- Pump to maintain water levels

Option #2
- Dredge and excavate to increase water depth

Crow Butte
No mitigation actions recommended

Reservoir Drawdown Area
- Re-establish native shrubs and grasses

Three Mile Island
Dredge an area between the east tip of the island and the mainland to maintain current level of access difficulty for mammalian predators and protection for the colonial nesting bird colonies on the island.

Cultural Resources

The usual final step in the impact assessment process for cultural resources under the NHPA requires preparation of a MOA or PA among the Federal agencies, SHPOs, Indian tribes, and the ACHP, which addresses adverse effects to cultural resources under the authority of Sections 106 and 110 of the NHPA. After two years of meetings and discussions among the parties involved in the SOR cultural resources studies, it has become apparent that common agreement among all parties cannot be achieved in a single agreement document. Instead, documentation for the undertaking and its effects will be forwarded without an agreement to the ACHP for comment under 36 CFR Part 800.6. ACHP comments will be addressed in the Records of Decision, if applicable, and in follow-on agreements for SOR implementation.

Several important steps are involved in the preparation of IPs. These include a process for the identification and evaluation of the significance of affected cultural resources and the development of coordinated plans taking into account and mitigating the adverse effects to significant resources. Mitigation or treatment refers to actions designed to lessen or offset the loss of significant resources due to the adverse effects of an agency undertaking. The individual IPs will describe the anticipated project impacts on cultural resources and identity the approved mitigation or treatment plans, including stipulations and conditions for identification, evaluation and management, as well as recommendations for protection, monitoring,

data recovery, site stabilization, and curation of recovered artifacts. In addition, the IPs will contain provisions for Native American consultation and coordination under the authorities of the AIRFA and NAGPRA, and will establish curation provisions.

According to the "Criteria of Effect and Adverse Effect" established in 36 CFR Part 800.9, a variety of reservoir operations would have adverse effects on cultural resources. Therefore, the adverse effects from operations at the Federal reservoirs in the Columbia River system must be addressed at the individual project level in IPs by each managing agency. The adverse effects of SOS alternatives would be increments beyond those occurring as a result of the current authorized operating limits at each Federal project. The comparison of effects for different SOS alternatives indicates that most of the proposed alternatives fall within existing authorized limits for most Federal projects. The problem in this analysis is that the majority of inventoried cultural resources sites at the Federal projects have not been evaluated for their significance or National Register eligibility (36 CFR Part 63). Discussion of mitigation or treatment for adversely affected cultural resources at the Federal dams in the Columbia River system must be addressed in IPs by the agencies on a facility-by-facility basis, considering the extent of each facility's compliance with Sections 106 and 110 of the NHPA.

The usual subjects for mitigation or treatment are National Register eligible sites threatened by adverse impacts such as construction impact, inundation, erosion or vandalism. This study has pointed out that the majority of inventoried cultural resource sites in the Federal reservoirs of the Columbia River system have not yet been evaluated (through Determinations of Eligibility for the National Register). However, the SOR affords an opportunity to advance the site evaluation process for mitigation or treatment planning at the individual Federal projects. Therefore, accelerated site evaluation studies are recommended as essential components in the development of IPs for each Federal project. Mitigation or treatment planning hinges upon this site evaluation process. Actual mitigation or treatment measures may vary. Some of the common options are discussed below.

Avoidance or Protection—Whenever possible, Federal agencies attempt to plan projects in such a way as to avoid impacts to cultural resources. Only as a last resort, when destructive effects cannot be avoided, will the agency conduct data recovery. In the case of reservoirs, it is often difficult to avoid impacts to resources. Some measure of protection can, however, be secured through bank stabilization programs or protective levees at locations where significant cultural resource sites occur and bedrock and soil characteristics permit such treatment. Covering sites or erecting barriers around them are other protective measures used in managing cultural resources. Site protection also includes intensive management efforts such as signage, public education programs and law enforcement efforts.

Monitoring—Reservoir monitoring, with special attention to site conditions, is a key means by which the operating agencies manage cultural resources. Site evaluation is not part of monitoring. Rather, monitoring describes on-the-ground activity to document impacts or changes to cultural resource sites over time, which can assist in the development of appropriate protection measures. Site observation and protection are directed specifically to areas of erosion impact, such as streambanks and the drawdown zone, and to preventing unlawful artifact collection and vandalism.

Data Recovery, Curation, and Site Stabilization—When an evaluated cultural resource from a geological deposit is threatened by loss due to erosion, vandalism or construction activity, strictly controlled scientific data recovery may constitute the only way to document the significance and offset the loss. All scientific excavation is conducted under site-specific research plans developed in consultation with the appropriate parties. A key legal requirement of the data recovery process

involves the curation of all recovered artifacts and associated documentation in a facility meeting the standards of 36 CFR part 79. This is to insure the preservation in perpetuity of such cultural resource collections for their scientific research and educational value. If the level of significance is high and geologic and soils conditions are favorable, significant sites may be protected by stabilization efforts such as site capping, slumpage control and stream-bank stabilization rather than excavation.

Coordination with Indian Tribes—Any mitigation or treatment effort undertaken by the managing agencies will require coordination with affected Indian tribes. Such coordination must take into account the Federal agency government-to-government and tribal trust responsibilities. Discussions need to include mitigation or treatment and management measures that are sensitive to tribal concerns, yet responsive to scientific data recovery and curatorial needs and requirements. Affected Indian tribes will participate in direct and meaningful ways in cultural resource management, including planning and implementation efforts, and tribes may contribute to the development of IPs at specific reservoirs.

Coordination with Mitigation Efforts for Other Resources—Other SOR work groups also are developing mitigation plans to address SOR impacts on a variety of natural resources and Federal project activities. These include anadromous and resident fish, wildlife, recreation, and irrigation In some situations, cultural resources appear in the same physical context as these other resources or activities. Where such overlaps occur, planners need to coordinate mitigation activities so that actions benefiting one resource do not inadvertently harm another. IPs for the treatment of cultural resources will attempt to address issues common to mitigation for multiple resources at a project. The reader is referred to other SOR technical appendices for their discussions of mitigation actions.

Aesthetics

Potential mitigation measures for aesthetics have not been identified. Aesthetic impacts result from shoreline exposure caused by reservoir drafting, which is an unavoidable consequence for several SOSs and projects.

Recreation

The Recreation Work Group considered mitigation for recreation impacts as part of their full-scale analysis process. Recommended mitigation actions are described in Appendix J. For each final alternative, the level of recreation impact that could be expected was analyzed. Opportunities for avoidance and/or minimization of recreational impacts were identified.

Several types of generic recreation mitigation concepts could be applied to any of the individual projects or to the system as a whole. They include:

1) Improve Public Information
   - provide better real-time information about operations (such as "flow phone" recorded messages on current conditions)
   - plan and identify annual operations in advance
   - promote alternative use activities that are not affected by operations
2) Modify Operations
   - reduce short-term (daily/weekly) fluctuations
   - train operators to have increased sensitivity to impacts of operations on recreation
3) Provide/Modify Facilities
   - modify existing facilities (in place) to operate over a wider range of conditions (e.g., extend boat ramps)
   - replace facilities at the same location or elsewhere at the same project
   - develop new facilities at alternative water resource projects in the region
   - acquire and develop alternative facilities off-project
4) Provide Additional Storage.

These mitigation concepts are listed in increasing order of cost and difficulty to implement. Improvement of public information and operational refinements are relatively easy to implement and probably ought to be considered for any of the alternatives. Structural modifications of facilities can range considerably in cost and difficulty to implement. As long as the reservoirs are maintained within their "normal" operational ranges, structural modifications of recreation facilities can probably be accommodated at a relatively low cost. For more severe drawdown ranges, the degree of difficulty and costs for structural modification of facilities increases dramatically.

Ultimately, there will be a point at which drawdown is so severe that it is not feasible to modify recreational facilities on-site. This point most clearly occurs where it becomes physically impossible to modify facilities to accommodate the range of fluctuations considered. However, a point can also be reached at which drawdown so diminishes aesthetics and other parameters of recreation suitability that facility modification is not a reasonable mitigation option. When drawdowns result in impacts that severe, the only feasible mitigation options may include relocation or replacement of facilities in-kind elsewhere in the region.

Using these generic concepts, the Recreation Work Group identified mitigation options specific to individual projects or river reaches. These options are identified in the sections below.

Libby and Hungry Horse—SOS PA would result in drawdowns at the Libby Project in excess of those experienced under the No Action Alternative. These drawdowns would affect facilities around the lake to varying degrees. The potential exists at Libby to modify many of the existing recreational facilities to make them usable over a wider operational range than they currently are so that they would be operational with SOS PA. However, because of physical and cost constraints, it would not be possible to modify all of the existing sites, particularly facilities at the upper end of the project. These facilities are dewatered when drawdowns exceed 20 feet.

Mitigation efforts at Libby should focus on improving the use of swimming beaches at Rexford Beach and the McGillvray Recreation Area. Extending or relocating the developed swimming beaches to make them usable at pool elevations as low as 20 feet below full pool elevation would make swimming safer and would allow both beaches to remain open longer. Extending the beaches would allow use of them for an average of 4 months under SOS PA. Alternative mitigation measures include developing swimming areas at other nearby lakes or building a swimming pool at a local community.

Kootenai River Below Libby Dam—SOS PA would result in higher summer flows (except in July) on the Kootenai River below Libby Dam. The higher flows would affect recreational access to the river. To improve boating access, several undeveloped Corps sites just downstream from Libby Dam, such as Blackwell Flats, could be developed to provide access at high flows. Fishing piers that extend into the river channel could be constructed to allow safer access to bank anglers during periods of high flow.

Canada—The extension of the concrete boat ramp at Indian Eddy would increase the use of this important facility at low flows. In conjunction with the ramp extension, the mooring docks could also be reconfigured and extended to improve the use of this facility. Dredging some large river cobbles at the entrance of Indian Eddy would improve general access to the facility at low flows.

Construction mooring docks at the Beaver Creek boat launch would improve the use of this facility at high river flows. The mooring docks would improve the ease of loading and unloading boats during high flows when river currents complicate the use of this facility.

The Canada Customs dock at Trail was destroyed by the high flows of 1991, but could be rebuilt in a manner that allows it to

accommodate high flows. Low flows do not pose a problem for a dock at this site.

Hungry Horse Reservoir—SOS PA would provide pool elevations at the reservoir that would be as high or higher than SOS 2c. Recreation facilities would therefore remain usable for longer periods of the summer than with SOS 2c, and no mitigation measures are recommended.

Albeni Falls/Lake Pend Oreille—SOS PA would allow a full, stable pool during the recreation season, which would be almost identical to that associated with SOS 2c. Therefore, no mitigation measures are recommended.

Grand Coulee/Lake Roosevelt—Recreation facilities at Lake Roosevelt have been constructed to accommodate recreation at reservoir elevations that are near full pool. Under SOS 2c, Lake Roosevelt reaches full pool by the end of July and remains there through the fall. SOS PA would result in summer pool elevations that would be from 6 to 9 feet below full pool. Therefore, some mitigation measures, generally at swimming beaches, are recommended.

Chief Joseph Project/Lake Woods—SOS PA would maintain a stable pool elevation, similar to that of SOS 2c, at the Chief Joseph Project. Therefore, no mitigation measures are recommended.

Middle Columbia Public Utility District Projects—There are few opportunities to mitigate for higher flows that would occur under SOS PA compared to SOS 2c. It would be difficult and costly to modify existing recreation sites and facilities. No mitigation measures are recommended.

Hanford Reach—There are few opportunities to mitigate for higher flows that would occur with SOS PA compared to SOS 2c. It would be difficult and costly to modify existing recreation sites and facilities. Therefore, no mitigation measures are recommended.

Snake River: Hells Canyon Reach—Under SOS PA, flows would remain within the desirable or acceptable range for summer recreation for longer periods than with SOS 2c. Therefore, no mitigation is recommended.

Dworshak Project and Lake—It may be feasible to modify or extend some recreational facilities to make them usable under the wider range of operating conditions that might occur under these SOSs. Where feasible, most of the existing boat ramps on the lake have already been extended to minimum lake elevations; it is not likely that the ramps could be further extended. Given the steepness of the shoreline, it also may not be feasible to modify the existing boat docks and moorage facilities. Some expansion of swimming facilities may be possible. However, these facilities are constrained by the physical characteristics of the site.

SOS PA would result in moderate to severe impacts to recreational facilities at Dworshak during the prime recreation season. Because of the severity of these impacts, mitigation measures at Dworshak might not be practical or feasible. Instead, opportunities for off-site mitigation should be explored. One alternative would be to develop a new state park elsewhere in the Clearwater River drainage.

Clearwater River Below Dworshak Dam—Most of the recreation sites along the lower Clearwater River are minimally developed and are designed to remain usable under a range of flows. SOS PA would result in river flows during the winter steelhead season and the summer recreation season that would be more beneficial to recreation, compared to SOS 2c. Therefore, no mitigation measures are recommended.

Lower Snake River Projects—Pool elevations at the lower Snake River projects would be higher during the prime summer

recreation season relative to SOS 2c. Therefore, no mitigation measures would be necessary.

John Day Project/Lake Umatilla—Under SOS PA, operation of John Day project at MOP during some or all of the year would have severe impacts on the usability of many of the recreation facilities at Lake Umatilla. Many of these facilities could be modified to improve their usability at MOP. Through the John Day Drawdown Advanced Planning and Design (AP&D) Study, authorized by the Energy and Water Development Appropriations Act of 1993 (Public Law 102-377, October 2, 1992), the Corps of Engineers, Portland District has undertaken advanced planning and design of modifications to public and private facilities, including recreation facilities at John Day Dam at MOP.

Portland District has recommended two levels of recreation mitigation action. The first level would be to implement the minimum actions required to allow drawdown to MOP to occur prior to Spring 1996. The second level would be the maximum mitigation that would be recommended.

Minimum Action/Mitigation Required: The public facilities that are jointly used for Indian treaty fishing access, including Railroad Island, Le Page Park, Sundale Park, Roosevelt Park, Three Mile Canyon, Crow Butte State Park, and Boardman Park, must be renovated to provide river access. The minimum mitigation that must be accomplished prior to drawdown to MOP at these sites is extension of the boat ramps to elevation 253 to provide a minimum of 4 feet of draft. Design for this work could be completed in time for construction in February 1996. The in-water work period is currently February 1 through March 31. It is likely that construction of these boat ramps could be completed during this period.

In addition to the treaty fishing access sites there are five leased sites: Arlington Marina/ Park, Crow Butte State Park, Boardman Park, Irrigon Park, and Umatilla Marina/Park. The lease holders will be economically disadvantaged by drawdown to MOP. Mitigation would likely address these sites. Due to major excavation and/or blasting required to deepen the marinas to accommodate deep draft vessels (10 feet) and to extend boat ramps, the construction of these sites could not be accomplished in one in-water work period. Coffer dams would be constructed to provide year-round construction capability during the first year of drawdown. Construction could be completed during the remainder of that year.

Maximum Action/Mitigation that Would be Provided: The maximum mitigation action would be to extend boat ramps and dock facilities, dredge and excavate to restore swim beaches and to provide adequate depth under floating docks, and blast/excavate to deepen marinas to provide for deep draft vessels at all of the existing (15) recreation/access sites.

The current estimate of costs (from the SCS Phase I Report, Corps 1992, indexed to 1995) to fully modify all existing recreation facilities at Lake Umatilla to mitigate fully for all impacts of operation at MOP during the summer is estimated at approximately $13.8 million. The largest percentage of that cost would be dredging shallow boat basins at Umatilla and Boardman Parks which have rock bottoms.

Other Lower Columbia Projects—None of the alternative SOSs under consideration involve any specific operational changes at McNary, The Dalles, or Bonneville Projects. Therefore, no recreation mitigation actions are recommended at Lake Bonneville, Lake Celilo, or Lake Wallula under any of the alternative SOSs.

Navigation

Mitigation options for navigation are sorted into three categories: mitigation common to flow augmentation alternatives, mitigation common to drawdown alternatives, and mitigation of stable pool alternatives.

Mitigation Common to Flow Augmentation Strategies (SOSs 1a, 1b, 2c, 2d, and PA)—Mitigation needs for

shallow-draft navigation and Dworshak log transport effects under flow augmentation alternatives have been considered.

Navigation on the Lower Snake and Columbia Rivers: Because the effects on commercial navigation and dependent facilities are negligible, mitigation strategies revolve mainly around dealing with the occurrence of high-flow conditions below Lower Monumental and Ice Harbor Dams. Because this situation has always occurred in the April to June period, mitigation measures would be similar to those currently employed. Currently, the mitigation is primarily operational on the part of the barge and dam operators. Breaking of tows and extreme caution on the part of the barge operator and provision of sufficient tie-off walls both upstream and downstream of the dams by the Corps may be all that is necessary to accommodate the annual occurrence of the high spring flows.

Log Rafting Operations at Dworshak: The possible mitigation measures identified for the Dworshak log operations include using alternate methods of log transportation to Lewiston, holding the water level up through the summers and early fall, and extending the length of the log dumps to as low of elevation as possible, without causing damage to the logs.

Mitigation Common to Drawdown Alternatives (SOSs 5b, 5c, 6b, 6d, 9a, 9b, and 9c)—Mitigation needs for shallow-draft navigation and Dworshak log transport under drawdown alternatives have been considered

Navigation on the Lower Snake and Columbia Rivers: Mitigation possibilities are limited for the effects of drawdown below MOP on the lower Snake River pools. Commodities ordinarily shipped by barge can be routed as rail or truck cargo. Additional storage at loading facilities and at the source (farms) can be employed to some degree, delaying the barging until after the outages. Revetments and other stabilization methods could be employed to stabilize the river banks around cargo transfer facilities.

Mitigation measures for drawdown to MOP on the lower Snake River pools and on John Day pool include increased dredging of access channels to facilities, modification of loading and unloading facilities to accommodate 5-foot water level fluctuations, and additional channel markings on the channel through the pool.

Effects on stage below Bonneville Dam can be mainly dealt with by careful scheduling of ships departures during September. The Port of Portland's LoadMax tidal and stage forecasting is currently used for this purpose. If conditions during a particular water year appeared to be causing more severe effects than were identified during the full-scale analysis, the possibility of drafting Columbia River main stem reservoirs to make up flow deficits should be considered.

Log Rafting Operations at Dworshak: The possible mitigation measures identified for the Dworshak log operations include using alternative methods of log transportation to Lewiston, holding the water level up through the summers and early fall, and extending the length of the log dumps to as low as elevation as possible, without causing damage to the logs.

Mitigation for Stable Pool Alternative (SOS 4c)—This alternative is the preferred alternative for navigation purposes and no mitigation measures are necessary for the beneficial effects of this operation.

Power

The power analysis assumes that energy and capacity losses associated with the SOS alternatives would be replaced through acquisition of combustion turbines or purchase of power on the spot market. Either of these responses would essentially represent mitigation for the power impacts. No other mitigation options have been identified.

SOR Agencies' Mitigation Policies

In many instances, the work groups identified preliminary and conceptual mitigation measures associated with the 13 SOSs. These have been

presented in the Final EIS and in the technical appendices. When the agencies formally adopt a preferred alternative, they will also specify mitigation measures designed to address that alternative. Mitigation measures related to the preferred alternative will then be detailed in the Record of Decision.

4.3.4 Cumulative Effects

The NEPA and the CEQ regulations require Federal agencies to consider the cumulative impacts of their actions. Cumulative impacts are defined as the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what other agency or person undertakes the other actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time (40 CFR 1506.7).

Assessment of potential cumulative impacts for the SOS alternatives involves two dimensions. One dimension relates to the cumulation of localized or project-specific effects from the SOS actions for the entire river system. The results reported in Section 4.2 for many of the resource areas identify a number of discrete impacts at individual projects or river reaches. In some cases, these individual or localized impacts are not significant, but the aggregate effect over the entire system may be. (Conversely, in some cases, there are considerable changes in multiple locations that tend to balance out at a systemwide level.) Therefore, one level of cumulative impact analysis is already contained in the results for the various resource or subject areas.

The second dimension for cumulative assessment relates to the effects of SOS alternatives within the context of other actions that have been affecting or will affect the same system resources. It is often difficult to determine this context with any precision, particularly with respect to reasonably foreseeable future actions. Nevertheless, the following summary observations attempt to identify the likely cumulative context of the expected SOS effects for each resource area.

- Earth Resources—Erosion caused by reservoir operations will add to sediment contributions from other activities in the basin. It is unknown whether sediment from these other sources will increase or decrease significantly in the future.

- Water Quality—Similarly, land use practices elsewhere in the basin affect water temperature conditions in the river system, and it is not known whether these activities will tend to increase or decrease temperatures. While natural sources can cause dissolved gas supersaturation, falling water at river system dams appear to be the primary source of this water quality problem. The cumulative aspects of sediment levels are as described above under earth resources.

- Air Quality—Blowing dust generated from exposed reservoir sediments will add to ambient dust from other sources, primarily agriculture and unpaved roads. It is possible that more dust from selected projects could combine with existing ambient levels to cause increased exceedances of air quality standards for particulates in highly localized areas.

- Anadromous Fish—River system operations, along with many other sources, have contributed to the historical declines in anadromous fish populations. In the future, however, it is likely that the general direction of change will be positive as recovery measures involving habitat, harvest, and hatchery operations are undertaken. Fish survival benefits associated with the SOSs will add to improvements in other areas, resulting in long-term population levels that will likely be higher than indicated in the SOR life-cycle model results.

- Resident Fish—The effects of system operations on resident fish take place within the context of potential changes in sport fishing pressure, water quality, and

management of other aquatic species, among other factors. These other factors vary considerably within the system, making cumulative impact assessment for resident fish a case-by-case situation. Section 4.2.5 identifies pertinent effects from other actions.

- Wildlife—The loss of wildlife habitat throughout the region as a result of development and habitat conversion has been widely noted. Consequently, wildlife habitat within the system that can be protected and maintained will take on increasing regional significance, and any loss of this habitat through operational changes would be cumulative.

- Cultural Resources—The situation for cultural resources is similar to that of wildlife. The continued loss and degradation of cultural resources in other areas and increases the significance of those resources that can be protected and maintained.

- Native Americans—Indian treaty fishing rights, and the trust assets represented by anadromous fish, have been significantly diminished over time. A similar pattern of long-term decline applies to resident fish and wildlife trust assets throughout the Basin, and to cultural resources. Anadromous fish survival benefits from the new SOS should serve to lessen these cumulative impacts. Depending upon the SOS and resource, there could be positive and continued negative changes to other resources of value to Native Americans. Development elsewhere in the Basin will likely continue to diminish Native American resources.

- Aesthetics—The visual environment of all of the project areas has been modified to varying degrees by human activities. SOS alternatives that would diminish visual quality would therefore have cumulative effects, although it appears the incremental change would be small.

- Recreation—The recreation analysis did not identify trends indicating that there would be significant absolute changes in the recreation resource base. If the supply of recreation opportunities does not keep pace with population growth and demand, the relative significance of the recreation opportunities provided by the river system will increase in the future.

- Flood Control—The flood control analysis did not identify other actions that would indicate a potential for cumulative impacts. Based on recent flood events in various portions of the region, it is possible that increased development in some valleys could elevate future flood peaks.

- Navigation—Significant trends that would change the context of potential navigation impacts have not been identified.

- Power—Power supply costs and electric rates have been increasing in recent years as a result of several factors, including drought and BPA's debt repayment obligations. Cost and rate impacts associated with the SOS alternatives would add to the level of financial strain on the regional electric system and ratepayers.

- Irrigation—System operation impacts on irrigators would not be the sole source of increased costs. Irrigation pumping operations are relatively sensitive to energy prices and have been adversely affected by recent electric rate increases.

- Municipal and Industrial Water Supply—The water supply analysis did not identify any other actions that would concurrently affect water supplies from system reservoirs. The potential for cumulative effects in this case would involve conditions specific to each water system.

- Economic and Social Effects—Some of the adverse economic effects associated with the SOS alternatives would be regionwide, while others would tend to be concentrated in selected rural areas. Some of the communities likely to be affected have been

experiencing long-term economic stagnation or declines through job and income losses in traditional resource-based industries. The cumulative effects of additional cost or employment impacts in these areas could be significant.

In addition to the potential cumulative effects of the SOS alternatives, the SOR agencies must consider possible cumulative effects from the other SOR actions and the interaction among the SOS, Forum, PNCA and CEAA actions. As discussed in Chapters 5, 6, and 7, the Forum, PNCA, and CEAA actions would not be the sources of identifiable environmental impacts. Environmental effects would result from implementing a given SOS, but not from the process (Forum) used to reach such decisions. Power coordination under a PNCA and the allocation of CEAA return obligations would both occur within the bounds of flexibility established by the selected SOS; therefore, environmental impacts are attributable to the SOS, and not to the other SOR actions. Similarly, the SOR analysis has not identified any potential interaction effects among the SOS, PNCA, and CEAA. That is, there do not appear to be any ways in which a Forum, PNCA or CEAA alternative would cause the impacts of a given SOS to be greater or less than the impacts identified in Section 4.2. Therefore, the SOR agencies do not believe that there would be cumulative impacts attributable to collectively implementing multiple SOR actions, beyond those already identified for the SOS alternatives.

4.3.5 Other Specific NEPA Considerations

This section addresses several environmental impact analysis concepts that are specifically mentioned in NEPA and CEQ regulations (40 CFR 1507.16).

Unavoidable Adverse Effects

Unavoidable adverse effects are those environmental consequences of an action that cannot be avoided, either by changing the nature of the action or through mitigation, if the action is to be undertaken. By and large, the adverse effects identified for each resource area in Section 4.2 are the unavoidable consequences of operating a large-scale integrated system of dams and reservoirs. Physical laws and processes make erosion and sedimentation unavoidable. If storage reservoirs are to be operated according to their intended function, with pronounced drafting and refilling cycles, it is inevitable that reservoir elevations will fluctuate significantly and reservoir shorelines will be exposed and islands will be bridged. Unavoidable effects from storage reservoir operations include blowing dust from exposed sediments, diminished visual quality, damage to archeological sites, and some degree of disruption to resident fish spawning and food supply. Seasonal limitations on use of recreation facilities could theoretically be avoided by modifying the facilities, but it would be impractical to eliminate all elevation-based recreation effects.

Large changes in elevation are not normal operating conditions at the run-of-river projects, but several types of effects are nevertheless unavoidable with the current configuration of the system. Projected impacts at the mainstem projects would result from operational changes that disrupt established uses dependent upon certain elevation patterns. If operations change those elevation patterns, some degree of impact to the established uses is unavoidable.

Irreversible and Irretrievable Commitments of Resources

Irreversible commitments are decisions affecting renewable resources such as soils, wetlands, and riparian areas. Such decisions are considered irreversible because their implementation would affect a resource that has deteriorated to the point that renewal can occur only over a long period or at a great expense, or because they would cause the resource to be destroyed or removed.

Because the adoption of an SOS involves operation of existing facilities and not construction of new facilities, few of the operational effects identified would be

irreversible. To the extent that a given operation would lead to a decline in the resident fish population at a given reservoir, for example, this decline could conceivably be counteracted by modifying the operation.

Loss of soil due to erosion is an irreversible commitment. Because all of the alternatives, including current operations, involve pool fluctuation at some of the projects, erosion would occur at these projects under all the alternatives. Greater pool fluctuations at storage reservoirs would result in more erosion generally than at the run-of-river reservoirs. Drawdowns under SOSs 5, 6, 9a and 9c would greatly increase soil erosion at the four lower Snake River reservoirs.

The abundance and quality of wetland and riparian habitat depend on water levels and timing. The desiccation of wetland plants due to drafting at storage reservoirs in some cases would be an irreversible commitment. Substantial drawdown at projects under SOSs 5, 6, 9a, and 9c would create irreversible commitments in the form of desiccation of submerged aquatic plants and mud-dwelling fauna and gradual loss of emergent marsh and riparian vegetation. These resources could conceivably be restored with higher water levels and replanting, but the existing resources would be lost.

Loss of cultural resources resulting from accidental damage or vandalism would be an irreversible commitment of resources. All alternatives, including current operations, would expose substantial percentages of known archeological sites to such damage or vandalism.

Irretrievable commitment of natural resources means loss of production or use of resources as a result of a decision. It represents opportunities foregone for the period of time that a resource cannot be used. The primary impacts that would be irretrievable are those involving physical processes and resources—soil eroded from the system could not be retrieved, nor could archeological resources that were damaged through operational factors be restored.

Short-term Uses and Long-term Productivity

This analysis looks at the relationship between short-term uses of environmental resources and the maintenance and enhancement of long-term productivity. River system operations may cause both short-term and long-term impacts to the affected environment that cannot be mitigated.

All of the SOS alternatives would cause some mix of short-term impacts, including soil erosion, dust generation, degradation of water quality, loss of riparian or wetland vegetation, disruption of fish and wildlife habitat, disruption of recreational use, degradation of visual quality, and damage to cultural resources. In general, the extent to which these would be long-term impacts would depend upon how long a given operation was continued. Some of the short-term changes could soon lead to long-term decreases in productivity. For example, periodic drawdowns to levels below those required for irrigation pumps could result in long-term agricultural productivity losses, if irrigators do not modify their pumps.

The short-term and long-term uses of the environment for system operations would, however, have some beneficial effect on long-term productivity. The continued availability of electric power should help maintain the region's economic health. Operations intended to benefit anadromous fish should contribute to the recovery of species listed under the ESA and to the maintenance of other stocks. Some of the SOS alternatives would improve conditions for resident fish and wildlife, and this improve the long-term productivity of these resources.

Energy Requirements and Conservation Potential of Alternatives

SOSs 5, 6, 9a, and 9c involving substantial drawdown of lower Snake River projects, would make the locks at Ice Harbor, Lower Monumental, Little Goose, and/or Lower Granite Dams unusable at certain times of year. Drawdown during the spring or summer could

overlap with much of the current navigation activity, requiring shippers to reschedule shipments, store commodities, and/or use trucks or railways to avoid major disruptions in the delivery of products. Alternate transportation methods needed to move commodities to market would increase fuel consumption.

Increased river velocities resulting from flow enhancement measures could impair navigation at certain locations along the river where physical constraints now exist. Increased difficulties in navigating constricted areas could result in a minor increase in fuel consumption.

A shorter operating season for Dworshak log transport under SOSs 2d, 9b, 9c, and PA would increase annual trucking costs and fuel consumption. On the other hand, SOSs 1a, 1b, 4c, 5, 6, and 9a would extend the operating season for Dworshak log transport, reducing trucking costs and, therefore, fuel consumption.

All of the SOS alternatives would result in some degree of change in the level of hydroelectric generation (see Section 4.2.13). These effects would entail some shifting in the mix of power resources used to meet regional electric demand, but would not directly affect the level of energy consumption.

Natural or Depletable Resource Requirements and Conservation Potential of Alternatives

There are no mining or other mineral resources that would be affected by the alternatives.

Urban Quality, Historic and Cultural Resources, and the Design of the Built Environment

The projects covered by the SOR are generally located away from urban areas; therefore, actions at these projects would have little direct effect on the quality of the urban environment. The primary potential to affect urban quality effects applies to the Lewiston, Idaho-Clarkston, Washington area. Drawdown actions under SOSs 5, 6, 9a, or 9c could lead to increased dust levels, reduced visual quality, and lost local recreation opportunities. These effects would reduce the quality of the local urban environment.

The major concern under this topic involves historic and cultural resources. All of the system operating strategies would result in exposure of cultural sites and subsequent damage. The SOR agencies will develop appropriate monitoring/surveillance methods and awareness programs to prevent or minimize vandalism, as part of overall monitoring and mitigation for cultural resources. The Corps and Reclamation, as the operating agencies for the Federal projects, will develop cultural resources management plans pursuant to Section 110 of the NHPA.

Chapter 5

Columbia River Regional Forum

5.0 COLUMBIA RIVER REGIONAL FORUM

5.1 COLUMBIA RIVER REGIONAL FORUM CONCEPT

In laying the foundation for the SOR, BPA, the Corps, and Reclamation realized they had to find a way to keep the SOS constantly tuned to the multiple uses and dynamic nature of the river system. Because a new SOS would not be developed annually, the issue was how to provide a continuous role in helping shape decisions on the Columbia River System for governments, such as tribes; organized interests, such as environmental and citizens groups; and state and Federal fish and wildlife agencies.

For convenience, the agencies named this new collaborative approach the "Columbia River Regional Forum." The intent is to encourage debate on system operation issues before decisions are made. The Forum also will provide an ongoing mechanism for resolving conflicting recommendations about river uses.

The Congressional authorizing legislation for the individual Federal projects stipulated intended use, but seldom contained explicit provisions for operating the individual projects or for their coordinated operation within the total system. Additional information is normally provided in project-specific reports by the agency to the Congress. Beyond those reports, the Corps and Reclamation are 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.

5.1.1 Current Decisionmaking Environment

Within the guideline of the authorizing legislation and the physical capabilities of the 14 Federal projects, there currently are three levels of decisionmaking. These range from very broad policy decisions to very specific, immediate kinds of decisions.

The first level of decisionmaking is to determine an overall strategy, or a broad operating regime of storage elevations, outflows, and their timing designed to balance the multiple uses of the river. The current operating strategy "exists" as a collection of multiple-use requirements for individual projects and several system objectives that are met through these project requirements. A more formal strategy (the SOS) will be one of the major products of the SOR.

At the next level of decisionmaking, annual operating plans are developed for power and nonpower uses. In the current decisionmaking process, the SOR lead agencies act as the decision maker. Project authorizing legislation established some broad, general guidelines, and other legislative mandates also established some requirements for flows and elevations necessary to meet needs and authorized purposes. Decisions also occur in response to advice provided by discussions and consultations with the NMFS, input from other Federal and state agencies, tribes, and the various river users. The agencies must comply with the provisions of the Pacific Northwest Electric Power Planning and Conservation Act, NEPA, and ESA.

The NPPC has established a Fish Operations Executive Committee (FOEC) that develops an annual plan for implementation of mainstem fish passage measures to implement the Council's Fish and Wildlife Program. Membership on the FOEC includes the NPPC, the Federal operating agencies, the Federal fisheries agencies, power users, operators of non-Federal dams, and environmental groups. In the event the FOEC is unable to reach consensus, the Council resolves disputes.

The 1995 Biological Opinion established a Technical Management Team (TMT) to advise the operating agencies on dam and reservoir

operations to help optimize passage conditions for juvenile and adult anadromous salmonids. The TMT consists of representatives from NMFS, USFWS, Reclamation, the Corps, and BPA. The TMT has a Technical Group, composed of technical specialists, and an Executive Group composed of senior managers to assist in resolving issues on which the Technical Group cannot reach consensus. Each year by April 15, and preferably before flow augmentation normally begins in the Snake River, the TMT will prepare a Water Management Plan. This plan will form the basis for consultations between the operating agencies and NMFS and USFWS.

Based on all these discussions and negotiations, the Corps and Reclamation determine the nonpower requirements and communicate these to numerous entities affected by system generation requirements. The SOR lead agencies then work with the fisheries agencies and tribes to develop a Coordinated Plan of Operation (CPO) for management of the nonpower resources, and also work with the other PNCA entities to develop an annual plan for management of the power resources. The Corps and Reclamation then operate the dams themselves. When decisions come up that require consultation, the SOR lead agencies consult with either the PNCA entities, the TMT, FOEC, the Fish Passage Center, or other interested and affected parties.

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 strategy and annual operating plan. Decisions may need to be made to respond to instream conditions for fish or navigation, or to take advantage of an opportunity to make a profitable power sale. Boating accidents, generator outages, short-term climatic events, even the timing of recreational events can influence these kinds of operational decisions.

Real-time operations decisions are made in a short time, ranging from several hours to several days, or sometimes, several weeks. Throughout the year, "users" of the river may request a specific operation. The operators review the request to determine whether it is consistent with the annual operating plans, whether it could have impacts on other uses, and whether there would have to be any consultation with or between the affected parties. If the interests of other parties could be affected, the operators usually contact them for a discussion of potential impacts prior to making decisions.

The 1995 NMFS Biological Opinion provides that the TMT will meet weekly during the fisheries season to examine and recommend flow quantities on the river system. If the official forecast indicates that flows will not meet the flow objectives described in the NMFS Biological Opinion, the TMT may either recommend lower summer reservoir elevations or recommend establishing an alternative flow objective, taking into account the ability to achieve flow objectives later in the current or future years. The TMT meetings will be open meetings, and individuals may provide information or recommend operations to the TMT. In particular, Operations Requests from the Fish Passage Center will be sent to the TMT for review. The operating agencies will make an agency decision on the recommendation(s) and will provide the decision, along with a written description and justification, to the TMT, and to the NPPC for distribution to its FOEC. The turn-around for these decisions will be very rapid, often less than 24-hours, since the decision will be implemented beginning the following week.

Because of the time urgency of real-time operations, the operators must have the authority to make the decisions. There may be questions to be resolved between the parties after the decisions are made, but the operators will do the best they can to consult with directly affected parties within the time constraints. Appendix Q contains a complete discussion of current

institutional decisionmaking and the development and evaluation of the alternatives described below.

5.1.2 Alternative Development

The SOR agencies began development and analysis of Forum alternatives after the September 1992 mid-point meetings and the subsequent selection of SOS alternatives. They created a Forum Alternatives Work Group through which ideas for enhanced regional participation in system planning and operations were identified and circulated for discussion. At key points in the process, the Forum group sponsored workshops attended by representatives of the full spectrum of regional interests. The work group used this feedback to define Forum alternatives. Appendix Q describes the Forum process in more detail.

The SOR lead agencies sought to meet six basic objectives in defining the Forum alternatives:

1. Enhance participation by providing all parties with effective, affordable access to the decision process;

2. Ensure an open, visible public process for decisionmaking;

3. Provide a setting that encourages interactive communication among all parties;

4. Develop a structure capable of providing timely decisions that meet real-time demands of river operations;

5. Provide accountability so that it is clear who makes the decisions and who bears the responsibility for the consequences; and

6. Provide a mechanism by which changes in strategy can be made based on new knowledge about the interaction between river operations and fish survival.

Two key elements are addressed in each of the Forum alternatives: who makes the final decision and how much involvement by the public will occur before the decision is made. Because these alternatives are strictly institutional, they do not have environmental impacts that need to be covered in a NEPA document. Section 5.2 however, discusses the merits of the various Forum alternatives.

5.1.3 Forum 1 Through 7

Table 5-1 identifies the characteristics of the seven Forum alternatives. These alternatives follow:

- Forum 1—Decisionmaking by the SOR Lead Agencies and a Public Involvement Lead Program Conducted by the SOR Agencies

- Forum 2—Decisionmaking by the SOR Lead Agencies and Recommendation by an Existing Regional Entity

- Forum 3—Decisionmaking by the SOR Lead Agencies and Recommendation by a New Entity

- Forum 4—Decisionmaking by a Federal Consultation Forum (all Federal Agencies with Jurisdiction) and a Public Involvement Program Conducted by the Federal Consultation Forum

- Forum 5—Decisionmaking by a New Entity and a Complete Public Involvement Program

- Forum 6—Decisionmaking by One Federal Operating Agency and a Public Involvement Program Conducted by the Federal Operating Agency

- Forum 7—Decisionmaking by Another Federal Agency and a Public Involvement Program Conducted by this Federal Agency

Public Involvement Characteristics

Under all seven alternatives, the Forum would develop and carry out a complete public involvement program to provide the opportunity for river users and the public to be consulted

Table 5-1. Forum alternatives

Process Steps	Forum 1 SOR Lead Agencies	Forum 2 Recommendation by Existing Entity	Forum 3 Recommendation by New Entity
Appraisal	• Conducted by Federal agencies.	• Conducted by SOR agencies.	• Federal agencies prepare a report for analysis by the new entity.
Public Involvement	• Conducted by Federal agencies. • Written public comment period. • Public workshops or meetings.	• Conducted by existing entity.	• Conducted by new entity.
Define Options	• Federal agencies screen options and combine into alternatives.	• Non-Federal entity proposes options, following consultation with SOR agencies.	• Options proposed by new entity or its staff.
Analysis of Options and Environmental Compliance	• Analysis of issues done by working groups. • Alternatively, Federal agencies complete analysis. • SOR agencies consult NMFS, USFWS.	• Analysis could be conducted by: Federal agencies; non-Federal agencies; jointly by agencies and entity. • SOR agencies consult NMFS, USFWS.	• Analysis could be conducted by staff of new entity or jointly by staff of new entity and Federal agencies. • SOR agencies consult NMFS, USFWS.
Public Review	• Conducted by Federal agencies.	• Designed and conducted by non-Federal entity.	• Designed and conducted by staff of new entity.
Summary and Evaluation of Alternatives	• Completed by Federal agencies. • Available to public after decisionmaking.	• Prepared by non-Federal entity and transmitted to Federal agencies.	• Recommendation approved by new entity.
Decision-making	• By Federal agencies. • Agencies publish a summary of why decision was made and relationship to public comment.	• Same as Forum 1.	• Same as Forum 1.
Communication to Operating Groups	• Publication of Annual Operating Plan.	• Same as Forum 1.	• Same as Forum 1.
Implementation	• Projects operated by Bureau of Reclamation and Corps of Engineers.	• Same as Forum 1.	• Same as Forum 1.

Table 5-1. Forum alternatives

Forum 4 Decision by Federal Consultation Forum	Forum 5 Decision by New Entity	Forum 6 Decision by One Operating Agency	Forum 7 Decision by One Other Federal Agency
• Conducted by Federal agencies with jurisdiction over river resources.	• Congress authorizes new decisionmaking body. • New entity hires staff to appraise existing situation.	• Conducted by the one operating agency.	• Conducted by the Federal agency.
• Same as Forum 1.	• Initiated and conducted by new entity.	• Conducted by the one operating agency.	• Conducted by the Federal agency.
• Federal agencies jointly screen options and propose alternatives.	• Proposed by new entity or its staff.	• Operating agency screens options and combines into alternatives.	• The Federal agency screens options and proposes alternatives.
• Same as Forum 1.	• Conducted by new entity. • SOR agencies consult NMFS, USFWS.	• Conducted by the operating agency • SOR agencies consult NMFS, USFWS.	• Could be conducted by Federal agency or jointly by Federal agency and SOR agencies. • SOR agencies consult NMFS, USFWS.
• Same as Forum 1.	• Designed and conducted by new entity.	• Designed and conducted by the operating agency.	• Designed and conducted by the Federal agency.
• Jointly completed by Federal agencies. • Available to public after decisionmaking.	• Prepared by new entity staff.	• Prepared by the one operating agency and transmitted to operating agencies.	• Prepared by the Federal agency and transmitted to operating agencies.
• Shared among several Federal agencies. • Agencies publish a summary of why decision was made and relationship to public comment.	• Made by new entity, and rationale described to public and Federal agencies.	• Made by the operating agency and rationale described to the public and other Federal agencies.	• Made by the Federal agency and rationale described to public and other Federal agencies.
• Same as Forum 1.	• Annual Operating Plan transmitted to Federal agencies.	• Annual Operating Plan transmitted to the other operating agency and others.	• Annual Operating Plan transmitted to operating agencies and others.
• Same as Forum 1.	• Projects operated by Bureau of Reclamation and Corps of Engineers under direction of new entity.	• Projects operated by Bureau of Reclamation and Corps of Engineers under direction of the operating agency.	• Projects operated by Bureau of Reclamation and Corps of Engineers under direction of the other Federal agency.

prior to the final decision. The differences in public involvement characteristics among the seven alternatives only involve the identity of the organization(s) conducting the program. A complete public involvement program would include:

- Full information about the nature of the issues, the alternatives being considered, and the impacts associated with them;
- Opportunities for the public to participate in all stages of decisionmaking;
- Forums to provide for interaction between the public and the decisionmakers;
- Full accounting of how public comments were incorporated into the decision; and
- Collaboration between the lead agencies and the public whenever possible to select an option that has broad public support.

Decisionmaking Characteristics

The key differences among the Forum alternatives relate to who would make the final decision. The identity of the decisionmaker(s) among the seven alternatives would range from the three lead agencies (as at present), acting alone or with other agencies, to an entirely new entity that would need to be authorized by Congress.

Under Forum 1, 2, 3, and 4, the three Federal lead agencies would continue to make the final system operation decisions.

Forum 1 essentially represents the existing situation, with enhanced public involvement. The three lead agencies would be joined by other Federal agencies with jurisdiction, such as NMFS and USFWS, to comprise the decisionmaking entity under Forum 4. Under Forum 2 or 3, the three lead agencies would make decisions only after considering recommendations from an existing regional entity (e.g., the NPPC) or a new entity. While the recommendations would be advisory only, they would carry considerable weight. The SOR lead agencies would report back to the regional entity on deviations from the recommendations and the reasons for those deviations. The regional entity would have qualified technical staff to evaluate proposals, and a legal mandate to make decisions on all river uses.

The new entity created in Forum 3 would have a representative board of directors responsible for making recommendations. This board might be composed of:

- Members of Federal and state agencies only;
- Representatives of Federal and state agencies, with some representation from river user groups; or
- Appointees of the governors of the four Northwest states.

Forum 5 represents the most significant departure from the existing situation. Under this alternative, Congress would authorize a new decisionmaking body, with members who would represent all users of the river. This body would take over decisionmaking from the SOR lead agencies and would have its own staff. The members of this body could include:

- Representatives of concerned state and Federal agencies and the current SOR lead agencies only;
- The SOR lead agencies, some state agencies, and some representatives of users groups; or
- Representatives of the four Northwest states only.

Forum 6 or 7 would address a public concern that comprehensive, integrated responses to system operation issues are hindered by the distribution of authority among several agencies. Under Forum 6, either the Corps or Reclamation would be responsible for the appraisal, analysis, and public involvement aspects of the process. Another agency with resource jurisdiction, such as NMFS, would assume this responsibility under Forum 7.

The Forum would continue to operate under all existing legal authorities and obligations including but not limited to the authorizations of the various projects, the Pacific Northwest Power Planning and Conservation Act, NEPA, and the ESA.

5.1.4 Forum Alternatives Not Studied in Detail

Appendix Q describes the development of Forum alternatives in detail. Section 3.3 of Appendix Q identifies the major characteristics of these alternatives and presents 12 decisionmaking options and 12 public involvement options. Theoretically, the range of Forum alternatives includes all possible combinations of these options. The seven Forum alternatives described in Section 5.1.2 of this chapter are considered to be the most logical combinations of decisionmaking and public involvement options. Consequently, other possible combinations of options were not considered in detail.

5.2 EVALUATION OF FORUM ALTERNATIVES

Appendix Q provides a full discussion of how the SOR lead agencies evaluated the Forum alternatives and what they concluded from this evaluation. The following discussion summarizes why the evaluation focused on the institutional characteristics of the Forum alternatives and describes the key institutional attributes of the alternatives.

5.2.1 Basis of Evaluation

In evaluating the Forum alternatives, the SOR agencies concluded that environmental effects would result from implementing the SOSs, but these environmental effects would be related to the content of decisions about river operations, not the process used to reach those decisions. The only basis for determining that one Forum alternative would be environmentally preferable to another would be if one could predict with certainty what kind of decisions would be made by different Forums. The SOR agencies believe it is not possible to predict the content of decisions that would be made by a particular Forum based on the composition of the Forum, the procedures it would follow, or the amount and type of public involvement the Forum employs. Consequently, there are no environmental impacts associated with any of the Forum alternatives.

Future revisions to a system operating strategy, the annual decisions for its implementation, and other actions that affect the strategy would have to be evaluated by the SOR agencies to determine whether additional environmental review is required by NEPA. The SOR agencies intend that the SOR analysis is broad enough in considering system operating strategy alternatives to enable future refinements without major environmental reviews.

The Forum Work Group established a number of criteria for evaluating the alternatives. The criteria considered institutional and administrative needs. These included:

- Extent to which decisionmaking is consolidated
- Ability to reduce legal/political challenges
- Credibility
- Equitable treatment of all interests
- Accountability
- Cost to implement
- Cost of annual operation
- Cost to participate

5.2.2 Institutional Characteristics by Alternative

A brief evaluation of each alternative based on these criteria follows. Table 5-2 summarizes this evaluation.

Forum 1: Decisionmaking by the SOR Lead Agencies and a Public Involvement Program Conducted by the SOR Lead Agencies

The primary strengths of this alternative are its low implementation costs and the fact that the three operating agencies could implement it at any time. Because decisionmaking would be by the same operating agencies as today, implementation costs would be minimal and the agencies could put it into effect at any time. This alternative would not consolidate decisionmaking. It may reduce legal/political

Table 5-2. Assessment of Forum alternatives

Process Steps	Forum 1 SOR Lead Agencies	Forum 2 Recommendation by Existing Entity	Forum 3 Recommendation by New Entity
Consolidates Decisionmaking	No change.	Little change; may add one additional step for influencing decision.	Little change; may add one additional step for influencing decision.
Reduces Legal/Political Challenges	No change if challenge is based on content; may improve credibility through more open process.	No change if challenge is based on content; may improve if entity is perceived as neutral.	No change if challenge is based on content; may improve if entity is perceived as neutral.
Trust/Credibility	Greater for those aligned with traditional interests.	Improved for those who are suspicious of SOR agencies.	Improved for those who are suspicious of SOR agencies.
Equitable Treatment of All Uses	No change.	No change or slight improvement if entity represents all uses.	More equitable because all interests represented.
Accountability	No change.	Could improve political accountability; might allow decisionmakers to "hide" behind entity's recommendations.	Could improve political accountability; might allow decisionmakers to "hide" behind entity's recommendations.
Cost/Effort to Get in Place	No change.	Requires memorandum of understanding and/or Federal Advisory Committee Act authorization.	Requires agreement on membership and Federal Advisory Committee Act authorization.
Cost of Annual Operation	Slight increase.	Slight increase to cover new activities.	Increase to cover new activities.
Cost to Participate	No change.	Somewhat higher to influence recommendations and decisions.	Somewhat higher to influence recommendations and decisions.

Forum 4 Decision by Federal Consultation Forum	Forum 5 Decision by New Entity	Forum 6 Decision by One Operating Agency	Forum 7 Decision by One Other Federal Agency
Improved; consolidates into one process.	Improved; consolidates decisions into one entity.	Improved; consolidates decisions into one entity.	Improved; consolidates decisions into one entity.
No change if challenge is based on content; may improve due to consolidation.	Uncertain; improvement with all parties at the table or no change other than who sues whom.	Number of decisionmakers reduced, but may result in little or no change.	Number of decisionmakers reduced but may result in little or no change.
Improved by bringing river uses to decision table.	Significant improvement if all uses at table; could decrease depending on how it is set up.	Possible improvement if individual interests are aligned with selected agency.	Possible improvement if individual interests are aligned with selected agency.
More equitable.	More equitable.	No change.	No change.
No change to slight improvement.	Increased, but may be confused; may be difficult to confer legal accountability on new entity.	Increased, but may be confused depending on setup.	Increased, but may be confused depending on setup.
Requires agreement on consultation process.	Requires Congressional authorization.	Requires Congressional authorization.	Requires Congressional authorization.
Slight decrease due to consolidation.	Reduced if decisionmaking is consolidated; increased if no clear authority given.	Reduced if decisionmaking is consolidated; increased if no clear transfer in authority given.	Reduced if decisionmaking is consolidated; increased if no clear transfer in authority given.
Slight decrease.	Increase for representation.	Reduced if decisionmaking is consolidated.	Reduced if decisionmaking is consolidated.

challenges to decisions based upon lack of public participation in decisionmaking. Enhanced public involvement would make the decisionmaking process more open and could reduce the number of legal and political challenges to operating decisions. If legal challenges are based on substantive decisions, this alternative would not reduce challenges, and could actually increase the perception that all uses were treated equitably. It would not materially improve accountability (although it does make the decisionmaking process more public) nor does it alter the costs to participate. It would increase costs over the current process, but would be less costly than having a recommendation developed by another entity.

Forum 2: Decisionmaking by the SOR Lead Agencies and Recommendation by an Existing Regional Entity

The primary strengths of this option are that it would increase trust and the perception that all uses are treated equitably. By basing decisions on recommendations from an existing regional entity, such as the NPPC, this alternative would increase public confidence in the equitable treatment of all river uses. It would potentially reduce legal or political challenges, and it is within the authority of the agencies to implement without Congressional action. This alternative does not alter accountability, although it increases visibility. Costs to participate could increase somewhat since interests may feel obliged to participate both with the recommending agency and with the three operating agencies. This alternative would cost more to implement than Forum 1 and less than Forum 3, which creates a new agency structure.

Forum 3: Decisionmaking by the SOR Lead Agencies and Recommendation by a New Entity

This alternative is similar to Forum 2 and its analysis yielded similar results. A decision based on outside recommendations developed by a new entity could have greater credibility, which would increase trust, foster equitable treatment of all river uses, and reduce legal/political challenges. Forum 3 would also foster the equitable treatment of all river uses. On the other hand, the costs to create and maintain a new entity would be higher than those of Forum 2.

Forum 4: Decisionmaking by a Federal Consultation Forum and a Public Involvement Program Conducted by the Federal Consultation Forum

One of the advantages of Forum 4 is that, like Forum 1, it can be implemented without Congressional authorization or Federal Advisory Committee Act authorization. It could reduce costs somewhat if it consolidates SOR/ESA decisionmaking. There would be costs for initial consultations among the agencies to develop agreement on the process, although these would be relatively modest compared to the costs of creating a new entity. Trust and credibility would potentially increase over the current process as well as Forum 1 because the ESA agencies would be at the table with the operating agencies. The downside would be the difficulty in getting the five agencies to agree on decisions.

Forum 5: Decisionmaking by a New Entity

A new entity would be created specifically to ensure representation of all interests. By placing decisionmaking in a newly created regional entity, and including a complete public involvement program, this alternative has the greatest potential to increase credibility in the decisionmaking process. This alternative would require Congressional action, and it would cost the most since it proposes creating a permanent new entity.

Forum 6: Decisionmaking by One Federal Operating Agency (e.g., Corps or Reclamation) and a Public Involvement Program Conducted by the Federal Operation Agency

This alternative would consolidate decisionmaking, and it would not require creation of a new bureaucracy. It also could

reduce total costs. It would, however, require Congressional authorization. Its effects on regional credibility and the issues of trust, equitable treatment, and legal/political challenges would be minor or insignificant.

Forum 7: Decisionmaking by Another Federal Agency (e.g., NMFS) and a Public Involvement Program Conducted by This Agency

This alternative is similar to Forum 5 and its analysis yielded similar results. The Federal agency to which decisionmaking would be transferred would be an agency with a major mandate for fish and wildlife. Groups concerned about fish and wildlife might view this option as more credible than Forum 5. Groups with a traditional relationship to the existing operating agencies might view this option as having considerably less credibility. Costs would likely be greater in transferring decisionmaking to an agency other than one of the existing operating agencies. This process would require Congressional action.

5.3 PROPOSED ACTION

As noted in Section 5.1, the establishment of a Regional Forum is an administrative process that would not result in impacts upon the environment and therefore does not require analysis in a NEPA context. The composition of and procedures followed by a decisionmaking body cannot—in and of themselves—be used to predict a particular decision with definable impacts on the environment. Nevertheless, because of the relationship to the other SOR actions, the SOR lead agencies have included documentation in the EIS Main Report and Appendix Q to provide opportunities for review and comment upon Forum alternatives.

Because the Forum is not subject to NEPA documentation requirements, the SOR lead agencies are not required to formally identify a Preferred Alternative. However, the SOR agencies want the public to know of its proposed action. Section 5.3 reviews the existing situation (which is informative, given recent events such as the 1995 Biological Opinions), describes a proposed interim action, and assesses the proposed action relative to the criteria presented in Section 5.2.

5.3.1 Review of Existing Situation

In many ways, recent events have overtaken the discussion of the need for a Forum. When the SOR was begun, the agencies heard frequent comments based on the perception that the PNCA served as the place where "real" operating decisions were made. Since fisheries interests did not have a seat at the PNCA table, it was argued that there was an inequity, with fisheries interests receiving inadequate representation. Power users, on the other hand, argued that a joint power and non-power decisionmaking process was unduly cumbersome, could delay the annual planning process and did not provide sufficient predictability for long-term power resource planning.

In 1991 and 1992, NMFS listed sockeye and then chinook under the provisions of the ESA. Subsequently the USFWS issued a Biological Opinion regarding sturgeon and other species. These actions have considerably altered the system planning process, and require extensive consultation between the SOR lead agencies and NMFS and the USFWS. In addition, there have been judicial reviews of many of the actions.

The world of power generation has changed as well. BPA has alerted the region that it is preparing for the possibility of a competitive world in which the cost of BPA power could be approximately the same as that from other sources of power. In addition, changes in Federal regulations make it easier for power generators, public or private, to transport power over the existing transmission grid. BPA is taking significant actions to reduce costs and adopt a market-driven approach to the delivery of power services. This new competitive world has, however, introduced even more uncertainty into power resource planning.

The analysis of the public comments shown in Appendix T is that there is no regional consensus to take the initiative to establish a new Regional Forum. The sparse number of comments received on this topic and the contradictory nature of these comments do not give the SOR lead agencies a sense that there is any single Forum alternative that enjoys the support of the region. Certainly the ESA listings have changed the perception that the "real" decisions are made by the PNCA. On the other hand, the ESA consultations have not simplified the process, made it more predictable, nor made the process more open and visible to all interested parties in the region.

5.3.2 Proposed Interim Action

In the absence of a regional consensus, the SOR lead agencies do not believe it is appropriate for Federal agencies to prescribe a forum to provide regional representation. On at least an interim basis, the SOR lead agencies propose to continue with the current decision making process, which is best described in Forum 1.

It should be noted that although Forum 1 indicates decisions are made by the SOR lead agencies, these decisions are made only after extensive consultation with NMFS and USFWS. There must also be consultation with the NPPC. At a minimum, all five Federal agencies are clearly at the decisionmaking table. On the other hand, the relationship between the parties is not that which is described in Forum 4. The Federal Consultation Forum described in Forum 4 would provide each of the five agencies a voice in all operating decisions. The current situation provides NMFS and the USFWS a voice in those decisions affecting anadromous fish.

The current situation—the proposed interim action—was summarized previously in Section 5.1. To recap, after publication of the Final EIS and consultation with NMFS and the USFWS, the SOR lead agencies will publish a Record of Decision describing the SOS to be used in the future. This SOS will allow for some degree of flexibility, and will be subject to annual scrutiny and modification in the future.

Once the SOS is in place to provide overall guidance, the lead agencies will continue to prepare annual operating plans. The process for developing annual operating plans is described in more detail in Appendix Q. It includes three separate elements: 1) preparing the Assured Operating Plan (AOP), which defines usable Treaty reservoir storage space for power and flood control; 2) preparing a CPO that will include the nonpower needs of the system; and 3) conducting PNCA planning for annual operations.

Actual operations will then proceed within the provisions of the SOS and the annual operating plans. In addition, under the treaty with Canada, a Detailed Operating Plan (DOP) may be developed to define actual Treaty storage rights and obligations during the upcoming operating year. This DOP can take into account the latest PNCA plan. PNCA operations are then simulated, using a program referred to as Actual Energy Regulation (AER). The simulation process in the AER, results in an "accounting" for the PNCA parties' ongoing entitlements and obligations to load carrying capability. During the spring and summer season, the TMT will meet on a weekly basis to prepare recommendations for operations needed for the fish protection and recovery programs. Actual operations of the system are determined by Reclamation or the Corps. They will strive to operate within all the various plans, taking into account the actual amounts of water and flows in the river, and responding to events as they occur.

5.3.3 Evaluation

The proposed interim action would not satisfy a number of the criteria identified Section 5.2 (see Appendix Q, Chapter 7 for a more detailed discussion). ESA consultations have actually increased the number of points at which people can influence decisions, introduced new legal issues, and may have increased the costs to participate. The SOR lead agencies would have

preferred a solution that simplified the decisionmaking process, encouraged all interests to meet at the same table, and consolidated the number of points at which people attempt to influence the process. However, the SOR lead agencies do not believe it is appropriate to propose a more dramatic course of action when there is little regional consensus on any particular course of action, or even agreement that changes need to be made in the decisionmaking process.

The SOR agencies have described the proposed action as an "interim" action precisely because they believe that there are deficiencies in the current institutional arrangements. It is possible that once the region has absorbed the impact of the ESA listings it may wish to consider new arrangements. If so, the SOR consideration of the Forum concept may provide some stimulus to the discussion of alternatives.

Chapter 6

Pacific Northwest Coordination Agreement

6.0 PACIFIC NORTHWEST COORDINATION AGREEMENT

6.1 PNCA ALTERNATIVES

The PNCA is a complex contract for power coordination among Federal agencies and power-generating utilities in the region. The PNCA optimizes the power benefits of the region's major hydroelectric generating utilities and Federal agencies by planning and operating the Columbia River as a single-owner system. The technical appendix on the PNCA (Appendix R) contains detailed information on the agreement and the alternatives under consideration in the SOR. There are currently 17 parties to the PNCA:

- United States (Corps, BPA, and Reclamation)
- U.S. Entity (Corps, BPA)
- Portland General Electric
- Pacific Power & Light
- Washington Water Power
- Puget Sound Power & Light
- Montana Power Company
- Eugene Water & Electric Board
- Seattle City Light
- Tacoma City Light
- Grant County PUD
- Chelan County PUD
- Douglas County PUD
- Cowlitz County PUD
- Snohomish County PUD
- Pend Oreille County PUD
- Colockum Transmission Company

The section below is a summary of the PNCA and the major elements of the alternatives.

In annual planning sessions, the parties jointly and cooperatively determine the system's aggregate firm energy capability. They mutually support each other's operations to meet nonpower requirements, carry firm load, use their hydroelectric resources most economically and effectively, and enhance the production of nonfirm energy. Load-carrying capability is ensured through entitlements and obligations related to assurance of storage operations or energy exchanges.

PNCA planning establishes guidelines for storage reservoirs that determine how much load can be carried under the most adverse streamflow conditions. These guidelines take the form of planned reservoir storage elevations. The agreement includes provisions that the nonpower uses of a coordinated reservoir have priority over power coordination. A coordinated approach to power production results in more power being produced from the available water. For more information on the PNCA, see the SOR public information document, *Power System Coordination: A Guide to the Pacific Northwest Coordination Agreement.*

6.1.1 Alternative Development

The lead agencies established a PNCA Alternatives Analysis Group in early 1992. This work group identified issues, alternatives, evaluation criteria, and analytical techniques for the comparative analysis of alternatives. Each alternative addresses four broad elements of coordination, which were defined on the basis of the power coordination issues the work group identified. The coordination elements are:

1. Administrative
   - Parties to the agreement
   - Operational control
   - Operating procedures

2. Planning
   - Planned nonpower requirements
   - Firm hydro resource capability planning criteria
     - Shifting
     - Shaping
   - Secondary hydro resource capability planning criteria

3. Uses of Hydro Resource Capability
   - In-lieu energy
   - Interchange energy

- Proportional draft
- Adjustments to firm hydro resource capacity
- Storage service
- Transmission service
- Provisional energy
- Treatment of unplanned nonpower requirements

4. Charges
   - Service charge process
   - Interchange energy pricing
   - Headwater benefit payments

Each element has several options within it that are discussed in Appendix R, PNCA.

The PNCA Alternatives Analysis Group decided the EIS would analyze five alternative approaches to the coordinated generation of power on the basis of these power coordination elements. These alternatives are identified in Table 6-1 and summarized below. Each alternative could operate in several different ways, depending on how the elements of coordination are combined to define that alternative (Appendix R, PNCA). It is the responsibility of the action agencies to designate a "no action" alternative. CEQ has stated that there are two distinct interpretations of what constitutes a no action alternative, the status quo and not going forward with the proposed action. Under these interpretations, there were two distinct "no action" PNCA alternatives, Alternative 1, which contemplates that there would not be a replacement agreement, and Alternative 3, which assumes a continuation of the status quo. Given the concerns of Draft EIS commentors, the SOR agencies redesignated Alternative 1 as the No Action Alternative in the Final EIS. However, Alternative 3 remains the base case for purposes of analyzing impacts resulting from different alternatives.

6.1.2 PNCA 1–Existing Contract Terminates, No Replacement Contract (No Action)

Parties to the PNCA would use the existing agreement until it expires in 2003. It would not be replaced by a similar agreement. This is the No Action Alternative. After 2003, the Corps, BPA, and Reclamation would most likely sign a written agreement for planning and operation to achieve continued coordinated Federal operations. The non-Federal part of the system would not be coordinated with the Federal system after 2003. After the PNCA expires, the Federal agencies would likely continue to base the Federal firm hydro resource capability on critical-period planning (the worst-case scenario based on the historical 50-year streamflow record). Non-Federal utilities could choose to determine their FELCC by other means.

After 2003, fees for services would be arranged among utilities. The FERC would determine and collect non-Federal payments for headwater benefits from Federal reservoirs. The current PNCA would address treatment of nonpower requirements until 2003; after that, it is expected that individual utilities would continue to meet nonpower operating requirements at their projects.

In the absence of a specific Federal action to renew the existing PNCA or adopt a new agreement, PNCA 1 is the most likely scenario for the Federal agencies. Given the size of the system, the benefits of coordinated operation, and the various demands placed on the Federal projects, it is unlikely that future operation of the Federal projects would occur without some form of coordination in the absence of a new PNCA.

6.1.3 PNCA 2–Contract to Maximize Regional Power Benefits

This alternative envisions a new agreement, which would maximize regional power benefits, both energy and capacity. The agreement likely would be open only to parties with major power resources of value to the Northwest. The objectives of this alternative are to:

- Provide for centralized control over planning and operation of regional projects;
- Maximize power generation to provide least-cost service;

Table 6-1. PNCA alternatives[1/]

PNCA	Administrative	Planning	Use of Hydro Resource Capability	Service Charges
PNCA 1 Existing Contract Terminates, No Replacement Contract (No Action)	Beyond 2003, administrative considerations would shift from regionwide to bilateral arrangements for power coordination. Current parties would operate systems independently. Federal agencies would require written agreement to operate in coordinated fashion.	Current critical period planning would likely continue. Firm resource capacity would be estimated by individual utilities on a period-by-period basis. All parties would be expected to include nonpower requirements in planning. Parties would likely use shifting and shaping mechanisms. Parties downstream of others' reservoirs would have to make assumptions of expected upstream operations to determine resource capability.	Parties with reservoirs would use their storage to develop firm resource capability. Those without reservoirs would lose ability to receive water or its energy equivalent from upstream parties in a coordinated manner. Unplanned nonpower requirements at Federal projects would continue to be met at the discretion of the involved Federal project operator.	No service charges or process to determine service charges. FERC would likely determine payments for storage benefits.
PNCA 2 Contract to Maximize Regional Power Benefits	Agreement open only to parties with major power resources of value in region. Complete pooling arrangement directed by a central control.	Six-year lead time for planned nonpower requirements before they are reflected in coordinated planning; nonpower requirements could be implemented by project owner with cooperation of central entity. Planning objectives designed to maximize power benefits.	Complete pooling arrangement directed by a single entity. Centralized operation of the coordinated system to maximize power benefits. Cost of unplanned nonpower requirements borne by project owner without impact to contract rights and obligations of other parties.	Service charges unnecessary because parties' loads would be met and benefits distributed by a single entity.
PNCA 3 Extension of Existing Contract (Base Case)	Parties would be the current signatories. Additional parties could be added pursuant to terms of the existing agreement. Parties would continue to operate their own projects. Operating procedures may or may not be used to help parties implement the contract.	Submitted nonpower requirements (e.g., fish flow) would continue to be incorporated into annual operating plan. Parties would continue to plan on a critical period basis and estimate firm resource capability for each party and the system.	Firm resource capability and maximum production of secondary energy would be achieved through current contract mechanisms. Impacts resulting from unplanned nonpower requirements would continue to be addressed by the parties.	No change from current process.

Table 6-1. PNCA alternatives[1/] Page 2 of 2

PNCA	Administrative	Planning	Use of Hydro Resource Capability	Service Charges
PNCA 4 Modified Contract Supplemented with Operating Procedures	Parties would be the current signatories. Additional parties could be added pursuant to terms of the existing agreement. Parties would continue to operate their own projects. Combination of short- and long-term operating procedures would be used.	Submitted nonpower requirements (e.g., fish flow) would continue to be incorporated into annual operating plan. Parties would continue to plan on a critical period basis. Shifting and shaping would probably continue.	Parties would attempt to develop firm resource capability and maximize production of secondary energy. Current in lieu energy, provisional energy, interchange energy, reservoir drafting for firm hydro resource production, and flexibility adjustments would continue. Impacts from unplanned nonpower requirements would be alleviated by available hydro resource flexibility, or distributed among affected parties.	Service charges would be used to compensate parties for providing contract services. Charges could be adjusted more frequently than under current contract.
PNCA 5 Power Coordination Agreement to Enhance Nonpower Considerations	Agreement would be open to extra-regional parties with major power resources and to regional parties with multiple-use authorities. Operational control would involve a pooling arrangement directed by a central authority.	Planned nonpower requirements for the Federal parties would be established by a regional forum. Firm hydro resource capability would be based on SOS selected. Shifting and shaping for power purposes would likely be precluded. Secondary hydro capability would give first priority to nonpower uses.	Single entity would control operation of pooled resources. System would operate to preserve system flexibilities for operational nonpower uses. Costs and benefits from operational nonpower uses would be shared by parties in an equitable formula of distribution agreed to by all.	Service charges would be unnecessary since costs and benefits would be distributed by a single entity.

1/ Each alternative has several options for each element of coordination. This table describes a representative example for each alternative to demonstrate how various options for each of the elements could be combined to define the alternative. For a complete description of the options, see Appendix R.

- Satisfy contractual entitlements of individual parties; and
- Provide for equitable distribution of contractual benefits.

Operations would involve a complete pooling arrangement. Pooled resources would be centrally planned and operated, under the direction of a single entity designated by the parties. The entity would operate the coordinated system, consistent with its authorities, to maximize power benefits. A project owner could implement nonpower requirements for a project at any time; planned nonpower requirements would require a 6-year lead time before they would affect coordination rights and obligations. The costs of unplanned nonpower requirements would be borne by project owners exclusively and not affect contract rights and obligations. The terms of the new agreement would extend to 2024 to coincide with the anticipated term of the Columbia River Treaty.

6.1.4 PNCA 3–Extension of Existing Contract (Base Case)

This alternative would roll over the current contract, either without operating procedures or with the existing operating procedures. The terms of the new agreement would extend to 2024, to coincide with the anticipated term of the Columbia River Treaty. Parties would be the same as for the current PNCA with provisions for new signatories. Parties would continue to operate their own projects, both for their own needs and to fulfill contract rights and obligations. Operating procedures might or might not be used to help the parties implement the contract.

Nonpower requirements would continue to be incorporated into the annual operating plan. Parties would continue to plan on a critical-period basis and estimate firm resource capability for their specific projects and the system. Parties would attempt to develop firm resource capability as planned, as well as maximize production of secondary energy through current contract mechanisms. Service charges and the process for modifying service charges would remain unchanged.

6.1.5 PNCA 4–Modified Contract Supplemented with Operating Procedures

Under this alternative, a combination of short- and long-term operating procedures would be added to the existing PNCA. Currently, PNCA parties prepare operating procedures each year that clarify terms of the existing agreement. This alternative would introduce an element of longer-term planning into operating procedures.

6.1.6 PNCA 5–Power Coordination Agreement to Enhance Nonpower Considerations

Under this alternative, the existing contract would be modified to make more accommodation for nonpower purposes. While multiple-use requirements are presumably being met, this alternative would dedicate the remaining flexibility of hydro system operations to serving and enhancing nonpower/environmental purposes. (The SOS adopted by the agencies would determine the amount of flexibility available.) Modifications could include allowing nonsignatories to the PNCA to submit nonpower requirements to the annual planning process, or removing the consensus requirement for sharing impacts from ad hoc nonpower operations. Operational control and operating procedures could be modified to better accommodate nonpower purposes. For example, system planning could de-emphasize planned firm hydro resource capability in favor of other concerns, such as environmental or economic objectives. Service charges could be eliminated or changed.

6.1.7 PNCA Alternatives not Studied in Detail

A significant issue that surfaced in the development of PNCA alternatives was whether alternatives should address coordination of multiple river uses or coordination of power only. Based on a review of key contract

elements of the existing PNCA, the PNCA Alternatives Analysis Group concluded that the agreement was truly a power coordination contract, since nonpower requirements were identified independently and presented to the PNCA Contract Committee as pre-existing obligations. The group decided, therefore, to limit the analysis to consider only power coordination alternatives. Multiple use coordination for Federal projects would be set by the SOS. Non-Federal project owners would also continue to define their requirements independently in other arenas, such as the FERC licensing process.

The PNCA Alternatives Analysis Group identified 17 power coordination issues that became elements used in developing PNCA alternatives for evaluation (see Appendix R, Chapter 3, for a detailed discussion). They also identified options for treating each element in a new agreement. The group developed a set of alternatives to incorporate the perspectives of various regional interests. Alternatives that were not included in this final set represent less plausible options for power coordination.

6.2 IMPACTS OF PNCA ALTERNATIVES

The PNCA is the mechanism for coordinating the generating resources of a number of agencies and utilities in the Columbia River Basin. The PNCA Work Group developed five alternatives to achieve this (see Section 6.1). The following discussion describes the environmental, hydropower system, and financial implications of the alternatives. Table 6-2 summarizes the work group's assessment of the PNCA alternatives against the environmental, power system, and financial evaluation criteria.

6.2.1 Environmental Impacts

The PNCA Work Group developed power coordination alternatives under the premise that Federal power operations would be coordinated within the limits and flexibility allowed by the SOS selected as a result of the SOR analysis. They concluded that the significant environmental impacts would derive from the SOS alternatives and not from PNCA alternatives. Non-Federal project power would be coordinated within the limits and the flexibility of the non-Federal nonpower requirements, as defined by those project owners.

Because the significant environmental impacts are captured in the analysis of SOS alternatives (Section 4.2 of this Main Report; see also Appendix R, Section 4.2), the impacts from power coordination are only those that occur within the flexibility allowed by the SOSs. These impacts were assumed to be small enough to be handled through a qualitative environmental analysis. Therefore, because Federal reservoir operators would be implementing the selected SOS alternative under any of the PNCA alternatives, the environmental analysis would essentially duplicate the environmental analysis of the SOS.

The analysis does not present any conclusion about the effects of the PNCA alternatives on other resources (fish, wildlife, etc.). To determine whether they are positive or negative for a specific user group, the reader must cross-reference the information regarding the potential physical changes to reservoir elevations and outflows with the appropriate SOR appendix.

The analysis in the PNCA Appendix, Appendix R, identifies potential physical changes to the reservoir system resulting from the various elements and options of the PNCA alternatives. These physical changes are: (1) impacts to reservoir levels and flows during different times of the year, and (2) impacts to power production requiring the use of existing nonrenewable resources and the need to develop replacement nonrenewable resources. Criteria used to evaluate the environmental effects of the physical changes include:

- the certainty/probability of being able to accommodate operations for nonpower uses;
- ability to accommodate changes in planned operations for nonpower uses; and

Table 6-2. Assessment of PNCA alternatives

Impact	PNCA 1 Existing Contract Terminates No Replacement Contract (No Action)	PNCA 2 Contract to Maximize Regional Power Benefits	PNCA 3 Extension of Existing Contract (Base Case)	PNCA 4 Modified Contract Supplemented with Operating Procedures	PNCA 5 Power Coordination Agreement to Enhance Nonpower Considerations
Physical	• Similar to PNCA 3.	• Similar to PNCA 3.	• Higher fall/winter flows from shifting, shaping, flexibility adjustments, and provisional drafts • Lower fall/winter storage reservoir elevations. • Reduced summer/ spring flows and storage reservoir elevations.	• Similar to PNCA 3.	• Eliminates shifting, shaping, flexibility adjustments, and provisional draft. • More water remains in storage; reduced flows result. • Impacts driven by nonpower focus. • Increases need for renewable resources.
Environmental Reliability	• Likely no loss of reliability to Federal system. • Non-Federal parties would lose reliability from lack of access to assured storage releases. • More difficult to meet some nonpower uses.	• Potentially more reliable than PNCA 3 due to central authority access to coordinated system.	• High degree of reliability. • Power operations consistent with nonpower uses.	• Similar to PNCA 3.	• More reliable than PNCA 3. • More water for nonpower needs. • Addition of nonpower parties should improve planning. • Potential conflicting nonpower demands could reduce reliability.
Environmental Flexibility	• Likely no loss of flexibility by Federal system. • Many non-Federal parties could lose flexibility.	Central authority improves ability to respond to changing conditions.	• High degree of flexibility.	• Similar to PNCA 3.	• If central authority is better for nonpower needs, would be better than PNCA 3 and about the same as PNCA 2.
Hydro Power System Reliability	• Little impact to Federal system. • Less reliable for non-Federal system because of loss of assured Federal storage releases and information.	• Central authority could plan and operate all pooled resources for maximum reliability.	• System coordinated to maintain reliability.	• Impact to firm hydro resource capability could be reduced to cover unplanned nonpower requirements.	• Ability to reliably produce firm resource capability nearly the same as PNCA 2, 3, and 4, although capability could be less. • More reliable than PNCA 1.
Hydro Power System Efficiency	• Total regional hydro power efficiency reduced from PNCA 3. • Loss of efficiency more pronounced in non-Federal system.	• Central authority's access to all resources for planning and operation would be more efficient than PNCA 3.	• High degree of efficiency.	• Similar to PNCA 3.	• Less efficient than PNCA 2, 3, and 4 because of weight given to nonpower considerations. • More efficient than PNCA 1 because of coordination for power purposes.

Table 6-2. Assessment of PNCA alternatives

Impact	PNCA 1 Existing Contract Terminates No Replacement Contract (No Action)	PNCA 2 Contract to Maximize Regional Power Benefits	PNCA 3 Extension of Existing Contract (Base Case)	PNCA 4 Modified Contract Supplemented with Operating Procedures	PNCA 5 Power Coordination Agreement to Enhance Nonpower Considerations
Hydro Power System Flexibility	• Most non-Federal parties would lose flexibility. • Minimal impact on Federal system. • Lose coordinated response.	• More flexible than PNCA 3 because of access by central authority to all pooled resources.	• Flexibility provided from coordinating diverse resources and maximizing power generation.	• More flexible than PNCA 3.	• Much less flexible for power than PNCA 2, 3 or 4 due to use of flexibility to enhance nonpower purposes.
Financial Reliability	• Greater cost to maintain current level of reliability. • Most additional costs borne by non-Federal parties.	• Operation by single entity should mean same reliability at lower cost than PNCA 3.	• High degree of reliability at low cost.	• Similar to PNCA 3.	• More costly than others. • Firm capability reductions could require acquisition or use of higher-cost nonrenewable resources.
Financial Efficiency	• More expensive than PNCA 3.	• Single-entity efficiencies should lower power costs.	• High level of efficiency. • Efficiency reduces costs of operating and acquiring renewable resources.	• Similar to PNCA 3.	• Most costly because nonpower enhancement could reduce efficient hydro system operation. • Could require acquisition of nonrenewable resources.
Financial Flexibility	• Less flexibility would increase costs for non-Federal parties.	• Greater flexibility should lower power costs.	• Flexibility reduces reliance on relatively expensive nonrenewable resources.	• Similar to PNCA 3 except for higher costs to cover unplanned nonpower requirements.	• More costly than other alternatives.

- efficiency, reliability, and flexibility for power.

Efficiency, relability, and flexibility for power refer to the environmental impacts attributable to an alternative's effect on power production, including the power generated by a given amount of water (efficiency), the certainty of producing planned resource capability (reliability), and the ability to modify the planned level of production to match changing needs (flexibility). These translate into environmental impacts if the region needs to acquire and/or operate nonrenewable replacement resources. For example, air quality could deteriorate if more coal-fired generation becomes necessary. The qualitative discussion of environmental impacts follows.

PNCA 1–Expiration of Existing Contract, No Replacement (No Action)

Under this alternative, there would be no power coordination. This alternative would have negative impacts on the environment because of the system's reduced reliability, efficiency, and flexibility for both nonpower and power purposes. In addition, increased acquisition and use of nonrenewable resources would have adverse environmental effects.

PNCA 2–Contract to Maximize Regional Power Benefits

The main feature of this alternative would be an arrangement under which parties would centrally plan and operate their pooled resources. This alternative could enhance benefits for both nonpower and power purposes because of the increased reliability, efficiency, and flexibility achieved by centralizing planning and operations within one entity.

PNCA 3–Extension of Existing Contract (Base Case)

PNCA 3 would be positive for both the environment and power. It would accommodate all nonpower requirements identified by the project owners before any power coordination takes place. It also would allow project owners to operate their projects to accommodate ad hoc nonpower requirements. It would extend the existing contract benefits of hydropower system coordination that have historically worked so well for the region.

PNCA 4–Modified Contract Supplemented With Operating Procedures (Preferred)

The environmental impacts of PNCA Alternative 4 would be similar to those of PNCA 1.

PNCA 5–Power Coordination Agreement to Enhance Nonpower Considerations

This alternative should be the most beneficial to the environment because it would gear regional power planning and operations primarily for nonpower use. These benefits could be offset if the emphasis on nonpower uses increased the need to acquire and/or operate nonrenewable resources.

6.2.2 Hydropower System Impacts

Hydropower system impacts refer to changes in the hydro system's ability to produce power reliably, efficiently, and flexibly. Reliability is defined as maintaining a level of certainty in producing planned capability from the hydro system. Efficiency refers to the cost of producing power, and flexibility is the system's ability to respond to changing conditions that affect power operations. The qualitative evaluation of the PNCA alternatives from this perspective follows.

PNCA 1

PNCA 1 would lack many of the benefits of current power coordination.

PNCA 2

This alternative would offer greater regional power benefits than today's operations and

would have generally positive results for hydropower system reliability, efficiency, and flexibility.

PNCA 3 and 4

Both alternatives would have generally positive hydro system impacts.

PNCA 5

This alternative would be about the same as PNCA 2, 3, and 4 with respect to the certainty of producing firm resource capability, although the magnitude of that capability could be lower under PNCA 5. The number of parties allowed to submit nonpower requirements would increase beyond project owners under this alternative. This would likely mean more requirements and less firm resource capability available for power production. It would not produce as much secondary resource capability that could be used strictly for power purposes, as would other alternatives.

6.2.3 Financial Impacts

Financial impacts include the cost of maintaining the reliability, efficiency, and flexibility of the hydro system. These terms are defined for financial purposes as: (1) reliability—the cost of maintaining the same level of certainty of producing one's planned resource capability; (2) efficiency—maintaining the ability to develop resource capability on a least-cost basis; and (3) flexibility—the financial impacts of adapting to changing conditions while maintaining a certain level of reliability.

PNCA 1

Without coordination, the Federal system could incur some financial risk because of the U.S. obligation to return energy and capacity to Canada under the Columbia River Treaty. Apart from Treaty issues, PNCA 1 would cause difficulties for the PNCA parties, particularly the non-Federal parties, as a result of losses in reliability, flexibility, and efficiency.

PNCA 2

This alternative would do the best job of all of the PNCA alternatives in reducing the regional cost of producing power.

PNCA 3 and 4

Under the current system, which is similar to PNCA 4, the region enjoys a high standard of reliable power at a relatively low cost.

PNCA 5

This alternative would likely be the most expensive for meeting the region's power needs. Nonpower considerations can increase the cost of power production, and this alternative would likely foster additional nonpower requirements.

Cumulative Impacts

NEPA requires that the cumulative impacts of a proposed action and all other foreseeable activity be identified and considered in an EIS. The financial or economic impacts of a coordination agreement are de minimis and fall within the impacts resulting from a system operating strategy. Thus, as currently structured, none of the PNCA alternatives would have significant additional economic impacts, either individually or cumulatively, from those identified with respect to the system operating strategy.

6.2.4 Contractual Impacts

Contractual impacts include several considerations. "Ability to implement" refers to the ease or difficulty of administering the contract. Legal considerations refer to the alternative's consistency with statutory authorities and FERC licenses. Columbia River Treaty considerations refer to the alternative's consistency with the Columbia River Treaty. Autonomy deals with parties' ability to control and be accountable for the operations of their own projects. Finally, given that this is a contract requiring the consent of the parties, acceptability refers to the willingness of parties

to enter into the arrangements contemplated in the alternatives.

PNCA 1

Although this is the no-contract alternative, contractual considerations have some relevance. Most importantly, legal considerations, such as the Treaty and Federal legislation, might require or encourage some form of coordination. Therefore, it is unlikely that this alternative would be acceptable to all the parties.

PNCA 2

This alternative appears to have the best overall regional power benefits, but the greatest obstacle to achieving those benefits would be loss of autonomy, as defined above under "Contractual Impacts."

PNCA 3

This alternative is positive with respect to all of the evaluation criteria.

PNCA 4

Contractually, this alternative is very similar to the base case.

PNCA 5

This alternative differs from the others in that it is more nonpower driven. Given that nonpower requirements are already taken into account prior to any consideration of power concerns, it is doubtful that this agreement would be acceptable to the majority of the parties.

6.3 SUMMARY AND COMPARISON

Section 6.3.1 presents a summary evaluation of five alternatives for renewing or modifying the PNCA, which coordinates the operations of Northwest hydroelectric resources for power generation. Section 6.3.2 identifies the SOR agencies' preferred alternative for the PNCA, and explains the rationale for that preference.

6.3.1 Evaluation of Alternatives

The PNCA Alternatives Analysis Group assigned numerical ratings to each of the alternatives for each of the evaluation criteria reported in Section 6.2. These ratings are presented in Table 6-3, which simplifies the comparison of the environmental, hydro power system, financial, and contractual impacts of the five alternatives. The following discussion summarizes the group's overall assessment of each alternative.

PNCA 1–Expiration of Existing Contract, No Replacement (No Action)

Under this alternative, the regional parties would lose the coordination that now results in dependable and usable hydro generation capability. This would result in a loss of both reliability and efficiency in operating the hydro power system. The Federal agencies would likely need a written agreement to coordinate their projects. The Federal system would also assume some financial risk because of the obligation to return energy and capacity to Canada under the Columbia River Treaty.

PNCA 2–Contract to Maximize Regional Power Benefits

This alternative would increase the regional power benefits offered by the current contract. The results would be greater system reliability, efficiency, and flexibility, which would also mean lower costs of producing power.

PNCA 3–Extension of Existing Contract (Base Case)

Continuation of the planning and coordination of operations for optimum energy production would have a positive effect on power system operations. The region would continue to enjoy a high standard of reliable power at a relatively low cost.

Table 6-3. Summary of comparative analysis of PNCA alternatives

Evaluation Criteria	PNCA 1 Existing Contract Terminates, No Replacement Contract (No Action)	PNCA 2 Contract to Maximize Regional Power Benefits	PNCA 3 Extension of Existing Contract (Base Case)	PNCA 4 Modified Contract Supplemented with Operating Procedures	PNCA 5 Power Coordination Agreement to Enhance Nonpower Considerations
Environmental					
Physical	4	4	4	4	5
Reliability	F=3, N=1	5	4	4	5
Flexibility	F=3, N=1	4 or 5	3	4	3
Hydro Power System					
Reliability	F=4, N=1	5	4	3 or 4	3
Efficiency	F=3, N=2	5	4	4	3
Flexibility	F=3, N=1	5	4	4	1 or 2
Ability to Implement	N/A	4	3	3	2 or 3
Financial					
Reliability	F=3, N=2	5	4	4	2
Efficiency	F=3, N=2	5	4	4	2
Flexibility	F=4, N=2	5	4	4	2
Contractual					
Ability to Implement	N/A	3	4	4	3
Legal	2	2	4	4	2
Columbia River Treaty	1	5	4	4	2
Autonomy	5	1	4	4	1
Acceptability	2	1	4	3	1

F=Federal, N=Non-Federal; 1=Poor, 2=Fair, 3=Satisfactory, 4=Good, 5=Excellent

PNCA 4–Modified Contract Supplemented with Operating Procedures

As with PNCA 3, this alternative would offer highly reliable and efficient power. In addition, some PNCA parties believe that including short-and long-term operating procedures would resolve some long-standing issues in the current contract.

PNCA 5–Power Coordination Agreement to Enhance Nonpower Considerations

This alternative would offer greater emphasis on system operations to benefit fish programs, meet flow targets, and achieve minimum reservoir elevations. It would not affect reliability, but the addition of nonpower interests in planning operations could mean more requirements and less firm capability for producing power. This alternative would be the most expensive for meeting the region's power needs.

6.3.2 Preferred Alternative

The Corps, Reclamation, and BPA have selected PNCA 4 as the Preferred Alternative for a power coordination agreement. This alternative reflects the tentative understandings reached to date between current contract parties during the negotiating sessions that began in 1989. The majority of concerns raised by the reviewers and other outside groups were well known to the action agencies prior to the commencement of the negotiations. The positions taken by the Federal agencies, and tentative agreements reached, reflect many of these concerns.

PNCA 4 is very similar to the existing contract, although there would be some degradation to the reliability of developing planned resource capability. The cause of this degradation is the decision of the Federal action agencies to further clarify the protection of non-power uses. PNCA 4 would be a significant improvement for power coordination compared to having no coordination agreement after the current contract expires in 2003 (PNCA 1).

This analysis concluded that there are not significant impacts that result from any of the PNCA alternatives. This is because all PNCA alternatives analyzed must accommodate reservoir party decisions for multiple-use operation. Those operational decisions (i.e., the SOS) result in the actual environmental impacts. Thus, all of the PNCA alternatives are environmentally preferred in the meaning of the CEQ guidelines. For the SOR action agencies, the keystone of the multiple use operation is the preferred alternative for a SOS. That SOS is effectively being implemented in actual operations and reflected in the existing PNCA (PNCA 3). PNCA 4 would be at least as effective. To the extent that there remains any operating flexibility that can be influenced by this preferred alternative, this is a much improved coordination agreement for the environment with respect to its additional restrictions to practices some may deem contrary to SOS objectives. The improvements are discussed in the following paragraphs.

The parties in PNCA 4 are those currently in the agreement. However, nothing would preclude additional entities from seeking to become a party.

PNCA 4 encourages reservoir owners to incorporate known non-power requirements into the PNCA planning process. The Corps and Reclamation are committed to incorporating multiple-use requirements, such as those from the March 1995 Biological Opinion recommendations, into PNCA planning. The SOS Preferred Alternative (SOS PA) is derived from that opinion. If adopted, it will effectively move the PNCA studies toward Option 4 of Element 5, wherein power production is incidental to non-power requirements.

PNCA 4 retains critical water planning as a tool to determine planned firm hydro resource capability. This is prudent as hydropower resources are a significant portion of the resource base of Northwest utilities, and those utilities desire a conservative estimate of hydro capability that results from implementation of the

SOS. This will not preclude consideration or use of other techniques outside of PNCA coordination, such as actual operations or short-term operational planning.

PNCA 4 allows shifting of firm resource capability between years in the planning studies to continue to the extent the shifting does not violate or negatively impact non-power uses. Shifting will be more limited under PNCA 4 than that allowed by the current contract.

PNCA 4 adopts the current practice of determining secondary hydro resource planning criteria. This will continue to provide northwest utilities with opportunity to reduce costs of producing energy while maintaining the non-power operation of the SOS. SOS PA has effectively moved the actual ability to produce secondary capability to that of Option 2 of Element 6, wherein all secondary capability is a result of operation for non-power uses.

Parties will continue to use Interchange as a mechanism to facilitate power coordination. The distinction between hydro and nonhydro interchange will be eliminated to relieve some of the concerns of the all-hydro systems that were addressed by Option 3.

The current practice of adjustments to firm hydro resource capability (flexibility adjustments) will be limited under PNCA 4. Flexibility adjustments will only be allowed to the extent that it can be demonstrated that the hydro system can continue to implement the SOS.

PNCA 4 will offer increased storage service. This could facilitate increased storage of energy in the system and could provide more water for use in meeting future power demands or implementing the SOS.

PNCA 4 offers improved treatment of unplanned non-power requirements (Option 2). This will facilitate use of hydro system flexibility to distribute costs of implementing non-power operations that were not addressed in planning. It could reduce the reluctance of some parties to implement non-power operations.

Interchange energy pricing under PNCA 4 will be a single price based on market value. This could result in less use of stored water to meet interchange rights and obligations, depending on market price as parties may choose to purchase on market versus drafting stored water.

Chapter 7

Canadian Entitlement Allocation Agreements

7.0 CANADIAN ENTITLEMENT ALLOCATION AGREEMENTS

7.1 CEAA ALTERNATIVES

The Columbia River Treaty (Treaty), signed in 1961 and ratified by the U.S. Congress in 1964, provided for the construction of four storage dams to harness 500 miles (805 km) of the upper Columbia River in Canada. Three of these dams (Mica, Duncan, and Keenleyside) are in British Columbia. The fourth (Libby) is in the United States but impounds water into Canada. The regulation of streamflows made possible by these projects enabled dams downstream in the United States and Canada to produce more usable power and also provided increased flood protection.

Because Canada did not need additional power at the time of the Treaty, it sold its share of the power (the Canadian Entitlement) for the first 30 years to a 41-member utility group in the Northwest, the Columbia Storage Power Exchange (CSPE). The CEAAs are contracts between BPA, acting on behalf of the U.S. Entity, and the three mid-Columbia PUDs that own the hydroelectric projects where CSPE power is generated.

There are five Allocation Agreements, one for 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 contracts establish how the Canadian Entitlement was attributed to each of the five non-Federal projects located downstream of Canadian Treaty storage.] The three PUDs are responsible for power generation and delivery to BPA. BPA is responsible for delivering the power to the 41 CSPE parties.

The agreements expire in 2003, but by April 1998, the Canadian Entitlement from the first of the Canadian projects (Duncan) must be returned to Canada. The benefits from the second Canadian project (Keenleyside) must be returned beginning in 1999, and the benefits from the third (Mica) beginning in 2003. The Columbia River Treaty specifies the method to be used to determine the downstream benefits, but leaves it up to U.S. parties to determine how the return obligation is to be shared among benefiting parties. The goal of the new allocation agreements is to equitably distribute the return obligations among the U.S. downstream parties that benefit from the upstream Canadian Treaty storage.

7.1.1 Alternative Development

The United States and Canada have conducted talks to identify alternatives for the return of the Canadian power entitlement. The allocation of the Canadian Entitlement among U.S. parties is intended to reflect the relative amounts of power benefits accruing on the Federal and non-Federal systems due to Canadian Treaty reservoir operation. The final allocation scheme will be negotiated among the U.S. parties. Several methods of allocating the Canadian Energy and Capacity Entitlement have been proposed to date. These methods are not a part of the SOR analysis, as these methods will almost certainly be superseded by negotiations. They will, however, fall within the bounds established for the environmental review, which represent a Federal/non-Federal allocation percentage that is applied to current estimates of the Canadian Entitlement. Appendix P describes the CEAA study process.

The lead agencies began development and analysis of CEAA alternatives after the September 1992 midpoint meetings and the subsequent selection of SOS alternatives. BPA staff conducted the SOR effort addressing the CEAA, with input and review from a subgroup of the Power Work Group. The subgroup based its identification of alternatives on informal, preliminary meetings between U.S. Entity staff and regional utilities; these meetings pre-dated the SOR.

7.1.2 Alternative CEAA Return Allocations

With respect to the SOR, the CEAA alternatives involve only the distribution of Canadian Entitlement return obligations among the Federal and non-Federal parties. The staff who developed CEAA alternatives followed a fundamental premise that the allocation of return obligations would be based on the relative distribution of downstream power benefits accruing to the respective parties. (These benefits reflect increments in both the average annual usable energy and dependable capacity provided by the Treaty storage to the Federal and non-Federal projects downstream.) The CEAA alternatives therefore are defined by the Federal and non-Federal percentages of the Canadian Entitlement return obligation. Table 7-1 summarizes these alternatives.

The allocations of the return obligation among the four CEAA alternatives range from 100 percent to 55 percent for the Federal government, and from 0 to 45 percent for the non-Federal parties. The differences in the percentages reflect differing ways of allocating the downstream power benefits of Treaty storage.

Under the No Action Alternative (CEAA 1), the current Allocation Agreements would expire without replacement. It is assumed that the Federal system would undertake the entire Canadian Entitlement delivery obligation beginning in 1998, while allowing the non-Federal projects to generate with water released from Treaty projects. The non-Federal parties would not be obligated to deliver Canadian Entitlement. This maximizes the Federal obligation (100 percent) and minimizes the non-Federal obligation (zero percent), while still allowing the non-Federal projects to use all flows on the Columbia River. The non-Federal project owners would generate and keep all downstream power benefits at their projects resulting from Canadian Treaty storage.

CEAA 2 represents the situation where the Federal obligation would be minimized and the non-Federal obligation is maximized. The Canadian Entitlement obligation for both capacity and energy in this case would be 55-percent Federal and 45-percent non-Federal. This allocation was determined by examining the series of studies that are used to compute the Canadian Entitlement obligation. The percentages roughly approximate the increase in annual average generation (over a 30-year streamflow period) accruing to the Federal and non-Federal projects as a result of Canadian Treaty storage. CEAA 3 represents a percentage allocation that lies between the bounds provided by CEAA 1 and 2. This distribution is based on the fact that Federal projects have about 70 percent of the downstream generating capacity, and non-Federal projects about 30 percent.

Table 7-1. CEAA alternatives

	CEAA 1 No Action	CEAA 2	CEAA 3	CEAA 4 No Agreement
Federal Obligation (Percent)	100	55	70	55-100
Non-Federal Obligation (Percent)	0	45	30	0-45

Source: Appendix P, Canadian Entitlement Allocation Agreements

CEAA 4 assumes U.S. parties negotiate but are unable to reach agreement on an allocation of the Canadian Entitlement among Federal and non-Federal systems. The U.S. Entity anticipates that it would condition the use of improved stream flows and employ rulemaking to obligate non-Federal parties to return a portion of the Canadian Entitlement commensurate with benefits received. It is likely that the outcome of this process would result in Federal and non-Federal obligations that are within the range examined in CEAA Alternatives 1 through 3.

7.1.3 CEAA Alternatives not Considered in Detail

CEAA Alternatives 1 through 4 bracket the range of reasonable allocations of the Canadian Entitlement return obligations. Additional alternatives could have been identified which would represent intermediate allocations between the endpoints defined by alternatives CEAA 1 and 3. The SOR agencies saw no need to make any further distinctions in the percentage allocation. Any alternatives using allocations beyond the stated endpoints would be unreasonable because they would have no basis in the relative distribution of downstream power benefits.

7.2 IMPACTS OF CEAA ALTERNATIVES

The renewed CEAA are not expected to greatly influence hydro system operations for two reasons. The most likely scenarios for satisfying the Canadian Entitlement obligation are the acquisition of new resources or the purchase of power. To the extent that the FCRPS and non-Federal projects would be used to generate power to deliver to Canada, changes in river flows would be minor.

The SOR analysis assumes that changes in hydro system operations would not occur because of different CEAA allocation methodologies. Each allocation alternative falls within the range of hydro system flexibility provided by the SOSs for power needs. To understand the potential environmental effects of the alternatives, the hydro system allocation operations should be compared to the evaluation in Section 4.2 of potential environmental effects.

The obligation to deliver the Canadian Entitlement power may ultimately be satisfied in one of a number of ways yet to be negotiated by the United States and Canada. The environmental impacts of delivering the power to various possible locations, purchasing all or a portion of the obligation, and issues attendant to the agreements were examined in a separate EIS—the Delivery of Canadian Entitlement EIS. The environmental impacts of resource acquisition choices that may be made to meet BPA's load obligations (including delivery of the Canadian Entitlement) were examined in the Resource Program EIS (BPA, 1993a) and are not repeated here.

In order to evaluate the potential environmental effects of CEAA energy alternatives, a version of the System Analysis Model (SAM II) was used that simulates the Pacific Northwest hydro and thermal system for Federal, Investor Owned Utilities, and Generating Public Utilities. Monthly flows at The Dalles were analyzed due to their importance for the migration of anadromous fish. Monthly reservoir elevations were analyzed at Grand Coulee, Libby, and Hungry Horse because of their importance for cultural resources, recreations, and resident fish.

The delivery of the capacity component of the Entitlement was not modeled explicitly, however, potential capacity effects of CEAA alternatives were examined by analyzing the flows required to generate the entire capacity Entitlement obligation. This analysis assumes the entire capacity Entitlement obligation is borne by the hydro system. This analysis is intended to provide an estimate of the magnitude of the power system requirements involved to compare with the environmental analyses and impacts presented in Section 4.2. The actual Entitlement return will be made from total "system" resources, including hydro generation, non-hydro generating facilities, and purchases. Table 7-2 shows the energy and capacity requirements for each of the alternatives.

7.2.1 CEAA 1–No Action

Under CEAA 1, the agreements would expire without replacement. CEAA 1 assumes that non-Federal parties would not be obligated to deliver any of the Canadian Entitlement. Therefore, the Federal system would be responsible for delivering all of the Entitlement. This alternative was used as the base case to which other alternatives were compared. SAM II was used to simulate hydro system operations on an energy basis. Flows at The Dalles and reservoir elevations at Grand Coulee, Libby, and Hungry Horse were established. Flows and reservoir elevations from other CEAA alternatives were compared to this alternative to measure incremental changes for evaluation of environmental effects. If the capacity Entitlement return is generated only from Grand Coulee downstream, the Federal system would be required to generate up to an estimated 1,400 MW of capacity and would require a flow of approximately 23 kcfs (651 cms).

7.2.2 CEAA 2–55 Percent Federal, 45 Percent Non-Federal

Compared to CEAA 1 (No Action), CEAA 2 may reduce the amount of resource acquisitions by the Federal system and increase those required by the non-Federal project owners. Based on the study results, it is apparent that allocation alternatives had virtually no impact on Columbia River flows or reservoir elevations when evaluating the energy component of the Entitlement. For delivery of the capacity Entitlement, 13 kcfs (368 cms) of flow would be needed to generate the capacity portion of the obligation. The non-Federal portion would require 25 kcfs (708 cms)for producing the capacity obligation.

7.2.3 CEAA 3–70 Percent Federal, 30 Percent Non-Federal

Compared to CEAA 1 (No Action), CEAA 3 may reduce the amount of resource acquisitions by the Federal system and increase those required by the non-Federal project owners, but less so than Alternative 2. Like Alternative 2, this alternative had virtually no impact on Columbia River flows or reservoir elevations when evaluating the energy component of the Entitlement. The system flows and water volumes needed to generate the capacity portion of the Entitlement obligation would be about the same for the Federal and non-Federal obligations. The flow needed to generate the capacity entitlement would be approximately 16 kcfs (453 cms) for both the Federal and non-Federal systems.

7.2.4 CEAA 4–No Agreement

CEAA 4 assumes U.S. parties negotiate but are unable to reach agreement on an allocation of the Canadian Entitlement among Federal and non-Federal systems. The U.S. Entity anticipates that it would condition the use of improved stream flows and employ rulemaking to obligate non-Federal parties to return a portion of the Canadian Entitlement commensurate with benefits received. It is likely that the outcome of this process would result in Federal and non-Federal obligations that are within the range examined in CEAA Alternatives 1 through 3. Therefore, the environmental effects of CEAA Alternative 4 will be bounded by CEAA Alternatives 1 through 3.

7.3 PREFERRED ALTERNATIVE

The SOR action agencies have selected CEAA Alternative 3—Entitlement Allocation: 70 percent Federal and 30 percent non-Federal—as the Preferred Alternative. This alternative mostly closely represents the expected outcome of negotiations between the U.S. Entity and non-Federal utilities for allocation of the Canadian Entitlement.

Because the determination of the Canadian Entitlement and the resulting allocation depend on a number of factors, the relative Federal and non-Federal percentage obligations will change during the proposed contract period 1998 through 2024. In addition, the Federal and non-Federal percentages for the capacity and energy allocation will likely be different as these

quantities are computed using different procedures specified by the Treaty.

The expected range of the Federal and non-Federal percentage allocation during the life of the proposed contract will probably be 70 to 75 percent Federal and 25 to 30 percent non-Federal. Factors that cannot be predicted at this time could cause the percentage allocations to be higher or lower than the expected range.

CEAA alternatives 1 and 2, however, effectively span the range of potential Federal and non-Federal percentage obligations for both the capacity and energy Entitlement. As Appendix P and the SOR documents have demonstrated, there would be no significant impacts to the environment from any of the CEAA alternatives.

Chapter 8

Making the SOR Decisions

8.0 MAKING THE SOR DECISIONS

This chapter provides the reader an overview of the NEPA process; the steps, timing, decision factors, and criteria that the SOR agencies must use for the decisionmaking process after the Final EIS; and the framework for how decisions will be made in the future. Chapter 8 also includes a series of diagrams that represent the decisions the agencies face.

The Final EIS presents preferred alternatives for three of the four of the SOR actions (SOS, PNCA, and CEAA). No preferred alternative is required for the Forum, for which the agencies' preference is expressed as the "proposed interim action." This proposed action is based on an analysis of the existing situation arising from the 1995 NMFS and USFWS Biological Opinions and the public review of the Forum as presented in the Draft EIS.

The PNCA and CEAA, while related to the SOS and Forum decisions, are not dependent upon them, and ongoing activities related to these agreements may force them onto their own schedule. The PNCA and CEAA involve multi-party contracts, and negotiations have been under way concurrently with the SOR. The negotiations may still be in progress when the Final EIS is published. Depending upon the outcome of the negotiations, the SOR decisions on the PNCA and CEAA will occur as needed to meet the various resulting contractual deadlines.

8.1 THE NATIONAL ENVIRONMENTAL POLICY ACT PROCESS

NEPA, Section 102 states that "the Congress authorizes and directs that, to the fullest extent possible ... all agencies of the Federal government shall ... include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement ... on: (i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided ..., (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

Regulations subsequently written by the Council on Environmental Quality (CEQ) further guide Federal agencies in the conduct of the NEPA review process. These regulations specify that preparation of an EIS should begin as the proposal is developed, that it should be timed to serve as an important contribution to the decisionmaking process, and that a Draft EIS should be prepared first and subjected to public review and comment prior to completion of the Final EIS. Agencies must wait at least 30 days after the Final EIS before decisions can be made and recorded. Consequently, NEPA is viewed as requiring Federal agencies to "look before they leap." They must consider publicly a range of possible alternatives and compare the impacts prior to taking actions.

Publication of the Draft EIS represented one key step in the process. It officially started the public review and comment period. The agencies evaluated the comments received, completed additional analysis where needed, and prepared the Final EIS. These steps ensured that the decisionmakers will have the appropriate information prior to making the decisions. Reviewers had an opportunity to make their views known on the potential alternatives, the adequacy of the analyses in the Draft EIS, and the decisions they would favor. The comments received have been combined with updated information from the Draft EIS to provide a complete environmental record for decisionmakers.

8.2 CRITERIA AND PATH FOR DECISIONS

The following section presents the objectives of the decisions and the criteria upon which the

decisions will be based. These include the SOR purpose statements presented in the May 1991 Scoping Document. Decisions must also be implementable and regionally acceptable.

8.2.1 Purposes

As identified in Section 1.1.2, the following purposes will be considered in decisions that are intended to provide balance among system uses.

Resource Purposes

- Provide equitable treatment of fish and wildlife
- Protect and preserve threatened, endangered, and sensitive species
- Provide an economic, reliable, and environmentally sound power system
- Provide an adequate supply of irrigation and M&I water
- Provide an economic and dependable flood damage reduction and public safety system
- Provide waterborne transportation capability
- 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

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

Legal/Regulatory Purposes

- 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.

There is no single equation or formula that the SOR agencies can use to weigh each of these purposes and decide upon the proper balance in system operations or the best alternative for the other actions. The degree to which each purpose is affected, impacted, or enabled will be considered in the decision. The SOR technical analysis provides that information.

8.2.2 Implementability

Implementability of a decision or action will be an important decision criterion. The ability to implement a decision depends upon several factors, including physical feasibility; authority; compatibility with existing contracts; compliance with the ESA, as well as other laws and regulations; and compliance with obligations to Indian tribes.

Physical feasibility refers to whether the agencies have the actual capability to turn a decision into action. For example, in the system operating strategies, some options such as natural river drawdown would require physical modifications to dams and reservoirs. While the SOR could conclude this strategy should be pursued, it could not be physically implemented without structural changes in the projects. This would take years of engineering and construction.

The agencies cannot implement actions for which they do not have authority. The SOR can, however, recommend acquisition of appropriate authority if it is determined to be needed for a particular decision. Similarly, the agencies must recognize any contractual obligations that relate to decisions. Decisions must comply with requirements of the ESA and other pertinent laws and regulations (Chapter 11). The agencies recognize their obligations under treaty rights and statutes, and their responsibilities to work directly with tribes

in government-to-government relationships and to reflect that obligation in the decisions the agencies make.

A preferred system operating strategy for the Columbia River system could have a number of elements or components to be implemented at different times. This could be true for the other SOR actions as well. In other words, both near-term and long-term decisions are involved. Near-term decisions are those which can be made immediately or soon after completion of the SOR. They include those for which the Federal agencies have authority and those which do not require substantial further planning, design, or construction. Some near-term decisions may be interim or temporary measures that precede implementation of long-term, permanent measures.

Long-term decisions are those upon which the agencies may have insufficient authority to act, for which a program and budget must be developed, and for which extensive further planning and analysis are needed. This could require several years to accomplish. In some cases, the separate activities must be performed sequentially, i.e., a design phase followed by construction, which further lengthens implementation time. These decisions would still be subject to review and coordination with other agencies, tribes, and stakeholders.

8.2.3 Acceptability

Acceptability was another important criterion for SOR decisionmaking and identification of preferred alternatives. While the SOR process is not a referendum on courses of action, it clearly sought agency, tribal, public, and other entities' views on acceptability of the alternatives. The Draft EIS was the most significant step in acquiring the views of interested parties on acceptability. The agencies also sought comment on how compatible and consistent each alternative was with other regional programs and activities that relate to issues considered in the SOR. Finally, the extent to which interested parties will be able to participate in future decisions and the actions which occur as a result of the decisions was a consideration in the identification of preferred alternatives.

8.3 THE PATH FOR SELECTING PREFERRED ALTERNATIVES

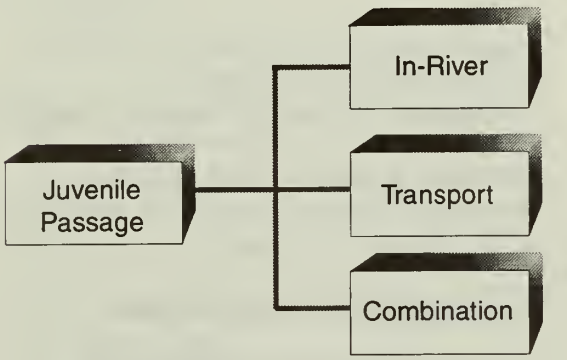
In any complex study, there are uncertainties which can affect decisionmaking. The SOR was no exception. The agencies welcomed comments on the areas of uncertainty in the SOR analysis to help to guide their decisions. All information gathered in the review was considered in selecting the preferred alternatives and is captured in the Final EIS.

8.3.1 System Operating Strategy

The decision to adopt a preferred SOS involved the largest number of variables and uncertainties of any of the four actions. The SOR has not attempted to look at all possible combinations of river operations and variables within the "bookends" that define a broad range of operating alternatives. The analysis has, however, developed substantial data on the major operating elements. These data provided a basis for combining the elements in new ways, consistent with public comment on the Draft EIS, consultation with NMFS and USFWS, and subsequent agency deliberation.

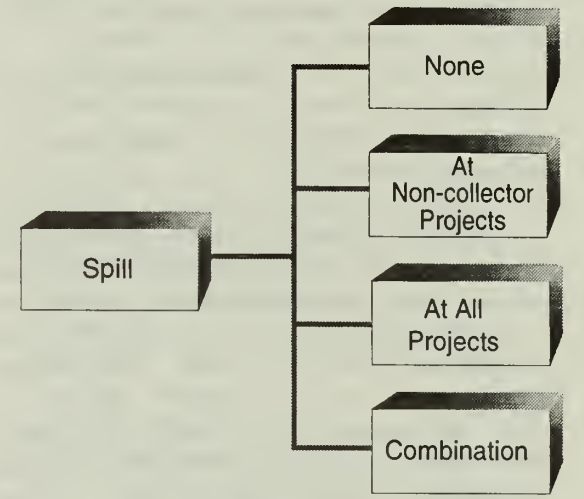
The agencies understand the choices that are entailed in a decision on the SOS. These choices represent a path the SOR decision process will follow. The most vital issue in selecting a preferred SOS was salmon recovery. Events, such as the ESA listings and recent court directives, moved salmon to the top of the list of operating priorities. Many of the system operating strategies and options studied in the SOR were designed specifically to test their potential to aid the migration of juvenile salmon. In considering how to improve juvenile passage, there are three possibilities under consideration: a comprehensive program for fish transportation, complete dependence on in-river migration, or some combination of the two tailored by species and river conditions.

Thus, the first major choice to be made is to pick one of these three approaches to juvenile passage (see box).

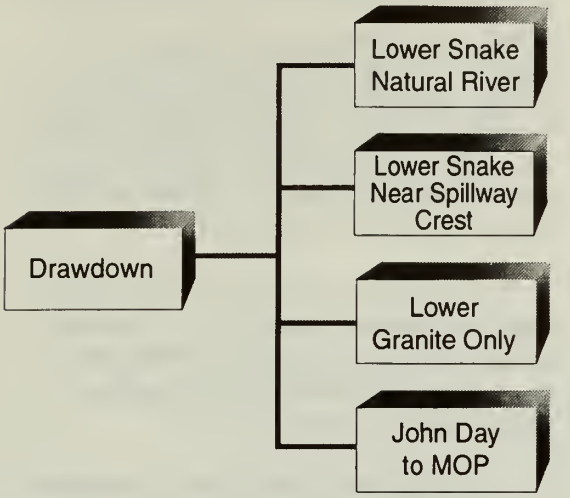


The 1995 NMFS Biological Opinion calls for an 80 percent FPE. This means 80 percent of the smolts must pass the projects through non-turbine routes. Spill has been part of seasonal operations since the 1980s, and can be used to move migrating salmon and steelhead safely past the dams. If water is put over the spillways instead of through the generating turbines, a portion of the smolts will go with it, avoiding a potentially hazardous trip through the turbine blades. While spill helps to accomplish the 80 percent FPE goal, it is not a cure-all, because spill can create gas supersaturation that can be harmful to aquatic life. All four Northwest states have legal limits for gas supersaturation, and gas levels must be monitored and controlled when spill is occurring. Spill also diverts fish away from barge collection areas at the dams. If spill is taking place at a project where fish are amassed for transport, fewer fish will enter the collection system.

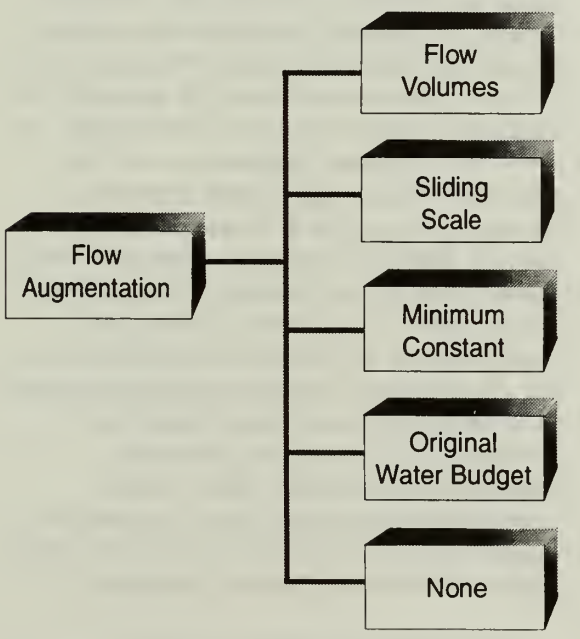
A combination of spill and transport operations can be viewed as a "share-the-risk" strategy. Such a strategy allows for spill at all projects when flows are good to capture the benefits of in-river migration for a larger number of smolts. There is, however, no spill at the collector projects when flow conditions are poor, in order to put more fish into barges, where they would be safe from predators and other adversities.



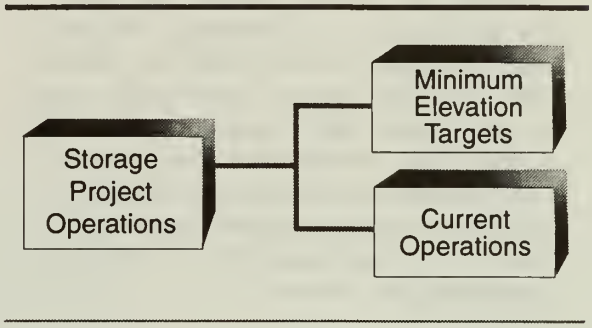
Another choice addresses drawdown. Aside from transportation, certain forms of drawdown proved to be the most promising way to increase juvenile survival. The diagram below depicts the four drawdown options in the SOR from which a decisionmaker can choose. The choice may be narrowed down by the approach to juvenile passage chosen above.



The fourth step in the path leads to a choice on flow augmentation. The SOR has considered five approaches to augmenting flows to move juveniles more quickly through the system, as shown in the following diagram.



Operation of the storage projects on the system has implications for all river uses, including anadromous fish recovery. This is the fifth choice on the path toward a system operating strategy, as shown below.



Not every choice makes sense if combined with every other. And some combinations work together better than others. For example, a decision to depend entirely upon in-river passage for juveniles would be most effectively coupled with natural river drawdown, since the results of the analysis showed this to be the most promising in-river option. John Day drawn down to MOP would, on the other hand, offer little benefit for in-river passage if it were implemented on its own.

A full-scale transportation program, under which most juveniles are moved in barges, would make further increase in flow augmentation unproductive and unnecessary. Increased flow targets would be important if juveniles are to travel largely in-river. Likewise, the drawdown strategies are aimed primarily to aid in-river fish migration. Drawdowns would not be needed if the majority of fish are transported in barges rather than left to migrate in-river.

The decisionmakers will also need to consider the near-term and long-term benefit and cost implications of the alternatives. While a natural river drawdown could provide considerable benefits for in-river juvenile migration, it is also the most costly and time-consuming strategy to implement. If this were

chosen, some near-term, temporary measures would have to be considered as well.

The SOR agencies have identified a preferred SOS alternative (SOS PA) in the Final EIS. This tentative selection, which does not constitute the final SOS decision, was made by the SOR agencies , in coordination with the recommendations of the USFWS and NMFS 1995 Biological Opinions. Following a 30-day no-action period after release of the Final EIS (during which time additional public review comments can be submitted), the agencies will confirm or modify the decision to select a preferred SOS and issue a Record of Decision documenting the selection.

8.3.2 The Forum

The Forum is a process the SOR agencies have examined during the SOR to accomplish periodic review and update of the SOS in the future. In this document and the Forum Appendix Q, several alternative designs for the Forum are presented. The analysis concluded that there were no environmental effects associated with the Forum, and implementation of any several of the alternative Forums could occur at any time.

Because the Forum is an administrative process resulting in no environmental effects, the requirement in NEPA for identifying a preferred alternative does not apply. Instead, the agencies described a "proposed interim action" that reflects the approach the agencies are currently taking. The proposed interim action stemmed from an analysis of the existing situation, particularly given the recent events surrounding the 1995 Biological Opinions, a review of the public comments on the Forum and an assessment of the agencies' ability and desire to create such a proposed decisionmaking process.

8.3.3 PNCA and CEAA

Federal agencies and contract parties have been negotiating the PNCA and the CEAA. For the PNCA, negotiations on the principles that would guide specific provisions of a new contract have been completed. The negotiators are drafting specific contract language and plan to have a new agreement available soon for signature. While the SOR agencies cannot formally commit to this agreement prior to a Record of Decision, it represents the preferred alternative identified in the Final EIS. The agencies expect to sign a new agreement after a Record of Decision is completed.

For the CEAA, negotiations have also been occurring, parallel to the PNCA. A similar process has been followed for identification of the preferred alternative, and will continue through the final decision.

A final decision on the CEAA is dependent, to some extent, on how the Canadian Entitlement is returned to Canada. The provisions in the Columbia River Treaty specify delivery of power at Oliver, British Columbia. However, alternate arrangements are possible with mutual consent by the parties. Late in 1994, a nonbinding agreement was reached with Canada that provided a different delivery arrangement than that in the Treaty. Specifically, the United States would have purchased a portion of the Canadian Entitlement, delivered the remaining amount over existing transmission lines located on the west side of the Cascade Mountains, and provided Canadians access to U.S. transmission to facilitate power sales in the United States. In mid-1995, the prices for power on the West Coast had changed significantly so that the agreement was judged to be uneconomical for the U.S. parties. Canada was informed that the United States did not intend to go forward with the agreement. This decision affected the negotiations on the CEAA, since the allocation for generating the Canadian Entitlement between U.S. Federal and non-Federal parties was connected to the non-binding agreement governing the entitlement return. Thus, negotiations on CEAA will likely continue in tandem with any further discussions with Canada on how to return the Canadian Entitlement.

The preferred alternative for CEAA evaluated in this EIS is based on the original

provisions of the Columbia River Treaty for return of the Canadian Entitlement.

NEPA requires that agencies wait at least 30 days after issuing the Final EIS before preparing a Record of Decision to document the chosen action. Decisions on the SOR actions can therefore be expected beginning this winter.

Chapter 9

Coordination and Public Involvement

9.0 COORDINATION AND PUBLIC INVOLVEMENT

The Columbia River and its multi-purpose water projects are critical to the Pacific Northwest and its economy. The projects provide water for crops, prevent flooding, power people's homes and businesses, supply outdoor recreation, serve as a trade route, and provide habitat for fish and wildlife. But, as noted in previous chapters, the river is finite and subject to competing demands. Because of the vast sweep of the river's influence, it was essential that the SOR be sensitive to the needs and recommendations of all parties dependent on, affected by, and interested in the river and its uses, including the many agencies responsible for managing the resources of the Columbia River system and the public that has become so dependent on the river's riches.

The three lead agencies—the Corps, BPA, and Reclamation—attempted to engage all interested parties in the SOR process from the outset of the study. This effort included an extensive scoping process, the inclusion of public and agency members on the resource work groups, regional public forums, and the constant exchange of information through regular issues of *Streamline*, the SOR newsletter. This effort met and exceeded all NEPA requirements and ensured that the public and relevant government agencies had ample opportunities to be active participants in SOR decisions. This consultation and public information process is described below. A more comprehensive discussion can be found in the *Scoping Document,* and in issues of *Streamline.*

9.1 AGENCY COORDINATION

9.1.1 Lead and Cooperating Agencies

The Corps and Reclamation operate the Federal dams on the Columbia River, and BPA sells the power the dams generate. These three lead agencies undertook the comprehensive review of Columbia River operations that led to this EIS. The SOR was triggered in part by the need to renegotiate agreements that affect system management—CEAA and PNCA—that expire soon. The SOR also provided an ideal vehicle for the lead agencies to examine ways to coordinate their management of the Columbia River system, which in the past they had pursued somewhat independently.

The lead agencies coordinated their SOR activities through the organizational structure and process described in Section 1.3.2 of the EIS. Each agency designated one senior staff person to be its project manager for the SOR. The project managers were the focal points for managing the flow of SOR information among the agencies, and ensured that the efforts of SOR staff within each agency were coordinated according to overall SOR direction. The work groups, which reported to the project managers, included representatives from all three lead agencies to enhance communication and mutual understanding among the agencies throughout the project.

The three lead agencies consulted frequently with the three cooperating agencies for the SOR—the NMFS, USFWS, and the NPS. The U.S. Department of Agriculture, Forest Service was initially a cooperating agency, but subsequently withdrew from that role. Each of the cooperating agencies has jurisdiction and special expertise with regard to some aspect of the SOR. Representatives of the cooperating agencies sat on work groups and contributed their analytical expertise. Cooperating agency managers were also on the distribution list for all SOR written communications to keep them informed of activities.

The technical work groups that conducted the SOR analysis were guided throughout the screening process by the Analysis Management Group. The Analysis Management Group is composed of the SOR project managers from the three lead agencies; the coordinators of each work group (work group coordinators were staff persons from one of the three lead agencies);

and representatives of the three cooperating agencies. The Analysis Management Group met frequently during the development and screening of the alternatives, and subsequently as needed during full-scale analysis. The Analysis Management Group offered alternatives for analysis and served as the primary forum for developing screening analysis conclusions. During full-scale analysis, Analysis Management Group meetings were used to identify, discuss, and resolve issues encountered by the work groups in carrying out their assignments.

The preliminary draft version of the SOR EIS was prepared in January 1994 and circulated to reviewers from the Corps, BPA, Reclamation, and the cooperating agencies, both within the region and in Washington, D.C. It was also reviewed by regional Indian tribes. Comments and suggestions made by the lead and cooperating agency review team and tribes were then incorporated into the Draft EIS.

The Draft EIS was officially released to the public on July 25, 1994. Approximately, 1,000 copies of the Draft EIS were sent to representatives of Federal, State, local, and tribal agencies; elected officials at Federal, State, and municipal levels; tribal organizations; public libraries; public utility districts; members of the agricultural, forest products, recreation, transportation, and other industry interest groups; environmental conservation organizations; and the general public. Release of the Draft EIS, and publication of the Notice of Availability in the Federal Register, opened a 144-day comment period for public review and comments. The review comment period, originally scheduled to close on October 24, 1994, was extended twice. The comment period was extended initially to November 7 and then again to December 15, 1994. This extension was requested by the Northwest governors, tribes, NPPC, and others. The SOR lead agencies felt that this extension was warranted to allow interested and affected parties a more complete review and more time to submit review comments. All comments postmarked within this period are addressed in the Final EIS. To provide additional opportunities for comment, the SOR agencies held a series of public meetings held between September 19 and October 4, 1994.

9.1.2 Other Agencies

The three lead agencies worked closely with state fish and wildlife agencies (Idaho Fish and Game Department; Montana Department of Fish, Wildlife, and Parks; Oregon Department of Fish and Wildlife; Washington Department of Fisheries; and Washington Department of Wildlife); state departments of parks and transportation; Federal agencies other than the cooperating agencies, including the BLM, Department of Agriculture, EPA, U.S. Geological Survey, and BIA; the NPPC; PUDs; and other government entities. Members of some of these other agencies sat on some of the work groups (see below). All were encouraged to participate in the 14 scoping meetings held throughout the region at the outset of the study. The lead agencies mailed coordination letters to over 50 agencies at various levels of government in the summer of 1991, to encourage their participation and solicit their views. The SOR managers held roundtable meetings in six locations in the region during November 1991 and 14 mid-point meetings in September 1992, after the work groups had completed preliminary screening of alternatives.

9.2 COORDINATION WITH TRIBES

There are 14 Federally recognized tribes in the Columbia River Basin that could be affected to a greater or lesser extent by SOR decisions. One of these, the Blackfeet of Idaho, is outside the SOR study area but has interests within the study area.

The lead agencies have encouraged the participation of Indian tribes and have attempted to coordinate with them on issues of concern to their people. The SOR agencies sent a letter to tribal chairpersons on June 20, 1991, informing them about the SOR and upcoming events and project milestones. A letter was also sent to tribal chairpersons on August 14, 1992, offering to present briefings to tribal governments and to

coordinate with them during full-scale analysis. This letter coincided with preparations to conduct a series of mid-point briefings for the general public throughout the region. The letters included information on how the tribes could get involved in the SOR. The tribes are on the general SOR mailing list and receive the same materials, such as the *Streamline* newsletter, as does the general public.

In April 1993, the SOR managers formed the Indian Coordination Group to solicit tribal participation and to improve communications with tribal governments. On July 27, 1993, the heads of the three SOR agencies sent a letter to the chairpersons of the 14 tribes offering to brief them on the current status of the SOR. As a result of this letter and numerous telephone conversations with tribal staffs, a coordination meeting was held in Spokane, Washington on September 29, 1993. It was attended by representatives of the Colville Confederated Tribes, Spokane Tribes, Coeur d'Alene Tribe, Nez Perce Indian Tribe, Kootenai Tribe of Idaho, Confederated Salish and Kootenai Tribes, Shoshone-Paiute Tribes of the Duck Valley Indian Reservation, and the Kalispel Tribe of Indians. Additional meetings were held with the Shoshone-Bannock Tribe, Burns-Paiute Tribe, Umatilla Tribe, Confederated Tribes of the Warm Springs Reservation, and Confederated Tribes and Bands of the Yakama Indian Nation on their reservations in late October, November, and December 1993.

As a direct consequence of the concerns expressed by the tribes regarding what they perceive as the inadequacy of consultation with them, they have repeatedly requested that the SOR process be halted and the study begun over or, at the least, that it be put on hold for a year to allow them time to catch up with the process. The SOR agencies have responded to the tribes' concerns by offering contracting opportunities to enable them to perform studies on issues of concern and reviews of SOR materials so that they could contribute their knowledge and views. To date, 12 tribes have entered into contracts with the SOR agencies, and most of them have provided input to the Final EIS through those contracts. In addition, at the request of the tribes, the agencies extended the period of comment on the Draft EIS to gain maximum benefit of their technical and/or policy views and concerns.

The SOR agencies have solicited comments from tribes within the region. The agencies attempted to address Native American resources and concerns in the Draft EIS; the Final EIS includes an expanded discussion that provides more emphasis on treaty rights and trust assets, using additional information developed since the Draft EIS was issued.

Subsequent to the close of comment on the Draft EIS, the CTUIR proposed an operating alternative for consideration in the Final EIS. Briefly, this alternative is a variation on or modification of the DFOP evaluated as SOS 9a. The SOR agencies determined that it would not be practicable or necessary to conduct a full-scale analysis of the CTUIR alternative to the same level as the 13 final SOSs. Nevertheless, the agencies agreed that this proposed operation should be investigated and addressed in the Final EIS. Working through the CTUIR contract for SOR participation, the Tribe, the Tribe's contractor, and the CRITFC developed operational specifications as input to hydroregulation modeling. ROSE performed a series of hydroregulation iterations for the CTUIR alternative, which at this point was termed SOS 9d. The SOR agencies then asked the work groups to consider SOS 9d and address its expected effects. The work group contributions are reported in Section 4.1 of the Final EIS.

In addition to these efforts for overall project-level coordination with the tribes, representatives of several of the tribes have participated in some SOR work groups from the beginning because they have special interests in those river uses or functions. The Resident Fish and Wildlife Work Groups have had the most tribal involvement, which dates from 1992. Biologists from the Colville Confederated Tribes, Confederated Salish and Kootenai Tribes, Spokane Tribes, and Shoshone-Bannock

Tribes attended many meetings of the Resident Fish Work Group. Representatives from the Colville Confederated Tribes, Nez Perce Indian Tribe, Spokane Tribes, and Confederated Tribes and Bands of the Yakama Indian Nation participated in Wildlife Work Group meetings.

In January 1993, the Cultural Resources Work Group invited the tribes to a meeting in February to initiate coordination with them on the preparation of the Cultural Resources Appendix to the Draft EIS. In September 1993, the work group solicited help from the tribes in collecting specific information needed to complete its appendix for the Draft EIS. The Burns-Paiute Tribe, the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Warm Springs Reservation, the Nez Perce Indian Tribe, and the Colville Confederated Tribes provided statements and cultural resources information.

9.3 PUBLIC INVOLVEMENT

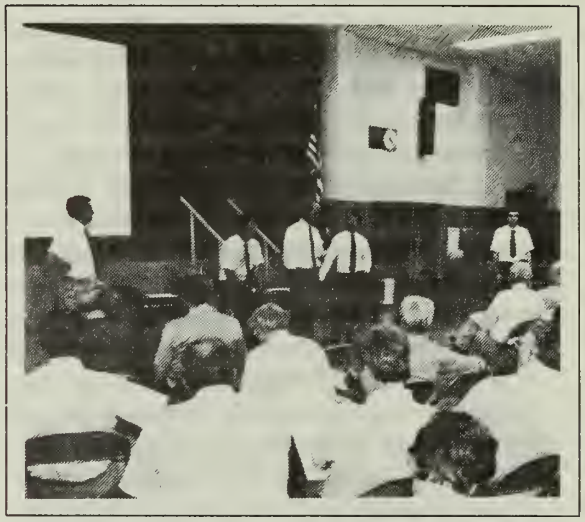
People in the Northwest have a great interest in the Columbia River system, and there has been a lot of public participation in the SOR in many different ways.

The SOR public involvement effort aimed at establishing a two-way dialogue between members of the public who are affected by system operations and the Federal agencies that plan and control those operations. Throughout the SOR, the public has been encouraged to make recommendations and comments to the agencies as they formulate and assess alternatives for decisions about the river system.

Members of the public served on SOR work groups and helped prepare technical appendices. Others followed work group activities by mail, without direct involvement. There were also hundreds of people who participated in the SOR on an ad hoc basis. They wrote letters, telephoned, attended meetings, and generally spoke their minds about the Columbia River system, its importance to them, and how they wanted to see it operated in the future.

The three SOR agencies appointed a team of specialists in the spring of 1990 to develop a formal public involvement program. The team came up with a plan designed for an audience with a diversity of interests, and laid the groundwork for a series of publications and activities that would reach all segments of that audience. The plan had two primary purposes:

- To inform and educate the general public throughout the multiyear SOR, and
- To provide the opportunity for members of the public to express their points of view and help shape the SOR outcome.



More than 2,100 people have attended the four public meetings held to date.

The public involvement team decided in the initial planning to create an SOR logo unique to the multiagency effort. The logo has been used on all SOR public information materials. The SOR also established a dedicated post office box and a toll-free phone line to give the public direct access to staff members working on the SOR. These arrangements also helped to keep the process from being dominated by any one agency or set of interests. Other methods used to inform and involve the public are: the *Streamline* newsletter; the mid-point review meetings held in September 1992; brochures,

slide-tape programs, public meetings on the Draft EIS, and other public information.

9.3.1 Scoping and Other Public Meetings

The Corps, Reclamation, and BPA jointly announced the SOR on July 18, 1990 and invited members of the public to scoping sessions. The following day, July 19, 1990, a Notice of Intent was published in the *Federal Register*. The notice of scoping and an initial public information piece on the SOR were sent on July 18, 1990 to a mailing list of 11,000, which was compiled from existing mailing lists of the three Federal agencies.

The SOR agencies sponsored a series of 14 scoping meetings around the region between August 6 and August 23, 1990. The meetings were scheduled in urban areas and in small communities near Columbia and Snake River reservoirs (see Figure 9-1 for locations of these and subsequent meetings). The locations were: Seattle, Spokane, Kennewick, and Grand Coulee, Washington; Sandpoint, Boise, Idaho Falls, and Orofino, Idaho; Libby, Eureka, Missoula, and Kalispell, Montana; and Pendleton and Portland, Oregon.



Figure 9-1. Locations of SOR public meetings

Each scoping meeting was led by a panel of representatives from the Federal agencies. Participants saw a slide show on the FCRPS. They also were given an overview of the SOR and an explanation of the decisions that were to be made as a result of the review. After these presentations, the public was given the opportunity to make comments on the scope of the SOR. Over 800 people attended the 14 meetings. The agencies also received about 220 comment letters and 600 coupons from newspaper ads, requesting information and a place on the SOR mailing list.

The public had three additional opportunities to meet face-to-face with the SOR management team. Roundtable meetings were held in seven locations from November 1991 to January 1992 to allow the public to preview and comment on the preliminary alternatives developed by the SOR work groups. The meetings were held in Sandpoint and Orofino, Idaho; Kalispell and Libby, Montana; and Kennewick, Grand Coulee, and Seattle, Washington. These meetings attracted about 300 people.

In September 1992, the SOR managers held 14 mid-point meetings. The roster of locations for the mid-point meetings was nearly the same as for the scoping meetings. The work groups had completed screening 90 preliminary system operation alternatives, and participants in the mid-point meetings were able to learn about and comment on the 10 candidate strategies being considered for full-scale analysis in the SOR. The purpose of the mid-point meetings was to ask people for their comments on the candidate

What Did the Public Have to Say During Scoping?

The public involvement team categorized the hundreds of public comments into over a dozen broad subjects, including geographic scope and content of the EIS, fish, wildlife, Endangered Species Act, hydropower, system operations, flood control, irrigation, navigation, and water use. The team prepared a detailed summary of comments, published as a part of the Scoping Document.

A majority of those who commented on the geographic scope said the SOR should consider the entire Columbia River system. Some members of the public urged the Federal agencies to provide more and better information about the river system and the many agreements that govern hydro project operations.

There were many calls for an expanded voice for fish and wildlife in system operations. Members of the public said they favor wildlife habitat restoration, and many want the Columbia River's fish resources to be a high priority in system management.

A number of commenters emphasized the importance of hydropower and its role in the regional economy. Others pointed to a need to increase generating efficiency at Federal projects. Comments on irrigation and recreation pointed up their economic significance to the Northwest economy. And there were many general comments on preserving and developing the Columbia River flood plain and shoreline.

In total, the comments covered a wide variety of topics and interests and confirmed the SOR agencies' belief that the public was very concerned about the future of the Columbia River and the resources the river system supports. The level of interest during the scoping phase of the SOR signaled the need for an ambitious educational and public involvement effort.

strategies, and to determine whether the strategies adequately reflected the scoping concerns that were expressed nearly 2 years earlier. The agencies presented the candidate strategies in a slide show; this was accompanied by a publication that summarized the screening methodologies the work groups had used. Nearly 500 people attended these meetings, which were held from September 8 to September 30.

Following these meetings, the public was given until October 15, 1992 to submit written statements on the candidate strategies. The public involvement team subsequently produced an analysis of all mid-point comments, which was available upon request.

The third series of public meetings following the scoping process occurred in 1994 and provided the opportunity to comment on the Draft EIS. These meetings are discussed in Section 9.3.3.

9.3.2 Involvement of the Public in Work Groups

The public involvement team recognized that the work groups could be an effective avenue for involving key publics in the ongoing technical work of the SOR. This had two advantages. First, it allowed interested members of the public to participate in the detailed work group deliberations and decisions. Second, it enabled the work groups to benefit from the knowledge and expertise of individuals and organizations

outside of the three agencies, resulting in a better technical product.

The work group leaders were given latitude to determine the appropriate degree of public involvement within their group. In some cases, members of the public participated as full-fledged members of a work group, attending meetings to discuss technical topics and participating in other related activities. There were also members of the public who did not attend meetings, but did receive minutes of meetings and were asked to comment on draft work group documents. The rest of the public was kept informed through articles in *Streamline* and other materials prepared by the three agencies to explain SOR topics and issues. A brief summary of the public involvement activities of each work group follows. The number of active members given for each group includes SOR agency staff.

Anadromous Fish

The Anadromous Fish Work Group met as needed and included a small active membership of five to six agency staff, in addition to work group consultants. Other members included representatives of various Indian tribes, the NMFS, USFS, and the NPPC. The group has a mailing list of 60 people.

Cultural Resources

Only members of the three SOR agencies attended Cultural Resources Work Group meetings early in the SOR project. During this early phase, attendance averaged around five to seven members. By May 1993, however, the work group began inviting representatives of Indian tribes as well as the BIA, NPS, USFS, and BLM. Attendance at meetings varied markedly, depending on the agenda, from 8 or 9 to as many as 25. The group has a mailing list of 56 people. The relationship of this and other SOR work groups with Indian tribes is discussed more fully in Section 9.2.

Economic Analysis

This work group met an average of once a month with an attendance of between seven and nine people. It maintains a mailing list of between 35 and 40 people. Included among its active members are representatives from the U.S. Bureau of Mines, the Port of Portland, the NPPC, PNUCC, and Northwest Economic Associates.

Flood Control

Active membership consists of staff from various utilities, the NPPC, and the PNUCC and totals around 13 people, including those from the three SOR agencies. This group has had relatively little public involvement outside of its active membership because flood control does not tend to be a dominant concern to most people.

Forum Alternatives

This work group drew on public involvement and decision analysis specialists from outside the SOR agencies and received input from a variety of regional organizations interested in system planning and operations decisions. Two workshops, attended by approximately 15 people each, were key events in the development of Forum alternatives. The work group met about 8 times over the 6 months during which they developed and evaluated alternatives. The average attendance at the work group meetings was 6 to 8 people.

Irrigation

The average attendance at Irrigation Work Group meetings has been 10 to 14. Active members include the U.S. Department of Agriculture, Natural Resources Defense Council, USFWS, state agencies, and NMFS. The group has a mailing list of over 100 people.

Navigation

As with the Flood Control Work Group, the Navigation Work Group has a small, well-

defined public, which includes the NPPC, waterways associations, grain grower associations, state departments of transportation, and tugboat operators. The group includes approximately 21 active members but typically draws 7 or 8 to its meetings.

Pacific Northwest Coordination Agreement Alternatives Analysis

Initially, the active membership totaled approximately 40 people representing diverse interests ranging from power coordination to conservation. As the focus of the group gradually narrowed to power coordination issues, the membership dropped to around 20, consisting mostly of people interested in power coordination issues. The group maintains a mailing list of just under 100 people.

Power

The active membership for this group is about 35; an average of 15 to 20 attend the meetings. Among the active members are the NPPC; Direct Service Industries, Inc.; various utilities; PNUCC; and NMFS. The group has a mailing list of about 60 people.

Recreation

Active members include staff from the NPS; Idaho, Oregon, and Washington parks and recreation agencies; the Oregon State Marine Board; and Chelan County PUD. The work group has met with various interest groups such as the Lake Roosevelt Forum and the Libby Chamber of Commerce. It maintains a mailing list of 110 agencies, organizations, and people.

Resident Fish

Meetings have been held on an as-needed basis, with a typical attendance of less than 20 people. The public member roster for this work group includes the USFS; USFWS; state fish and wildlife agencies; the Nez Perce, Spokane, and Colville Indian Tribes; and the Upper Columbia United Tribes. The group maintains a mailing list of approximately 200 people.

River Operation Simulation Experts

Active members of ROSE include the PNUCC and the NPPC. This group is made up of people who have an interest in hydro regulation; the group has a mailing list of 58 people.

Water Quality

This work group's meetings have been held on an as-needed basis with attendance varying between 8 and 14. Among the most active participants in the group are the U.S. Geological Survey, the EPA, the NMFS, the U.S. Soil Conservation Service, the Lake Roosevelt Water Quality Council, and Citizens for a Clean Columbia.

Wildlife

An average of 10 to 15 people have attended this group's meetings, which are monthly or as needed. Representatives from Indian tribes, state agencies, the USFS, and the Audubon Society attended and participated in several meetings. The group has a mailing list of over 60 people.

9.3.3 Draft EIS Meetings

After the Draft EIS was released, a series of nine public hearings was held between September 19 to October 4, 1994. The majority of meetings was held in the evenings, beginning at 7:00 p.m. However, two meetings (Portland and Seattle) were held in the afternoon. The dates and cities hosting the meetings follow:

- September 19—Sandpoint, Idaho
- September 20—Kalispell, Montana
- September 21—Libby, Montana
- September 22—Grand Coulee, Washington
- September 26—Boise, Idaho
- September 27—Lewiston, Idaho
- September 28—Pasco, Washington
- October 3—Portland, Oregon
- October 4—Seattle, Washington

Each meeting consisted of three parts. The first part was a slide presentation and narrative discussion addressing the purposes, alternatives, issues involved, and anticipated effects of the SOR and the EIS. The second part was a question-and-answer session that allowed the public to ask questions of a technical panel. The panel included key staff from BPA, the Corps, and Reclamation. The meeting concluded with an official hearing to receive the formal public testimony on the Draft EIS. A court reporter transcribed word-for-word to ensure that all comments and panel discussions were documented. Transcripts of the hearing are available for purchase, at the cost of reproduction, from the SOR lead agencies. These hearings are in compliance with the NEPA requirements to provide a 45-day public comment period for EISs.

Approximately 500 people who were not affiliated with the SOR agencies attended the nine public hearings. Attendance ranged from about 18 at Grand Coulee, Washington to over 150 at Lewiston, Idaho. Of the 500 attendees, 101 people offered verbal comment on the Draft EIS. Many meeting attendees were critical of the SOR, including the "Grim Reaper," an environmentalist who attended the Boise, Idaho meeting wearing a skull mask and black hood and carrying a scythe with an SOR sign attached to it.

The SOR agencies received written or verbal comments from over 360 people during the public review process. These comments included testimony from 101 speakers at the public hearings, 253 letters, and seven comments written on comment cards issued at the public meetings. The total number of individuals commenting on the Draft EIS was actually fewer than 360, as many of the public hearing speakers also submitted letters and/or comment cards. The comment letters ranged from one-page handwritten notes, to form letters, to large packages with lengthy reviews supported by multiple attachments. All comments received full consideration, regardless of their style or volume (see Appendix T for a complete discussion of Draft EIS comments).

9.3.4 Publications

The public involvement team learned a great deal about the SOR audience during the 1990 scoping meetings. This helped to guide planning for future communications and other public involvement activities. First, the team found there were hundreds of river users around the region with a high level of interest in a specific activity, such as fishing or boating, but little specific knowledge about how uses interrelate or might conflict. Second, the audience included people who have technical knowledge about a specific river use, such as irrigation or fish production, but may not know how the coordinated hydro system operates.

In response to these apparent needs, the SOR team produced a series of publications. The team published 20 editions of a newsletter called *Streamline* between November 1990 and October 1995. The newsletter will continue to be produced until the Final EIS and Record of Decision are released. *Streamline* carries news and feature articles about river uses, the Federal projects, milestones in the SOR process, and related topics, such as the ESA and the Columbia River Treaty. One goal of the newsletter is to increase awareness of the tradeoffs among river uses that must be considered when operating changes are contemplated.

In addition, several larger informational and educational background documents were produced for the public as part of the SOR:

- *The Columbia River: A System Under Stress*—an introduction to the SOR.
- *The Columbia River System: The Inside Story*—a publication that describes the Coordinated Columbia River system and its operation.
- *Screening Analysis: A Summary*—a report on the SOR alternatives screening process.

- *Screening Analysis*—a two-volume report on screening the 90 alternatives developed by the SOR work groups.

- *Modeling the System: How Computers Are Used in Columbia River Planning*—a description of the computer models used to plan and regulate hydro operations in the Columbia River Basin. These models have been used in screening and analyzing SOR alternatives.

- *Power System Coordination: A Guide to the Pacific Northwest Coordination Agreement*—an explanation of the role of the PNCA in system operations.

- *Daily/Hourly Hydrosystem Operation: How the Columbia River System Responds to Short-Term Needs*—a review of the process and considerations that determine the day-to-day operation of the river system.

There has been considerable interest in the publications. For example, the initial 7,500 copies of *The Inside Story* were distributed, and the publication is in its second printing. All of the people on the 5,000-plus SOR mailing list receive copies of the *Streamline* newsletter, which has been used to announce the publication and availability of the other documents, including technical reports and information from work groups. All of these materials are provided upon request.

9.3.5 Future Public Involvement Efforts

After the agencies complete the Final EIS, they must wait at least 30 days after publication of the Final EIS before making final decisions. These decisions will be announced in the Records of Decision issued by the respective agencies. The 30-day no-action period will provide a final opportunity for public review and comment before actions are implemented.

Chapter 10

Related Regional Processes and Studies

10.0 RELATED REGIONAL PROCESSES AND STUDIES

The regional response to the need to aid salmon recovery includes many efforts that encompass a broad scope beyond the operating regime of Columbia-Snake River dams. Because the scope of the SOR is limited to analyzing the effects of long-term river management operations, studies beyond this scope are not considered in the SOR analysis. The purpose, however, of all these studies, short-term and long-term, operational and structural, is essentially the same—to help improve salmon survival while meeting the needs of other river users. In addition, there are several current studies that involve the region's electric power resources but do not directly address salmon issues. Actions taken as a result of any of these other studies may require additional NEPA documentation and consultation with NMFS. The objective of this section is to clarify the related studies and other activities that are outside the scope of the SOR.

10.1 RELATED REGION-WIDE FISHERIES AND RIVER SYSTEM STUDIES

At the SOR public meetings, people expressed confusion over the scope and purpose of the many river and fish-related studies under way, and the roles of different government agencies in them. The following is a brief description of the related programs and studies that focus specifically on the coordinated Columbia River system, or that involve the system in a significant way. Table 10-1 is a matrix that attempts to put their respective scopes in perspective.

10.1.1 National Marine Fisheries Service ESA Listing and Recovery Plan

While programs to improve the status of Columbia/Snake River salmon have been ongoing for decades, the filing of formal petitions with NMFS in 1990 for ESA listing of three Snake River stocks as threatened or endangered focused regional attention on the need for more aggressive action to address the precarious status of specific wild salmon stocks. Outgrowths of the petition filing included the Salmon Summit, the beginning of the NPPC's amendments to rebuild salmon stocks, and several Corps-led studies to improve dam operations. The formal listings in November 1991 and April 1992 triggered the initiation of a NMFS recovery plan and Federal agency consultation on the effects of actions, including operation of the coordinated Columbia River System, on listed salmon.

Under the ESA, the SOR agencies have a responsibility to ensure their actions are not likely to jeopardize the continued existence of the listed species. The agencies have prepared Biological Assessments on their prior short-term action proposals and entered consultation with NMFS under the ESA, Section 7. NMFS issued Biological Opinions as to whether the river operating plans proposed for 1992, 1993, and 1994 to 1998 jeopardized the continued existence of the subject species. The latter Biological Opinion was superseded in March 1995 by a replacement document that addressed system operation in 1995 and future years. This Biological Opinion provided the basis for most of the preferred alternative for the SOS.

Ultimately, a recovery plan will guide all aspects of activities that might affect salmon restoration and recovery. NMFS convened a recovery team, which issued draft recommendations in October 1993. The recovery team's draft report was subjected to peer review, and was followed by a final recommendations report in October 1994. NMFS considered the team's recommendations in developing a draft recovery plan, which was released for public review in March 1995.

The SOR has accommodated the ESA process to date by incorporating guidance from NMFS' Biological Opinions among the system operating strategy alternatives. The preferred SOS alternative in the Final EIS reflects the pertinent draft recovery plan provisions, which

Table 10-1. Scope of related regional study processes

Study Process	Hydro System: Fish Transportation	Hydro System: Project O&M	Hydro System: Structural Changes	Habitat	Harvest	Production	Power System	Status[a/]
Fisheries and River System Studies								
Columbia River System Operation Review (SOR)	X	X	X					1995
NMFS Recovery Plan	X	X	X	X	X	X		1995
USFWS ESA Listings		X		X		X		1994/1995
NPPC Fish & Wildlife Program								
Phase I				X		X		1992
Phase II	X	X	X	X	X	X		1992
Phase III	X	X	X	X	X	X		1993
Phase IV				X		X		1994
Corps/BPA/Reclamation 1991 Operations Plan	X	X						Completed 1991
1992 Columbia River Salmon Flow Measures OA/EIS		X						Completed 1992
Interim Columbia and Snake River Flow Improvement Measures for Salmon Supplemental EIS (SEIS)		X						Completed 1993
BPA Annual Implementation Work Plan and ESA-Related Programs		X		X		X		Ongoing
System Configuration Study (SCS)	X	X	X					1997 (Phase II)
Lower Snake River Biological Drawdown Test	X	X	X					Uncertain
NMFS Salmon Survival Study	X	X				X		1992-1996
Federal Land Management Policy Review				X				1994
Hatchery Comprehensive Environmental Analysis						X		1996
Reclamation Snake River Augmentation Programs								
Uncontracted Storage Space		X						
New Storage Appraisal			X					1994
Water Rental Group/Snake R. Anadromous Fish Water Management Committee		X						Ongoing
Snake River Basin Water Committee		X						1996
Water Acquisition		X						Ongoing
Snake River Resource Review		X						1999
Other Actions								
BPA Resource Programs EIS							X	1993
CEAA Return EIS (BPA)							X	1995
BPA Business Plan EIS							X	1995
Continued Development of the Columbia Basin Project, Washington		X						Uncertain
Hanford Reach Comprehensive River Conservation Study and EIS				X				1994

a/ Status represents best estimate of expected completion date.

were also included in NMFS's March 1995 Biological Opinion.

NMFS also conducted a status review under the ESA of wild mid-Columbia River summer chinook salmon. This review was in response to a petition for listing filed by 11 conservation groups in 1993. NMFS made a determination in September 1994 that these stocks did not warrant listing under the ESA. The SOR anadromous fish analysis has addressed these fish.

10.1.2 U.S. Fish and Wildlife Service ESA Listings

The USFWS recently completed ESA listing processes involving Kootenai River white sturgeon and bull trout. On June 11, 1992, conservation groups headed by the Idaho Conservation League petitioned to list the Kootenai River white sturgeon under the ESA. The USFWS proposed listing the sturgeon as endangered in a July 7, 1993 notice in the Federal Register, stating that the population is in danger of extinction throughout its range. Interested parties suggested various proposals for spring flow enhancement to encourage sturgeon spawning. The USFWS formally listed the white sturgeon as endangered in September 1994, and issued a Biological Opinion concerning system operations in March 1995. The preferred SOS alternative incorporates the flow provisions for the white sturgeon that are specified in the USFWS Biological Opinion.

On October 30, 1992, the USFWS was petitioned to consider bull trout for listing as a threatened or endangered species under the ESA. On May 17, 1993 the USFWS published in the Federal Register a notice that it had determined that the petitions had merit and began the 1-year status review for listing. The species occurs in many Columbia River Basin reservoirs, including Libby (and the Kootenai River), Hungry Horse (and the Flathead River and its South Fork), Lake Pend Oreille (and the Pend Oreille River), Lake Roosevelt, and Dworshak. In June 1994, the USFWS determined that the bull trout warranted protection under ESA, but the species was precluded from listing because of other priority species.

10.1.3 NPPC Fish and Wildlife Program

The NPPC, made up of appointed representatives of the States of Idaho, Montana, Oregon, and Washington, was entrusted under the Northwest Power Act of 1980 to: (1) develop a conservation and electric power plan to ensure an adequate, efficient, economical, and reliable power supply for the Pacific Northwest; (2) prepare a program to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, affected by the development and operation of any hydroelectric project on the Columbia River and its tributaries; and (3) involve the public in these activities.

In 1982, the NPPC issued a comprehensive Fish and Wildlife Program that addressed salmon and steelhead production, safe passage, and harvest management. In 1991, responding to the potential NMFS listings, the NPPC began a series of amendments to its Fish and Wildlife Program centering on a salmon rebuilding program. The amendment process was initially undertaken in four phases that focus on different aspects of salmon survival, including production, habitat improvement, harvest, and fish passage improvements at Federal dams, as well as resident fish and wildlife measures (which were subsequently amended in 1995). The role of the NPPC in the salmon issue is in part a natural outgrowth of its Fish and Wildlife Program responsibilities, and in part a response to a direct request from elected representatives within the region.

In 1990, the NPPC contracted with the region's Tribes and fish agencies to prepare an integrated system plan addressing coordinated management goals for all of the salmon and steelhead rearing subbasins within the Columbia River system. Moreover, following the Salmon Summit in 1990 to 1991, the governors of the Northwest states requested the NPPC to take the lead in developing regionally acceptable recovery actions.

The SOR agencies have coordinated closely with the NPPC in developing recent Fish and Wildlife Program amendments and will continue to do so as the amendments are implemented. The SOR agencies have also incorporated actions proposed by the NPPC into existing river operations and one or more alternatives for future operations. While NMFS has the final responsibility for issuing the salmon recovery plans, NMFS has indicated that it favors regionally developed recovery plans and expected to use the Fish and Wildlife Program amendments to help form the foundation for its recovery plans (Harrison, 1992).

10.1.4 Short-Term System Operations

The 1992 OA/EIS, prepared by the Corps, BPA, and Reclamation in part in response to the Salmon Summit recommendations, was designed to provide NEPA documentation for short-term (1992) river management actions. It examined ways to improve flow conditions during the 1992 juvenile salmon migration period by altering the operation of Federal dams on the lower Columbia and Snake rivers, and to provide test measurements that would be helpful in designing long-term structural actions. The preferred alternative identified in the Final 1992 OA/EIS was designed to incorporate the relevant components of the NPPC's Phase II Fish and Wildlife Program amendments of December 1991.

1992 Operations Plan

As indicated above, the ESA requires that Federal agencies consult with NMFS in taking actions to conserve the listed salmon species. In compliance with this requirement, the Corps and the cooperating agencies consulted with NMFS on actions that would potentially affect the listed species; the process resulted in a preferred 1992 Operations Plan. NMFS (1992) issued a Biological Opinion concluding that proposed operations "were not likely to jeopardize the continued existence of listed or proposed salmon species." The river management agencies then began implementing the 1992 Operations Plan described in the Records of Decision, which are consistent with this Biological Opinion.

Interim Columbia and Snake River Flow Improvement Measures for Salmon Supplemental EIS

The Corps, BPA, and Reclamation prepared this NEPA document as a supplement to the 1992 OA/EIS. The SEIS addressed actions similar to the 1992 operations plan that would be taken in 1993 and subsequent years. The agencies intended for the SEIS to address river operations for the interim period until a long-term plan is adopted through the SOR.

1993 and 1994 Operations Plans

As with the 1992 OA/EIS, consultation with NMFS on the SEIS resulted in a preferred 1993 Operations Plan. NMFS' Biological Opinion for 1993 identified operations requirements needed to make a no-jeopardy finding. The Corps, BPA, and Reclamation agreed to these requirements and issued Records of Decision for interim operations that were consistent with the Biological Opinion. This Biological Opinion was challenged in court, however, and was subsequently set aside by Federal district court Judge Malcolm Marsh (see Section 1.1 for additional discussion). In March 1994, NMFS released a Biological Opinion on a longer-term plan for river system operations from 1994 through 1998, which identified recommended actions for the 1994 operating year. Following Judge Marsh's ruling on the 1993 Biological Opinion, NMFS and the Federal action agencies (the SOR agencies) reinitiated consultation on the operations plan for 1994 through 1998. This subsequent consultation process resulted in the March 1995 Biological Opinion that is reflected in the SOS Preferred Alternative.

BPA's Annual Implementation Work Plan and ESA-Related Programs

BPA, in cooperation with fishery agencies and Tribes, produces an Annual Implementation Work Plan (AIWP) to guide the performance of actions called for in the NPPC Fish and Wildlife

Program. The AIWP identifies and prioritizes projects and procurement. Increasingly, the AIWP includes projects related to the listed Snake River stocks.

BPA also funds programs and research aimed at restoring runs of listed Snake River salmon. This work includes Snake River sockeye rearing habitat restoration, captive rearing program, and broodstock rearing research; studies of Snake River fall chinook spawning ground distribution, inter-dam losses of adults, genetic structure, population status, factors influencing juvenile migratory behavior, and characteristics of rearing habitat in mainstem reservoirs; and Snake River spring/summer chinook migrational dynamics.

10.1.5 System Configuration Study

The SCS is a long-term study of structural alternatives to improve salmon migration conditions in the Columbia River Basin. The 1992 OA/EIS referred frequently to the Columbia River Salmon Mitigation Analysis (CRSMA) as the Corps' long-term study to address salmon recovery and potential structural responses. The CRSMA program has been a funding mechanism for a number of Corps actions addressed in the SEIS, including the 1992 OA/EIS, the March 1992 drawdown test, and the SCS. With completion of the initial items, the SCS has become the primary focus the of CRSMA and efforts to develop long-term plans.

A status report on the SCS was submitted to the NPPC in December 1992. A draft Phase I report was released in April 1994. Alternatives examined in Phase I included possible additions of upstream storage sites for flow augmentation and temperature control; annual drawdowns of John Day and the four lower Snake reservoirs; the addition of a new collection facility that would intercept juveniles in the upper reaches of Lower Granite Reservoir; and construction of a migratory canal or conduit that would allow fish to bypass the mainstream dams completely. Following public review and comment, the Corps identified several structural alternatives for more detailed evaluation in a Phase II study. In May 1995, the Corps issued a notice of intent to prepare an EIS on the Phase II study; the EIS will address structural modification alternatives related to reservoir drawdown, surface-oriented bypass systems, and dam passage improvements. The scoping period for this EIS closed in August 1995, and a draft EIS is scheduled for release in 1997.

The SCS will provide information on the feasibility and effectiveness of some of the long-term measures recommended by the NPPC in its Fish and Wildlife Program amendments. The Corps is also incorporating recommendations for study of structural modifications that NMFS included in its March 1995 Biological Opinion.

The SOR lead agencies are closely coordinating the SOR and SCS efforts. The agencies are sharing information between the two programs and are ensuring that both follow consistent approaches. The SOR impact analysis is also evaluating the operational aspects of structural modifications that might occur through the SCS.

10.1.6 Lower Snake River Biological Drawdown Test

In April 1994, the Corps issued a Draft EIS on a biological test of the reservoir drawdown concept for the lower Snake River. This study is an adjunct of the SCS. The March 1992 physical drawdown test of Lower Granite and Little Goose Reservoirs indicated that modifications could be made to mitigate adverse physical and structural effects of a drawdown (Corps 1992b). The next step for drawdown testing is to determine biological effects on salmon populations. A Final EIS on the test was initially scheduled for late 1994, but has been delayed indefinitely as a result of data collected during 1993 and 1994 juvenile fish survival studies in Lower Granite Reservoir. NMFS is a co-lead agency with the Corps on this study, while BPA is a cooperating agency.

10.1.7 Other Key Fishery Studies

Several agencies within the region are conducting studies related to salmon recovery that do not have direct involvement by the SOR lead agencies. One of these studies relates to salmon survival within the river system, while the other two involve habitat and hatcheries.

NMFS Salmon Survival Study

NMFS initiated a 4-year study of juvenile salmon survival through the Columbia and Snake River dam and reservoir system in 1992. Juvenile salmon are being marked so that their travel time and survival through the system can be measured. The study is intended to address the effects of flows, water temperature, and spill levels, as well as fish transportation and hatchery programs. It will provide a much-needed update of baseline juvenile salmon survival conditions, which are currently described on the basis of research conducted in the late 1970s. State fishery agencies are cooperating in the study, which is funded by BPA. Initial results from the 1993 and 1994 migration seasons have been widely publicized, debated, and scrutinized in the SOR, SCS, and ESA processes over the past year.

Federal Land Management Policy on Habitat

The USFS and BLM manage extensive areas of Federal lands that provide important salmon spawning and rearing habitat. The two agencies have developed a broad-based, interim policy intended to maintain salmon habitat conditions, through a program popularly known as PACFISH. The policy addresses land management actions on USFS and BLM lands in Idaho, Oregon, and Washington, as well as in California and Alaska that are outside the range of the northern spotted owl. The interim PACFISH policy was implemented in 1994, following release of an environmental assessment. It will be superseded by long-term policies being developed through several geographic-specific EISs.

Hatchery Comprehensive Environmental Analysis

The USFWS is funding a 3-year study to review hatchery practices within the Columbia River Basin. The study is being conducted by the CBFWA, which is made up of Federal, state, and Tribal fish and wildlife agencies. The study will use existing data on genetic diversity to analyze how hatchery and wild stocks have interacted, and is expected to result in recommendations on future hatchery practices.

10.2 BUREAU OF RECLAMATION SNAKE RIVER AUGMENTATION PROGRAMS

The NPPC's recent amendments to the Columbia River Basin Fish and Wildlife Program identify Reclamation as having a lead or cooperative role in a number of additional action items intended to assist in the recovery of the Snake River salmon runs. Reclamation is working to implement these items as part of the regional salmon recovery program. Reclamation has agreed to seek and facilitate the securing of flow augmentation water from the Snake River Basin above Lower Granite Dam to improve conditions for salmon migration. Because some of these activities are ongoing or not necessarily scheduled for completion in the time frame covered by the SOR, their inclusion here is intended as a partial status report on Reclamation's water acquisition efforts.

10.2.1 Water Acquisition

The regional salmon program for 1991 requested the release of 90 KAF (111 million m^3) of uncontracted space in Cascade and Deadwood Reservoirs and the purchase of 100 KAF (123 million m^3) of water from Idaho rental pools.

The NPPC's comprehensive salmon strategy adopted in December 1991, called for the delivery of 427 KAF (527 million m^3) from Bureau of Reclamation uncontracted storage space and water rentals. This same volume of water has been requested by NMFS in its Biological Opinions for 1992, 1993, 1994, and

1995. Table 10-2 shows the volumes of water that have been provided from Reclamation projects since 1991.

Reclamation has dedicated reservoir space not contracted or formally committed to instream or in-reservoir uses for flow augmentation. It has also actively sought to reacquire storage space in project reservoirs, and has permanently reacquired two blocks of storage space, totaling 22.4 KAF (28 million m^3).

Reclamation has expressed a firm intention to comply with state law in providing water for flow augmentation. The NPPC's Fish and Wildlife Program and NMFS' 1995 Biological Opinion stipulate that flow augmentation water will be acquired from willing sellers and in accordance with state water law. Reclamation first applied for a change of use in 1992, after which the Idaho Legislature enacted I.C. 42-1763A that provided temporary authority to provide water for flow augmentation through the 1994 season, later extended to the end of the 1995 season. All subsequent releases of stored water have complied with that provision of state law.

Reclamation filed change of use applications with the Idaho Department of Water Resources (IDWR) on May 15, 1995, to add flow augmentation as a beneficial use of storage releases. Some 80 protests and interventions were filed. The parties reached a negotiated settlement that was formalized in a stipulation signed by Reclamation and 100 percent of the protestants and intervenors. The anticipated outcome to the settlement is draft flow augmentation legislation acceptable to the parties to be submitted to the Idaho Legislature for action in the 1996 session.

10.2.2 Water Rental Group/Snake River Anadromous Fish Water Management Committee

An Idaho Water Rental Policy Group was formed in 1991 to conduct a 3-year study of the feasibility of renting water from Idaho rental pools for lower Snake River flow augmentation. The group consists of representatives from Reclamation, IDWR, IDFG, BPA, Nez Perce and Shoshone-Bannock Tribes, irrigators, and Idaho Power Company. It has been a focal point for key groups to address and coordinate flow augmentation water rentals and releases of water from uncontracted space. The group has been renamed the Snake River Anadromous Fish Water Management Committee. IDFG has assumed the lead role in organizing and coordinating committee activities.

10.2.3 Snake River Basin Water Committee

Reclamation participated with the States of Idaho and Oregon, BPA, the Council, and others to form the Snake River Basin Water Committee, which began work in August 1992. The committee has reviewed ongoing water activities in the Snake River Basin and prepared a work plan that was approved by the NPPC and state water managers in November 1992. One of the committee's assignments from the NPPC has been to consider how an additional 1 MAF (1.2 billion m^3) might be provided from the Snake River Basin. The Committee has worked with an independent consultant (Bookman-Edmonston Engineering, Inc.) and others on this task, and has provided a report to the NPPC.

10.2.4 New Storage Appraisal Study

This work was initiated in late 1991 with the formation of an advisory group of representatives from water user organizations, fish and wildlife experts, and state and Federal agencies. The objective of this study is to identify promising new reservoir projects that could provide storage supplies for flow augmentation. The group inventoried and mapped over 400 potential storage sites above Lower Granite Reservoir. The advisory group evaluated the master site list in July 1992, and 12 basins were selected to receive further evaluation as to potential water supplies. In January 1993, the advisory group further narrowed the list to 11 specific sites for the development of appraisal-level information on costs, system operation, and geologic and other

Table 10-2. Volumes of flow augmentation water from Reclamation projects in Idaho, 1991-1995.

	Volume Provided (KAF)[a/]		
Year	Reclamation Space	Rental Pools	Total Volume Provided
1991	40	160	200[b/]
1992	90	0	90
1993	324	100	424
1994	383	45	428
1995	141	286	427

a/ 1 KAF = 1.234 million m^3

b/ Additional water provided by Idaho Power Company for a total of 427 KAF.

factors. A final report on the study was completed and released to the NPPC and regional interests in January 1994.

NPPC began a rulemaking in August 1994 to consider information included in the damsite report, the Corps' SCS Phase I report, and a report on nonstructural alternatives for securing an additional 1 MAF (1.2 billion m^3) of water from the Snake River Basin. The purpose of the rulemaking was to select alternatives for feasibility-level analysis. NPPC issued final rules in December 1994 that identified three sites, Galloway, Rosevear Gulch, and Jacobsen Gulch. Detailed studies and reports on the reservoir sites were requested by 2002. The Corps has responsibility for the Galloway Project and Reclamation is responsible for Rosevear Gulch and Jacobsen Gulch. In response to public concerns, Reclamation advised the NPPC that it would substitute the Moores Hollow site for Jacobsen Gulch. The sites are adjacent to each other and Moores Hollow is deemed to be the better site from environmental and public acceptability perspectives. Reclamation will provide NPPC an interim report on Moores Hollow in 1997, at which time a decision can be made as to completing the detailed studies by 2002. Rosevear Gulch studies are not being undertaken at this time because of funding constraints.

10.2.5 Snake River Resource Review

Reclamation is beginning a 4-year study of the Federal reservoir system on the Snake River above Brownlee. The scope of the study extends upstream to Jackson Lake in the headwaters area and includes Reclamation-operated projects on the Snake River mainstem and on the Henrys Fork of the Snake River and the Blackfoot, Owyhee, Malheur, Powder, Little Wood, Boise, Payette, and Weiser Rivers. When completed in 1999, this study will provide in-depth, additional information on operation of those projects and on impacts that might result from additional flow augmentation. Data or results from this study were not available for the Final EIS; however, data from other studies or ongoing work have been incorporated where available.

10.3 OTHER ACTIONS

BPA is currently involved in, or has recently completed, three decision processes relating to the regional electric power system. One is a programmatic action addressing the broad scope of BPA's resource acquisition and marketing

activities; another specifically addresses the physical aspects of the return of the Canadian Entitlement power; and the third relates to BPA's efforts to compete effectively in the current utility environment. In addition, for the past several years, Reclamation has been conducting planning and environmental analysis for expansion of the Columbia Basin Project, and the National Park Service has been studying the wild and scenic river potential of the Hanford Reach of the Columbia River. All five of these processes have some relation to the SOR.

10.3.1 Resource Programs EIS

In early 1993, BPA released its Final EIS on future acquisition of electric power resources. This document identifies several alternative resource acquisition programs and assesses their environmental impacts. To the extent that any SOR actions trigger the need for any replacement electric power sources, such new sources would be developed under the direction provided by BPA's resource programs. The Resource Programs EIS also provides detailed documentation of the environmental impacts of any replacement power sources, and is therefore incorporated by reference in the SOR.

10.3.2 Canadian Entitlement Return EIS

The SOR action involving the CEAA relates only to the allocation of the Canadian Entitlement return obligation among the Federal and non-Federal parties, as described in Chapter 7 of this EIS. The SOR scope with respect to the CEAA is therefore limited to the proportional distribution of power obligations, denominated in megawatt or dollar terms, and does not include the physical or tangible actions of returning the power. BPA is also preparing a separate EIS on the physical aspects of the return of Canadian Entitlement power. This EIS primarily addresses transmission system construction and operational actions needed for the return; it was released in August 1994. The Final EIS on this action is scheduled to be published and distributed in November 1995.

10.3.3 Business Plan EIS

In early 1993, BPA began its Competitiveness Project to adapt the agency to rapidly changing utility business conditions. Initial components of this project included a review of BPA's internal administrative and program efficiencies and the development of a marketing plan. The agency then began to develop "strategic action plans" for each major BPA program. These components of the Competitiveness Project formed an overall Business Plan which represents BPA decisions on fundamental agency directions, and as such, requires NEPA compliance. This EIS is an expansion of a previously planned EIS on Commercial Services and Rates. The NEPA process is intended to occur simultaneously with Business Plan development. A Draft EIS was released in summer 1994. The Final EIS was issued in June 1995, and a Record of Decision followed in August 1995.

10.3.4 Continued Development of the Columbia Basin Project, Washington

In 1989, Reclamation released a Draft EIS on the proposed continued development of the Columbia Basin Project, a large irrigation project in central Washington served by pumping water from behind Grand Coulee Dam. The Draft EIS addressed two alternatives that would provide irrigation service to an additional 538,600 acres (218,000 ha) or 87,000 acres (35,200 ha). Reclamation issued a Supplement to the Draft EIS in September 1993. The Supplement focused on two options for the smaller-scale expansion, coupled with flow augmentation and other anadromous fish considerations. Reclamation is currently considering public comment on the Supplement.

10.3.5 Hanford Reach Comprehensive River Conservation Study and EIS

The NPS has completed a comprehensive river conservation study on the Hanford Reach of the mid-Columbia River. The Final EIS was issued in June 1994. It recommends that Congress designate the Hanford Reach a national wildlife refuge and a national wild and scenic river. The proposal would protect 49.5 miles (79.6 km) of river and approximately 105,000 adjacent acres, 42,492 ha) both of which would be managed by the USFWS. Congressional action is required to implement this proposal, and none has yet occurred.



Environmental Consultation, Review, and Permit Requirement

Chapter 11

11.0 ENVIRONMENTAL CONSULTATION, REVIEW, AND PERMIT REQUIREMENTS

This section addresses Federal statutes, implementing regulations, and executive orders potentially applicable to the proposed SOR actions. In each case, the text provides a brief synopsis of the relevant aspects of the law or order and a summary of SOR compliance with these requirements. The conclusions on compliance are based on the impact analysis presented in Section 4.2 and the technical appendices. Unless otherwise noted, the compliance summaries apply specifically to the system operating strategy alternatives.

11.1 NATIONAL ENVIRONMENTAL POLICY

This EIS was prepared pursuant to regulations implementing NEPA (42 USC 4321 *et seq.*). NEPA provides a commitment that Federal agencies will consider the environmental effects of their actions. It also requires that an EIS be included in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The EIS must provide detailed information regarding the proposed action and alternatives, the environmental impacts of the alternatives, potential mitigation measures, and any adverse environmental impacts that cannot be avoided if the proposal is implemented. Agencies are required to demonstrate that these factors have been considered by decisionmakers prior to undertaking actions.

The SOR EIS was prepared to provide NEPA compliance for four proposed actions: developing a long-term plan for river system operations, providing a means for periodic review and updating of the plan, and renewing or replacing the CEAA and the PNCA. The SOR lead agencies held several series of public meetings to gather public opinions and comments on the scope of the study, proposed alternatives, and the Draft EIS. Public comments received on the Draft EIS were addressed in the Final EIS. The EIS and the overall SOR process comply with NEPA's requirements for documentation and public involvement.

11.2 ENDANGERED AND THREATENED SPECIES AND CRITICAL HABITAT

The ESA, most recently amended in 1988 (16 USC 1536), establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the preservation of the ecosystems upon which they depend. Section 7(a) of the ESA requires Federal agencies to consult with the USFWS and the NMFS, as appropriate, to ensure that the actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats. Actions that might jeopardize listed species include direct and indirect effects, and the cumulative effects of other actions.

Section 7(c) of the ESA and the Federal regulations on endangered species coordination (50 CFR § 402.12) also require that Federal agencies prepare biological assessments of the potential effects of major construction actions on listed or proposed endangered species and critical habitat. The SOR lead agencies consulted with USFWS and NMFS concerning listed species that could be affected by the actions addressed in this EIS. The Final EIS reflects the outcome of those consultation processes and the recommendations made by the USFWS and NMFS in their respective 1995 Biological Opinions.

The USFWS identified four listed threatened and endangered species expected to occur in the vicinity of one or more of the projects potentially affected by the SOR. Specifically, resident and migrant peregrine falcons and bald eagles are known to inhabit the area of these projects, and grizzly bears and gray wolves may use some of the project areas. Project-related

impacts on peregrine falcons are not expected because these birds have a substantial and diverse prey base that would not be diminished by SOR actions. Project-related impacts on nesting and wintering bald eagles could be positive or negative depending on the location, time of year, time of day, and degree of operational changes. Project-related effects on grizzly bears are not expected because the timing and location of SOR actions do not overlap with grizzly bear use patterns. Gray wolves, if they use any of the project areas, do not depend on the resources that would be affected by the proposed SOR actions.

The Snake River sockeye salmon was listed by the NMFS as an endangered species on November 10, 1991 (56 Federal Register 58619), effective December 10, 1991, and the Snake River fall and spring/summer chinook salmon were initially listed as threatened on April 22, 1992 (51 Federal Register 14653), effective May 22, 1992. The chinook stocks were subsequently reclassified as endangered in August 1994. In support of these listings, the portions of the Columbia and Snake Rivers that are used by the listed stocks have been designated as critical habitat. The analysis presented in this EIS is partially the result of concerns regarding these species. Several of the system operating strategy alternatives evaluated in the EIS are intended to increase survival of these threatened and endangered species and other anadromous fish by increasing water velocity and thereby decreasing travel time through the system.

The operating alternatives considered in the EIS could have both positive and negative effects on salmon survival. These effects could result from operations that change rearing habitat quality and quantity due to reservoir drafting; gas saturation levels; mortality rates from passage through turbines at the dams; predation conditions; and the distribution of water flows. To comply with the ESA, the SOR alternatives will need to result in a net increase in survival for migrating juvenile salmon, and thereby contribute to the recovery of the listed stocks. The SOR agencies and NMFS have concluded that the preferred SOS alternative identified in the Final EIS meets this requirement.

11.3 FISH AND WILDLIFE CONSERVATION

11.3.1 Fish and Wildlife Conservation Act

The Fish and Wildlife Conservation Act of 1980 (16 USC 2901 *et seq.*) encourages Federal agencies to conserve and to promote conservation of nongame fish and wildlife species and their habitats. The SOR agencies are responding to this policy through full consideration of fish and wildlife needs in developing operations alternatives and in comprehensive analysis of fish and wildlife impacts and identification of potential mitigation measures.

11.3.2 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) requires consultation with USFWS when any water body is impounded, diverted, controlled, or modified for any purpose. USFWS and state agencies charged with administering wildlife resources are to conduct surveys and investigations to determine the potential damage to wildlife and the mitigation measures that should be taken. The USFWS incorporates the concerns and findings of the state agencies and other Federal agencies, including the NMFS, into a report that addresses fish and wildlife concerns and provides recommendations for mitigating or enhancing impacts to fish and wildlife affected by a Federal project. The Federal project must include justifiable measures that address the USFWS recommendations and concerns. Federal agencies that construct or operate water-control projects are authorized to modify or add to the structures and operation of those projects to accommodate the means and measures for conservation of fish and wildlife.

The SOR lead agencies have coordinated with the USFWS throughout the SOR. The USFWS is a cooperating agency, and USFWS staff have participated in the analyses conducted

by several SOR work groups. The USFWS has completed a Coordination Act Report (Appendix S), which is appended to the EIS. The system operating strategy alternatives considered in the EIS include an operating plan proposed by the USFWS, which received full evaluation in the analysis.

11.3.3 National Wildlife Refuge System Administration Act

The National Wildlife Refuge (NWR) System Administration Act consolidates various categories of wildlife ranges and refuges for management under one program. The Act provides protection for both wildlife and refuge lands from destruction and injury. The Act also provides authority for the regulation of hunting and fishing within refuge boundaries. Two major NWR areas located within the SOR scope are the Umatilla NWR (located near John Day) and McNary NWR (located at the confluence of the Snake and Columbia Rivers). Although most of the system operating strategy alternatives are expected to have minimal impacts on these wildlife areas, Umatilla Refuge lands would be affected by lowered pool operations at John Day. Wetlands in the Umatilla NWR might be lost or species composition might be altered by operating the reservoir several feet below full pool, if the wetlands are dependent on full pool levels for water supply. Extensive wetland areas at the Umatilla NWR would be lost if John Day were operated at minimum pool. Backwater areas at the McNary NWR could experience siltation problems as a result of lower Snake River drawdowns. The SOR agencies will consider mitigation for the impacts to refuge lands or will restore resources.

11.3.4 Migratory Waterfowl Act

The Migratory Waterfowl Act (16 USC 715 *et seq.*,) requires that lands, waters, or interests acquired or reserved for purposes established under the Act be administered under regulations promulgated by the Secretary of the Interior. These regulations must conserve and protect migratory birds in accordance with treaties entered into between the United States and Mexico, Canada, Japan, and the former Union of Soviet Socialist Republics; must protect other wildlife, including threatened or endangered species; and must restore or develop adequate wildlife habitat. The migratory birds protected under this Act are specified in the respective treaties. In regulating these areas, the Secretary of the Interior is authorized to manage timber, range, agricultural crops, and other species of animals, and to enter into agreements with public and private entities.

Some Umatilla NWR lands at Crow Butte on the John Day pool were acquired as Special Law Lands and transferred to the U.S. Department of the Interior. Any migratory birds specified in the aforementioned treaties inhabiting this National Wildlife Refuge are protected under the provisions of this Act and the international treaties. Operating John Day pool near elevation 262.5 feet (80 m) could potentially affect island-nesting waterfowl that are protected under the Migratory Waterfowl Act. These impacts include exposure of mudflats between emergent marsh community and open-water habitat that could result in the loss of ducklings that are unable to use emergent marsh habitat for escape from predators. Impacts to Canada goose nests at the John Day pool with this operation would not be expected because no land bridging of islands is anticipated.

Alternatives that include operating John Day at the minimum pool elevation of 257 feet (78 m) would have more significant impacts on migratory waterfowl. Exposure of mudflats and loss of wetlands would be more extensive, while land bridging would be more likely. Mitigation measures such as construction of dikes, installation of pumps, and provision of water distribution systems to maintain backwater habitat and emergent marsh areas on the NWR would be difficult to implement because of the existing substrate conditions.

11.3.5 Marine Protection, Research, and Sanctuaries Act

The Marine Protection, Research, and Sanctuaries Act regulates dumping of material into the ocean and prevents or strictly limits the dumping of any material that would adversely affect human health, welfare, the marine environment, ecological systems, or economic potentialities. Because none of the proposed SOR actions would result in the dumping of material into the ocean, the Act does not apply.

11.3.6 Pacific Northwest Electric Power Planning and Conservation Act

The Northwest Power Act was passed by Congress on December 5, 1980. This law created the eight-member NPPC, an interstate agency whose members are appointed by the Idaho, Montana, Oregon, and Washington governors. NPPC was entrusted with adopting a Fish and Wildlife Program for the Columbia River Basin by November 1982 and preparing a 20-year Regional Electric Power and Conservation Plan by April 1983. These plans are periodically updated.

NPPC's Fish and Wildlife Program established a number of goals for restoring and protecting fish and wildlife populations in the basin. These goals led to changes in the operation of the Coordinated Columbia River System during the mid-1980s. One of the most notable changes is the Water Budget, which provides for the release of specific amounts of water in the upper Columbia and Snake Rivers to help juvenile salmon migrate downstream in the spring. More recently, the NPPC has developed its own proposals to protect threatened and endangered salmon stocks. The NPPC has completed amendments to its Columbia River Basin Fish and Wildlife Program. The amendments adopted to date include mainstem survival, harvest, production, habitat, and flow measures that can be used to increase salmon and steelhead runs, and resident fish and wildlife measures.

The SOR agencies have been coordinating with the NPPC to integrate the system operating strategy alternatives with the NPPC amendments for priority salmon actions. Several of the alternatives incorporate flow improvement measures adopted by the NPPC in December 1991 and September 1992, while the drawdown alternatives are evaluated in the EIS reflect the NPPC's long-term strategy. NPPC staff have participated in the SOR analysis.

Several of the system operating strategy alternatives would temporarily reduce the power generation capability of some of the hydro affected projects in the study area. The SOR agencies are coordinating with the NPPC regarding these effects and their relation to the regional electric power plan.

11.4 HERITAGE CONSERVATION

A number of Federal laws have been promulgated to protect the nation's historical, cultural, and prehistoric resources.

11.4.1 National Historic Preservation Act

Section 106 of the NHPA requires that Federal agencies evaluate the effects of Federal undertakings on historical, archeological, and cultural resources and afford the Advisory Council on Historic Preservation (ACHP) opportunities to comment on the proposed undertaking. The first step in the process is to identify cultural resources included on (or eligible for inclusion on) the National Register of Historic Places that are located in or near the project area. The second step is to identify the possible effects of proposed actions. The lead agency must examine whether feasible alternatives exist that would avoid such effects. If an effect cannot reasonably be avoided, measures must be taken to minimize or mitigate potential adverse effects.

The SOR agencies, in coordination with other Federal agencies, the State Historic Preservation Offices (SHPDs), and Native American Tribes, are identifying cultural resources and sites in the project area for

inclusion on the National Register. In addition, the agencies are evaluating the effects of the proposed alternatives on these sites, and measures that might be implemented to mitigate the potential effects. Implementation of any of the system operating strategy alternatives would affect cultural sites to varying degrees. Larger areas of the cultural sites would be exposed at lower pool levels under some alternatives. Sites normally inundated might be exposed and subject to impacts from traffic, vandalism, and erosion from wind and waves. Repeated cycles of exposure and inundation might accelerate decomposition of organic materials contained within the sites. New reservoir operating conditions might require an accelerated program of site testing to determine National Register eligibility, and increased mitigation efforts.

Section 110 of the NHPA requires active management protection for Federally owned historic properties. This protection pertains specifically to archeological sites, historic sites, and historic structures or objects. The SOR agencies will develop two types of agreement documents to comply with Section 110 of the NHPA. The three SOR lead agencies will sign an interagency agreement, based on a statement of shared principles and commitments, that will identify specific agency roles, responsibilities, and commitments for budget allocations necessary to meet cultural resources requirements for Sections 106 and 110 compliance. The agencies will also develop individual agreements, called Implementation Plans (IPs), covering specific projects or river reaches. IPs will specify appropriate treatments for the effects of the SOR on historic properties, require detailed historic preservation plans, interim measures necessary to carry out the agreed upon treatments, and identify funding actions that may be called for in the historic preservation plans. Whereas the interagency agreement will involve only the lead SOR agencies, the IPs will involve consultation with affected tribes, other cooperating agencies, ACHP, and SHPOs.

11.4.2 Existing Programmatic Agreements

In 1982, the Walla Walla District, U.S. Army Corps of Engineers (Corps) executed a Programmatic Memorandum of Agreement (PMOA; since 1989, these have been termed simply Programmatic Agreements) with the Advisory Council on Historic Preservation (ACHP) and the Idaho, Oregon, and Washington State Historic Preservation Offices (SHPOs) for operation and maintenance of all Corps hydroelectric projects within the Walla Walla District, including McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, and Dworshak Dams. Implementation of the terms of the PMOA satisfies the Corps' Section 106 responsibilities of the NHPA for these specific projects.

In 1991, all of the SOR agencies executed a Programmatic Agreement (PA) with the U.S. Forest Service; the National Park Service; the Confederated Tribes of the Colville Reservation; the Spokane Tribe of Indians; the Idaho, Montana, Oregon, and Washington SHPOs; and the ACHP, regarding Federal Columbia River Power System hydroelectric operations affecting the reservoir drawdown areas of Grand Coulee, Hungry Horse, Dworshak, Libby, and Albeni Falls Dams (i.e., the storage reservoirs). The PA also provides procedures for consistency with the Native American Graves Protection and Repatriation Act. Implementation of the PA is in progress.

11.4.3 Archeological Resources Protection Act

The Archeological Resources Protection Act (ARPA) provides for the protection of archeological sites located on public and Indian lands, establishes permit requirements for the excavation or removal of cultural properties from public or Indian lands, and establishes civil and criminal penalties for the unauthorized appropriation, alteration, exchange, or other handling of cultural properties.

Any of the system operating strategy alternatives would result in continued exposure of cultural sites and subsequent damage. The drawdown or flow augmentation measures included in several of the strategies could result in the new or increased exposure of sites. This in turn could lead to vandalism or an increase in ongoing vandalism at cultural sites. Appropriate monitoring/surveillance methods and awareness programs will be developed to prevent or minimize vandalism, as part of overall monitoring and mitigation for cultural resources. The Corps and Reclamation, as the operating agencies for the Federal projects, are prepared to take appropriate action, including prosecution of individuals caught vandalizing cultural sites.

11.4.4 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) addresses the recovery, treatment, and repatriation of Native American and Native Hawaiian human remains and cultural items (associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony).

The implementation of any of the system operating strategy alternatives could result in the exposure of Native American human remains and cultural items. This situation will be addressed by an interagency agreement and project-specific implementation plans on monitoring and mitigation for cultural resources (see Section 11.4.1). In the event this should happen, the appropriate Indian tribe(s) and lineal descendants will be notified and the necessary actions taken to protect the burials as prescribed by law. The Corps and Reclamation have been complying with the provisions of NAGPRA in their operation of the Federal projects and will continue to do so.

11.4.5 American Indian Religious Freedom Act

The American Indian Religious Freedom Act (AIRFA) of 1978 was a joint resolution of Congress establishing a policy that the United States will protect and preserve American Indians' rights of freedom of belief, expression, and exercise of traditional religions. Courts have interpreted AIRFA to mean that public officials must consider Indians' interests before undertaking actions that might harm those interests. The agreements discussed in Sections 11.4.1 and 11.4.2 include (or will include) provisions for Native American consultation and coordination under AIRFA.

11.5 STATE, AREA-WIDE, AND LOCAL PLAN AND PROGRAM CONSISTENCY

The CEQ regulations for implementing NEPA (40 CFR § 1506.2) require agencies to consider the consistency of a proposed action with approved state and local plans and laws. Given the extremely large number of state and local jurisdictions within the SOR study area, the lead agencies were not able to review all of the individual plans and laws that may be applicable. Based on the orientation and typically limited applicability of state and local authorities to the Federal multipurpose projects, the agencies assume the proposed actions would generally be consistent with state and local plans and laws. Because most local planning ordinances establish restrictions for development and growth in areas, local ordinances would generally not be applicable to the system operating strategy alternatives, or the other SOR actions.

State and local government agencies operate a variety of recreational, infrastructure and related resources along the river system. Impacts to these resources that could result from the various SOS alternatives are identified in Section 4.2, and corresponding mitigation measures are discussed in Section 4.3.3.

In accordance with Executive Order 12372, this EIS will be circulated to the appropriate state clearinghouses to satisfy review and consultation requirements.

11.6 COASTAL ZONE MANAGEMENT CONSISTENCY

The Coastal Zone Management Act of 1972 requires that Federal actions be consistent, to the maximum extent practicable, with approved state coastal zone management programs. A state coastal zone management program (developed under state law and guided by the Act) sets forth objectives, policies, and standards to guide public and private uses of lands and waters in the coastal zone. The coastal zone as defined in the Act extends inland as far as necessary to account for factors that influence coastal shorelines. Washington and Oregon have approved coastal zone management programs, both of which list seven types of Federal activities directly affecting the coastal zone. The upper boundary of the coastal zone is downstream of Bonneville Dam.

The SOR alternatives would have little effect on water levels or river uses downstream of Bonneville Dam. Several of the system operating strategies would result in river flow patterns that more closely resemble the natural hydrograph, which would presumably have beneficial or neutral effects for the coastal zone.

11.7 FLOOD PLAIN MANAGEMENT

If a Federal agency program will affect a flood plain, the agency must consider alternatives to avoid adverse effects in the flood plain or to minimize potential harm. Executive Order 11988 requires Federal agencies to evaluate the potential effects of any actions they might take in a flood plain and to ensure that planning, programs, and budget requests reflect consideration of flood hazards and flood plain management.

The impacts of the system operating strategy alternatives on flood control capability are considered minor or negligible. Some of the alternatives would result in small increases in the calculated average annual flood damages, although it is also acknowledged that the analysis might overstate these impacts. Flood storage capacity at some upstream reservoirs could be diminished with flow augmentation measures, but this capacity would be shifted elsewhere to maintain overall system flood control capacity. Further, flood storage shifts would only be implemented if projected runoff were relatively low, in which case the risk of flooding would also be reduced. Stable storage project operations would also decrease flood storage capacity at the affected reservoirs, but flood control rule curves specified for these alternatives would maintain flood protection. Lowered pool operation at run-of-river projects under several alternatives would enhance the flood control capacity of the system during drawdowns. None of the alternatives would induce land use changes that would adversely affect flood plain characteristics.

11.8 WETLANDS PROTECTION

Executive Order 11990 authorizes Federal agencies to take actions to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands when undertaking Federal activities and programs. Any agency considering a proposal that might affect wetlands must evaluate factors affecting wetland quality and survival. These factors should include the proposal's effects on the public health, safety, and welfare due to modifications in water supply and water quality; maintenance of natural ecosystems and conservation of flora and fauna; and other recreational, scientific, and cultural uses.

Emergent wetlands communities are prevalent in several areas under study. If these wetlands depend on full pool levels for water supply through subirrigation or shallow inundation, the wetlands might be lost or species composition might be altered. Alternatively, with some operations, shoreline areas that could support wetland habitat might be exposed. The EIS identifies the expected positive and negative effects of the system operating strategy alternatives on wetlands and addresses measures to minimize impacts to wetlands.

11.9 FARMLAND PROTECTION

11.9.1 Farmland Protection Policy Act

The Farmland Protection Policy Act (7 USC 4201 *et seq.*) requires Federal agencies to identify and take into account the adverse effects of their programs on the preservation of farmlands. Each operating strategy has been evaluated to determine whether it would cause physical deterioration and/or reduction in productivity of farmlands (see Section 11.9.2 below).

11.9.2 CEQ Memorandum on Analysis of Impacts on Prime or Unique Agricultural Lands

This CEQ Memorandum establishes criteria to identify and consider the adverse effects of Federal programs on the preservation of prime and unique farmland; to consider alternative actions, as appropriate, that could lessen adverse effects; and to ensure Federal programs are consistent with all state and local programs for protection of farmland. The proposed SOR actions were determined not to have a direct impact on prime or unique agricultural lands; direct impacts would be confined to the reservoirs. Proposed SOS alternatives have been specified in an attempt to avoid interrupting the supply of water to irrigated prime farmlands. Where this was not possible, the lead agencies have assumed that replacement facilities needed to maintain water delivery would be constructed as mitigation. The SOR actions would not displace or diminish the productive capacity of prime or unique agricultural lands.

11.10 RECREATION RESOURCES

11.10.1 Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act designates qualifying free-flowing river segments as wild, scenic, or recreational. The Act establishes requirements applicable to water resource projects affecting wild, scenic, or recreational rivers within the National Wild and Scenic Rivers System, as well as rivers designated on the National Rivers Inventory. Under the Act, a Federal agency may not assist the construction of a water resources project that would have a direct and adverse effect on the free-flowing, scenic, and natural values of a wild or scenic river. If the project would affect the free-flowing characteristics of a designated river or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the area, such activities should be undertaken in a manner that would minimize adverse impacts and should be developed in consultation with the NPS.

Several reaches of the Snake River have been designated under the Wild and Scenic Rivers System. The Hells Canyon reach, which is downstream of Brownlee Reservoir, is of primary interest. Several of the system operating strategy alternatives include flow augmentation options involving release of stored water from Brownlee, which would temporarily elevate flows in Hells Canyon over what would otherwise occur. These flow levels would, however, be well within the range of regulated flows normally experienced in Hells Canyon. The SOR lead agencies are coordinating with the USFS, which administers this reach of the river and is a cooperating agency in the SOR.

The Hanford Reach of the Columbia River was recently studied by the NPS and an interagency team as a potential Federal wild and scenic river. The preferred alternative in the Final EIS distributed in June 1994 recommended that the reach be designated as a combination national wildlife refuge and national wild and scenic river. There would be no apparent recreational effects from the SOS alternatives on the Hanford Reach as long as the Vernita Bar agreement is maintained. The SOR lead agencies will consult with the NPS on this matter as appropriate.

Several tributaries to the Snake and Columbia Rivers have also been added to the Wild and Scenic Rivers System. These include portions of the Klickitat and White Salmon Rivers in Washington and the Sandy, Deschutes, John Day, Grande Ronde, and Imnaha Rivers in

Oregon. The SOR actions would not adversely affect resource values of these protected waters.

11.10.2 Columbia River Gorge National Scenic Area Act

On November 17, 1986, Congress established the Columbia River Gorge National Scenic Area (Scenic Area) as a Federally recognized and protected area (PL 99-663). The Scenic Area Act also created the bi-state Columbia River Gorge Commission and directed the Commission and the USFS to jointly develop a management plan for the Scenic Area. The management plan is to reflect legislatively established purposes, which include a mandate to protect and provide for the enhancement of the scenic, cultural, recreational, and natural resources of the Scenic Area.

The Commission adopted a management plan on October 15, 1991. Counties affected by the plan have been encouraged to adopt ordinances consistent with this plan. The plan establishes land use designations for lands within the Scenic Area and specifies broad policies that provide for the protection of resources within the Scenic Area. The system operating strategy alternatives do not include any specific actions at the projects located within the Scenic Area (Bonneville and The Dalles). These projects would continue to operate within their normal ranges.

Therefore, the SOR actions would have no effect on visual, recreational, or other conditions on the Columbia River within the Scenic Area, and would be compatible with the Scenic Area management plan.

11.10.3 Wilderness Act

The Wilderness Act of 1964 established the National Wilderness Preservation System. Areas designated as wilderness under the original act and subsequent wilderness legislation are to be administered for the use and enjoyment of the public in such a manner as to leave them unimpaired as wilderness. Development activities are generally prohibited within wilderness areas, and Federal agencies proposing actions must consider whether the effects of those actions would impair wilderness values.

Wilderness areas and other Federal protected lands that are located near the SOR reservoirs are identified in Section 2.2.4 of this volume, and in Section 2.2 of Appendix G, Land Use and Development. None of the actions evaluated in this EIS would change conditions evident within wilderness areas so as to impair wilderness values. The Great Bear Wilderness Area in western Montana, which extends to within approximately 1.5 miles (2.4 km) of Hungry Horse Reservoir, is the closest wilderness to the action sites addressed in the SOR. The effects of Hungry Horse operations on the Great Bear Wilderness would be limited to long-distance views of exposed reservoir shoreline from a small portion of the wilderness; such views have been evident since the Great Bear was designated, and would not change greatly in character under the SOS alternatives evaluated.

11.10.4 Water Resources Development Act

Congress generally authorizes water resources projects through biennial legislation, such as the Water Resources Development Act (WRDA) of 1990. Section 310(b) of WRDA 1990 requires public participation in changes to reservoir operation criteria. Section 415(b) specifically requires public notification (hearings) of actions associated with drawdown of Dworshak Reservoir. The SOR has held several meetings in the Dworshak area and is in compliance with these requirements. Section 415 requires a report to Congress concerning the effects of operations on recreation and log transport at Dworshak. The SOR will comply with this provision through the EIS and its appendices.

11.10.5 Federal Water Project Recreation Act

In planning any Federal navigation, flood control, reclamation, or water resource project, the Federal Water Project Recreation Act requires that full consideration be given to the

opportunities that the project affords for outdoor recreation and fish and wildlife enhancement. The Act requires planning with respect to the development of recreation potential. Projects must be constructed, maintained, and operated to provide recreational opportunities, consistent with the purpose of the project.

Recreation sites have been developed at all of the Federal projects in the SOR study area; these are operated by a variety of entities. Developed facilities and informal use areas at several of the Federal projects should experience minimal or no impacts from the alternatives considered. Lowered pool operations at several of the mainstem run-of-river projects under some alternatives would have minor impacts on recreation, but alternatives that involve deep drawdowns at these projects would have significant impacts. Use of recreation facilities at upstream storage reservoirs could be impaired as a result of flow augmentation under some alternatives; this could cause reservoir elevations to be lower than normal under some water conditions. Specific impacts could include dewatering boat ramps, docks, marinas, and swimming beaches. Water-oriented campgrounds and day-use areas could become less desirable because of exposed shoreline and increased distance to water. Stable storage project operation alternatives would enhance recreation at certain reservoirs by maintaining higher water level.

11.10.5 Land and Water Conservation Fund Act

The Land and Water Conservation Fund Act (LWCFA) assists in preserving, developing, and ensuring accessibility of outdoor recreation resources. The LWCFA establishes specific Federal funding for acquisition, development, and preservation of lands, water, or other interests authorized under the ESA and National Wildlife Refuge Areas Act. Funds appropriated under the Act are allocated to Federal agencies or as grants to states and localities. Numerous recreation sites and public land parcels along the SOR projects have been acquired or developed with LWCFA monies. Although maintenance and use of these resources could be intermittently impaired under some of the system operating strategy alternatives, the intended uses would not be precluded or displaced on a long-term basis. The SOR agencies will consider replacement of facilities or other means for mitigation in cases where the seasonal impacts would be significant. Because the expected impacts would not displace intended uses from LWCFA areas, or because impacts would be mitigated, system operations would be consistent with the LWCFA.

11.11 GLOBAL WARMING

The SOR EIS includes an assessment of potential direct and indirect air quality impacts. Indirect impacts include the potential for increases in chemical emissions from power resources used to replace lost hydro generation. The assessment does not specifically analyze emissions of greenhouse gases and possible contribution to global warming. Instead, it identifies the magnitude of the potential power resource effects, indicates the approximate levels of air emissions that could be associated with obtaining replacement generation, and incorporates by reference the more detailed air quality analysis of BPA's Resource Programs EIS, which addresses global warming in detail.

11.12 PERMITS FOR STRUCTURES IN NAVIGABLE WATERS

The Rivers and Harbors Act of 1899 prohibits constructing bridges, dams, dikes, or causeways over harbors or navigable waters of the United States without approval of the Corps. The Act also prohibits any obstruction to the navigable capacity of any waters of the United States.

The SOR actions would not involve constructing obstacles in navigable waters, although operations being evaluated could impede navigation under certain circumstances. Under most of the alternatives, the impacts to commercial navigation would be minimal or nonexistent. Operation of several mainstem projects at minimum elevations would maintain

water levels at or above the authorized 14-foot (4.3-m) minimum channel required for barge shipping and transfer operations. Log transportation operations at Dworshak would generally experience minimal increases in elevation limitations compared to existing conditions. These operations are currently constrained during annual drawdown periods, generally from late September until early June. Some of the system operating strategies involve drawdown of one or more lower Snake River projects for several months of the year, while one would result in permanent drawdown of these projects to natural river levels. These alternatives would interrupt barge transportation on the affected pools for the duration of the drawdown and refill cycle, and would cause shifts in regional commodity transportation patterns.

11.13 PERMITS FOR DISCHARGES INTO WATERS OF THE UNITED STATES

A Department of the Army permit under Section 404 of the Federal Water Pollution Control Act (Clean Water Act) of 1972, as amended (see Section 10.16.2), is required from the Corps to discharge dredged or fill material into waters of the United States for non-Corps actions. Discharge or fill actions by the Corps require a Section 404 (1)(b) Evaluation to obtain a state water quality certification under Section 401 of the Federal Water Pollution Control Act. The SOR actions addressed in this EIS would not directly involve such discharges, although it is conceivable that future mitigation actions could trigger Section 404 requirements.

11.14 PERMITS FOR RIGHTS-OF-WAY ON PUBLIC LAND

If the proposed action involves the use of public or Indian lands not in accordance with the primary objective of the management of those lands, under the Federal Land Policy and Management Act (43 USC 1701 *et seq.*), a permit for a right-of-way across such lands will be required. No such action is proposed in the system operating strategies.

11.15 ENERGY CONSERVATION AT FEDERAL FACILITIES

Energy conservation at Federal facilities is not addressed in the EIS because the proposed actions do not involve the operation, maintenance, or retrofit of an existing Federal building; the construction or lease of a new Federal building; or the procurement of insulation products.

11.16 POLLUTION CONTROL AT FEDERAL FACILITIES

11.16.1 Clean Air Act

The Clean Air Act (CAA) establishes a comprehensive program for improving and maintaining air quality throughout the United States. The goals of the CAA are achieved through permitting of stationary sources, restricting the emission of toxic and other pollutants from stationary and mobile sources, and establishing AAQS. The CAA programs are implemented through combined Federal, state, and local efforts. The U.S. EPA has generally delegated responsibility for attaining and maintaining the national standards to the states through approval of state implementation plans (SIPs).

Several of the system operating strategy alternatives presented in this EIS would likely increase fugitive dust emissions from the exposed reservoir shorelines and bottom areas. The impact analyses indicated that these emissions would not likely violate existing standards for fine particulate matter in the air at receiving sources, and that the increased particulate matter would not likely affect the status of attainment areas (places where the AAQS are met) or nonattainment areas. The SIPs for Idaho, Montana, Oregon, and Washington do not prescribe any specific fugitive dust requirements beyond the applicable AAQS (see Appendix B, Air Quality). Therefore, by complying with the PM_{10} standards, the SOS alternatives would also comply with the respective SIPs.

Reduced generation of hydroelectric power as a result of changes in river operations might indirectly cause additional air emissions from thermal power plants in the Pacific Northwest or in California. New Source Performance Standards and permitting requirements restrict the air emissions from such facilities to protect air quality. The EIS addresses this issue in general terms and incorporates by reference the air quality assessment in BPA's Resource Programs EIS.

11.16.2 Clean Water Act

The Clean Water Act (CWA) sets national goals and policies to eliminate discharge of water pollutants into navigable waters, to regulate discharge of toxic pollutants, and to prohibit discharge of pollutants from point sources without permits. The CWA also authorizes EPA to establish water quality criteria that are used by states to set specific water quality standards.

The primary water quality issues pertaining to the system operating strategy alternatives are increased turbidity, gas saturation levels, and water temperatures. The alternatives could cause departures from required water quality levels, as discussed in Section 4.2.2.

Dissolved gas supersaturation associated with Corps dams in the Columbia-Snake River system has routinely exceeded the EPA criterion and the Oregon and Washington state water quality standards of 110-percent saturation. While the Corps does not consider the release of water from its dams as point sources of discharge, it does everything practicable to meet state water quality standards. Further, the dissolved gas levels result from spilling water at the dams, which is done under agreement with Federal and state fish agencies to assist the downstream migration of juvenile salmon and steelhead. A larger volume of water spilled at the dams, over a longer time, could result in gas saturation values that exceed 130 percent.

Changes in water temperatures are expected to be minimal. Although operating the lower Snake River projects near minimum pool would cause minimal turbidity, increased flow during spring and summer might increase turbidity for short periods. Turbidity levels would be increased on a seasonal basis under the alternatives (SOS 5, 6, 9a, or 9c) which involve deeper drawdowns on the lower Snake River projects and at John Day. Lowered pool operation might also cause local water quality changes due to modifications in mixing zone characteristics. These changes might violate state water quality standards and state and Federal standards and conditions in NPDES permits (for point source discharges to the river by other parties). Future monitoring activities will seek to address potential effects on compliance with NPDES permits.

11.16.3 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) is intended to protect the water quality of domestic water supplies and sole source aquifers, as defined under the Act. The EIS addresses the potential effects of system operations on groundwater resources. These effects would consist of seasonal changes in groundwater elevations within a short distance of system reservoirs, which experience significant elevation fluctuations.

11.17 INDIAN TREATIES

The existing Indian tribal and reservation structure in the Columbia River Basin 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 Tribes in 1855 which includes:

- Treaty with the Yakama, June 9, 1855, 12 Stat. 951;
- Treaty with the Nez Perce, June 11, 1855, 12 Stat. 957;

- Treaty with the Tribes of Middle Oregon, June 25, 1855, 12 Stat. 963;

- Treaty with the Flathead Kootenay, and Upper Pend d'Oreille, July 16, 1855, 12 Stat. 975.

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.

With respect to the SOR, key tribal rights based on these treaties include anadromous fish (where present), and resident fish and wildlife. The EIS addresses the expected effects of the SOS alternatives on these resources in general and on treaty rights specifically. The SOS preferred alternative reflects an attempt to contribute to recovery of anadromous fish stocks while balancing concern for resident fish and wildlife.

11.18 OTHER

11.18.1 Estuary Protection Act

The purpose of the Estuary Protection Act is to establish a program to protect, conserve, and restore estuaries. It includes provisions for Federal management of estuarine areas in coordination with states and requires that all Federal projects consider impacts on estuarine areas. The Act does not affect an agency's authority for existing programs within an estuary. As described in Section 10.6, the impact of the SOR actions on the Columbia River estuary would likely be minor, and could be positive.

11.18.2 Watershed Protection and Flood Protection Act

The purpose of the Watershed Protection and Flood Protection Act is to protect watersheds from erosion, floodwater, and sediment damages. It provides assistance programs to local organizations to conduct investigations and surveys, prepare plans and estimates, develop soil and water conservation practices, and install improvement works for protection of watersheds. The effects of the SOR alternatives are not likely to conflict with watershed protection programs developed under this Act.

Chapter 12

Distribution of the Final EIS

12.0 DISTRIBUTION OF THE FINAL EIS

This chapter lists those who were sent the complete Final EIS or the main report. Not listed are the many individuals and organizations who requested only the EIS Summary or some appendices.

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Blackfeet Tribe
Burns Paiute Tribe
Celilo-Wyam Indian Community, Mid-Columbia River Council
Coeur d'Alene Tribe of Idaho
Columbia River Inter-Tribal Fish Commission
Colville Confederated Tribes
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Boyer Park & Marina Stillwaters Inn, Colfax, WA
Braun Ltd., Portland, OR
British Columbia Power Exchange Corporation, Vancouver BC, Canada
BST Associates, Seattle, WA
Bullivant Houser Baily Pendergras & Hoffman, Portland, OR
Cambridge Energy Research, Oakland, CA
Canby Utility Board, Canby, OR
Capital Press, Kennewick, WA
Capitol Press, Salem, OR; Kennewick and Spokane, WA
Carpenter Consulting Associates, Spokane, WA
Cascade Geographic Society, Rhododendron, OR
Centennial High School, Gresham, OR
Chelan County PUD No. 1, Wenatchee, WA
Cheran Orchards, Inc., Plymouth, WA
CH2M Hill, Portland, OR, and Bellevue, WA
Citizens for a Clean Columbia, Kettle Falls, WA
City of Los Angeles, Department of Water & Power, Los Angeles, CA
City of McMinnville, Department of Water & Light, McMinnville, OR
City of Moses Lake, Conservation District, Moses Lake, WA
Clallam County PUD No. 1, Port Angeles, WA
Clark Jennings & Associates, Inc., Pasco, WA
Class Harvor Association, Portland, OR
Clatskanie PUD, Clatskanie, OR
Clearing Up, Seattle, WA
Clearwater Power Company, Lewiston, ID
Cockrill, Weaver, & Bjur, Yakima, WA
College of Southern Idaho, Twin Falls, ID
Colockum Transmission Company, Wenatchee, WA
Columbia Basin Development League, Othello, WA
Columbia Grain International, Inc., Portland, OR
Columbia River Estuary Study Task Force, Astoria, OR
Columbia River Towboat Association, Portland, OR
Columbia Rural Electric Association, Inc., Pasco, WA
Columbian, Vancouver, WA
Cominco Ltd. Utility Services, Trail BC, Canada
Conservation Northwest, Tacoma, WA
Convergence Research, Seattle, WA
Consolidated Diking District #1 of Wahkiakum County, Cathlamet, WA
Coos Curry Electric Cooperative, Inc., Myrtle Point, OR
Cope Program, Newport, OR
Cornell University, Department of Natural Resources, Ithaca, NY
County of Benton, Conservation District, Prosser, WA

County of Wahkiakum, Consolidated Diking Impr. District No.1, Cathlamet, WA
Cowlitz County PUD, Longview, WA
Creighton & Creighton Inc., Los Gatos, CA
CRIS, Inc., Umatilla, OR
Crookham Company, Caldwell, ID
Culp Guterson & Grader, Attorneys at Law, Seattle, WA
Cummings Brothers, Spokane, WA
Daily Astorian Chinook Observer, Long Beach, WA
Daily Sun News, Sunnyside, WA
Dames & Moore, Boise, ID
David Evans & Associates, Inc., Portland, OR and Bellevue, WA
David M. Dornbusch Company, Inc., San Francisco, CA
Davis Wright Tremaine, Portland, OR
Direct Services Industries, Inc., Portland, OR
Don Chapman Consultants, Inc., Redmond, WA
Douglas County PUD No. 1, East Wenatchee, WA
Douglas Electric Cooperative, Roseburg, OR
Douglas Parkinson & Associates, Bayside, CA
DPA, Vancouver, WA
Duncan Orchards, Skykomish, WA
Dworshak Excursions, Orofino, ID
East Columbia Basin Irrigation District, Othello, WA
East Fork Economics, Association of Public Agency Customers, La Center, WA
Eco Northwest, Eugene, OR
Eastern Washington University, Archeological and Historic Services and Departments of Biology and Economics, Cheney, WA
Edaw, Inc., Seattle, WA
EG & G Idaho, Inc., Idaho Falls, ID
Eldo R. Murphy & Associates, Salem, OR
Electric Sales & Service, Fall River Mills, CA
Elk Valley Miner, Fernie, BC Canada
Ellisforde Grange No. 1010, Tonasket, WA
Emerald PUD, Governing Board, Springfield, OR
Eugene Water & Electric Board, Eugene, OR
Evergreen Forest Products, Boise, ID
Ewing Street Moorings, Seattle, WA
F. H. Stoltze Land & Lumber Company, Columbia Falls, MT
Fales and Associates, Seattle, WA
Farm Credit Services, Spokane, WA
FBN Radio Network, Olympia, WA
Ferry Conservation District, Republic, WA
First Interstate Bank of Idaho, Weiser, ID
Fishman Environmental Services, Portland, OR
Flathead Basin Commission, Kalispell, MT
Flathead Lakers Inc., Lakeside, MT
Foianini Law Office, Ephrata, WA
Forest Resource Options, Inc., Issaquah, WA
Foss Maritime Company, Portland, OR
Foster Pepper Shefelman, Seattle, WA
Foster Wheeler Environmental Corporation, Bellevue, WA

Fremont-Madison Irrigation District, St. Anthony, ID
Fritz Maritime, Portland, OR
Fuel Energy Consulting, Inc., Hillsboro, OR
G. H. Bowers Engineering, Seattle, WA
Gallatin Group, Portland, OR
Gary Danielson & Associates, Inc., Jamestown, CA
Gazette Tribune, Oroville, WA
General Electric Company, Tigard, OR
GES Consultants, Los Angeles, CA
Gilliam, SWCD, Condon, OR
Givens & Funke, Coeur d'Alene, ID
Goodman Group, Boston, MA
Golder Associates, Inc., Redmond, WA
Gonzaga University, Spokane, WA
Grant County PUD No. 2, Ephrata, WA
Grand Coulee Project Hydroelectric Authority, Ephrata, WA
Greater Sandpoint Chamber of Commerce, Sandpoint, ID
Grays Harbor County PUD No. 1, Aberdeen, WA
Great Feeder Canal Company, Rigby, ID
Grover & Walker Law Offices, Rigby, ID
HDR Engineering, Inc., Boise, ID and Bellevue, WA
H. H. Burkitt Project Management, Inc., Portland, OR
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Heller, Ehrman, White, & McAuliffe, Portland, OR
Hecla Mining Company, Stanley, ID
Henry's Fork Foundation, Inc., Island Park, ID
Henwood Energy Services, Sacramento, CA
Heritage Research Center, Seattle, WA
Hermiston Development Corporation, Hermiston, OR
Hermiston Herald, Hermiston, OR
Hess Farms, Inc., Ashton, ID
High County News, Paonia, CO
Highline Community College, Department of History, Des Moines, WA
Hoffer Railroad Consultants, Inc., Boise, ID
Holland & Hart, Boise, ID
Horstman Trk., Inc., Kalispell, MT
Hurn Shingle Company, Inc., Concrete, WA
Hydro Review Magazine, Kansas City, MO
Hydroacoustic Technology, Inc., Seattle, WA
Ichthyological Associates, Inc., Lansing, NY
ICIE, Boise, ID
ICL, Ahsahka, ID
Idaho Cattle Association, Boise, ID
Idaho Power Company, Boise, ID
Idaho State University, Pocatello, ID
Idaho Statesman, Boise, ID
Idaho Water Users Association, Boise, ID
Idaho Women in Timber, Lewiston, ID

IMS, Natick, MA
Independent Hydro Developers Inc., Minneapolis, MN
Intercompany Pool, Spokane, WA
International Longshoreman's & Whse. Union No. 7, Bellingham, WA
IRZ Consulting, Hermiston, OR
J. Weber Farms, Inc., Seattle, WA
James River Corporation, Camas, WA
Jean Terra Communications, Boise, ID
John Geyer and Associates, Vancouver, WA
John Nimmons & Associates, Olympia, WA
Johnstone Supply, Eugene, OR
Jones & Stokes Associates, Inc., Sacramento, CA
JUB Engineers, Inc., Twin Falls, ID
Juniper Flat District Improvement Company, Maupin, OR
Kaiser Aluminum & Chemical Corporation, Spokane, WA
Kamerrer Brothers, Pullman, WA
KIHR, News Director, Hood River, OR
Kittitas County PUD, Ellensburg, WA
Konkolville Lumber Company, Inc., Orofino, ID
Koocanusa International Coalition, Eureka, MT
Kootenai Angler, Libby, MT
Kootenai Electric Cooperative, Inc., Hayden Lake, ID
Kramer Chin & Mayo Inc., Seattle, WA
KSRA, News Room, Salmon, ID
KV Rec Association, Bonners Ferry, ID
KYLT 100 FM, News Room, Missoula, MT
Lafferty Transportation Company, Coeur d'Alene, ID
Lake Roosevelt Property Owners Association, Ephrata, WA
Lane Electric Cooperative, Inc., Eugene, OR
Lanox Institute of Water Technology, Lenox, MA
League of Oregon Cities, Salem, OR
Les Tumidaj & Associates, Portland, OR
Lethbridge Northern Irrigation District, Lethbridge, AB Canada
Lewiston Chamber of Commerce, Lewiston, ID
Lewiston Tribune, Lewiston, ID
LFG Company, Seattle, WA
Libby Area Chamber of Commerce, Libby, MT
Lincoln Electric Coop., Inc., Davenport, WA
Ling, Nielsen, & Robinson, Rupert, ID
Litchfield Consultants Inc., Portland, OR
Lockheed Idaho Technologies Company, Idaho Falls, ID
Louis Berger & Associates, Inc., Seattle, WA
MacKay and MacDonald, Vancouver, WA
Malacha Hydro, Boise, ID
Mariners Haven, Eureka, MT
Mason County PUD No. 3, Shelton, WA
Merlin Instruments, Eugene, OR
Merrill Schultz & Associates, Seattle, WA
Michigan State University, Department of Resource Development, East Lansing, MI
Microdesign Northwest, Olympia, WA

Mid-Columbia Economic Development District, The Dalles, Or
Mid-Columbia PUD Regional Coordination Office, Portland, OR
Middle Snake Regional Water Resource Commission, Wendell, ID
Mission Energy, Irvine, CA
Missoulian, Kalispell, MT
Modern Electric Water Company, Spokane, WA
Monahan & Robinson, Seattle, WA
Monsanto Company, Soda Springs, ID
Montana Power Company, Butte, MT
Moody's Investors Service, Inc., New York, NY
Morgan, Lewis, & Bockius, Washington, DC
Morning News Tribune, Tacoma, WA
Morse Richard Weisenmiller & Associates, Oakland, CA
Municipal Research & Services Center, Kirkland, WA
Nespelem Valley Electric Coop, Inc., Nespelem, WA
Nickel Joint Venture, Riddle, OR
Non-Generating Public Utilities, Portland, OR
North Beach & Pacific Company, Seattle, WA
North Side Canal Company, Jerome, ID
Northeast Utilities Service Company, Hartford, CT
Northeast Washington Rural Resource, Colville, WA
Northern Lights, Inc., Sandpoint, ID
Northern Wasco County Peoples Utility District, The Dalles, OR
Northrup Devine & Tarbell, Portland, ME and Vancouver, WA
Northwest Aluminum Company, The Dalles, OR
Northwest Economic Associates, Vancouver, WA
Northwest Irrigation Utilities, Portland, OR
Northwest Natural Gas Company, Astoria and Portland, OR
Northwest Power Pool, Portland, OR
Northwest Small Hydro Association, Salem, OR
Northwestern University, Center for Urban Affairs & Policy Research, Evanston, IL
NPI Inc., Edmonds, WA
NW Cogeneration & Industrial Power Coalition, Seattle, WA
Ogden Environmental, San Diego, CA
Ohio State University, Columbus, OH
Okanogan County Electric Coop., Inc., Winthrop, WA
Okanogan County PUD No. 1, Okanogan, WA
Omak Okanogan County Chronicle, Omak, WA
Ore Ida Foods Inc., Boise, ID
Oregon Farm Bureau Federation, Salem, OR
Oregon Grains Commission, Portland, OR
Oregon Insider, Eugene, OR
Oregon State University, Departments of Agriculture & Resource Economy, Anthropology, Fish and Wildlife, and Geosciences, Corvallis, OR
Oregon State University, Extension Service, Enterprise, OR
Oregon State University, Water Resource Research Institute, Corvallis, OR
Oregon Water Coalition, Hermiston, OR
Oregon Wheat Growers League, The Dalles, OR
Orofino Chamber of Commerce, Orofino, ID
Oroville-Tonasket Irrigation District, Oroville, WA

Otley Brothers, Inc., Diamond, OR
Outdoor Press, Spokane, WA
Pacific County Economic Development Council, Raymond, WA
Pacific Gas & Electric Company, Department of Power Contracts, San Francisco, CA
Pacific Power and Light Company, Portland, OR
Pacific Marine Technology, Duvall, WA
Pacific NW Utilities Conference Committee, Portland, OR
Pacific Northwest Project, Kennewick, WA
Pacific Northwest Waterways Association, Vancouver, WA
Pacific States Marine Fisheries Commission, Gladstone, OR
PacifiCorp Regulatory & Agency Affairs, Portland, OR
Paine, Hamblin, Coffin, Brooke, & Miller, Spokane, WA
Parametrix Inc., Kirkland, WA
Parsons, Smith, Stone, & Fletcher, Burley, ID
PC Jantz Land Company, Shawnee Mission, KS
Pend Oreille County PUD No. 1, Usk and Ione, WA
Perkins Coie, Bellevue, WA
Phils Sporting Goods, Pasco, WA
Pierce College, Tacoma, WA
Plum Creek Timber Company, Seattle, WA
PMC Hydro, Inc., Bellevue, WA
Point Grey RPO, Vancouver, BC Canada
Pomeroy Grain Growers, Inc., Pomeroy, WA
Ponderay Newsprint Company, Usk, WA
Portland General Electric, Portland, OR
Potlatch Corporation, San Francisco, CA
Powder River Tackle Company, Baker, OR
Power Resource Managers, Bellevue, WA
Preston Gates & Ellis, Seattle, WA
Priestley Associates, Berkeley, CA
Public Power Council, Portland, OR
Puget Sound Power & Light Company, Bellevue, WA
Quincy-Columbia Basin Irrigation District, Quincy, WA
Quincy Grange No. 990, Quincy, WA
R W Beck & Associates, Seattle, WA
Raft River Rural Electric Cooperative, Inc., Declo, ID
Ravalli County Electric Coop., Inc., Stevensville, MT
Reddy Communications, Inc., Albuquerque, NM
Regional Services, Inc., Challis, ID
Resource Management International, Inc., Portland, OR and Sacramento, CA
Resource Writers, Inc., Seattle, WA
Resources for the Future, Lake Oswego, OR, and Washington, DC
Robert L. Teeter, Inc., Harrisonburg, VA
Roosevelt Recreational Enterprises, Coulee Dam, WA
Royal Paacific Orchards, Royal City, WA
RR Warehouse, Inc., Ritzville, WA
R S Anderson & Associates, Inc., Vancouver, WA
S & K Holding Company, Inc., Polson, MT
S. Martinez Livestock, Inc., Moxee, WA
Sacramento Municipal Utility District, Sacramento, CA

Salem Public Schools, Keizer School District 24J, Salem, OR
Salt River Project, Phoenix, AZ
SCLDS, Seattle, WA
Seattle City Light, Seattle, WA
Seattle Post Intelligencer, Seattle, WA
Semi Tech International, Seattle, WA
Shapiro & Associates, Inc., Seattle, WA
Shaver Transportation Company, Portland, OR
Sierra Energy & Risk Assessment, Roseville, CA
Sithe Energies, Inc., San Diego, CA
Small Towns Institute, Ellensburg, WA
Snake Dancer Excursions, Lewiston, ID
Snohomish County PUD No. 1, Everett, WA
Solar Wind Energy Conversion, Libby, MT
South Columbia Basin Irrigation District, Pasco, WA
Southern California Edison Company, Rosemead, CA
Spokesman Review, Spokane, WA
Stanley Redwood Motel, Boise, ID
Star Newspaper, Grand Coulee, WA
Stegner Grain & Seed Company, Lewiston, ID
Stetson Engineers, San Rafael, CA
Stoel Rives Boley Jones & Grey, Portland, OR
Sustainable Resource Development Group, Underwood, WA
Sverdrup Corporation, Kirkland, WA
Synergic Resources Corporation, Oakland, CA
Tacoma Public Utilities, Tacoma, WA
Taylor Economic Research, Portland, OR
Tetra Tech, Inc., Alexandria, WA
Texas A&M University, College Station, TX
Tigard Sand & Gravel Company, Tigard, OR
Tillamook County PUD, Tillamook, OR
Tobacco Valley Economic Development Council, Eureka, MT
Traffic Safety Supply Company, Portland, OR
Trans Pacific Geothermal, Inc., Oakland, CA
Tree Top, Inc., Selah, WA
Tri Cities Technical Council, West Richland, WA
Truman Price, Inc., Bethesda, MD
Tualatin Valley Irrigation District, Forest Grove, OR
Turlock Irrigation District, Turlock, CA
Umatilla Electric Cooperative Association, Hermiston, OR
Union County Economic Development Corp., LaGrande, OR
Union Pacific System, Omaha, NE
University of Idaho, College of Law, Moscow, ID
University of Idaho, Departments of Agricultural Economics, Economics, Fish & Wildlife Resources, and Fisheries, Moscow, ID
University of Idaho, Kimberly and Moscow, ID
University of Montana, Departments of Environmental Studies and Geology, Missoula, MT
University of Montana, Flathead Lake Biological Station, Polson, MT
University of Washington, Departments of Civil Engineering and History, Institutes for Environmental Studies and Marine Studies, and School of Fisheries, Seattle, WA

University of Wyoming, Department of Geography and Recreation, Laramie, WY
Upper Columbia United Tribes, Eastern Washington University, Cheney, WA
Upper Grant Conservation District, Ephrata, WA
USA Dry Pea and Lentil Council, Moscow, ID
USA Emerald Corporation, Spokane, WA
US Bancorp, Portland, OR
Venture Motor Inn, Libby, MT
W&H Pacific, Boise, ID
Walla Walla College, Technical Services, Walla Walla, WA
Walla Walla Union Bulletin, Walla Walla, WA
Washington Association of Wheat Growers, Ritzville, WA
Washington Public Power Supply System, Richland, WA
Washington State Grange, Pasco, WA
Washington State University, Office of Applied Energy Studies; Social & Economic Sciences Research Center; Departments of Engineering, Rural Sociology, Agricultural Economics, and Applied Energy Studies; and Water Research Center, Pullman, WA
Washington State Water Resources Association, Yakima WA
Washington Water Power Company, Spokane, WA
Washington Wheat Commission, Spokane, WA
Washington Wool Growers Association, Roy, WA
Water Resource Management, Portland, OR
Watermaster District No. 6, La Grande, OR
Webster's Dictionary, Banks, OR
Wells Rural Electric Company, Carlin, NV
West Extension Irrigation District, Umatilla, OR
Western Empires Corporation, Irrigon, OR
Western Environmental Trade Association, Helena, MT
Western Farmer Stockman Magazines, Spokane, WA
Western Forest Industries Association, Portland, OR
Western Montana Electric Generating & Transmission Cooperative, Missoula, MT
Western New England College, School of Law, Springfield, MA
Western News, Libby, MT
Western Pulp Products Company, Corvallis, OR
Western Washington University, Department of Economics, Bellingham, WA
Westinghouse, Moxee, WA
Westinghouse Hanford Company, Richland, WA
Weyerhaeuser Company, Federal Way, WA
Wilvur Gem Mineral Club, Wilbur, WA
Wilbur Register, Wilbur, WA
Wild River Ranch, Kooskia, ID
Willamette Manufacturing Supply Company, Inc., Tualatin, OR
Wm. J. Melcher & Associates, Libby, MT
Wolfkill Feed & Fertilizer Corporation, Mattawa, WA
Wyatt Jaykim Engineers, Lewiston, ID
Yakima Valley Grape Producers, Inc., Grandview, WA

LIBRARIES

Blue Mountain Community College Library, Pendleton, OR
Boise Public Library, Boise, ID

Boise State University Library, Boise, ID
California State Library, Sacramento, CA
California State University Library, Documents Section, Sacramento, CA
Camas Public Library, Camas, WA
Canby Public Library, Canby, OR
Central Washington University Library, Ellensburg, WA
City of Albany, Public Library, Albany, OR
Clackamas County Library, Oak Grove, OR
County of Multnomah, Law Library, Portland, OR
Denver Public Library, Regional Depository, Denver, CO
East Bonner City Library, Sandpoint, ID
Eastern Oregon College Library, La Grande, OR
Eastern Washington University Library, Documents Department, Cheney, WA
Environment Canada Library, North Vancouver BC, Canada
Fort Vancouver Regional Library, Vancouver, WA
Huntington Public Library, Huntington, OR
Idaho State Library, Boise, ID
Idaho State Law Library, Boise, ID
Idaho State University Library, Pocatello, ID
Kirkland Public Library, Kirkland, WA
Lake Oswego Public Library, Lake Oswego, OR
Lewis & Clark College Library, Lewiston, ID
Lewis & Clark College Library, Portland, OR
Library Association of Portland, Portland, OR
Lincoln County Library, Eureka, MT
Linfield College Library, McMinnville, OR
Longview Public Library, Longview, WA
Mid Columbia Library, Pasco, WA
Montant State Law Library, Helena, MT
Montana State Library, Documents Section, Helena, MT
Montana State University Library, Bozeman, MT
North Central Regional Library, Wenatchee, WA
Odessa Public Library, Odessa, WA
Oregon State Library, Salem, OR
Oregon State University, Kerr Library Documents Division, Corvallis, OR
Oregon Supreme Court Library, Salem, OR
Pacific University Library, Forest Grove, OR
Portland State University Library, Portland, OR
Reed College Library, Portland, OR
Richland Public Library, Richland, WA
Ritzville Public Library, Ritzville, WA
Scappoose Public Library, Scappoose, OR
Seattle Public Library, Seattle, WA
Southern Oregon State College Library, Ashland, OR
Spokane Public Library, Spokane, WA
Springfield Public Library, Springfield, OR
Tacoma Public Library, Tacoma, WA
University of Idaho Library, Moscow, ID
University of Montana, Mansfield Library, Missoula, MT
University of Nevada Library, Reno, NV

University of Oregon Libraries, Eugene, OR
University of Washington Libraries, Seattle, WA
University of Washington Law Library, Seattle, WA
US Court of Appeals, 9th Circuit Library, Seattle, WA
Wastington State Law Library, Olympia, WA
Washington State Library, Olympia, WA
Washington State University Library, Pullman, WA
Western Washington University, Mabel Zoe Wilson Library Documents Division Bellingham, WA
Whitman College, Penrose Library, Walla Walla, WA
Willamette University Law Library, Salem, OR
Willamette University Library, Salem, OR
Wyoming State Library, Cheyenne, WY
Yakima Public Library, Department of Reference, Yakima, WA

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Ron Kowitz
Roger Kreitzberg
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Nita Kreuzer
Norman C. Kunkel
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Gene Peterson
H. Peterson
G. and M. Peterson
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Chapter 13

EIS Preparers



13.0 EIS PREPARERS

The System Operation Review EIS was prepared by an interdisciplinary team consisting of staff from the Bonneville Power Administration, the Bureau of Reclamation, and the Corps of Engineers.

Foster Wheeler Environmental Corporation (formerly Enserch Environmental), a consulting firm under contract to BPA, helped the interagency team in developing the EIS. Staff from three other contractors also contributed directly to the EIS.

Individuals responsible for preparing the main EIS volume are listed in Tables 13-1 through 13-5, organized by agency and contractor. Because of the number of people involved in coordinating this study, the information presented in these tables is limited to the names, education, experience, expertise, and general roles these individuals had in developing the EIS. Each technical appendix provides a separate list of preparers. Appendix contributors include a large number of staff from the three lead agencies, the three cooperating agencies, state agencies, Indian tribes, and contractor organizations. Contributions to the EIS and appendices by individual preparers were subject to revision during the internal review process.

Table 13-1. List of preparers, Bonneville Power Administration

Name	Education/Years of Experience	Experience and Expertise	Role in SOR Preparation
Linda Burbach	15 years	NEPA compliance	Contract management Review
Audrey Perino	M.A. Economics B.A. Mathematics 14 years	Economics Project management and coordination	Power analysis
Robyn MacKay	B.S. Mechanical Engineering 15 years	Long term hydrosystem operations planning	Anadromous fish analysis
Robert Shank	M.R.P. Regional Planning B.S. Biology 13 years	NEPA compliance Land use, recreation, environmental planning	Wildlife analysis Review
Philip Thor	B.S. Mechanical Engineering 19 years	Project management and coordination Operational analysis NEPA compliance	Project management Review
John Rowan	B.S. Biology/Soil Science 10 years	NEPA compliance Environmental analysis, project management, and coordination	Anadromous fish analysis
Kelly Wallace	B.A. International Studies 4 years	Contract management Public involvement	Contract management Recreation analysis

Table 13-2. List of preparers, Bureau of Reclamation

Name	Education/Years of Experience	Experience and Expertise	Role in SOR Preparation
John Dooley	B.S. Civil Engineering 29 years	Hydrology Reservoir operations Project management and coordination	Project Management Review
Jim Fodrea	B.S. Civil Engineering 20 years	Hydrology Reservoir operations/planning Project management	PNCA Work Group Coordinator Project Review
Ronald McKown	Ph.D. Speciation 24 years	NEPA compliance Biological studies	Grand Coulee Dam effects EIS coordination/SOR study management

Table 13-3. List of preparers, U.S. Army Corps of Engineers

Name	Education/Years of Experience	Experience and Expertise	Role in SOR Preparation
Witt Anderson	M.S. Resource Management B.S. Botany 17 years	Water resources planning	Project manager
Lynne Hamilton	M.A. Geography/Biology B.A. Geography 21 years	EIS coordination, writing, editing Community planning Outdoor recreation planning	NEPA coordination Review
Ray Jaren	B.S. Civil Engineering 35 years	Water resources planning	Project manager Technical project management
John Tyger	B.S. Resource Management 23 years	EIS Coordination Planning	NEPA Coordination Review

Table 13-4. List of preparers, Foster Wheeler Environmental (contractor)

Name	Education/Years of Experience	Experience and Expertise	Role in SOR Preparation
Chris Lawson Resource Planner	M.A. Geography B.S. Geography 16 years	Multidisciplinary environmental studies and planning Environmental assessments Regulatory compliance	Project manager Review
Judith Schneider Communications Specialist	B.A. English/History 26 years	Public involvement Communications Multidisciplinary environmental studies Project management	Assistant project manager Review
Dennis Burns Resource Planner	M.A. Recreation and Resource Development B.S. Economics 11 years	Recreation planning Natural resource economics Environmental planning Survey research	Flood control Navigation Irrigation Socioeconomics
John Cannon Ecologist	M.F.S. Forest Ecology B.A. Biology 20 years	Terrestrial ecology	Vegetation and wildlife
Peter Carr Public Involvement Specialist/ Technical Editor/Writer	B.S. Journalism 6 years	Technical editing and writing Public involvement	Writer/editor
Doug Davy Archeologist	Ph.D. Archeology M.A. Ethnology B.A. Anthropology 17 years	Prehistory Historic engineering and architecture Cultural resources management	Cultural resources
Domoni Glass Fisheries Biologist	B.S. Fisheries Biology 13 years	Fisheries management Fisheries biology	Resident fish
Mark Greenig Landscape Resource Planner	M.U.P. Urban Planning B.S. Landscape Arch. 13 years	Visual resources Recreation planning and design Site planning and design	Recreation and aesthetics
Ellen Hall Economist	Ph.D. Resource Economics M.Ag. Agricultural Economics B.A. History/Economics 20 years	Agricultural economics Economics Land Use	Agricultural economics Navigation economics
Garrett Jackson Geomorphologist	M.S. Geosciences B.S. Geosciences 7 years	Geomorphology Soil-vegetation associations Mapping stream channels Geologic hazard evaluation	Shoreline erosion Groundwater

Table 13-4. List of preparers, Foster Wheeler Environmental (contractor)

Name	Education/Years of Experience	Experience and Expertise	Role in SOR Preparation
Amichay Greenstein	M.A. Development Economics A.S. Business Administration/Acounting 5 years	Economic analysis Socioeconomics Feasibility analysis	Economics
Coreen Johnson-Dean Technical Editor/Writer	B.A. English 6 years	Technical writing and editing Document production	Lead writer/editor Document production manager
Marthlyn Jones Environmental Medicine Specialist	M.D. M.P.H. Environmental Health B.A. Biology 15 years	Toxicology Environmental health risk assessment	Human health evaluation
John Knutzen Aquatic Scientist	M.S. Fisheries B.S. Biology 17 years	Aquatic resources Water quality Fisheries	Anadromous fish
Tom Martin Civil Engineer	B.S. Civil Engineering 14 years	Water quality modeling	Water quality
Patricia Reynolds Resource Planner	B.A. Economics 3 years	Socioeconomics Recreation and land use planning	Land use and economics
Tim Richards Graphic Artist	19 years	Graphic design/production Computer-generated graphics Illustration Architectural design	Graphics, illustrations
Stacie Seaver Technical Editor	B.A. English 4 years	Technical writing and editing Document production	Editing Document production
Lynn Skaves Graphic Artist	A.S. Business 12 years	Graphic design Desktop publishing Computer-generated graphics	Graphics
Bruce Stoker Geomorphologist	M.S.E. Civil Engineering M.S. Remote Sensing/Geology B.S. Geology 17 years	Geology Sediment transport Hydrology Slope stability	Geology and soils
Danene Warnock Graphic Artist	B.A. Anthropology 15 years	Graphic design Computer-generated graphics Desktop publishing	Graphics

Table 13-4. List of preparers, Foster Wheeler Environmental (contractor)

Name	Education/Years of Experience	Experience and Expertise	Role in SOR Preparation
Kristin Avery Technical Editor	B.A. (pending) English-Writing Arts/Philosophy 5 years	Technical writing and editing Document production Public involvement	Editing Document production
Peter Hummer Air Quality Specialist	M.S. Physical Oceanography B.S. Meteorology and Oceanography 19 years	Air quality and meteorological monitoring, dispersion modeling, emission estimates	Air quality

Table 13-5. List of preparers, other contractors

Name	Education/Years of Experience	Experience and Expertise	Role in EIS Preparation
Sonya Bruce, Resource Writers Inc.	M.A. Journalism B.A. Community Service 17 years	Communications Writing and editing	Summary Editing
Jim Creighton, Creighton & Creighton	Ph.D. Psychology 25 years	Public involvement Dispute resolution Social impact assessment	Public involvement Forum process development
Steve Derby, Strategic Decisions Group	Ph.D. Engineering Economics 25 years	Decision analysis	Technical Review Forum process development
Susan Whittington, Resource Writers, Inc.	M.P.A. Public Administration B.A Political Science 19 years	Communications Writing and editing	Summary Editing

Chapter 14

Glossary of Terms and Acronyms

14.0 GLOSSARY OF TERMS AND ACRONYMS

AAQS: Ambient Air Quality Standards

ACEC: Areas of Critical Environmental Concern

ACHP: Advisory Council on Historic Preservation

AIRFA: American Indian Religious Freedom Act

Acre-foot: The volume of water that will cover an area of 1 acre to a depth of 1 foot.

AER: Actual Energy Regulation

AIRFA: American Indian Religious Freedom Act

AIWP: Annual Implementation Work Plan

Ambient air: Ambient air is the air surrounding a particular spot, such as a powerplant.

AMG: Analysis Management Group

Anadromous fish: Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Annual operating plan: A yearly plan for operating reservoirs on the Columbia River. Such a plan is specifically required by the Columbia River Treaty and by the Pacific Northwest Coordination Agreement.

Aquifer: Any geological formation containing water, especially one that supplies water to wells, springs, etc.

ARPA: Archeological Resources Protection Act

Artifact: An object of any type made by human hands. Tools, weapons, pottery, and sculptured and engraved objects are artifacts.

ASIL: Acceptable Source Impact Level

Assured refill curve: A curve showing minimum elevations that must be maintained at each storage project to ensure refill even if the third lowest historical water year occurred; it sets limits on the production of energy.

Augmenting: Increasing; in this application, increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs.

Average megawatts (aMW): The average amount of energy (number of megawatts) supplied or demanded over a specified time.

Baseload: In a demand sense, a load that varies only slightly over a specified time period. In a supply sense, a plant that operates most efficiently at a relatively constant level of generation.

B.C. Hydro: The British Columbia Hydro and Power Authority. This Crown corporation was formed in 1962 following the merger of an expropriated private utility and the B.C. Power Commission.

BIA: Bureau of Indian Affairs

Biological rule curve: A reservoir operation guideline indicating monthly elevation targets, intended to provide improved conditions for resident fish. Biological rule curve (currently termed integrated rule curve) operations have been simulated in the SOR for the Hungry Horse and Libby storage projects in Montana.

BKD: Bacterial kidney disease of salmonid fish

BLM: Bureau of Land Management

BNRR: Burlington Northern Railroad

BP: Before the present time

BPA: Bonneville Power Administration

BRC: Biological Rule Curve

Bypass system: Structure in a dam that provides a route for fish to move through or around the dam without going through the turbines.

CAA: Clean Air Act

Canadian Entitlement: The Canadian Entitlement is Canada's 50-percent share of the downstream power benefits of Canada's three large storage dams, Duncan, Keenleyside, and Mica. These dams were built as part of the Columbia River Treaty. Canada offered the rights to this Entitlement for sale in the United States for an agreed upon period of 30 years, beginning with the operational dates of the Canadian storage project dams.

Canadian Entitlement Allocation Agreements (CEAA): Contracts that specify how much power is to be provided by five mid-Columbia projects as a result of increased flows made possible by the Columbia River Treaty projects.

Capacity: The maximum sustainable amount of power that can be produced by a generator or carried by a transmission facility.

Capacity/energy exchange: A transaction in which one utility provides another with capacity service in exchange for additional amounts of firm energy (exchange energy) or money, under specified conditions, usually during offpeak hours.

Carcinogen: A substance capable of causing cancer.

CBFWA: Columbia Basin Fish and Wildlife Authority

CEAA: Canadian Entitlement Allocation Agreements

CEQ: Council on Environmental Quality

cfs: Cubic feet per second

cms: Cubic meters per second

COE: U.S. Army Corps of Engineers

Cogeneration: The generation of power in conjunction with (usually) an industrial process, using waste heat from one process to fuel the other.

Columbia River Treaty: A treaty signed by the United States and Canada on September 16, 1964, for joint development of the Columbia River. Under the Treaty, Canada built three large storage dams (Duncan, Keenleyside, and Mica) on the upper reaches of the Columbia River, which originates in Canada. It is a U.S.-Canadian agreement for bilateral development and management of the Columbia River to achieve flood control and increased power production.

Columbia Storage Power Exchange (CSPE): A non-profit corporation of 11 Northwest utilities that issued revenue bonds to purchase the Canadian Entitlement and sold it to 41 Northwest utilities through a Bonneville Power Administration exchange agreement.

Consumer surplus: Economic value received by the consumer of a good, service, or resource (e.g., by a recreational user) that is above the price actually paid.

Corps: U.S. Army Corps of Engineers

Council: Northwest Power Planning Council

CPO: Coordinated plan of operations

CRBG: Columbia River Basalt Group

CRGNSA: Columbia River Gorge National Scenic Area

CRiSP: Columbia River Salmon Passage Model

CRITFC: Columbia River Inter-Tribal Fish Commission

Critical period: The portion of the 50-year streamflow record that would produce the least amount of energy with all reservoirs drafted from full to empty.

Critical rule curves: A set of curves that define reservoir elevations that must be maintained to ensure that firm energy requirements can be met under the most adverse historical streamflow conditions. Critical rule curves are derived for all four years in the critical period. They are used to guide reservoir operation for power.

CRM: Columbia River Mile

CROHMS: Columbia River Operational Hydromet Management System

CRSMA: Columbia River Salmon Mitigation Analysis; a Corps of Engineers study program that includes evaluations of short-term (such as the 1992 Lower Granite and Little Goose reservoir drawdown) and long-term measures.

CRWMG: Columbia River Water Management Group

CSPE: Columbia Storage Power Exchange

Cubic feet per second (cfs): A unit of measurement pertaining to flow or discharge of water. One cfs is equal to 449 gallons (1.7 m^3) per minute.

Cultural resources: The nonrenewable evidence of human occupation or activity as seen in any district, site, building, structure, artifact, ruin, object, work of art, architecture, or natural feature that was important in human history at the national, state, or local level.

CWA: Clean Water Act

Damage center: A geographic location on the river system that has historically been subject to damage from flooding.

DEIS: Draft Environmental Impact Statement

Demand: The rate at which electric energy is used, whether at a given instant or averaged over any designated period of time.

Depletions: Withdrawals of water from a stream, thereby reducing the volume of instream flow.

Direct-service industries (DSIs): Industrial customers, primarily aluminum smelters, that buy power directly from BPA at relatively high voltages.

Discharge: Volume of water flowing at a given time, usually expressed in cubic feet per second.

Displacement: The substitution of less-expensive energy generation for more-expensive energy generation (usually hydroelectric energy transmitted from the Pacific Northwest or Canada is substituted for more expensive coal and oil-fired generation in California). Such displacement usually means that a thermal plant can reduce or shut down its production, saving money and often reducing air pollution.

Dissolved gas concentrations: The amount of chemicals normally occurring as gases, such as nitrogen and oxygen, which are held in solution in water, expressed in units such as milligrams of the gas per liter of liquid.

Draft: Release of water from a storage reservoir.

Drawdown: The distance that the water surface of a reservoir is lowered from a given elevation as water is released from the reservoir. Also refers to the act of lowering reservoir levels.

DSIs: Direct service industries

Edaphic: Pertaining to the soil.

EIS: Environmental impact statement

ELCM: Empirical Life-Cycle Model

Endangered: A plant or animal species which is in danger of extinction throughout all or a significant portion of its range because its habitat is threatened with destruction, drastic modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors; Federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the *Federal Register*.

Endemism: Native or limited to a certain region (endemic).

Energy content curves: A set of curves that establishes limits on the amount of reservoir drawdown permitted for nonfirm energy production.

Entrainment: The drawing of fish and other aquatic organisms into tubes or tunnels carrying water for cooling purposes into thermal plants, or for power generating purposes into hydroelectric plants. Entrainment increases mortality rates for those organisms.

EPA: Environmental Protection Agency

ESA: Endangered Species Act

Escapement: Number of salmon that actually return to a stream to spawn.

Exotic species: Introduced species not native to the place where they are found.

F: Fahrenheit

FCRPS: Federal Columbia River Power System

FEIS: Final Environmental Impact Statement

FELCC: Firm Energy Load Carrying Capability

Firm Energy Load Carrying Capability (FELCC): The amount of energy the region's generating system, or an individual utility or project, can be called on to produce on a firm basis during actual operations. FELCC is made up of both hydro and non-hydro resources, including power purchases.

FERC: Federal Energy Regulatory Commission

Firm energy: The amount of energy that can be generated given the region's worst historical water conditions. It is energy produced on a guaranteed basis.

Fish Guidance Efficiency (FGE): The efficiency of juvenile fish screens at diverting downstream juvenile migrants from the turbine intakes, measured as the percentage fish approaching the powerhouse that are routed through the collection and bypass facilities.

Fish hatchery: A facility in which fish eggs are incubated and hatched and juvenile fish are reared for release to rivers or lakes.

Fish ladders: A series of ascending pools constructed to enable salmon or other fish to swim upstream around or over a dam.

Fish passage facilities: Features of a dam that enable fish to move around, through, or over without harm. Generally an upstream fish ladder or a downstream bypass system.

Flip lips: Also known as spill deflectors; structural modifications made to the spillways of some Columbia-Snake River projects to deflect flows and reduce the deep plunging flows that create high dissolved gas levels.

Flood control rule curve: A curve, or family of curves, indicating reservoir drawdown required to control floods. (Also called Mandatory Rule Curve or Upper Rule Curve.)

Flow: The volume of water passing a given point per unit of time.

FLUSH: Fish Leaving Under Several Hypotheses

FOB: Free-on-board, without charge for delivery to and placing on board a carrier at a specific point of origin.

Forebay: The portion of the reservoir at a hydroelectric plant which is immediately upstream of the generating station.

Forum: Columbia River Regional Forum

FPC: Fish Passage Center

FPDEP: Fish Passage Development and Evaluation Program

fps: Feet per second

Freshet: A rapid temporary rise in streamflow caused by heavy rains or rapid snowmelt.

Full pool: The maximum level of a reservoir under its established normal operating range.

FY: Fiscal year

Gas supersaturation: Concentrations of dissolved gas in water that are above the saturation (100 percent capacity) level of the water.

Generation: Act or process of producing electric energy from other forms of energy. Also refers to the amount of electric energy so produced.

ha: Hectare

HCNRA: Hells Canyon National Recreation Area

Historical streamflow record: The unregulated streamflow data base of the 50 years beginning in July 1928; data are modified to adjust for factors such as irrigation depletions and evaporations for the particular operating year being studied.

HMU: Habitat Management Unit

Housepit villages: Archeological sites where prehistoric peoples constructed villages of semi-subterranean pit houses.

Hydraulic head: The vertical distance between the surface of the reservoir and the surface of the river immediately downstream from the turbine and dam.

Hydraulic jump: A transition in water flow when water accelerates over a local steep gradient and enters a lower gradient immediately downstream. The water accelerates, its surface lowers, and accumulates energy. At the lower gradient, the flow accelerates, the water surface rises, and the accumulated energy is dissipated in an area of extremely turbulent flow.

Hydroelectric: Referring to the production of electric power through use of the gravitational force of falling water.

Hydrology: The science of dealing with the continuous cycle of evapotranspiration, precipitation, and runoff.

Hydrometeorological observations: Data that combine snowpack measurements and climatic forecasts to predict runoff.

Hydroregulation model: A computer-based mathematical model that simulates the regulation of water in the coordinated operation of a river system.

ICC: Interstate Commerce Commission

IDFG: Idaho Department of Fish and Game

IDWR: Idaho Department of Water Resources

IJC: International Joint Commission

Independent power producers: Non-utility producers of electricity who operate generation plants under the 1978 Public Utilities Regulatory Policy Act of 1978 (PURPA). Many independent power producers are cogenerators who produce power as well as steam or heat for their own use and sell the extra power to their local utilities.

Inflow: Water that flows into a reservoir or forebay during a specified period.

INHP: Idaho Natural Heritage Program

Intake: The entrance to a conduit through a dam or water facility.

Integrated rule curve: A reservoir operation guideline indicating monthly elevation targets intended to provide improved conditions for resident fish in balance with flood control and power generation needs. Integrated rule curve (formerly known as biological rule curve) operations have been simulated in the SOR for the Hungry Horse and Libby storage projects in Montana.

Interchange energy: Electric energy received by one utility system usually in exchange for energy to be delivered to another system at another time or place. Interchange energy is different from direct purchase or sale, although accumulated energy balances are sometimes settled in cash.

Interruptible: A supply of power which, by agreement, can be shut off on relatively short notice (from minutes to a few days).

Intertie: A transmission line or system of lines permitting a flow of energy between major power systems. BPA has several interties, both AC and DC, connecting the Pacific Northwest to the Southwest.

IPC: Idaho Power Company

IRC: Integrated Rule Curve

ITD: Idaho Transportation Department

Juvenile: The early stage in the life cycle of anadromous fish when they migrate downstream to the ocean.

KAF: Thousand acre-feet

kcfs: Thousand cubic feet per second; a measurement of water flow equivalent to 1,000 cubic feet of water passing a given point in one second.

km: Kilometer (1,000 meters)

Ksfd: Thousand second-foot day, a measure of water volume equivalent to 1,000 cubic feet per second for an entire day.

kV: Kilovolt (1,000 volts)

kW: Kilowatts (1,000 watts)

kWh: Kilowatt hour

Lateral: A side ditch or conduit in an irrigation water delivery system.

Levee: An embankment constructed to prevent a river from overflowing.

Littoral zone: The shallower waters near the shore of a reservoir or lake.

Load: The amount of electric power or energy delivered or required at any specified point or points on a system. Load originates primarily at the energy-consuming equipment of customers.

Load shaping: The adjustment of storage releases so that generation and load are continuously in balance.

Local flood control: Flood protection for nearby downstream areas provided by a portion of the allocated flood storage space at a reservoir.

Lock: A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

Low pool: At or near the minimum level of a reservoir under its established normal operating range.

LTSA: Long-Term Spill Agreement

LWCFA: Land and Water Conservation Fund Act

m^3: cubic meters

Macrophytes: Aquatic plants that are macroscopic, or large enough to be seen with the naked eye.

MAF: Million acre-feet

Mainstem: The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.

MDFWP: Montana Department of Fish, Wildlife and Parks

Megawatt (MW): A megawatt is one million watts, a measure of electrical power.

Megawatt-hour (MWh): A unit of electrical energy equal to 1 million watts, or 1,000 kilowatts.

mg/l: Milligram per liter

Mid-Columbia: The section of the Columbia River from the Canadian border to its junction with the Snake River.

Mill: A tenth of one cent. A thousand mills equals one dollar. The cost of electricity is often expressed in mills per kilowatt hour.

Model: A mathematical function with parameters that can be adjusted so that the function closely describes a set of empirical data. A "mathematical" or "mechanistic" model is usually based on biological or physical mechanisms and has model parameters that have real-world interpretation. In contrast, "statistical" or "empirical" models involve curve-fitting to data where the math function used is selected for its numerical properties. Extrapolation from mechanistic models (e.g., pharmacokinetic equations) usually carries higher confidence than extrapolation using empirical models (e.g., logic).

MOP: Minimum operating pool; the minimum elevation of the established normal operating range of a reservoir.

MPC: Montana Power Company

MPN: Most probable number

MRCs: Mandatory flood control rule curves

MW: Megawatt

MWh: Megawatt hour(s)

NAAQS: National Ambient Air Quality Standards

NAGPRA: Native American Grave Protection and Repatriation Act

NED: National economic development

NEPA: National Environmental Policy Act

NFH: National Fish Hatchery

NGVD: National geodetic vertical datum (mean sea level)

NHPA: National Historic Preservation Act

Nitrogen supersaturation: A condition of water in which the concentration of dissolved nitrogen exceeds the saturation level of water. Excess nitrogen can harm the circulatory systems of fish.

NMFS: National Marine Fisheries Service

Nonfirm energy: Energy available when water conditions are better than the worst historical pattern; generally such energy is sold on an interruptible (nonguaranteed) basis. Sometimes called secondary energy.

Nonpower operating requirements: Operating requirements at hydroelectric projects that pertain to navigation, flood control, recreation, irrigation, and other nonpower uses of the river.

Non-Treaty Storage Agreement (NTSA): Three storage dams were built under the Columbia River Treaty—Mica, Duncan, and Keenleyside—together, these dams provide more storage than is required under the Treaty. This additional storage space was not covered by the Treaty. In November 1990, BPA and B.C. Hydro signed an agreement to share and coordinate the use of 4.5 million acre-feet of this storage.

Northwest Power Pool (NWPP): An associate of generating utilities serving the Pacific Northwest, British Columbia, and Alberta. Members include BPA, the Corps, Reclamation, and public and private utilities. The group's primary functions are administering the Pacific Northwest Coordination Agreement and coordinating operations and transmission.

Northwest Power Pool Coordinating Group: One of three subcommittees of NWPP, responsible for coordinating operations among generating utilities belonging to the pool.

NPDES: National Pollutant Discharge Elimination System

NPPC: Northwest Power Planning Council

NPS: National Park Service

NRHP: National Register of Historic Places

NTSA: Non-Treaty Storage Agreement

NTU: Nephelometric turbidity units; a measure of the amount of suspended sediment in the water.

NWR: National Wildlife Refuge

OA/EIS: 1992 Options Analysis/Environmental Impact Statement

ODFW: Oregon Department of Fish and Wildlife

Offpeak hours: Period of relatively low demand for electrical energy, as specified by the supplier (such as the middle of the night).

ONHP: Oregon National Heritage Program

Operating limits: Limits or requirements that must be factored into the planning process for operating reservoirs and generating projects. (Also see operating requirements, below.)

Operating requirements: Guidelines and limits that must be followed in the operation of a reservoir or generating project. These requirements may originate in authorizing legislation, physical plant limitations, or other sources.

Operating rule curve: A curve, or family of curves, indicating how a reservoir is to be operated under specific conditions and for specific purposes.

Operating year: The 12-month period from August 1 through July 31.

Outages: Periods, both planned and unexpected, during which the transmission of power stops or a particular power-producing facility ceases to provide generation.

Outflow: The volume of water per unit of time discharged at a hydroelectric project.

PA: Programmatic Agreement

Pacific Northwest Coordination Agreement: A binding agreement among BPA, the Corps, Reclamation, and the major generating utilities in the Pacific Northwest that stemmed from the Columbia River Treaty. The Agreement specifies a multitude of operating rules, criteria, and procedures for coordinating operation of the system for power production. It directs operation of major generation facilities as though they belonged to a single owner.

Pacific Northwest Electric Power Planning and Conservation Act: In December 1980, Congress passed this Act, Public Law 96-501 (referred to as the Northwest Power Act). This Act authorized the four Pacific Northwest States—Idaho, Montana, Oregon, and Washington—to enter into an interstate compact for long-range planning and protection of shared resources. As a result of the Act, each of the four States passed enabling legislation to create the Northwest Power Planning Council in April 1981.

PAHs: Polyaromatic hydrocarbons

PAM: Passage Analysis Model

Particulates: Substances that consist of minute separate particles, such as dust or soot.

PCBs: Polychlorinated biphenyls

PCPI: Per capita personal income

Peak load: The maximum electrical demand in a stated period of time. It may be maximum instantaneous load or the maximum average load within a designated period of time.

PGE: Portland General Electric

Phytoplankton: The plant portion of floating or weakly swimming organisms, often microscopic in size, in a body of water.

PL: Public Law

PMOA: Programmatic Memorandum of Agreement

PNCA: Pacific Northwest Coordinating Agreement; see definition above.

PNRBC: Pacific Northwest River Basins Commission

PNUCC: Pacific Northwest Utilities Conference Committee

Pool: Reservoir; a body of water impounded by a dam.

P_R: Pool elevation range

Project outflow: The volume of water per unit of time discharged from a project.

Proportional draft: A condition in which all reservoirs are drafted in the same proportion to meet firm loads.

PSC: Pacific Salmon Commission

PUD: Public utility district

Reclamation: U.S. Bureau of Reclamation

Record of Decision: ROD, a document notifying the public of a decision taken, together with the reasons for making that decision. Records of Decision are published in the *Federal Register*.

Recreation day: A unit of recreational use consisting of one person engaging in one recreational activity for any portion of a day.

Redds: Salmon spawning nests in gravel.

Refill: The point at which the hydro system is considered "full" from the seasonal snowmelt runoff. Also refers to the annual process of filling a reservoir.

Relative change in survival: The difference in survival between two alternatives divided by the base case survival value. The change in survival in relation to the base case survival.

Reliability: For a power system, a measure of the degree of certainty that the system will continue to meet load for a specified period of time.

Reregulation: Storing erratic discharges of water from an upstream hydroelectric plant and releasing them uniformly from a downstream storage plant.

Reservoir draft rate: The rate at which water, released from storage behind a dam, reduces the elevation of the reservoir.

Reservoir elevations: The levels of the water stored behind dams.

Reservoir storage: The volume of water in a reservoir at a given time.

Resident fish: Fish species that reside in fresh water throughout their lives.

Residualism: A condition in which migrating juvenile salmonid smolts lose their urge to migrate, physiologically revert to their freshwater life form, and remain in fresh water rather than migrate to sea.

Riprap: Broken rock, cobbles, or boulders placed on the bank of a stream or river for protection against the erosive action of water.

RM: River mile

RNA: Research Natural Areas

ROD: Record of Decision

ROSE: River Operation Simulation Experts (an SOR work group)

Rule curves: Water levels, represented graphically as curves, that guide reservoir operations.

Run-of-river dams: Hydroelectric generating plants that operate based only on available streamflow and some short-term storage (hourly, daily, or weekly).

Run-of-river reservoirs: The pools or impoundments formed behind run-of-river dams.

Salmonids: Fish of the family Salmonidae, such as salmon, trout (including steelhead), char, and whitefish.

SAM: System Analysis Model; a mathematical model developed and operated by BPA to simulate the operation of the integrated Northwest hydroelectric system.

Scoping: The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

SCS: System Configuration Study; a long-term evaluation being conducted by the Corps under the Columbia River Salmon Mitigation analysis.

SDWA: Safe Drinking Water Act

Secondary energy: Hydroelectric energy in excess of firm energy, often used to displace thermal resources. Sometimes called nonfirm energy.

Sedimentation: The settling of material (such as dust or other particles) into water and eventual deposition on the bottoms of streams and rivers.

Shaping: The scheduling and operating of generating resources to meet changing load levels. Load shaping on a hydro system usually involves the adjustment of reservoir releases so that generation and load are continuously in balance.

Shifting: In planning, moving surplus or deficit FELCC from one year of the critical period to another to increase the FELCC's value.

SHPO: State Historic Preservation Office

Simulation: The representation of an actual system by analogous characteristics of a device that is easier to construct, modify, or understand; or by mathematical equations.

SIPs: State implementation plans

SLCM: Stochastic Life Cycle Model

Smolt: A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.

SOR: (Columbia River) System Operation Review

SOS: System Operating Strategy

Spawning: The releasing and fertilizing of eggs by fish.

Spill: Water passed over a spillway without going through turbines to produce electricity. Spill can be forced, when there is no storage capability and flows exceed turbine capacity, or planned, for example, when water is spilled to enhance juvenile fish passage.

Spillway: Overflow structure of a dam.

STFA: State and Tribal Fisheries Agencies

Stochastic: Involving chance or probability.

Storage reservoirs: Reservoirs that have space for retaining water from springtime snowmelts. Retained water is released as necessary for multiple uses—power production, fish passage, irrigation, and navigation.

Streamflow: The rate at which water passes a given point in a stream, usually expressed in cubic feet per second (cfs).

Subyearlings: Juvenile fish less than 1 year old.

Surplus energy: Energy generated that is beyond the immediate needs of the producing system. This energy may be sold on an interruptible basis or as firm power.

System flood control: Flood protection for the Portland, Oregon-Vancouver, Washington metropolitan area that is coordinated among all of the storage reservoirs in the Columbia River system.

Tailrace: The canal or channel that carries water away from a dam.

Tailwater: The water surface immediately downstream from a dam or hydroelectric powerplant.

TBR: Transport benefit ratio

TCR: Transport control ratio

Thermal powerplant: Generating plant that converts heat energy into electrical energy. Coal, oil, and gas-fired powerplants and nuclear powerplants are common thermal resources.

Threatened: Legal status afforded to plant or animal species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

TIR: Transport/In-river ratio

TRG: Transportation Review Group

Tules: The name commonly applied to fall chinook salmon originating on the lower Columbia River.

Turbidity: A measure of the optical clarity of water, which depends on the light scattering and absorption characteristics of suspended and dissolved material in the water.

Turbine: Machinery that converts kinetic energy of a moving fluid, such as falling water, to mechanical or electrical power.

UCUT: Upper Columbia United Tribes

µg/l: micrograms per liter

µg/m^3: micrograms per cubic meter

Upper rule curve (URC): The flood control rule curve for a storage reservoir which typically is the uppermost of the family of rule curves used to guide reservoir operations.

Upriver brights: The name commonly applied to fall chinook salmon originating on the middle Columbia River, primarily in the area below Priest Rapids Dam.

UPRR: Union Pacific Railroad

URC: Upper rule curve, see definition above.

Usable storage: Water occupying active storage capacity of a reservoir.

Usable storage capacity: The portion of the reservoir storage capacity in which water normally is stored or from which water is withdrawn for beneficial uses, in compliance with operating agreements.

USFS: U.S. Forest Service

USFWS: U.S. Fish and Wildlife Service

USGS: U.S. Geological Survey

Variable energy content curve (VECC): The January through July portion of the energy content curve. The VECC is based on the expected amount of spring runoff.

Velocity: Speed; the rate of linear motion in a given direction.

VECC: Variable energy content curve; see definition above.

Water Budget: A part of the Northwest Power Planning Council's Fish and Wildlife Program calling for a volume of water to be reserved and released during the spring, if needed, to assist in the downstream migration of juvenile salmon and steelhead.

Water conditions: The overall supply of water to operate the Pacific Northwest hydroelectric generating system at any given time, taking into account reservoir levels, snowpack, needs to provide water or retain water to meet various operating constraints (such as the Water Budget, flood control, flow constraints, etc.), weather conditions, and other factors.

Water particle travel time: The theoretical time that a water particle would take to travel through a given reservoir or river reach. It is calculated by dividing the flow (volume of water per unit time) by the cross-sectional area of the channel.

Water retention time: The length of time that a particle of water is resident in a lake or reservoir, based on rates of inflow, outflow, and circulation within the water body.

Water rights: Priority claims to water. In western states, water rights are based on the principle "first in time, first in right," meaning older claims take precedence over newer ones.

WDF: Washington Department of Fisheries

WDFW: Washington Department of Fish and Wildlife

WDW: Washington Department of Wildlife

WKP&L: West Kootenay Power & Light

WNHP: Washington National Heritage Program

WSDOT: Washington State Department of Transportation

WRDA: Water Resources Development Act

Xerophytic: Plants that are structurally adapted for life and growth with a limited water supply.

Yearlings: One-year-old juvenile salmon and steelhead.

Zooplankton: Aquatic animals that cannot actively swim against the current and cannot make their own food by photosynthesis.

Chapter 15

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Chapter 16

Index



16.0 INDEX

Air quality 2-8, 2-9, 4-29, 4-43, 4-69, 4-70, 4-71, 4-73, 4-74, 4-75, 4-216, 4-219, 4-220, 4-223, 4-224, 4-235, 6-9, 11-10, 11-11, 11-12, 14-1, 14-10
Albeni Falls 1-7, 2-2, 2-16, 2-22, 2-34, 3-3, 3-4, 3-5, 3-6, 3-9, 3-10, 3-11, 3-14, 3-21, 3-22, 3-23, 3-29, 3-34, 4-5, 4-20, 4-32, 4-35, 4-48, 4-49, 4-52, 4-53, 4-54, 4-55, 4-73, 4-108, 4-113, 4-122, 4-123, 4-126, 4-137, 4-142, 4-151, 4-150, 4-156, 4-165, 4-166, 4-167, 4-169, 4-170, 4-171, 4-232, 11-5
Algae 2-7, 2-8, 2-16, 4-58, 4-107
Algal blooms 2-7, 2-8, 2-16
Alluvial soils 2-4
Almota 3-3
Alternatives not studied in detail 4-23, 5-7, 6-5
Ambient Air Quality Standards 2-8, 14-1, 14-10
American shad 2-9, 4-104
Ammonia 4-57, 4-67
Amphibian 2-18, 2-20
Anadromous fish 1-11, 1-12, 1-17, 1-18, 2-1, 2-9, 2-14, 2-15, 2-24, 2-25, 2-28, 2-37, 3-7, 3-14, 3-15, 3-17, 3-19, 3-20, 4-1, 4-2, 4-4, 4-5, 4-18, 4-19, 4-22, 4-23, 4-25, 4-30, 4-34, 4-40, 4-43, 4-60, 4-75, 4-76, 4-83, 4-88, 4-90, 4-99, 4-134, 4-143, 4-145, 4-146, 4-147, 4-176, 4-178, 4-188, 4-189, 4-190, 4-192, 4-195, 4-196, 4-197, 4-198, 4-199, 4-217, 4-218, 4-219, 4-220, 4-226, 4-235, 4-236, 4-238, 5-12, 7-3, 8-5, 9-7, 10-2, 10-3, 10-7, 10-9, 11-2, 11-13, 14-1, 14-8
Analysis Management Group 1-10, 9-1, 9-2, 14-1
Anglers 1-18, 2-10, 2-15, 3-28, 3-30, 4-24, 4-104, 4-155, 4-166, 4-190, 4-231
Aquatic organisms 2-7, 2-8, 2-16, 2-17, 4-136, 14-5
Aquatic plants 2-6, 2-16, 2-17, 2-18, 4-127, 4-130, 4-131, 4-132, 4-238, 14-9
Aquifer 4-46, 4-57, 14-1
Archeological Resources Protection Act 11-5, 14-1
Astoria 1-7, 2-24, 4-198
Backwater 2-15, 2-17, 2-18, 4-81, 4-107, 4-114, 4-132, 4-133, 4-148, 4-219, 4-227, 11-3
Bald eagle 2-19, 2-20, 4-133, 4-134, 10-7
Beaver 2-19, 2-24, 4-131, 4-231
Bedrock 2-4, 4-49, 4-229
Benthic organisms 2-16, 4-106, 4-112, 4-113, 4-130, 4-132, 4-134
Benthos 2-16, 4-32
Bighorn sheep 2-20
Birds 2-10, 2-19, 4-107, 4-124, 4-125, 4-126, 4-128, 4-130, 4-131, 4-132, 4-133, 11-2, 11-3
Black bear 2-20
Blackfeet Tribe 2-26
Blue Mountains 2-2, 2-3, 2-4
Bluegill 2-15
Boat ramp(s) 3-26, 3-28, 3-29, 3-30, 3-31, 4-37, 4-148, 4-152, 4-154, 4-155, 4-156, 4-157, 4-158, 4-159, 4-192, 4-219, 4-220, 4-230, 4-231, 4-232, 4-233, 11-10
Boating 2-36, 3-8, 3-13, 3-14, 3-26, 3-27, 3-29, 4-36, 4-37, 4-150, 4-154, 4-155, 4-191, 4-231, 5-2, 9-9
Bonners Ferry 3-9, 3-10, 3-22, 4-31, 4-38, 4-111, 4-167, 4-169, 4-198

Bonneville Dam 1-7, 2-11, 2-13, 2-14, 2-22, 2-25, 2-29, 3-9, 3-11, 3-15, 3-29, 3-31, 3-35, 4-24, 4-28, 4-29, 4-31, 4-37, 4-38, 4-76, 4-83, 4-84, 4-88, 4-89, 4-90, 4-91, 4-93, 4-99, 4-105, 4-126, 4-160, 4-167, 4-169, 4-234, 11-7
Bonneville Power Administration 1-1, 1-6, 14-2, 14-3
BPA 1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-9, 1-14, 2-17, 2-18, 3-1, 3-7, 3-18, 3-19, 3-20, 3-21, 3-22, 3-23, 3-24, 3-25, 3-26, 4-1, 4-3, 4-25, 4-26, 4-48, 4-74, 4-75, 4-176, 4-179, 4-180, 4-191, 4-236, 5-1, 5-2, 5-11, 6-1, 6-2, 6-13, 7-1, 7-3, 9-1, 9-2, 9-5, 9-9, 10-2, 10-4, 10-5, 10-6, 10-7, 10-8, 10-9, 11-10, 11-12, 14-2, 14-4, 14-8, 14-10, 14-11, 14-14
British Columbia 1-7, 2-1, 2-2, 2-8, 2-25, 2-30, 2-36, 3-2, 3-19, 3-28, 4-25, 4-74, 4-180, 7-1, 8-6, 14-2, 14-10
British Columbia Hydro and Power Authority 4-25, 14-2
Brownlee 1-7, 2-16, 2-18, 2-34, 3-2, 3-14, 3-18, 3-30, 3-35, 4-5, 4-18, 4-19, 4-28, 4-32, 4-36, 4-48, 4-49, 4-52, 4-53, 4-54, 4-55, 4-56, 4-60, 4-61, 4-108, 4-116, 4-117, 4-125, 4-128, 4-131, 4-133, 4-158, 4-225, 10-7, 10-8, 11-8
Bull trout 2-16, 3-20, 4-107, 4-108, 4-112, 4-113, 4-114, 4-117, 10-3
Burbot 2-16, 4-108
Bureau of Reclamation 1-1, 1-5, 10-6, 14-12
Burns-Paiute Tribe 2-26, 9-3, 9-4
California floater 2-16
Canada 1-3, 1-4, 1-7, 1-13, 1-14, 1-17, 2-1, 2-2, 2-19, 2-20, 3-1, 3-4, 3-7, 3-10, 3-14, 3-24, 3-25, 3-28, 3-29, 3-31, 4-3, 4-25, 4-26, 4-35, 4-36, 4-43, 4-74, 4-126, 4-127, 4-128, 4-130, 4-131, 4-132, 4-156, 4-166, 4-167, 4-168, 4-231, 5-12, 6-10, 6-11, 7-1, 7-3, 8-6, 11-3, 14-2, 14-3, 14-4
Canadian Entitlement Allocation Agreements 1-3, 1-4, 7-1, 7-2, 14-2, 14-3
Carp 2-15, 2-16, 4-133, 4-227, 4-228
Cascade Mountains 2-2, 2-4, 2-5, 2-24, 2-38, 8-6
Cascades 2-2, 2-4, 2-5, 2-6, 2-22, 2-32, 2-33, 2-34
CEAA 1-3, 1-4, 1-7, 1-9, 1-13, 1-14, 1-15, 4-43, 4-237, 7-1, 7-2, 7-3, 7-4, 7-5, 8-1, 8-6, 9-1, 10-2, 10-8, 11-1, 14-2, 14-3
CEQ Memorandum 11-8
CEQ regulations 4-235, 4-237, 11-6
Channel catfish 2-15, 2-16, 4-116, 4-117
Chelan County PUD 1-4, 3-2, 6-1, 7-1, 9-8
Chief Joseph 1-7, 2-3, 2-11, 3-3, 3-2, 3-4, 3-5, 3-14, 3-22, 3-29, 3-35, 4-33, 4-36, 4-47, 4-73, 4-137, 4-151, 4-157, 4-232
Chinook 1-1, 1-16, 2-9, 2-11, 2-12, 2-13, 2-12, 2-13, 2-12, 2-13, 2-12, 2-13, 2-23, 2-24, 3-16, 3-17, 3-18, 4-22, 4-31, 4-30, 4-31, 4-76, 4-77, 4-78, 4-79, 4-80, 4-81, 4-82, 4-83, 4-84, 4-85, 4-86, 4-87, 4-88, 4-89, 4-90, 4-91, 4-92, 4-91, 4-92, 4-91, 4-92, 4-93, 4-96, 4-97, 4-98, 4-99, 4-102, 4-103, 4-104, 4-105, 4-216, 5-11, 10-3, 10-5, 11-2, 14-15, 14-16
Chum 2-9, 2-11
Clark Fork-Pend Oreille 1-7
Clean Air Act 11-11, 14-2
Clean Water Act 11-11, 11-12, 14-4
Clearwater River 2-11, 2-17, 2-18, 3-9, 3-10, 3-11, 3-22, 3-30, 3-32, 3-35, 4-37, 4-146, 4-159, 4-166, 4-167, 4-169, 4-171, 4-173, 4-227, 4-232
Climate 2-2, 2-5, 4-44
Coastal Zone Management Act 11-7
Coeur d'Alene Tribe 1-15, 2-26, 4-145, 9-3
Coho 2-9, 2-11, 2-14, 3-17
Columbia Basalt Plain 2-2, 2-4

Columbia Falls 3-10, 3-11, 4-32, 4-167, 4-169, 4-170
Columbia Gorge 2-31
Columbia Plateau 2-2, 2-3, 2-4, 2-5, 2-23, 2-33, 2-34, 4-140
Columbia River Basin 1-1, 1-5, 1-7, 1-8, 1-7, 2-1, 2-2, 2-4, 2-5, 2-6, 2-8, 2-9, 2-11, 2-15, 2-16, 2-17, 2-19, 2-20, 2-21, 2-22, 2-26, 2-30, 2-31, 2-33, 2-34, 2-35, 2-36, 2-38, 3-1, 3-9, 3-11, 3-14, 3-15, 3-17, 3-20, 3-21, 3-23, 3-25, 3-31, 3-34, 4-30, 4-31, 4-44, 4-46, 4-60, 4-63, 4-70, 4-124, 4-147, 4-153, 4-161, 4-172, 4-180, 4-181, 6-6, 9-2, 9-10, 10-3, 10-5, 10-6, 11-4, 11-12
Columbia River Gorge National Scenic Area 2-33, 3-30, 11-9, 14-3
Columbia River Inter-Tribal Fish Commission 3-20, 4-84, 14-3
Columbia River Regional Forum 1-2, 1-3, 1-13, 5-1, 14-6
Columbia River Treaty 1-3, 1-4, 1-7, 2-29, 3-2, 3-7, 3-9, 3-19, 3-24, 4-25, 4-26, 4-167, 6-5, 6-10, 6-12, 6-11, 7-1, 8-6, 9-9, 14-1, 14-2, 14-3, 14-10, 14-11
Columbia Storage Power Exchange 1-4, 7-1, 14-3, 14-4
Colville Confederated Tribes 1-15, 2-26, 3-29, 4-145, 9-3, 9-4
Combustion turbine 4-177
Confederated Salish and Kootenai Tribes 2-26, 9-3
Confederated Tribes of the Umatilla Indian Reservation Alternative 4-27
Cottonwood 2-17, 2-18, 2-19, 4-126, 4-130
Coulee Dam National Recreation Area 2-33, 3-22, 3-29
Crappie 2-15, 2-16, 4-116, 4-117
Cultural resources 1-5, 1-6, 1-15, 1-18, 2-20, 2-21, 3-1, 3-34, 3-35, 4-2, 4-33, 4-34, 4-43, 4-134, 4-135, 4-136, 4-137, 4-140, 4-141, 4-142, 4-143, 4-145, 4-146, 4-147, 4-199, 4-216, 4-218, 4-219, 4-220, 4-228, 4-229, 4-230, 4-236, 4-238, 4-239, 7-3, 8-2, 9-4, 9-7, 11-4, 11-5, 11-6, 14-4
Cutthroat trout 2-9, 2-16, 4-108, 4-109, 4-112, 4-113, 4-117, 4-118
DDT 4-57, 4-67, 4-68, 4-67, 4-68
Deer 2-20, 2-23, 2-24, 2-32, 4-124, 4-126
Deschutes River 2-11, 4-31
Direct service industries 3-26, 9-8, 14-4
Dissolved gas 1-18, 3-19, 3-32, 3-34, 4-3, 4-19, 4-20, 4-28, 4-57, 4-58, 4-59, 4-60, 4-63, 4-64, 4-63, 4-76, 4-77, 4-78, 4-79, 4-85, 4-87, 4-123, 4-216, 4-218, 4-219, 4-223, 4-235, 11-12, 14-4, 14-6
Douglas County PUD 1-4, 3-2, 6-1, 7-1
Douglas-fir 2-17, 2-18
Drought 2-5, 2-17, 2-18, 4-109, 4-110, 4-236
Duck 2-19, 2-26, 4-127, 4-128, 4-132, 9-3
Duncan 1-3, 3-2, 3-6, 4-25, 4-123, 4-167, 4-168, 7-1, 14-2, 14-3, 14-10
Dust 2-8, 4-29, 4-69, 4-70, 4-71, 4-72, 4-147, 4-149, 4-219, 4-223, 4-224, 4-235, 4-237, 4-238, 4-239, 11-11, 14-12, 14-14
Dworshak 1-7, 2-2, 2-16, 2-18, 2-34, 2-36, 3-3, 3-4, 3-5, 3-6, 3-10, 3-11, 3-13, 3-14, 3-18, 3-21, 3-22, 3-23, 3-30, 3-34, 3-35, 4-5, 4-18, 4-19, 4-20, 4-22, 4-23, 4-28, 4-31, 4-30, 4-32, 4-33, 4-35, 4-37, 4-38, 4-47, 4-48, 4-49, 4-51, 4-52, 4-53, 4-54, 4-55, 4-56, 4-57, 4-60, 4-61, 4-73, 4-92, 4-96, 4-97, 4-99, 4-102, 4-108, 4-117, 4-118, 4-119, 4-125, 4-126, 4-137, 4-141, 4-142, 4-151, 4-150, 4-158, 4-159, 4-166, 4-167, 4-168, 4-169, 4-170, 4-172, 4-173, 4-174, 4-175, 4-191, 4-216, 4-225, 4-232, 4-234, 4-239, 10-3, 11-5, 11-9, 11-11
Dworshak State Park 3-30
Earth resources 2-1, 2-2, 4-27, 4-43, 4-44, 4-187, 4-222, 4-235
Economy 1-17, 2-20, 2-25, 2-34, 2-35, 2-37, 2-38, 4-175, 4-181, 4-192, 4-196, 9-1, 9-6
Elk 2-20, 4-124
Embayment(s) 2-18, 2-19, 4-45, 4-53, 4-106, 4-140, 4-147, 4-148, 4-227

Employment 2-35, 2-37, 2-38, 4-192, 4-196, 4-197, 4-196, 4-197, 4-198, 4-199, 4-237
Endangered species 1-1, 1-6, 1-16, 2-16, 2-17, 2-19, 2-20, 3-19, 4-107, 4-108, 4-125, 4-133, 9-6, 10-3, 10-6, 11-1, 11-2, 11-3, 14-5
Endangered Species Act 1-1, 4-107, 9-6, 14-5
Entiat River 2-11
Erosion 2-2, 2-4, 2-7, 2-17, 4-24, 4-27, 4-28, 4-29, 4-33, 4-34, 4-44, 4-45, 4-46, 4-45, 4-47, 4-48, 4-49, 4-50, 4-51, 4-52, 4-53, 4-54, 4-55, 4-59, 4-65, 4-70, 4-71, 4-113, 4-126, 4-135, 4-136, 4-137, 4-138, 4-139, 4-138, 4-140, 4-141, 4-142, 4-143, 4-145, 4-146, 4-147, 4-148, 4-152, 4-170, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-222, 4-223, 4-228, 4-229, 4-235, 4-237, 4-238, 11-5, 11-13
Estuary Protection Act 11-13
Executive Order 11990, Protection of Wetlands 11-7
Fallback 4-86, 4-99
Federal Water Project Recreation Act 3-26, 11-9
Fish and Wildlife Coordination Act 11-2
Fish ladders 3-1, 3-6, 3-15, 4-85, 4-86, 4-218, 14-6
Fish passage 1-5, 2-15, 3-7, 3-15, 3-17, 3-18, 3-19, 3-20, 3-34, 4-22, 4-28, 4-59, 4-77, 4-80, 4-83, 4-84, 4-86, 4-91, 4-98, 4-134, 4-224, 4-225, 5-1, 5-2, 10-3, 14-6, 14-14, 14-15
Fish Passage Center 3-17, 3-19, 4-80, 4-84, 5-2, 14-6
Fish Passage Development and Evaluation Program 3-15, 14-6
Fish transport 3-15, 4-30, 4-76, 4-83, 4-90, 4-91, 4-98, 4-103
Fish Transportation Oversight Team 3-16
Fisher 4-77
Fishing 1-1, 1-17, 1-18, 2-10, 2-23, 2-24, 2-28, 2-29, 2-36, 2-37, 2-38, 3-19, 3-20, 3-26, 3-27, 3-28, 3-29, 3-30, 3-35, 4-24, 4-34, 4-117, 4-143, 4-144, 4-145, 4-146, 4-147, 4-150, 4-151, 4-152, 4-154, 4-155, 4-159, 4-161, 4-166, 4-188, 4-190, 4-191, 4-195, 4-219, 4-220, 4-231, 4-233, 4-235, 4-236, 9-9, 11-3
Flathead National Forest 3-22
Flood control 1-4, 1-5, 1-17, 2-25, 3-1, 3-3, 3-2, 3-6, 3-8, 3-9, 3-10, 3-18, 3-21, 3-24, 3-26, 3-27, 3-31, 4-1, 4-2, 4-5, 4-18, 4-19, 4-20, 4-21, 4-27, 4-35, 4-37, 4-43, 4-44, 4-124, 4-166, 4-167, 4-168, 4-169, 4-168, 4-170, 4-189, 4-191, 4-216, 4-219, 4-225, 4-236, 5-12, 9-6, 9-7, 11-7, 11-9, 14-3, 14-6, 14-8, 14-9, 14-10, 14-15, 14-16
Forum 1-2, 1-3, 1-9, 1-10, 1-11, 1-13, 1-15, 1-16, 4-237, 5-1, 5-3, 5-4, 5-3, 5-6, 5-7, 5-8, 5-10, 5-11, 5-12, 5-13, 8-1, 8-6, 9-2, 9-7, 9-8, 14-6
Freshet 2-10, 14-6
Fry 2-10, 4-120, 4-121
Furbearers 2-19, 2-20, 4-125, 4-126, 4-130, 4-131, 4-217, 4-227
Gas bubble disease 4-78, 4-79, 4-87, 4-219
Gas supersaturation 1-18, 2-7, 4-60, 4-61, 4-63, 4-64, 4-77, 4-78, 4-84, 4-87, 4-219, 4-223, 4-224, 4-235, 8-4, 11-12, 14-6
Geology 2-1, 2-2, 2-4, 4-44, 4-47
Glacier National Park 2-20, 3-22
Golden eagle 2-19
Goose 1-7, 2-3, 3-3, 3-4, 3-5, 3-12, 3-13, 3-15, 3-16, 3-21, 4-2, 4-3, 4-18, 4-19, 4-39, 4-52, 4-54, 4-61, 4-73, 4-74, 4-76, 4-77, 4-85, 4-89, 4-90, 4-104, 4-127, 4-131, 4-132, 4-151, 4-172, 4-186, 4-238, 10-5, 11-3, 11-5, 14-4

Grand Coulee 1-5, 1-7, 1-9, 2-2, 2-3, 2-12, 2-17, 2-22, 2-31, 2-36, 3-1, 3-3, 3-2, 3-4, 3-5, 3-6, 3-10, 3-13, 3-14, 3-18, 3-22, 3-23, 3-29, 3-32, 3-34, 3-35, 4-5, 4-18, 4-19, 4-20, 4-21, 4-22, 4-26, 4-33, 4-35, 4-36, 4-38, 4-39, 4-47, 4-49, 4-52, 4-53, 4-54, 4-55, 4-56, 4-60, 4-61, 4-73, 4-108, 4-114, 4-116, 4-123, 4-126, 4-137, 4-141, 4-151, 4-150, 4-157, 4-166, 4-167, 4-168, 4-173, 4-181, 4-182, 4-183, 4-182, 4-185, 4-187, 4-189, 4-198, 4-216, 4-218, 4-232, 7-3, 7-4, 9-5, 9-8, 9-9, 10-9, 11-5
Grand Coulee Dam 1-5, 2-12, 2-17, 2-31, 3-13, 3-14, 3-29, 3-32, 3-35, 4-108, 4-123, 4-126, 4-173, 4-182, 10-9
Grant County PUD 1-4, 3-2, 3-18, 6-1, 7-1
Gray wolf 2-20, 4-133
Grazing 2-24, 2-27, 2-33, 2-35, 4-24
Great blue heron 2-19, 4-130
Grizzly bear 2-20, 4-133, 11-2
Groundwater 2-6, 2-7, 3-34, 4-44, 4-45, 4-46, 4-47, 4-55, 4-56, 4-57, 4-148, 4-186, 4-187, 11-12
Habitat 1-1, 1-16, 1-18, 2-10, 2-12, 2-15, 2-17, 2-18, 2-19, 2-20, 2-24, 2-31, 2-33, 3-1, 3-19, 3-21, 3-22, 3-23, 4-2, 4-3, 4-24, 4-30, 4-32, 4-33, 4-76, 4-78, 4-81, 4-82, 4-88, 4-104, 4-105, 4-106, 4-108, 4-109, 4-112, 4-113, 4-114, 4-117, 4-118, 4-119, 4-120, 4-121, 4-122, 4-123, 4-124, 4-125, 4-126, 4-127, 4-128, 4-129, 4-128, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-146, 4-147, 4-151, 4-155, 4-216, 4-217, 4-219, 4-220, 4-221, 4-224, 4-225, 4-226, 4-227, 4-235, 4-236, 4-238, 9-1, 9-6, 10-2, 10-3, 10-5, 10-6, 11-1, 11-2, 11-3, 11-4, 11-7, 14-5, 14-7
Hanford 2-11, 2-30, 2-32, 3-29, 4-31, 4-30, 4-36, 4-88, 4-92, 4-98, 4-103, 4-104, 4-107, 4-123, 4-126, 4-128, 4-133, 4-146, 4-147, 4-157, 4-158, 4-216, 4-232, 10-2, 10-8, 10-9, 11-8
Hanford Reach 2-11, 3-29, 4-30, 4-36, 4-88, 4-92, 4-98, 4-123, 4-126, 4-128, 4-133, 4-146, 4-147, 4-157, 4-158, 4-216, 4-232, 10-2, 10-8, 10-9, 11-8
Hatcheries 2-13, 2-14, 3-14, 3-17, 3-19, 3-20, 4-76, 4-105, 4-186, 10-6
Hells Canyon 2-4, 2-12, 2-31, 2-33, 2-34, 2-38, 3-2, 3-13, 3-14, 3-22, 3-27, 3-30, 4-36, 4-60, 4-123, 4-131, 4-133, 4-158, 4-232, 11-8, 14-6
Hells Canyon National Recreation Area 2-32, 3-22, 3-27, 14-6
Highways 2-33, 2-34, 3-11, 3-27, 4-150
History 2-10, 2-20, 2-21, 2-22, 2-26, 2-28, 2-37, 3-9, 3-27, 4-58, 14-4
Hood River 2-11, 2-14
Human environment 2-1, 2-20, 8-1, 11-1
Hungry Horse 1-5, 1-6, 1-7, 2-2, 2-16, 2-17, 2-34, 3-1, 3-3, 3-4, 3-5, 3-6, 3-10, 3-11, 3-14, 3-21, 3-22, 3-28, 3-32, 3-34, 4-5, 4-18, 4-20, 4-22, 4-32, 4-33, 4-35, 4-36, 4-38, 4-48, 4-49, 4-52, 4-53, 4-54, 4-55, 4-57, 4-60, 4-73, 4-108, 4-112, 4-113, 4-112, 4-113, 4-125, 4-124, 4-126, 4-128, 4-131, 4-132, 4-133, 4-137, 4-151, 4-150, 4-153, 4-155, 4-156, 4-166, 4-167, 4-168, 4-170, 4-198, 4-216, 4-218, 4-224, 4-225, 4-227, 4-231, 4-232, 7-3, 7-4, 10-3, 11-5, 11-9, 14-2, 14-8
Hydrology 2-5, 4-37, 4-109, 14-7
Hydropower 1-17, 1-18, 2-9, 3-1, 3-2, 3-6, 3-9, 3-21, 3-23, 3-24, 3-25, 4-39, 4-74, 4-141, 4-175, 4-176, 4-179, 4-188, 4-191, 6-6, 6-9, 6-10, 6-13, 9-6
Hydroregulation model 1-12, 1-13, 4-3, 4-5, 4-43, 4-47, 4-72, 4-154, 4-159, 4-174, 14-7
HYDROSIM 4-28, 4-88
Ice Harbor 1-7, 2-3, 2-13, 2-21, 3-3, 3-4, 3-5, 3-12, 3-13, 3-15, 3-18, 3-21, 3-23, 3-30, 3-32, 3-35, 4-18, 4-19, 4-29, 4-38, 4-39, 4-40, 4-56, 4-61, 4-64, 4-63, 4-64, 4-66, 4-65, 4-68, 4-67, 4-68, 4-73, 4-74, 4-79, 4-131, 4-151, 4-172, 4-173, 4-181, 4-182, 4-183, 4-184, 4-185, 4-184, 4-185, 4-184, 4-186, 4-196, 4-217, 4-218, 4-234, 4-238, 11-5
Idaho Department of Fish and Game 3-20, 3-22, 3-29, 3-30, 4-84, 4-128, 14-7
Idaho Department of Transportation 3-30
Idaho Power Company 1-7, 3-2, 10-7, 14-8

Imnaha River 2-11
Income 2-31, 2-37, 2-38, 4-183, 4-190, 4-191, 4-192, 4-196, 4-197, 4-198, 4-237, 14-12
Incubation 3-21, 4-78, 4-106, 4-111, 4-114, 4-120, 4-124
Indian Trust Assets 2-20, 2-29, 2-30, 4-34, 4-146, 4-199
Indians 2-24, 2-25, 2-26, 2-27, 2-28, 2-31, 4-144, 9-3, 11-5, 11-6
Industrial effluents 2-7
Irrigation 1-5, 1-17, 2-6, 2-7, 2-33, 2-36, 2-37, 3-1, 3-3, 3-4, 3-6, 3-7, 3-8, 3-9, 3-23, 3-31, 3-32, 4-1, 4-2, 4-3, 4-4, 4-20, 4-24, 4-25, 4-39, 4-40, 4-43, 4-130, 4-132, 4-134, 4-148, 4-152, 4-180, 4-181, 4-182, 4-183, 4-182, 4-183, 4-184, 4-185, 4-184, 4-185, 4-184, 4-186, 4-189, 4-190, 4-192, 4-197, 4-198, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-225, 4-227, 4-230, 4-236, 4-238, 8-2, 9-6, 9-7, 9-9, 10-9, 14-7, 14-8, 14-10, 14-15
Islands 2-17, 2-18, 2-19, 4-124, 4-125, 4-126, 4-128, 4-130, 4-131, 4-132, 4-237, 11-3
John Day 1-7, 1-12, 2-3, 2-4, 2-11, 2-18, 2-23, 2-29, 2-33, 2-34, 3-3, 3-4, 3-5, 3-12, 3-15, 3-18, 3-23, 3-32, 3-35, 3-36, 4-4, 4-5, 4-18, 4-19, 4-20, 4-25, 4-27, 4-28, 4-29, 4-30, 4-31, 4-32, 4-33, 4-34, 4-35, 4-37, 4-38, 4-39, 4-40, 4-49, 4-51, 4-52, 4-53, 4-55, 4-56, 4-57, 4-63, 4-66, 4-65, 4-67, 4-71, 4-72, 4-80, 4-81, 4-87, 4-98, 4-104, 4-105, 4-108, 4-122, 4-123, 4-125, 4-124, 4-131, 4-132, 4-133, 4-134, 4-137, 4-142, 4-144, 4-147, 4-151, 4-150, 4-160, 4-165, 4-166, 4-167, 4-181, 4-182, 4-185, 4-184, 4-185, 4-184, 4-186, 4-187, 4-188, 4-196, 4-217, 4-218, 4-219, 4-222, 4-224, 4-225, 4-226, 4-227, 4-233, 4-234, 8-5, 10-5, 11-3, 11-8, 11-12
John Day River 2-11
Juvenile Fish Transportation Program 3-16, 3-17, 4-24, 4-83, 4-91, 4-172, 4-199
Kalispel Tribe 2-26, 9-3
Kalispell 1-9, 2-23, 2-35, 3-9, 3-11, 4-29, 4-71, 4-170, 9-5, 9-8
Kaniksu National Forest 3-22
Keenleyside 1-3, 3-6, 3-28, 4-25, 4-26, 4-36, 4-47, 4-156, 4-167, 4-168, 7-1, 14-2, 14-3, 14-10
Kennewick 1-9, 2-33, 3-9, 3-30, 3-32, 4-73, 4-186, 9-5
Kettle Falls 2-23, 3-35, 4-136, 4-173
Klickitat River 2-11
Kokanee 2-15, 2-16, 3-20, 3-21, 4-32, 4-109, 4-110, 4-113, 4-114, 4-115, 4-114, 4-115, 4-116, 4-117, 4-118, 4-119, 4-166
Kootenai National Wildlife Refuge 2-33, 3-22
Kootenai River 1-2, 2-16, 3-9, 3-10, 3-22, 3-28, 3-34, 4-20, 4-22, 4-31, 4-32, 4-33, 4-35, 4-36, 4-108, 4-111, 4-112, 4-155, 4-166, 4-169, 4-171, 4-216, 4-218, 4-219, 4-224, 4-231, 10-3
Kootenai Tribe 1-15, 2-26, 4-145, 9-3
Lake Bonneville 3-5, 4-233
Lake Bryan 3-5
Lake Celilo 3-5, 4-233
Lake Herbert G. West 3-5
Lake Koocanusa 2-16, 2-17, 2-34, 3-5, 3-6, 3-22, 3-28, 3-34, 4-31, 4-32, 4-35, 4-70, 4-108, 4-109, 4-110, 4-111, 4-124, 4-126, 4-128, 4-131, 4-133, 4-154, 4-216
Lake Roosevelt 1-5, 2-16, 2-17, 2-19, 2-28, 2-34, 2-36, 3-5, 3-13, 3-20, 3-21, 3-22, 3-29, 3-32, 3-35, 4-29, 4-32, 4-36, 4-38, 4-39, 4-47, 4-60, 4-68, 4-74, 4-108, 4-115, 4-114, 4-115, 4-124, 4-126, 4-128, 4-133, 4-136, 4-146, 4-147, 4-173, 4-174, 4-175, 4-182, 4-198, 4-225, 4-232, 9-8, 10-3
Lake Sacajawea 3-5, 4-56, 4-65
Lake Umatilla 3-5, 4-37, 4-51, 4-56, 4-57, 4-65, 4-81, 4-122, 4-124, 4-127, 4-128, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-160, 4-217, 4-233
Lake Wallula 3-5, 4-37, 4-54, 4-233
Land and Water Conservation Fund Act 11-10, 14-9
Land use 2-15, 2-20, 2-27, 2-30, 2-31, 2-33, 3-10, 3-11, 4-235, 11-7, 11-9

Landforms 2-1, 2-2, 2-33, 2-34, 4-140, 4-141, 4-142, 4-143
Landslides 4-44, 4-47, 4-48, 4-49, 4-135, 4-148, 4-222
Largemouth bass 2-15, 4-114, 4-122, 4-123
Law enforcement 3-19, 4-229
Lead 1-4, 1-5, 1-6, 1-7, 1-9, 1-10, 1-11, 1-12, 1-13, 1-14, 1-15, 1-16, 2-7, 3-1, 3-2, 3-7, 3-8, 3-19, 3-20, 3-23, 3-26, 3-32, 4-25, 4-27, 4-49, 4-57, 4-60, 4-67, 4-68, 4-67, 4-68, 4-136, 4-140, 4-141, 4-143, 4-155, 4-178, 4-182, 4-188, 4-191, 4-221, 4-225, 4-238, 4-239, 5-1, 5-2, 5-3, 5-6, 5-7, 5-10, 5-11, 5-12, 5-13, 6-1, 6-5, 7-1, 9-1, 9-2, 9-9, 10-3, 10-5, 10-6, 10-7, 11-1, 11-2, 11-4, 11-5, 11-6, 11-8
Levee(s) 3-9, 3-10, 3-11, 4-33, 4-53, 4-167, 4-171, 4-227, 4-228, 4-229, 14-8
Lewiston 2-8, 2-9, 2-25, 2-32, 2-33, 2-34, 2-36, 3-4, 3-9, 3-10, 3-11, 3-12, 3-13, 3-30, 3-32, 4-29, 4-56, 4-69, 4-73, 4-74, 4-167, 4-171, 4-172, 4-188, 4-197, 4-198, 4-234, 4-239, 9-8, 9-9
Libby 1-2, 1-3, 1-7, 1-9, 2-2, 2-16, 2-22, 2-34, 3-3, 3-2, 3-4, 3-5, 3-6, 3-10, 3-14, 3-21, 3-22, 3-23, 3-28, 3-34, 4-5, 4-18, 4-20, 4-21, 4-22, 4-29, 4-35, 4-38, 4-48, 4-49, 4-52, 4-53, 4-54, 4-55, 4-57, 4-60, 4-71, 4-72, 4-73, 4-108, 4-109, 4-111, 4-112, 4-126, 4-132, 4-137, 4-151, 4-150, 4-154, 4-155, 4-166, 4-167, 4-168, 4-169, 4-170, 4-171, 4-198, 4-199, 4-216, 4-218, 4-224, 4-227, 4-231, 7-1, 7-3, 7-4, 9-5, 9-8, 10-3, 11-5, 14-2, 14-8
Life-cycle models 4-83, 4-88
Little Goose 1-7, 2-3, 3-3, 3-4, 3-5, 3-12, 3-13, 3-15, 3-16, 3-21, 4-2, 4-18, 4-19, 4-39, 4-52, 4-54, 4-61, 4-73, 4-74, 4-76, 4-77, 4-85, 4-89, 4-90, 4-104, 4-131, 4-151, 4-172, 4-186, 4-238, 10-5, 11-5, 14-4
Littoral zone 4-135, 4-136, 14-8
Locks 1-5, 2-22, 2-36, 3-1, 3-6, 3-11, 3-12, 3-13, 3-35, 4-24, 4-38, 4-172, 4-195, 4-238
Log transportation 3-14, 4-234, 11-11
Logging 2-38, 4-25, 4-150, 4-173, 4-174
Long-Term Spill Agreement 3-18, 14-9
Longview 3-11
Loon 2-19
Lower Columbia 1-7, 2-3, 2-6, 2-11, 2-13, 2-14, 2-18, 2-19, 2-23, 2-24, 2-25, 2-30, 2-32, 2-33, 2-34, 2-36, 3-1, 3-3, 3-4, 3-9, 3-10, 3-11, 3-13, 3-15, 3-16, 3-17, 3-18, 3-21, 3-23, 3-30, 3-32, 3-35, 4-25, 4-28, 4-37, 4-38, 4-47, 4-62, 4-63, 4-64, 4-76, 4-80, 4-81, 4-89, 4-90, 4-92, 4-98, 4-99, 4-104, 4-108, 4-123, 4-126, 4-129, 4-137, 4-144, 4-145, 4-160, 4-165, 4-167, 4-168, 4-169, 4-168, 4-170, 4-171, 4-173, 4-174, 4-190, 4-217, 4-219, 4-227, 4-233, 10-4, 14-15
Lower Granite 1-7, 2-3, 2-9, 2-12, 2-13, 2-12, 2-13, 2-12, 2-21, 2-22, 2-25, 3-1, 3-3, 3-4, 3-5, 3-10, 3-12, 3-13, 3-15, 3-16, 3-18, 3-21, 3-30, 3-32, 3-35, 4-2, 4-5, 4-18, 4-19, 4-20, 4-21, 4-23, 4-27, 4-28, 4-29, 4-35, 4-39, 4-50, 4-51, 4-52, 4-53, 4-54, 4-55, 4-56, 4-57, 4-62, 4-66, 4-65, 4-68, 4-67, 4-68, 4-69, 4-71, 4-72, 4-73, 4-74, 4-76, 4-77, 4-78, 4-79, 4-80, 4-81, 4-83, 4-84, 4-85, 4-86, 4-87, 4-89, 4-90, 4-92, 4-93, 4-104, 4-105, 4-108, 4-119, 4-120, 4-119, 4-120, 4-121, 4-123, 4-131, 4-141, 4-144, 4-147, 4-151, 4-160, 4-166, 4-169, 4-172, 4-173, 4-184, 4-186, 4-188, 4-218, 4-225, 4-238, 10-5, 10-7, 11-5, 14-4
Lower Monumental 1-7, 2-3, 2-21, 3-3, 3-4, 3-5, 3-12, 3-13, 3-15, 3-16, 3-18, 3-21, 4-18, 4-19, 4-38, 4-39, 4-63, 4-73, 4-76, 4-80, 4-85, 4-89, 4-90, 4-131, 4-151, 4-172, 4-173, 4-186, 4-234, 4-238, 11-5

Lower Snake 1-5, 1-7, 1-12, 2-2, 2-3, 2-12, 2-15, 2-17, 2-18, 2-21, 2-23, 2-25, 2-33, 2-34, 3-3, 3-2, 3-4, 3-6, 3-12, 3-16, 3-17, 3-18, 3-19, 3-20, 3-23, 3-30, 3-32, 3-35, 3-36, 4-4, 4-5, 4-18, 4-19, 4-20, 4-22, 4-23, 4-27, 4-28, 4-29, 4-30, 4-32, 4-33, 4-34, 4-35, 4-37, 4-39, 4-40, 4-49, 4-50, 4-51, 4-52, 4-53, 4-54, 4-55, 4-56, 4-60, 4-61, 4-62, 4-63, 4-64, 4-65, 4-67, 4-68, 4-71, 4-74, 4-75, 4-76, 4-77, 4-80, 4-82, 4-83, 4-85, 4-86, 4-87, 4-88, 4-102, 4-103, 4-104, 4-123, 4-129, 4-130, 4-131, 4-132, 4-134, 4-137, 4-138, 4-140, 4-141, 4-142, 4-144, 4-146, 4-147, 4-150, 4-159, 4-160, 4-165, 4-166, 4-172, 4-173, 4-174, 4-178, 4-179, 4-187, 4-197, 4-198, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-222, 4-223, 4-225, 4-227, 4-232, 4-234, 4-238, 10-2, 10-5, 10-7, 11-3, 11-11, 11-12
Lyons Ferry Hatchery 2-12, 4-105
Macrophytes 2-17, 14-9
Marine Protection, Research, and Sanctuaries Act 11-4
Marmes Rockshelter 2-21, 3-35
Mass wasting 4-27, 4-44, 4-45, 4-47, 4-48, 4-49, 4-50, 4-51, 4-52, 4-53, 4-55, 4-135, 4-140, 4-145, 4-146, 4-222
McCormack Slough 4-129, 4-132, 4-228
McNary 1-7, 2-3, 2-18, 2-29, 2-32, 2-34, 3-3, 3-4, 3-5, 3-10, 3-12, 3-13, 3-15, 3-16, 3-18, 3-21, 3-23, 3-29, 3-32, 3-36, 4-18, 4-19, 4-20, 4-25, 4-27, 4-29, 4-30, 4-37, 4-38, 4-47, 4-54, 4-55, 4-61, 4-73, 4-76, 4-77, 4-80, 4-81, 4-83, 4-84, 4-89, 4-90, 4-96, 4-98, 4-103, 4-123, 4-151, 4-160, 4-165, 4-173, 4-186, 4-187, 4-227, 4-233, 11-3, 11-5
Metamorphic rocks 2-4
Meteorology 2-8
Methow River 2-11, 4-91, 4-93, 4-97, 4-98, 4-103, 4-216
Mica Dam 3-19
Mid-Columbia 1-4, 1-7, 1-15, 2-11, 2-31, 2-34, 3-3, 3-2, 3-13, 3-15, 3-22, 3-29, 4-26, 4-28, 4-30, 4-33, 4-36, 4-45, 4-47, 4-61, 4-62, 4-63, 4-64, 4-65, 4-76, 4-77, 4-80, 4-81, 4-84, 4-87, 4-92, 4-93, 4-97, 4-98, 4-99, 4-103, 4-104, 4-123, 4-146, 4-157, 4-161, 4-162, 4-190, 4-197, 4-198, 4-219, 7-1, 10-3, 10-9, 14-2, 14-9
Migratory Waterfowl Act 11-3
Mining 2-6, 2-7, 2-8, 2-21, 2-27, 2-33, 2-38, 3-35, 4-25, 4-61, 4-239
Montana Power Company 3-21, 6-1, 14-9
Moose 2-20
Mountain lion 2-20
Mountain whitefish 2-15, 4-109
Municipal wastes 2-6, 2-7
National Environmental Policy Act 1-1, 1-2, 8-1, 14-10, 14-14
National Historic Preservation Act 2-20, 4-143, 11-4, 14-10
National Marine Fisheries Service 1-1, 1-6, 10-1, 14-5, 14-10, 14-15
National Park Service 1-6, 2-32, 10-8, 11-5, 14-11
National Register of Historic Places 2-21, 3-35, 4-33, 4-142, 11-4, 14-11
National Wildlife Refuge System Administration Act 11-3
Native American Graves Protection and Repatriation Act 11-5, 11-6
Native Americans 1-18, 2-21, 2-25, 2-26, 2-28, 2-35, 4-34, 4-43, 4-143, 4-144, 4-146, 4-147, 4-219, 4-220, 4-236
Navigation 1-5, 1-17, 2-21, 2-25, 2-36, 3-1, 3-3, 3-6, 3-7, 3-8, 3-11, 3-12, 3-13, 3-14, 4-2, 4-4, 4-20, 4-24, 4-29, 4-38, 4-40, 4-43, 4-54, 4-172, 4-173, 4-174, 4-175, 4-189, 4-191, 4-197, 4-198, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-223, 4-233, 4-234, 4-236, 4-239, 5-2, 9-6, 9-7, 11-9, 11-10, 14-10, 14-15
NEPA 1-1, 1-2, 1-3, 1-4, 1-11, 2-1, 2-30, 4-3, 4-221, 4-235, 4-237, 5-1, 5-3, 5-6, 5-7, 5-11, 6-10, 8-1, 8-6, 8-7, 9-1, 9-9, 10-1, 10-4, 10-8, 10-9, 11-1, 11-6, 14-10

Newport 3-3, 4-167, 4-169
Nez Perce National Historic Park 3-30
Nez Perce Tribe 1-15, 2-26, 2-29, 3-22, 4-23, 4-145
Nonattainment area 2-8, 2-9, 4-70, 4-73
Nonfirm energy sales 3-8, 3-26, 4-176
Nonpoint source 2-6, 2-7
Northern squawfish 2-15, 4-78, 4-119, 4-120, 4-121, 4-122, 4-123
Northwest Power Planning Council 1-12, 14-3, 14-11, 14-12, 14-16
Nutrients 2-7, 2-8, 2-10, 2-17, 4-61, 4-106, 4-115
Odors 4-147, 4-149
Okanogan River 2-11
Oregon Department of Fish and Wildlife 3-21, 3-23, 9-2, 14-11
Oregon State Parks 3-30, 3-31
Orofino 1-9, 2-33, 3-3, 4-198, 9-5
Osprey 2-19, 4-128
Owl 2-19, 10-6
Oxygen 2-7, 2-8, 14-4
Pacific lamprey 2-9, 2-14, 4-104
Pacific Northwest Coordination Agreement 1-2, 1-3, 1-13, 1-14, 3-24, 4-40, 6-1, 9-8, 9-10, 14-1, 14-10, 14-11
Pacific Northwest Electric Power Planning and Conservation Act 5-1, 11-4, 14-12
Pacific Ocean 1-7, 2-1, 2-36, 3-11, 3-15
Pacific Power & Light 6-1
Particulate matter 2-8, 4-29, 4-69, 4-70, 4-73, 11-11
Pasco 2-25, 2-33, 3-3, 3-9, 3-30, 3-32, 4-56, 4-57, 4-186, 9-8
Paterson Slough 4-127, 4-129, 4-228
Pend Oreille County PUD 6-1
Pend Oreille River 2-17, 2-22, 3-9, 3-10, 3-22, 4-32, 4-122, 4-123, 4-169, 4-171, 10-3
Peregrine falcon 2-20, 4-133
Phytoplankton 2-16, 4-58, 4-106, 4-107, 4-108, 4-110, 4-112, 4-115, 14-12
Point source discharges 4-68, 11-12
Pollution 2-6, 2-8, 2-9, 2-15, 2-30, 3-26, 4-25, 4-70, 4-223, 11-11, 14-4
Ponderosa pine 2-17, 2-18
Population 1-9, 2-8, 2-9, 2-16, 2-20, 2-23, 2-24, 2-26, 2-35, 2-34, 2-35, 2-38, 3-11, 3-16, 3-19, 3-20, 3-30, 4-93, 4-102, 4-104, 4-107, 4-109, 4-112, 4-117, 4-118, 4-124, 4-128, 4-133, 4-134, 4-152, 4-192, 4-225, 4-226, 4-235, 4-236, 4-238, 10-3, 10-5, 10-7
Portland 1-9, 2-24, 2-25, 2-29, 2-33, 2-34, 2-35, 3-9, 3-10, 3-11, 3-17, 3-31, 4-79, 4-81, 4-85, 4-173, 4-174, 4-198, 4-233, 4-234, 6-1, 9-5, 9-7, 9-8, 14-12, 14-15
Potlatch Corporation 3-32, 4-69, 4-188
Power 1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-9, 1-11, 1-12, 1-13, 1-14, 1-16, 1-17, 2-9, 2-36, 3-1, 3-3, 3-2, 3-4, 3-6, 3-7, 3-8, 3-10, 3-14, 3-19, 3-21, 3-23, 3-24, 3-25, 3-26, 3-27, 4-1, 4-2, 4-4, 4-5, 4-18, 4-20, 4-25, 4-27, 4-38, 4-39, 4-40, 4-43, 4-44, 4-59, 4-70, 4-74, 4-75, 4-82, 4-106, 4-113, 4-125, 4-175, 4-176, 4-177, 4-178, 4-179, 4-178, 4-179, 4-180, 4-182, 4-184, 4-189, 4-188, 4-189, 4-191, 4-192, 4-195, 4-196, 4-197, 4-198, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-223, 4-225, 4-234, 4-236, 4-237, 4-238, 4-239, 5-1, 5-2, 5-6, 5-11, 5-12, 6-1, 6-2, 6-5, 6-6, 6-9, 6-10, 6-11, 6-12, 6-11, 6-13, 6-14, 7-1, 7-2, 7-3, 8-2, 8-6, 9-1, 9-8, 9-10, 10-1, 10-2, 10-3, 10-7, 10-8, 11-4, 11-5, 11-10, 11-12, 14-2, 14-3, 14-4, 14-5, 14-7, 14-8, 14-9, 14-10, 14-11, 14-12, 14-13, 14-15, 14-16, 14-17
Power marketing 3-25
Power plants 4-74, 4-75, 11-12

Prairie falcon 2-19
Precipitation 2-5, 2-7, 4-28, 4-45, 14-7
Predator(s) 2-10, 2-17, 3-17, 3-19, 3-23, 4-78, 4-107, 4-126, 4-219, 4-228, 8-4, 11-3
Priest Rapids Dam 2-11, 2-13, 2-12, 2-13, 3-12, 3-18, 3-29, 4-5, 4-62, 4-64, 4-92, 4-123, 14-16
Public involvement 1-11, 1-14, 1-15, 4-172, 5-3, 5-6, 5-7, 5-10, 5-11, 9-1, 9-4, 9-6, 9-7, 9-9, 9-10, 11-1
Public utility district 3-2, 4-232, 14-12
Railroads 2-18, 2-33, 3-11, 4-150, 4-171, 4-174
Rainbow trout 2-16, 3-20, 3-28, 4-32, 4-105, 4-109, 4-113, 4-114, 4-115, 4-116, 4-117
Raptors 2-19, 4-125, 4-126, 4-130
Recovery plan 1-6, 1-16, 4-4, 10-2, 10-1
Recreation 1-5, 1-6, 1-11, 1-12, 1-18, 2-1, 2-6, 2-31, 2-32, 2-33, 2-35, 2-36, 2-37, 3-1, 3-6, 3-7, 3-9, 3-13, 3-14, 3-22, 3-26, 3-27, 3-28, 3-29, 3-30, 3-31, 3-32, 4-1, 4-2, 4-4, 4-18, 4-23, 4-35, 4-36, 4-37, 4-40, 4-43, 4-70, 4-136, 4-143, 4-148, 4-149, 4-150, 4-151, 4-152, 4-153, 4-154, 4-155, 4-156, 4-157, 4-158, 4-159, 4-160, 4-161, 4-162, 4-163, 4-162, 4-165, 4-166, 4-172, 4-188, 4-189, 4-190, 4-191, 4-192, 4-195, 4-197, 4-198, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-226, 4-230, 4-231, 4-232, 4-233, 4-236, 4-237, 4-239, 8-2, 9-1, 9-2, 9-6, 9-8, 11-8, 11-9, 11-10, 14-6, 14-10, 14-13
Red alder 2-18
Redfish Lake 2-12
Regulations 1-5, 3-20, 3-34, 4-75, 4-103, 4-235, 4-237, 5-11, 8-1, 8-2, 11-1, 11-3, 11-6
Reptiles 2-19, 2-20, 4-125, 4-227
Resident fish 1-11, 1-12, 1-15, 1-18, 2-15, 2-16, 2-30, 3-1, 3-16, 3-19, 3-20, 3-21, 4-2, 4-4, 4-18, 4-23, 4-31, 4-32, 4-34, 4-43, 4-78, 4-105, 4-106, 4-108, 4-109, 4-110, 4-112, 4-114, 4-119, 4-120, 4-121, 4-122, 4-123, 4-124, 4-125, 4-124, 4-143, 4-144, 4-145, 4-146, 4-147, 4-166, 4-168, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-224, 4-225, 4-230, 4-235, 4-236, 4-237, 4-238, 7-3, 9-3, 9-4, 9-8, 10-3, 11-4, 11-13, 14-2, 14-8, 14-13
Richland 2-33, 3-9, 3-32, 4-186
Riparian 2-17, 2-18, 2-19, 2-20, 3-21, 3-23, 4-24, 4-33, 4-106, 4-108, 4-124, 4-125, 4-126, 4-129, 4-128, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-145, 4-146, 4-147, 4-217, 4-219, 4-225, 4-226, 4-227, 4-237, 4-238
Rivers and Harbors Act 11-10
Rock Island 1-4, 3-1, 3-2, 3-29, 4-36, 4-81, 4-123, 4-157, 7-1
Rocky Mountains 2-1, 2-2, 2-3, 2-4
Rocky Reach 1-4, 3-2, 3-29, 4-36, 4-157, 7-1
Roosevelt elk 2-20
ROSE 1-11, 1-12, 1-13, 2-38, 4-3, 4-27, 4-137, 9-3, 9-8, 14-13
Sagebrush 2-17, 2-34, 4-124
Salmon 1-1, 1-2, 1-6, 1-11, 1-12, 1-15, 1-16, 2-1, 2-2, 2-9, 2-10, 2-11, 2-10, 2-11, 2-12, 2-13, 2-12, 2-13, 2-12, 2-13, 2-14, 2-15, 2-23, 2-24, 2-32, 2-37, 3-8, 3-14, 3-15, 3-16, 3-17, 3-18, 3-19, 4-1, 4-2, 4-3, 4-5, 4-18, 4-20, 4-21, 4-23, 4-28, 4-30, 4-76, 4-77, 4-78, 4-82, 4-84, 4-85, 4-86, 4-87, 4-88, 4-89, 4-99, 4-119, 4-144, 4-146, 4-172, 4-179, 4-189, 4-199, 4-216, 4-218, 4-220, 4-224, 8-3, 8-4, 10-1, 10-2, 10-1, 10-3, 10-4, 10-5, 10-6, 11-2, 11-4, 11-8, 11-12, 14-1, 14-3, 14-4, 14-5, 14-6, 14-12, 14-13, 14-14, 14-15, 14-16, 14-17
Salmon River 2-11, 2-12
Sawtooth Valley 2-12
Scenery 2-20, 3-27
Scoping 1-5, 1-9, 1-10, 1-11, 1-13, 1-14, 1-15, 1-16, 4-1, 4-23, 4-24, 4-43, 4-69, 4-83, 4-105, 4-124, 4-175, 4-181, 8-2, 9-1, 9-2, 9-5, 9-6, 9-5, 9-6, 9-9, 10-5, 14-14
Sea-run cutthroat trout 2-9

Sediment 1-18, 3-34, 4-27, 4-28, 4-29, 4-44, 4-45, 4-47, 4-50, 4-51, 4-52, 4-53, 4-54, 4-55, 4-57, 4-58, 4-59, 4-60, 4-61, 4-64, 4-65, 4-66, 4-65, 4-67, 4-68, 4-70, 4-71, 4-74, 4-82, 4-86, 4-87, 4-88, 4-113, 4-123, 4-140, 4-148, 4-187, 4-216, 4-219, 4-222, 4-223, 4-235, 11-13, 14-11
Seep lakes 4-147, 4-148
Sewage 2-8, 4-61, 4-186, 4-187
Sheep 2-20, 2-23
Shorebirds 2-19, 4-124, 4-125, 4-126, 4-127, 4-128, 4-130, 4-131, 4-217
Shortface lanx 2-16
Shoshone-Bannock Tribes 1-15, 2-26, 4-145, 9-3, 10-7
Shoshone-Paiute Tribes 2-26, 9-3
Smallmouth bass 2-15, 2-16, 4-32, 4-78, 4-107, 4-114, 4-116, 4-117, 4-118, 4-119, 4-120, 4-121, 4-122
Smolt Monitoring Program 3-19
Smoltification 2-10
Snake River Basin 1-7, 2-12, 4-22, 4-84, 10-2, 10-6, 10-7
Sockeye 1-1, 1-16, 2-9, 2-11, 2-12, 2-13, 2-12, 2-13, 2-15, 3-17, 4-81, 4-84, 4-85, 4-86, 5-11, 10-5, 11-2
Soil(s) 2-1, 2-2, 2-4, 2-5, 2-8, 2-32, 4-44, 4-45, 4-50, 4-58, 4-125, 4-126, 4-130, 4-133, 4-135, 4-136, 4-137, 4-140, 4-141, 4-143, 4-145, 4-229, 4-230, 4-237, 4-238, 9-8, 11-13, 14-5
Spillway 4-2, 4-19, 4-20, 4-22, 4-23, 4-52, 4-53, 4-58, 4-59, 4-77, 4-79, 4-84, 4-85, 4-86, 4-102, 4-224, 14-14, 14-15
Spokane 1-9, 1-15, 2-2, 2-23, 2-25, 2-26, 2-30, 2-33, 2-34, 3-22, 3-29, 4-71, 4-73, 4-144, 4-145, 4-198, 4-225, 9-3, 9-4, 9-5, 9-8, 11-5
Spokane River 2-2
Spokane Tribe 1-15, 2-26, 3-29, 4-144, 11-5
Sportfish 4-108, 4-116
Spruce 2-17, 2-18
Steelhead 1-12, 2-9, 2-10, 2-11, 2-10, 2-11, 2-12, 2-13, 2-14, 3-8, 3-14, 3-16, 3-17, 3-18, 3-19, 3-30, 4-1, 4-2, 4-30, 4-31, 4-30, 4-76, 4-77, 4-78, 4-79, 4-80, 4-81, 4-82, 4-84, 4-85, 4-86, 4-87, 4-88, 4-89, 4-90, 4-91, 4-92, 4-96, 4-97, 4-98, 4-99, 4-102, 4-103, 4-105, 4-159, 4-166, 4-172, 4-216, 4-232, 8-4, 10-3, 11-4, 11-12, 14-1, 14-14, 14-16, 14-17
Steppe 2-17, 2-18, 2-34, 4-124
Stratification 2-7, 4-223
Streamline 1-14, 4-144, 9-1, 9-3, 9-4, 9-7, 9-9, 9-10
Sturgeon 1-2, 2-9, 2-14, 2-15, 2-16, 3-20, 4-20, 4-21, 4-22, 4-31, 4-104, 4-105, 4-106, 4-108, 4-111, 4-112, 4-119, 4-120, 4-121, 4-123, 4-125, 4-124, 4-216, 4-218, 4-219, 4-224, 5-11, 10-3
Suspended(s) 2-7, 3-34, 4-59, 4-82, 4-86, 4-87, 14-11
System Operating Strategy 1-1, 1-2, 1-3, 1-11, 4-1, 4-6, 5-7, 6-10, 8-3, 8-5, 10-1, 11-1, 11-2, 11-3, 11-4, 11-5, 11-6, 11-7, 11-8, 11-9, 11-10, 11-11, 11-12, 14-14
System Operation Review 1-1, 1-2, 1-5, 1-7, 1-10, 10-2, 14-14
Temperature 1-18, 2-5, 2-7, 3-32, 3-33, 3-34, 4-3, 4-28, 4-32, 4-57, 4-58, 4-59, 4-60, 4-61, 4-62, 4-61, 4-62, 4-67, 4-76, 4-78, 4-80, 4-81, 4-82, 4-83, 4-87, 4-99, 4-107, 4-109, 4-111, 4-113, 4-199, 4-216, 4-218, 4-222, 4-223, 4-235, 10-5, 10-6
The Dalles 1-7, 2-1, 2-3, 2-6, 2-22, 2-23, 2-24, 2-29, 2-34, 3-3, 3-4, 3-5, 3-4, 3-9, 3-11, 3-12, 3-15, 3-18, 3-23, 3-31, 3-36, 4-19, 4-25, 4-27, 4-28, 4-37, 4-38, 4-47, 4-62, 4-61, 4-64, 4-63, 4-64, 4-73, 4-123, 4-151, 4-160, 4-165, 4-167, 4-169, 4-171, 4-233, 7-3, 7-4, 11-9
Thermal power 2-9, 4-74, 11-12
Topography 2-8, 4-50, 4-125, 4-131, 4-132, 4-133, 4-137, 4-217
Tri-Cities 2-17, 2-33, 2-34, 3-10, 3-36, 4-167, 4-197
Tucannon River 2-11

Turbidity 2-7, 2-8, 3-34, 4-58, 4-59, 4-78, 4-81, 4-107, 4-148, 4-153, 4-187, 11-12, 14-11, 14-15
Turbine 3-15, 3-20, 4-30, 4-77, 4-79, 4-80, 4-84, 4-85, 4-96, 4-105, 4-177, 4-179, 8-4, 14-5, 14-7, 14-14, 14-15
U.S. Fish and Wildlife Service 1-2, 2-32, 10-3, 14-5, 14-15, 14-16
U.S. Forest Service 2-32, 11-5, 14-16
Umatilla 1-15, 2-4, 2-11, 2-12, 2-23, 2-26, 2-27, 2-29, 2-32, 3-3, 3-5, 3-23, 3-36, 4-27, 4-37, 4-51, 4-56, 4-57, 4-65, 4-81, 4-105, 4-122, 4-124, 4-126, 4-127, 4-128, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-144, 4-145, 4-146, 4-160, 4-186, 4-187, 4-197, 4-217, 4-233, 9-3, 11-3
Umatilla Hatchery 2-12, 4-105
Umatilla River 2-11, 4-186, 4-187
Umatilla Tribe 9-3
Upper Columbia 2-11, 2-12, 2-13, 2-14, 2-17, 2-23, 2-32, 3-10, 3-14, 3-21, 3-28, 4-36, 4-40, 4-68, 4-123, 4-124, 4-129, 4-133, 4-145, 4-146, 4-156, 4-167, 4-169, 4-168, 4-170, 4-171, 4-198, 4-216, 7-1, 9-8, 11-4, 14-15
Upper Columbia United Tribes 3-21, 9-8, 14-15
Vancouver 2-22, 2-24, 2-25, 2-33, 2-34, 2-35, 3-9, 3-11, 4-173, 4-174, 14-15
Vandalism 1-18, 4-33, 4-136, 4-145, 4-219, 4-229, 4-238, 4-239, 11-5, 11-6
Vegetation 2-7, 2-17, 2-18, 2-23, 2-34, 2-37, 3-21, 4-24, 4-32, 4-33, 4-105, 4-106, 4-109, 4-125, 4-126, 4-128, 4-130, 4-131, 4-132, 4-133, 4-135, 4-146, 4-147, 4-223, 4-225, 4-238
Velocity 2-7, 2-8, 3-31, 4-18, 4-25, 4-45, 4-53, 4-57, 4-58, 4-59, 4-60, 4-67, 4-70, 4-71, 4-78, 4-81, 4-86, 4-89, 4-105, 4-119, 4-120, 4-121, 4-123, 4-126, 4-140, 4-148, 4-149, 4-152, 4-153, 4-160, 4-172, 4-220, 11-2, 14-16
Vernita Bar Agreement 3-18, 4-157, 11-8
Visitation 3-27, 3-28, 4-35, 4-36, 4-37, 4-150, 4-151, 4-153, 4-154, 4-155, 4-158, 4-161, 4-162, 4-165, 4-166, 4-216, 4-218, 4-219
Walla Walla River 2-11, 2-22
Walleye 2-15, 2-16, 4-114, 4-115, 4-122
Wallula 2-8, 2-25, 3-5, 4-29, 4-37, 4-54, 4-73, 4-233
Wanapum 1-4, 2-6, 2-23, 3-2, 3-29, 4-36, 4-123, 4-157, 7-1
Warm Springs Tribes 2-27
Washington Department of Fisheries 4-84, 9-2, 14-17
Washington Department of Wildlife 3-29, 9-2, 14-17
Water Budget 3-17, 3-18, 4-5, 4-18, 4-140, 11-4, 14-16
Water quality 1-18, 2-1, 2-5, 2-6, 2-7, 2-8, 2-30, 3-1, 3-7, 3-32, 3-34, 4-2, 4-3, 4-27, 4-28, 4-43, 4-50, 4-53, 4-54, 4-57, 4-61, 4-64, 4-67, 4-68, 4-69, 4-82, 4-85, 4-87, 4-107, 4-148, 4-151, 4-153, 4-187, 4-216, 4-218, 4-219, 4-222, 4-223, 4-235, 4-238, 9-8, 11-7, 11-11, 11-12
Water Resources Development Act of 1990 11-9
Waterfowl 2-18, 2-19, 3-22, 3-23, 3-29, 4-124, 4-125, 4-126, 4-127, 4-128, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-146, 4-217, 4-226, 4-227, 11-3
Watershed Protection and Flood Protection Act 11-13
Wells 1-4, 3-2, 3-22, 4-27, 4-36, 4-40, 4-46, 4-47, 4-55, 4-56, 4-57, 4-123, 4-157, 4-186, 4-187, 7-1, 14-1
Wells Dam 3-2
Wenatchee River 2-11
Western red cedar 2-18
Western screech owl 2-19
Westslope cutthroat trout 2-16, 4-108, 4-112, 4-113
Wetlands 1-18, 2-17, 2-18, 2-19, 3-21, 4-33, 4-124, 4-125, 4-130, 4-132, 4-133, 4-227, 4-237, 11-3, 11-7
White Salmon River 2-11

White sturgeon 1-2, 2-9, 2-14, 2-16, 4-20, 4-22, 4-104, 4-105, 4-106, 4-108, 4-111, 4-112, 4-119, 4-121, 4-125, 4-124, 4-216, 4-218, 4-224, 10-3
Wild and Scenic Rivers Act 11-8
Wilderness 2-20, 2-30, 2-31, 2-32, 2-34, 3-22, 11-9
Wildlife 1-2, 1-3, 1-5, 1-6, 1-11, 1-12, 1-13, 1-15, 1-16, 1-18, 2-6, 2-17, 2-18, 2-19, 2-20, 2-28, 2-30, 2-31, 2-32, 2-33, 2-37, 3-1, 3-7, 3-14, 3-17, 3-18, 3-19, 3-20, 3-21, 3-22, 3-23, 3-29, 4-2, 4-3, 4-4, 4-18, 4-23, 4-24, 4-32, 4-33, 4-34, 4-43, 4-124, 4-125, 4-126, 4-127, 4-128, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-143, 4-144, 4-145, 4-146, 4-147, 4-151, 4-152, 4-161, 4-166, 4-186, 4-191, 4-199, 4-216, 4-217, 4-218, 4-219, 4-220, 4-221, 4-222, 4-225, 4-226, 4-227, 4-230, 4-236, 4-238, 5-1, 5-11, 6-6, 8-2, 9-1, 9-2, 9-3, 9-4, 9-6, 9-8, 10-2, 10-3, 10-4, 10-5, 10-6, 10-7, 10-9, 11-1, 11-2, 11-3, 11-4, 11-8, 11-10, 11-13, 14-2, 14-5, 14-9, 14-11, 14-15, 14-16, 14-17
Wildlife refuges 2-31, 3-21, 3-22
Willamette River 2-4, 2-11, 3-9, 3-31
Willow 2-18, 4-126, 4-129, 4-130, 4-133, 4-222, 4-227
Wind 1-18, 2-5, 2-8, 2-11, 4-28, 4-29, 4-33, 4-58, 4-70, 4-71, 4-72, 4-73, 4-135, 4-136, 4-149, 4-152, 4-223, 11-5
Windust Caves 2-21, 3-35
Yakima River 2-6, 2-11
Yellow perch 2-15, 2-16, 4-115, 4-122
Zooplankton 2-16, 4-32, 4-82, 4-106, 4-107, 4-110, 4-112, 4-115, 4-116, 4-118, 4-123, 14-17

DOE/BP-2725
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2320