Columbia River System Operation Review

Final Environmental Impact Statement

Appendix B

Air Quality

BONNEVILLE POWER ADMINISTRATION

US Army Corps of Engineers
North Pacific Division

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

DOE/EIS-0170

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PUBLIC INVOLVEMENT IN THE SOR PROCESS

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

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

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

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

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

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

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Portland, OR 97208–2988

PREFACE: SETTING THE STAGE FOR THE SYSTEM OPERATION REVIEW

WHAT IS THE SOR AND WHY IS IT BEING CONDUCTED?

The Columbia River System is a vast and complex combination of Federal and non–Federal facilities used for many purposes including power production, irrigation, navigation, flood control, recreation, fish and wildlife habitat and municipal and industrial water supply. Each river use competes for the limited water resources in the Columbia River Basin.

To date, responsibility for managing these river uses has been shared by a number of Federal, state, and local agencies. Operation of the Federal Columbia River system is the responsibility of the Bureau of Reclamation (Reclamation), Corps of Engineers (Corps) and Bonneville Power Administration (BPA).

The System Operation Review (SOR) is a study and environmental compliance process being used by the three Federal agencies to analyze future operations of the system and river use issues. The goal of the SOR is to achieve a coordinated system operation strategy for the river that better meets the needs of all river users. The SOR began in early 1990, prior to the filing of petitions for endangered status for several salmon species under the Endangered Species Act.

The comprehensive review of Columbia River operations encompassed by the SOR was prompted by the need for Federal decisions to (1) develop a coordinated system operating strategy (SOS) for managing the multiple uses of the system into the 21st century; (2) provide interested parties with a continuing and increased long–term role in system planning (Columbia River Regional Forum); (3) renegotiate and renew the Pacific Northwest Coordination Agreement (PNCA), a contractual arrangement among the region's major hydroelectric–generating utilities and affected Federal agencies to provide for coordinated power generation on the Columbia River system; and (4) renew or develop new Canadian Entitlement Allocation Agreements (contracts that divide Canada's share of Columbia River Treaty downstream power benefits and obligations among three participating public utility districts and BPA). The review provides the environmental analysis required by the National Environmental Policy Act (NEPA).

This technical appendix addresses only the effects of alternative system operating strategies for managing the Columbia River system. The environmental impact statement (EIS) itself and some of the other appendices present analyses of the alternative approaches to the other three decisions considered as part of the SOR.

WHO IS CONDUCTING THE SOR?

The SOR is a joint project of Reclamation, the Corps, and BPA—the three agencies that share responsibility and legal authority for managing the Federal Columbia River System. The National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and National Park Service (NPS), as agencies with both jurisdiction and expertise with regard to some aspects of the SOR, are cooperating agencies. They contribute information, analysis, and recommendations where appropriate. The U.S. Forest Service (USFS) was also a cooperating agency, but asked to be removed from that role in 1994 after assessing its role and the press of other activities.

HOW IS THE SOR BEING CONDUCTED?

The system operating strategies analyzed in the SOR could have significant environmental impacts. The study team developed a three–stage process–scoping, screening, and full–scale analysis of the strategies–to address the many issues relevant to the SOR.

At the core of the analysis are 10 work groups. The work groups include members of the lead and cooperating agencies, state and local government agencies, representatives of Indian tribes, and members of the public. Each of these work groups has a single river use (resource) to consider.

Early in the process during the screening phase, the 10 work groups were asked to develop an alternative for project and system operations that would provide the greatest benefit to their river use, and one or more alternatives that, while not ideal, would provide an acceptable environment for their river use. Some groups responded with alternatives that were evaluated in this early phase and, to some extent, influenced the alternatives evaluated in the Draft and Final EIS. Additional alternatives came from scoping for the SOR and from other institutional sources within the region. The screening analysis studied 90 system operation alternatives.

Other work groups were subsequently formed to provide projectwide analysis, such as economics, river operation simulation, and public involvement.

The three–phase analysis process is described briefly below.

- **Scoping/Pilot Study**—After holding public meetings in 14 cities around the region, and coordinating 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. The geographic area for the study is the Columbia River Basin (Figure P–1). The jurisdictional scope of the SOR encompasses the 14 Federal projects on the Columbia and lower Snake Rivers that are operated by the Corps and Reclamation and coordinated for hydropower under the PNCA. BPA markets the power produced at these facilities. A pilot study examining three alternatives in four river resource areas was completed to test the decision analysis method proposed for use in the SOR.

- **Screening**—Work groups, involving regional experts and Federal agency staff, were created for 10 resource areas and several support functions. The work groups developed computer screening models and applied them to the 90 alternatives identified during screening. They compared the impacts to a baseline operating year—1992—and ranked each alternative according to its impact on their resource or river use. The lead agencies reviewed the results with the public in a series of regional meetings in September 1992.

- **Full–Scale Analysis**—Based on public comment received on the screening results, the study team sorted, categorized, and blended the alternatives into seven basic types of operating strategies. These alternative strategies, which have multiple options, were then subjected to detailed impact analysis. Twenty–one possible options were evaluated. Results and tradeoffs for each resource or river use were discussed in separate technical appendices and summarized in the Draft EIS. Public review and comment on the Draft EIS was conducted during the summer and fall of 1994. The lead agencies adjusted the alternatives based on the comments, eliminating a few options and substituting new options, and reevaluated them during the past 8 months. Results are summarized in the Final EIS.

Alternatives for the Pacific Northwest Coordination Agreement (PNCA), the Columbia River Regional Forum (Forum), and the Canadian Entitlement Allocation Agreements (CEAA) did not use the three–stage process described above. The environmental impacts from the PNCA and CEAA were not significant and there were no anticipated impacts from the Regional Forum. The procedures used to analyze alternatives for these actions are described in their respective technical appendices.

For detailed information on alternatives presented in the Draft EIS, refer to that document and its appendices.

WHAT SOS ALTERNATIVES ARE CONSIDERED IN THE FINAL EIS?

Seven alternative System Operating Strategies (SOS) were considered in the Draft EIS. Each of the seven SOSs contained several options bringing the total number of alternatives considered to 21. Based on review of the Draft EIS and corresponding adjustments, the agencies have identified 7 operating strategies that are evaluated in this Final EIS. Accounting for options, a total of 13 alternatives is now under consideration. Six of the alternatives remain unchanged from the specific options considered in the Draft EIS. One 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 numbering of the final SOSs are not consecutive. There is one new SOS category, Settlement Discussion Alternatives, which is labeled SOS 9 and replaces the SOS 7 category. This category of alternatives arose as a consequence of litigation on the 1993 Biological Opinion and ESA Consultation for 1995.

The 13 system operating strategies for the Federal Columbia River system that are analyzed for the Final EIS are:

SOS 1a Pre Salmon Summit Operation represents operations as they existed from around 1983 through the 1990–91 operating year, prior to the ESA listing of three species of salmon as endangered or threatened.

SOS 1b Optimum Load–Following Operation represents operations as they existed prior to changes resulting from the Regional Act. It attempts to optimize the load–following capability of the system within certain constraints of reservoir operation.

SOS 2c Current Operation/No–Action Alternative represents an operation consistent with that specified in the Corps of Engineers' 1993 Supplemental EIS. It is similar to system operation that occurred in 1992 after three species of salmon were listed under ESA.

SOS 2d [New] 1994–98 Biological Opinion represents the 1994–98 Biological Opinion operation that includes up to 4 MAF flow augmentation on the Columbia, flow targets at McNary and Lower Granite, specific volume releases from Dworshak, Brownlee, and the Upper Snake, meeting sturgeon flows 3 out of 10 years, and operating lower Snake projects at MOP and John Day at MIP.

SOS 4c [Rev.] Stable Storage Operation with Modified Grand Coulee Flood Control attempts to achieve specific monthly elevation targets year round that improve the environmental conditions at storage projects for recreation, resident fish, and wildlife. Integrated Rules Curves (IRCs) at Libby and Hungry Horse are applied.

SOS 5b Natural River Operation draws down the four lower Snake River projects to near river bed levels for four and one–half months during the spring and summer salmon migration period, by assuming new low level outlets are constructed at each project.

SOS 5c [New] Permanent Natural River Operation operates the four lower Snake River projects to near river bed levels year round.

SOS 6b Fixed Drawdown Operation draws down the four lower Snake River projects to near spillway crest levels for four and one–half months during the spring and summer salmon migration period.

SOS 6d Lower Granite Drawdown Operation draws down Lower Granite project only to near spillway crest level for four and one–half months.

SOS 9a [New] Detailed Fishery Operating Plan includes flow targets at The Dalles based on the previous year's end–of–year storage content, specific volumes of releases for the Snake River, the drawdown of Lower Snake River projects to near spillway crest level for four and one–half months, specified spill percentages, and no fish transportation.

SOS 9b [New] Adaptive Management establishes flow targets at McNary and Lower Granite based on runoff forecasts, with specific volumes of releases to meet Lower Granite flow targets and specific spill percentages at run–of–river projects.

SOS 9c [New] Balanced Impacts Operation draws down the four lower Snake River projects near spillway crest levels for two and one–half months during the spring salmon migration period. Refill begins after July 15. This alternative also provides 1994–98 Biological Opinion flow augmentation, integrated rule curve operation at Libby and Hungry Horse, a reduced flow target at Lower Granite due to drawdown, winter drawup at Albeni Falls, and spill to achieve no higher than 120 percent daily average for total dissolved gas.

SOS PA Preferred Alternative represents the operation proposed by NMFS and USFWS in their Biological Opinions for 1995 and future years; this SOS operates the storage projects to meet flood control rule curves in the fall and winter in order to meet spring and summer flow targets for Lower Granite and McNary, and includes summer draft limits for the storage projects.

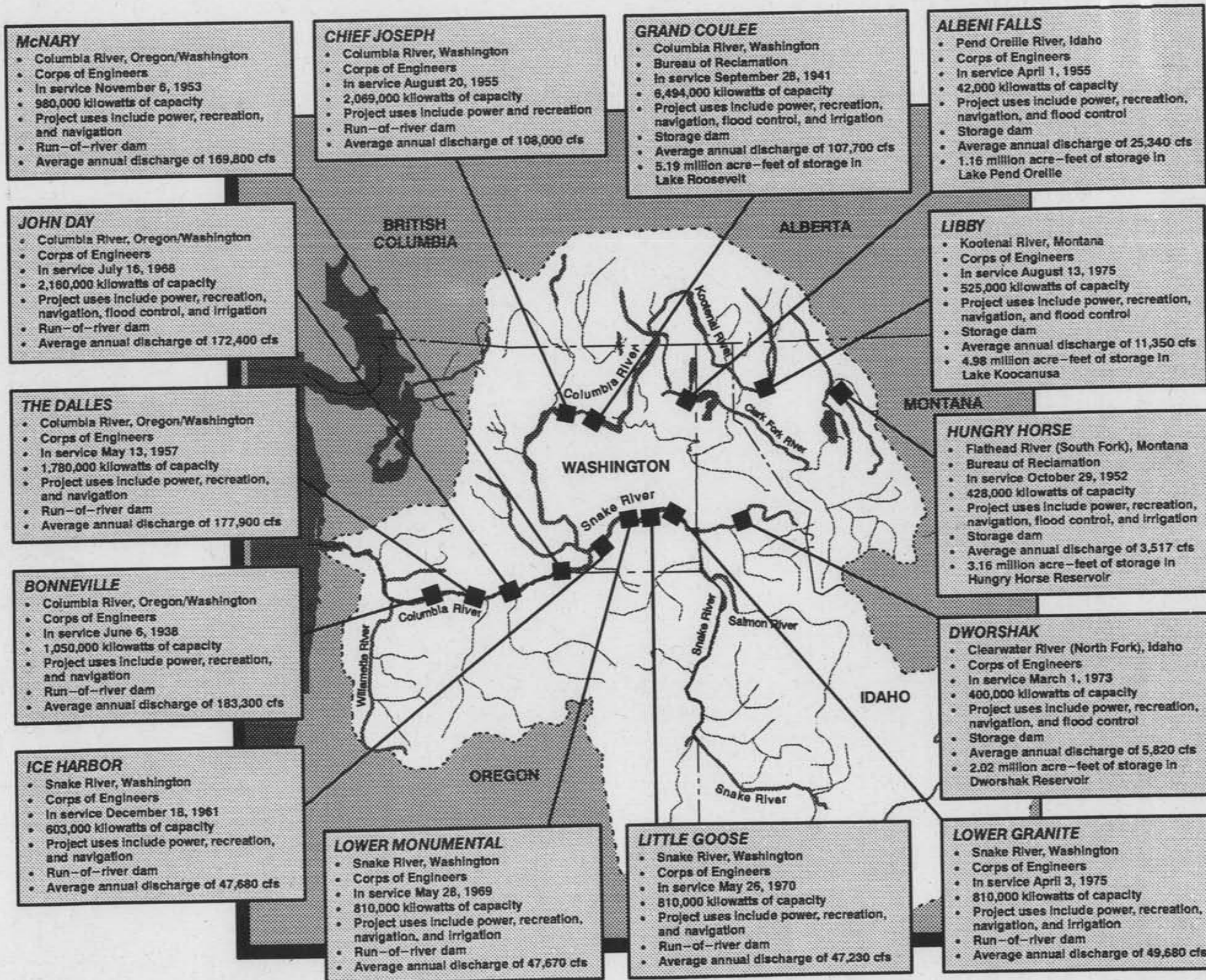
WHAT DO THE TECHNICAL APPENDICES COVER?

This technical appendix is 1 of 20 prepared for the SOR. They are:

A. River Operation Simulation
B. Air Quality
C. Anadromous Fish & 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
O. Economic and Social Impacts
P. Canadian Entitlement Allocation Agreements
Q. Columbia River Regional Forum
R. Pacific Northwest Coordination Agreement
S. U. S. Fish and Wildlife Service Coordination Act Report
T. Comments and Responses

Each appendix presents a detailed description of the work group's analysis of alternatives, from the scoping process through full–scale analysis. Several appendices address specific SOR functions (e.g., River Operation Simulation), rather than individual resources, or the institutional alternatives (e.g., PNCA) being considered within the SOR. The technical appendices provide the basis for developing and analyzing alternative system operating strategies in the EIS. The EIS presents an integrated review of the vast wealth of information contained in the appendices, with a focus on key issues and impacts. In addition, the three agencies have prepared a brief summary of the EIS to highlight issues critical to decision makers and the public.

There are many interrelationships among the different resources and river uses, and some of the appendices provide supporting data for analyses presented in other appendices. This Air Quality Appendix relies on supporting data contained in Appendices G, J, L, and M. For complete coverage of all aspects of land use, readers may wish to review all five appendices in concert.



1 million acre feet = 1.234 billion cubic meters
1 cubic foot per second = 0.028 cubic meters per second

Figure P–1. Projects in the System Operation Review.

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CHAPTER 1

INTRODUCTION: SCOPE AND PROCESS

This appendix consists of eight chapters. Chapter 1 describes the air quality issues that were raised in the System Operation Review (SOR) scoping process and provides an overview of the study process used to evaluate air quality effects from various system operation alternatives. Chapter 2 describes the Federal, state, and local programs that regulate air quality and discusses the air quality standards that are relevant to the analysis. It also gives an overview of the limatology of the region and the existing air quality in the Columbia River Basin, including areas of non–attainment for relevant air quality standards. Chapter 3 presents the methods this study uses for the analysis of air quality and for the evaluation of human health effects from air pollutants. Chapter 4 provides the study results for the System Operating Strategy (SOS) alternatives and potential mitigation measures. Chapter 5 compares impacts on air quality and human health across alternatives, and discusses mitigation measures and cumulative effects. Chapters 6, 7, and 8 contain the list of preparers, glossary, and references, respectively. Technical exhibits supporting the analysis are also included.

1.1 ISSUES RAISED IN SCOPING

Section 1.1 describes the air quality issues that were raised in the scoping process for the SOR. Some of these issues were identified by members of the public during the scoping meetings at the beginning of the process or through subsequent public involvement. The SOR lead agencies also defined air quality issues, based primarily on pertinent aspects of air quality regulatory programs.

1.1.1 Public Concerns

Public scoping comments relating to air quality addressed the indirect air quality impacts associated with potential changes in hydropower generation. The SOR agencies received many comments stating that the environmental impacts of replacement power sources must be considered if the SOR operation alternatives included actions that would reduce the generating capability of the hydro system. The available replacement power sources include technologies such as thermal power plants that produce air emissions and could adversely affect air quality. Most of these comments generally addressed the concept of the environmental tradeoffs of alternate power sources, but some specifically stated that air quality should be included in the EIS.

Air quality associated with reservoir operation was not specifically identified as an area of concern during the public scoping process for the SOR. In the relatively recent past, however, the operating agencies have on occasion gotten complaints about dust associated with normal operation of the storage reservoirs. For example, the U.S. Army Corps of Engineers (Corps) received public comment and Congressional inquiry about the levels of dust generated during recent annual drawdown periods at Lake Koocanusa (Libby Dam). Such comments note that dust can be blown off dry banks that are exposed when the reservoir is drafted. Review of this situation and similar reports from other project areas indicates that the primary public concern is over the nuisance effects of fugitive (blowing) dust on people living or recreating near the reservoirs. Based on this input, the SOR agencies identified blowing dust as an air quality issue to be investigated in the SOR.

1.1.2 Agency Concerns

In addition to the public concerns related to nuisance effects of fugitive dust, SOR agency and contractor staff identified three other areas of concern regarding potential air quality impacts in the Columbia River Basin. First, windblown sediments from the reservoirs could cause exceedances of air quality standards for particulate matter or for chemicals in the sediments. Federal, state, and local agencies are responsible for assuring compliance with ambient air quality standards within the region. They are responsible for implementing programs that maintain air quality for particulate matter smaller than 10 microns in diameter (PM_{10}) and for responding to public complaints about air quality. Additional guidance on air quality issues relating to the chemical makeup of particulate matter is provided by air toxics regulations established by some states in the region.

Second, adverse health effects could occur if people are exposed to high levels of particulate matter or airborne chemicals. PM_{10} is the portion of particulate matter that is small enough to enter the lungs and be absorbed into the bloodstream. If people are exposed to high levels of PM_{10}, they may experience respiratory illnesses. In addition, chemicals that are attached to the particulate matter can also be inhaled and may lead to health problems.

The third concern is related to the potential impacts on air quality that could result from chemical emissions from coal–fired or other thermal power plants. Thermal plants might have to increase their energy production to compensate for the loss of hydroelectric power from the Columbia River system when flows are decreased.

The additional air pollution that would result from increased use of thermal power plants must be considered when evaluating the alternatives. Investigation of this issue requires identification of the type and location of likely replacement power sources and the time of year when this energy might be needed. The amount of replacement energy required, and therefore the degree of impact on air quality, would vary for each SOS alternative.

1.1.3 Review of the Draft Environmental Impact Statement

The Draft EIS, issued in July 1994, was reviewed by Federal and state air quality agencies. Comments on the Draft EIS focused on two primary issues. First, some agency comments stated that the emission factors and modeling results presented in the Draft EIS were not sufficiently supported by technical data, and that the uncertainties and limitations of the analysis were understated. Second, reviewers believed that the Draft EIS did not rely on available air quality data and did not adequately characterize the air quality of the Columbia River basin, including the existing non–attainment areas and other local air quality problems. Other concerns raised in the Draft EIS comments included classifying wind-blown dust as a non–anthropogenic problem, and the increase in traffic–related air emissions associated with the SOS alternatives that call for drawing down the lower Snake River projects. For these alternatives materials hauled by river barges would have to be shifted to trucks, increasing the amount of traffic–related emissions.

The Final EIS has addressed the agency concerns regarding the air quality analysis. The Final EIS characterizes the air quality of the Columbia River Basin with monitoring data from the region. The location of project reservoirs relative to PM non-attainment areas is discussed. The relationship between emissions from exposed lake sediments and measured PM_{10} concentrations is currently under study and will not be available until late 1996. The generic emission factors and air dispersion modeling presented in the Draft EIS has been replaced by emission estimates for all of the SOS alternatives for three projects (Lower Granite, Libby, and John Day). These emission estimates follow EPA recommended methodologies. Representative emissions for the three projects were modeled to predict maximum PM_{10} concentrations and to demonstrate how the concentrations diminish with distance from the emitting source. The health risk analysis presented in the Final EIS has been revised to rely less on the original modeling results. And finally, the Final EIS includes more background details regarding the process of wind erosion.

During the preparation of the Final EIS, the Coeur d'Alene Tribe provided some review comments that expressed concern over air quality issues and addressed specific aspects of the impact issues previously identified. The Tribe's concerns included the potential health hazards from chemical contaminants that may be present in blowing reservoir sediments, monitoring and testing efforts related to blowing dust and its constituents, exposure of recreationists near reservoirs to blowing dust, and effects on tribes adjacent to the reservoirs. The SOR agencies believe that some of these concerns were adequately addressed in the Draft EIS documentation for air quality, and have added material at several locations in Appendix B to clarify or highlight other concerns raised by the Coeur d'Alene Tribe.

1.2 STUDY PROCESS

Air quality is not one of the major resource uses of the Columbia River System. Instead, there can be several types of air quality consequences as a result of the way the system is operated. The SOR scoping input touched on some of these air quality consequences, but did not suggest that air quality was a major public concern for the SOR. Therefore, the SOR lead agencies did not establish a work group assigned to address air quality.

The study process for air quality consequently differed from that for most of the SOR resource or functional topics. Air quality is one of several subject areas for which the SOR National Environmental Policy Act (NEPA) Action Group had general responsibility. This functional work group was staffed by NEPA compliance specialists from the three Federal agencies, and operated with support from private contractors for technical and editorial services. Because the Federal agencies have limited air quality expertise, the air quality appendix was prepared by a contractor (Foster Wheeler Environmental, formerly Enserch Environmental) under the direction of the SOR NEPA Action Group.

Technical study and report production activities for air quality were all conducted during the full–scale analysis phase of the process. Air quality was not one of the resources addressed in the pilot study, nor was it evaluated in the screening analysis. As indicated previously, the agencies received some public input concerning air quality during the scoping phase of the SOR. The scope for air quality was defined further by SOR and contractor staff during the full–scale analysis phase. Subsequent key activities included data collection; characterization of existing air quality conditions and regulatory considerations; review and evaluation of the hydroregulation results; assessment of the public health effects associated with system operations; and comparison and evaluation of the alternatives. Additional detail on this process and the associated study methods is provided in Chapter 3 of the appendix.

The nature of the air quality issues required little coordination among work groups. External inputs to the air quality studies from other SOR elements consisted primarily of the hydroregulation results from the River Operation Simulation Experts (ROSE), power generation consequences from the Power Work Group, and data on contaminant concentrations in sediment from the Water Quality Work Group. No SOR work groups were dependent upon air quality results as inputs to their analyses. Contractor activities on the air quality studies were coordinated through the SOR NEPA Action Group.

CHAPTER 2

AIR QUALITY IN THE COLUMBIA RIVER BASIN TODAY

This chapter describes the affected environment for air quality. Section 2.1 summarizes Federal, state, and local air quality programs and identifies the air quality standards that pertain to the SOR. Section 2.2 provides an overview of existing air quality in the basin. Section 2.3 addresses climatic factors that are relevant to the air quality analysis.

2.1 AIR QUALITY MANAGEMENT

The Federal Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to set ambient air quality standards to protect the public health and welfare. Standards to protect public health (primary standards) must provide for the most sensitive individuals and allow a margin of safety, without regard to the cost of achieving the standards. When a health standard does not protect public property or resources (public welfare), a secondary standard may be established which is more restrictive than the primary standard, but which takes into account other factors including cost and technical feasibility to achieve the standard.

Primary and secondary standards have been established for particulate matter which can be respired by humans (PM_{10}). These standards were established several years ago and replaced Federal standards which measured total (both large and small) suspended particulate matter (TSP). When the Federal government stopped regulating TSP, several states maintained the old standards, in part to address nuisance dust problems.

The reservoirs of the Columbia River system are exposed to urban/industrial water pollution from sources throughout the basin. Chemical contaminants accumulate in river and reservoir sediments and can be transported with dust particles when the sediments are exposed. Exposure to windblown dust, therefore, is potentially a health hazard.

EPA has delegated several air quality regulatory responsibilities to state and local agencies. Delegation of air quality regulatory responsibilities depends on EPA approval of each state's implementation plan (SIP) for attainment and maintenance of the national standards under Section 110 of the Clean Air Act, and for satisfying the requirements of Part D, Title 1 of the Clean Air Act. SIPs for Oregon, Washington, Idaho, and Montana have been approved. The responsibilities of the state and local agencies, as outlined in the Federal regulations, includes enforcement of the National and State Ambient Air Quality Standards (AAQS, listed in Table 2–1), including those for particulate matter (PM) and respirable particulate matter (PM_{10}). The SIPs follow the national regulations in focusing attention on mitigation of urban dust problems from industrial activity. Consequently, natural windblown dust is not specifically regulated in any of the four states' SIPs.

The Oregon SIP contains general regulations regarding fugitive dust, contained in the Oregon Air Pollution Rules 340-21-050 to 340-21-060:

> No person shall cause, suffer, allow, or permit any materials to be handled, transported, or stored; or a building, its appurtenances, or a road to be used, constructed, altered, repaired, or demolished; or any equipment to be operated, without taking reasonable precautions to prevent particulate matter from becoming airborne.

This requirement is followed by a list of reasonable precautions, including water or other chemical application for dust suppression, or full or partial enclosure. There is no direct reference in the Oregon SIP to natural windblown dust.

Table 2–1. Ambient Air Quality Standards

Pollutant	National[a/] Primary	National[a/] Secondary	Idaho[b/]	Montana[c/]	Oregon[d/]	Washington[e/]
Particulate Matter (PM_{10}) (µg/m³)						
Annual Arithmetic Average	50	50	50	50	50	50
24-hour Average[1/]	150	150	150	150	150	150
Carbon Monoxide (ppm)						
8-hour Average	9		9	9	9	9
1-hour Average	35		35		35	35
Total Suspended Particulates (µg/m³)						
Annual Geometric Average			60			60
24-hour Average			150			150
Ozone (ppm)						
1-hour Average[2/]	0.12	0.12	0.12	0.12	0.12	0.12
Sulfur Dioxide (ppm)						
Annual Average	0.03		0.03	0.02	0.10	0.02
24-hour Average	0.14		0.14	0.5	0.5	0.10
3-hour Average		0.50		0.5		
1-hour Average[3/]						0.25
1-hour Average				0.5		0.40
Lead (µg/m³)						
Calendar Quarter Average	1.5	1.5		1.5	1.5	1.5
Nitrogen Dioxide (ppm)						
Annual Average	0.053	0.053	0.053	0.05	0.053	0.05
1–hour Average				0.30		

Sources:

a/ 40 CFR Part 50
b/ IDAPA 16.01 .01.577
c/ ARM 18.8.811, .815–.817, .820, .821
d/ OAR 340–31–015 through –040
e/ WAC 173–470, –474, –475

Notes:

ppm = parts per million
µg/m³ = micrograms per cubic meter

Annual standards never to be exceeded, shorter-term standards not to be exceeded more than once per year unless noted.

1/ Standard attained when expected number of days per year with a 24-hour concentration above 150 µg/m³ is less than or equal to one.

2/ Standard attained when expected number of days per year with an hourly average above 0.12 ppm is less than or equal to one.

3/ Not to be exceeded more than twice in 7 days.

The Washington SIP, which lists tilled land as an example of an originator of fugitive dust, requires in WAC 173-400-040 that:

> The owner or operator of any emission unit engaging in materials handling, construction, demolition, or any other operation which is a source of fugitive emission:
>
> a) If located in an attainment area and not impacting any non-attainment area, shall take reasonable precautions to prevent the release of air contaminants from the operation.
>
> b) If the emissions unit has been identified as a significant contributor to the nonattainment status of a designated nonattainment area, shall be required to use best available control technology (BACT) to control emissions of the contaminants for which nonattainment has been designated.

However, the Washington Particle Fallout Standards (WAC 173-470-110) makes allowances for measured ambient particle fallout rates "in recognition of natural dust in areas of the state," allowing background levels to be considered.

The Idaho SIP only contains general rules for control of fugitive dust focused mainly on industrial operations (01.01252). The SIP requires that:

> All reasonable precautions shall be taken to prevent particulate matter from becoming airborne. In determining what is reasonable, consideration will be given to factors such as the proximity of dust emitting operations to human habitations and/or activities and atmospheric conditions which might affect the movement of particulate matter.

This requirement is followed by a list of reasonable precautions, including water or other chemical application for dust suppression, or full or partial enclosure. There is no direct reference in the Idaho SIP to natural windblown dust.

The Montana SIP contains emissions standards for particulate matter in subchapter 14, section 16.8.1401, stating that:

> No person shall cause or authorize the production, handling, transportation, or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.

However, this section specifically states that the regulations do not apply to fugitive particulate emissions originating from any activity or equipment associated with the use of agricultural land.

Each SIP requires "reasonable precautions" for fugitive dust. Therefore, by considering reasonable methods of dust suppression for the proposed alternatives, the plan will be in compliance with each state's SIP. Possible mitigation methods are discussed in Section 5.3 of this appendix.

The National AAQS for PM_{10} is 50 micrograms per cubic meter ($\mu g/m^3$) of air on an annual basis and 150 $\mu g/m^3$ on a 24-hour averaging time. These are primary standards which EPA believes are stringent enough to protect public welfare also.

State and local regulatory responsibilities also include protecting human health from toxic air pollutants. The standards for toxic air pollution vary by state. The States of Idaho, Oregon, and Washington have individualized toxic air pollution regulations and the State of Montana has not yet developed regulations. The Washington Department of Ecology (WDOE) Toxic Air Pollutants Regulations were adopted in June 1991. These regulations represent more than two years of research, planning, and consultation on controlling air pollution from more than 500 toxic or cancer-causing chemicals. The purpose of the WDOE rule is to protect the public from exposure to unhealthful levels of toxic and cancer-causing emissions from new industrial sources. Although this rule does not apply directly to the windblown dust under consideration here, as explained later, it can be used as a means of comparison.

Local air pollution control programs for particulate matter include restrictions on woodsmoke, open burning, and industrial operations. Complaints of windblown dust are reported to local authorities, who in turn will investigate potential mitigation measures and impacts to human health. Windblown dust is one component of fugitive emissions, which are emissions from sources other than industrial vents and stacks. Fugitive dust sources are difficult to limit because they are not localized, are subject to extreme changes in character with weather, and are generally not under human control. As such, mitigation measures may be extremely difficult to identify, and naturally occurring fugitive dust sources are a low priority for air pollution control agencies.

2.2 OVERVIEW OF EXISTING AIR QUALITY

Industrial operations, woodsmoke, road dust, and windblown dust from disturbed surfaces (such as fields) are the primary sources of fugitive dust in the atmosphere, both nationally and in the Columbia River Basin. Industrial emissions are the primary source of toxic air pollution. Further discussion of specific local industries and other pollution sources is found in Section 5.2.

2.2.1 Nonattainment Areas

The air quality in the Columbia River Basin generally continues to meet AAQS. Nevertheless, there are nonattainment areas in which air pollution concentrations do not comply with one or more portions of the 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 PM_{10}.

PM_{10} nonattainment areas within the Columbia River Basin include the Sandpoint, Boise, and Pocatello areas, as well as Shoshone County in Idaho; the Libby, Whitefish–Columbia Falls, Thompson Falls, Ronan–Polson, Missoula, and Butte areas in Montana; the Eugene–Springfield, Oakridge, and La Grande areas in Oregon; and the Yakima, Walla Walla, and Spokane areas in Washington. Figure 2–1 shows the PM_{10} nonattainment areas in the Columbia River Basin. Sandpoint, Idaho is the only PM_{10} nonattainment area near an SOR reservoir. Several TSP nonattainment areas are also located in the Columbia River basin. TSP nonattainment areas include Lewiston, Boise, Pocatello, and Soda Springs areas in Idaho; the Whitefish–Columbia Falls, Missoula, Helena, and Butte areas in Montana; the Portland, and Eugene–Springfield areas in Oregon; and the Longview, Vancouver, Clarkston, and Spokane areas in Washington. The Clarkston and Lewiston TSP nonattainment areas are adjacent to the eastern end of Lower Granite Reservoir.

As indicated by this list, many of the PM_{10} nonattainment areas are cities or larger towns that are not located on the Columbia River or its tributaries. Many of the nonattainment areas have industries that emit particulate matter. Another common problem is wood smoke that builds up to dangerously high levels during periods of inversions. Throughout the Columbia River Basin windblown dust has been identified as an air quality problem. The air quality problem in the Pendelton area is associated with windblown dust from dryland farming. In the La Grande area wood smoke and windblown dust contribute to the air quality problems. The air quality problem in the Richland–Kennewick–Pasco area is probably related to windblown dust. The Spokane area experiences high PM_{10} concentrations originating from roads, wood stoves, industries, and blowing dust. Blowing dust and wood smoke are responsible for the air quality problems in many of the nonattainment areas in Idaho and Montana.

The air quality in any particular location will be a consequence of a number of factors, including the type, duration, and timing of local and regional emissions, and meteorological and topographic influences. Air quality problems frequently are a combination of industrial emissions, wood smoke, and windblown dust.

Particulate sources within the basin include area sources, such as dirt or gravel roads and plowed fields, wood smoke, and industrial point sources (manufacturing plants). The area sources produce blowing dust, while typical manufacturing plant emissions include soot and fine wood particles.

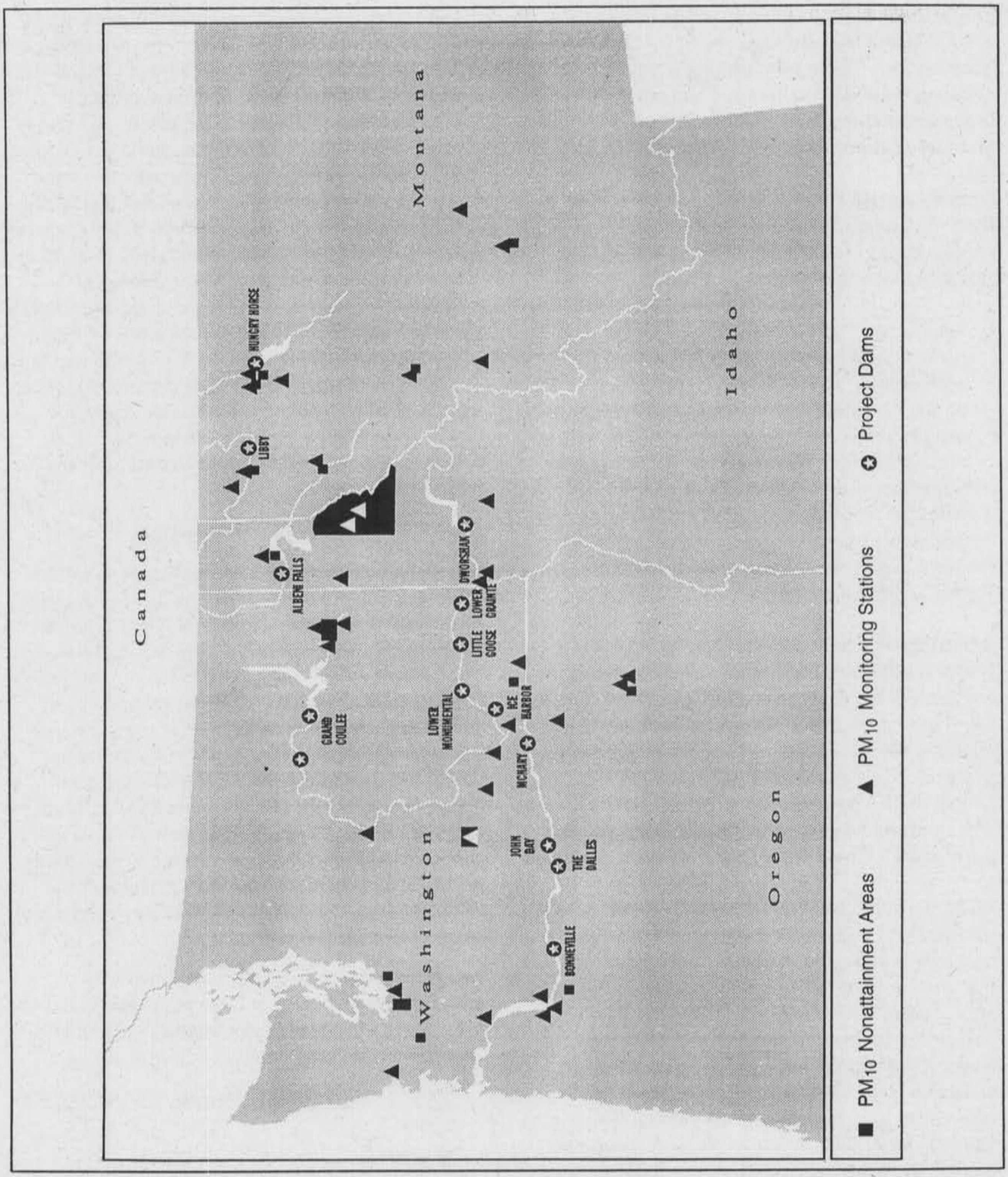

Figure 2–1. PM_{10} Nonattainment Areas in the Columbia River Basin

Throughout the arid and semi-arid portions of the western states, the primary cause of dust emissions is wind erosion. This type of erosion is usually associated with dryland farming, but can also be produced by irrigated agriculture and nonagricultural sources (such as exposed reservoir shorelines).

Similar conditions for particulate emissions apply to the SOR study area. Bureau of Reclamation (Reclamation) (1989) reported the following characterization for eastern Washington:

> Area sources are far more important than point sources because of the prevalence of wind erosion. Wind erosion is greatest during the spring and fall, when high winds and dry soil conditions create dust storms of varying severity. Highway and road closings are sometimes necessary because of reduced visibility. The severity of dust storms is exacerbated by dryland agricultural practices, which expose the soil during spring cultivation and fall harvesting.

Annual total suspended particulate readings at Pasco, Washington (based on a 12-month moving geometric mean concentration) ranged from 45 to 65 $\mu g/m^3$ during the mid-1980s and in some years exceeded the Washington State annual standard of 60 $\mu g/m^3$ (Reclamation, 1989). Over the same period, there were from 2 to 4 days per year on which particulate concentrations exceeded the 150 $\mu g/m^3$ standard for a 24-hour period.

While the above conditions and measurements apply specifically to eastern Washington and the Pasco area, respectively, they are likely to be representative of all or most of the reservoirs covered by the SOR. There are extensive agricultural areas around or near the reservoirs on the middle and lower Snake River and the upper, middle, and lower Columbia River. Parts of Lake Koocanusa are adjacent to concentrations of agricultural land. Hungry Horse, Lake Pend Oreille, and Dworshak are the primary SOR cases in which significant agricultural areas are not located in the immediate vicinity of the reservoir.

Thermal power plants commonly emit particulates, sulfur dioxide (SO_2), and nitrogen oxides (NO_x), and create carbon dioxide (CO_2) as a by-product of the combustion process. Air quality is a particular concern around these generating plants, and more stringent emission controls are required for existing facilities and new projects in these affected areas. Boardman, Oregon and Centralia, Washington, the locations of existing major coal-fired power plants in the region, are not listed as nonattainment areas for the above pollutants (BPA, 1993). All recent additions to Pacific Northwest thermal plant capacity have been natural gas-fired combustion turbines. These plants use the least-polluting carbon fuel in highly efficient engines, in which chemical emissions can be effectively controlled. Consequently, for combustion turbines the primary environmental concerns related to air quality are water use and visible steam plumes.

2.2.2 Air Quality Monitoring Data

Ambient measurements of air pollutant concentrations may help to characterize the air quality of the Columbia River Basin. State and local air pollution control authorities in Idaho, Montana, Oregon, and Washington routinely measure PM_{10} concentrations. Unfortunately, many of these measurements are conducted at locations which are at some distance from the SOR reservoirs, or are in areas where known air quality problems exist. However, the measurements can be used as an indication of the magnitude of maximum PM_{10} concentrations in the areas where the reservoirs are located. The source of the PM_{10} measurements and the methods used to estimate PM_{10} concentrations near the reservoirs are presented in this section.

Ambient PM_{10} concentrations are measured throughout the Columbia River drainage basin. The number of PM_{10} monitoring stations operated during 1994 are as follows:

State	Number of PM_{10} Monitoring Stations
Idaho	21
Montana	88
Oregon	32
Washington	37

Some of these stations, such as those located in central and eastern Montana, southern Oregon, and northwestern Washington, are not located in the Columbia River Basin and were not included in this data review.

The Aerometric Information Retrieval System (AIRS) data base is the repository for ambient air pollution data. The AIRS data base, maintained by EPA, includes PM_{10} data for the Pacific Northwest for the last several years. The AIRS data base was searched for PM_{10} data from 1992 through 1994 (EPA, 1995). From the data base, the four highest 24–hour concentrations, and the annual average PM_{10} concentrations for the last 3 years were obtained for each monitoring station. From this subset the maximum 24–hour and annual average PM_{10} concentrations were obtained for each station. These concentrations may be considered representative of the maximum PM_{10} values that occurred during the last several years. The maximum PM_{10} concentrations in the region are presented in Table 2–2.

Concentrations presented in Table 2–2 that are greater than the 24–hour PM_{10} Ambient Air Quality Standard (AAQS, 150 µg/m^3) don't necessarily indicate an exceedance of the AAQS. The 24–hour PM_{10} AAQS is a concentration that may not be exceeded more than once a year. The 24–hour concentrations in Table 2–2 are the highest concentrations from a 3–year period, 1992 through 1994 and are intended to indicate the magnitude of the PM_{10} concentrations that are possible at each of the monitoring stations.

Large concentrations measured in areas of known air quality problems are usually a consequence of a number of sources of emissions. It is possible to identify industrial emissions, wood smoke, or windblown dust as contributing to the high concentrations. But it is very difficult to identify specific sources of any of the components. The regions where the reservoirs are located are also subject to windblown dust problems. It will be extremely difficult to distinguish the difference between dust originating from agricultural lands, dirt or gravel roads, or exposed shorelines, when measured by the existing PM_{10} monitoring stations.

Table 2–2. Maximum PM_{10} Concentrations in the Columbia River Basin, 1992–1994

State	County	City or Town	Maximum PM_{10} Concentration (µg/m^3)	
			24–Hour	Annual
Idaho	Ada	Boise	113	40.8
	Bannock	Pocatello	232	52.7
	Bonner	Sandpoint	199	40.2
	Bonneville	Idaho Falls	145	35.4
	Caribou	Soda Springs	153	31.6
	Kootenai	Coeur d'Alene	135	40.0
		Post Falls	592	59.9
	Lemhi	Salmon	150	44.7
	Lewis	Kamiah	162	40.1
	Nez Perce	Lewiston	106	42.9
	Shoshone	Pinehurst	149	44.1

Table 2–2. Maximum PM_{10} Concentrations in the Columbia River Basin, 1992–1994 – CONT

State	County	City or Town	Maximum PM_{10} Concentration ($\mu g/m^3$)	
			24–Hour	Annual
Montana	Flathead	Columbia Falls	113	36.0
		Kalispell	122	31.5
		Whitefish	333	51.2
	Lewis and Clark	Helena	133	34.7
	Lincoln	Libby	120	40.5
		Troy	90	27.5
	Missoula	Missoula	121	32.2
	Ravalli	Hamilton	92	32.4
	Sanders	Thompson Falls	149	33.8
	Silver Bow	Butte	132	29.4
Oregon	Clackamas	Carus	43	16.0
	Deschutes	Bend	142	48.4
	Lane	Cottage Grove	109	26.6
		Eugene	126	43.2
		Oakridge	178	47.3
		Springfield	75	27.6
	Multnomah	Portland	103	34.4
	Umatilla	Pendleton	333	42.2
	Union	La Grande	148	33.6
Washington	Adams	Othello	109	32.3
	Asotin	Clarkston	148	39.6
	Benton	Kennewick	155	28.2
	Chelan	Wenatchee	361	25.2
	Clark	Vancouver	85	22.5
	Cowlitz	Longview	84	25.1
	Spokane	Millwood	123	37.1
		Turnbull Slough	146	17.7
		Spokane	803	46.0
	Walla Walla	Walla Walla	101	28.8
		Wallula Junction	195	38.4
	Yakima	Yakima	147	38.0

2.3 CLIMATIC FACTORS

Climatic conditions throughout the basin are diverse, but there is a common characteristic of relatively warm, dry summers and cooler, wetter winters (Jackson and Kimerling, 1993). The Cascade Range has a major influence on subregional climatic variations. Western Oregon and Washington have a mild and wet coastal climate, with only occasional temperature extremes. East of the Cascades in these states, the summer months are hot and dry and most of the annual precipitation falls during the winter in the form of snow.

Northern Idaho and western Montana receive some moderating influence from Pacific air masses, but more generally reflect a continental pattern of greater temperature extremes. The plateau areas in the interior of the basin are characterized by large seasonal temperature differences, low precipitation, and relatively less cloud cover. Valley bottoms along the Columbia and Snake Rivers record some of the highest summer temperatures in the region, although they tend to stay slightly warmer than surrounding upland areas in the winter.

Most of the reservoirs evaluated in the SOR are within the interior plateau climatic subregion of the basin. The remainder are generally in areas of mountain influence on local climate. Precipitation is typically concentrated in the late fall, winter, and early spring, with more arid conditions prevailing from late spring through the summer. At The Dalles, for example, precipitation averages 19.7 inches (500 mm) annually and over 2 inches (50 mm) per month from October through February; precipitation from May through July is negligible. The reservoirs on the middle and lower Snake River and the lower Columbia River generally have measurable precipitation from 90 to 120 days per year, compared to 120 to 150 days or more for reservoirs in the mountain areas (Jackson and Kimerling, 1993).

Air quality at specific locations within the basin is heavily influenced by wind conditions, which in turn reflect both prevailing regional or subregional patterns and local topographic factors. The prevailing wind direction in southeastern Washington, for example, is from the southwest in both winter and summer. In the Hells Canyon area of the Snake River, winds are typically from the south in January and from the north or northwest in July. Average wind speeds throughout the basin are generally in the range of 7 to 8 miles per hour (11 to 13 km/hr). Some locations have considerably higher wind speeds. Winds blowing through the Columbia Gorge, which is widely known for strong winds, average 10 miles per hour (16 km/hr) in both January and July (Jackson and Kimerling, 1993).

Table 2–3 lists primary wind directions and average wind speeds for selected local meteorological monitoring stations, and the SOR reservoirs for which they are considered to be representative. Wind roses for weather stations at Kalispell, Spokane, and Yakima are primary wind directions and average wind speeds included as Figure 2–2. The wind roses indicate a high frequency of occurrence of wind speeds, leading to a significant potential for windblown dust, if soil or sediments are exposed. Much of the interior plateau area near the Columbia and Snake Rivers is dominated by fine-grained loessal soils that are particularly susceptible to wind erosion (Jackson and Kimerling, 1993). Winter weather conditions in these areas often produce strong winds flowing across the plateau.

Apart from the prevailing larger-scale wind influences, local winds in the reservoir areas are typically channeled parallel to the shoreline by the river valleys. Local topography in the Columbia Gorge and elsewhere also can act as a funnel that increases wind speeds. A daily cycle of changing up-valley and down-valley local wind directions can be common, particularly at the reservoirs in mountain areas.

Table 2–3. Wind Direction and Speeds for Selected Monitoring Stations

Location	Primary Direction	Average Speed (mile/hr)[a/]	Maximum Speeds (mile/hr)[a/]	Reference SOR Reservoirs
Kalispell	S	6.5	69	Libby (Lake Koocanusa) Hungry Horse
Spokane	SSW	8.9	62	Albeni Falls (Lake Pend Oreille) Grand Coulee (Lake Roosevelt) Dworshak Lower Snake River Projects
Yakima	W	7.1	69	McNary, John Day

Sources: Jackson and Kimerling, 1993.
NOAA, 1990

a/ 1 mile/hr = 1.609 km/hr.

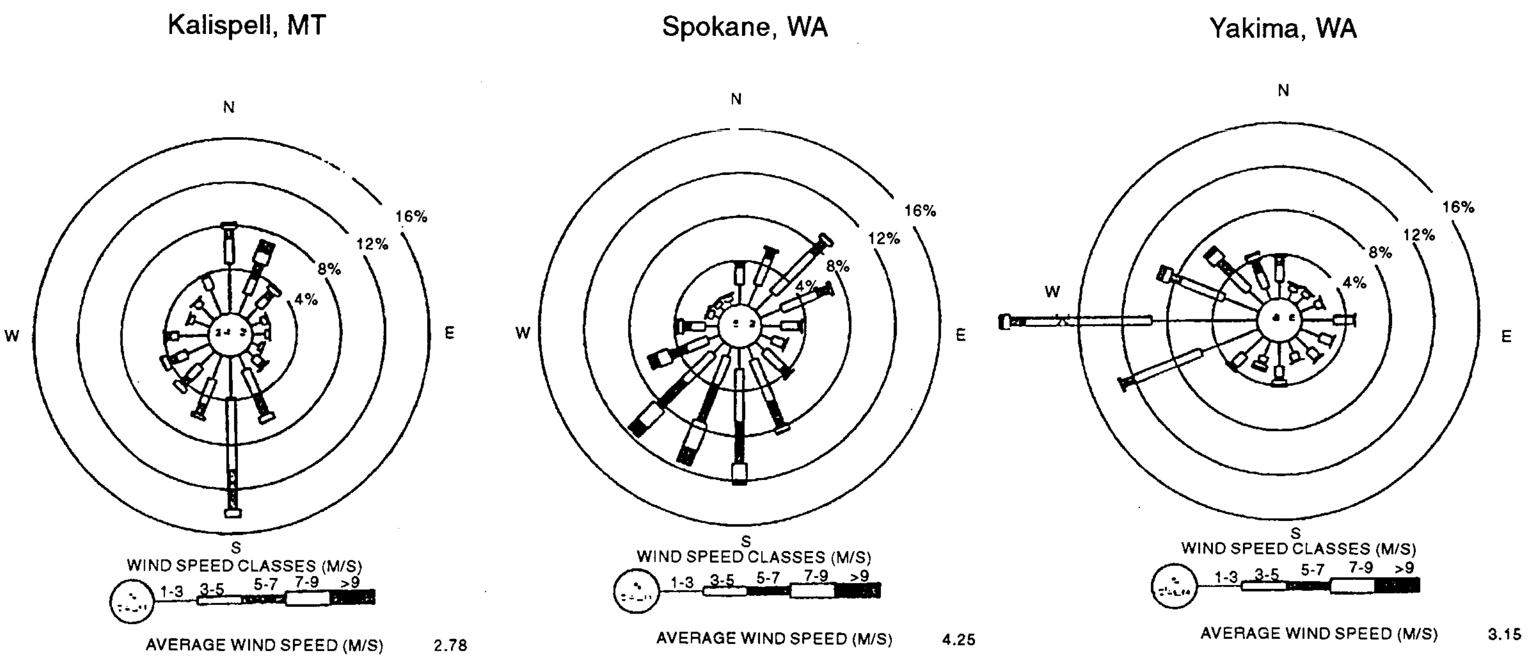

Figure 2–2. Wind Roses for Representative Weather Stations

CHAPTER 3

STUDY METHODS

Chapter 3 presents the methods used to address the air quality issues identified in Chapter 1. These include direct and indirect potential air quality impacts.

Wind generated dust originating from dry reservoir sediments could be a problem in areas where the ambient PM_{10} concentrations are already high. Blowing dust resulting from exposed sediments would also be a nuisance problem to recreationists and residences. Air pollutant concentrations are measured throughout the Columbia River Basin, particularly in areas of known air quality problems. Site–specific atmospheric emissions data and reservoir–related PM_{10} concentrations are not available. As an alternative, a method for predicting the amount of particulate matter (PM) emitted during high wind events is presented (Section 3.1). Examples of PM_{10} emissions and concentrations are presented for several of the projects. Contaminants attached to blowing dust may present a health problem. Human health problems associated with elevated air pollutant concentrations are also discussed in Section 3.1.

There are several indirect air quality impacts associated with the SOR alternatives. Reduced hydropower generation would require that replacement power be purchased or generated. Replacing this power would result in atmospheric emissions from thermal power plants. Chemical emissions from thermal power plants were addressed in detail by the Bonneville Power Administration (BPA) in the recent Resource Programs Environmental Impact Statement (EIS) (BPA, 1993). The study methods for assessing these indirect impacts are presented in Section 3.2

3.1 FUGITIVE DUST

The Corps, in the past, has received public comments regarding fugitive particulate matter associated with drawdowns of Lake Koocanusa. Residents of Eureka, about 8 miles (13 km) east of the reservoir, believe that the exposed reservoir shoreline significantly contributes to blowing dust problems in Eureka. In response to this concern, the Corps is conducting a geotechnical survey in an attempt to better understand the dust problem. Real–time meteorological and PM_{10} monitoring is being conducted at several sites in the area. The study will attempt to link PM_{10} concentrations with the area of exposed shoreline. The 2–year study will be completed in early 1996 (personal communication, C. Bloom, Corps of Engineers, Seattle District, Seattle, Washington, April 26, 1995). The Corps program at Libby is currently the only active air quality monitoring effort associated with the Federal reservoirs included in the SOR.

Without the advantage of on–site data, it is difficult to estimate the magnitude of PM_{10} and TSP concentrations expected to result from blowing reservoir sediments. PM concentrations are a function of many variables that are not clearly understood at this time. Among the factors that contribute to blowing dust are the amount of shoreline exposed, the amount of fine material in the sediments, the moisture content of the sediments, the frequency of winds strong enough to lift erodible particles, and the roughness of the exposed surface (a smooth surface versus one impregnated with rocks or other obstacles).

To gain some understanding of the nature of the blowing dust problem, examples of PM_{10} emission calculations for several reservoirs are presented below. These examples use, wherever possible, information relevant to the area where the project is located, and discuss the representativeness and limitations of the data.

3.1.1 PM_{10} Emission Calculations

Wind–generated erosion is dependent upon the amount of erodible material present, the roughness of the surface, the surface wind speed, and the frequency with which the surface is disturbed. Particulate emission rates will rapidly decrease as the erodible material is removed from the surface. If the surface remains undisturbed, the amount of erodible material is limited. EPA has developed a method to predict the amount of particulate matter emitted during a wind erosion event. The methodology is presented below.

The amount of material removed from a surface is a function of the difference between the wind velocity at the surface and the velocity required to erode the surface, and may be expressed as the following (EPA, 1990):

$$EF = k * (58 (u^* - u^*_t)^2 + 25 (u^* - u^*_t))$$

where EF = emission factor, in g/m

k = dimentionless aerodynamic particle size multiplier

u^* = frictional velocity, in m/sec

u^*t = threshold frictional velocity, in m/sec

The above expression is valid for dry exposed materials with limited erosion potential. For total emissions k is equal to 1. For particles with aerodynamic diameters less than 10 micrometers (PM_{10}), k is equal to 0.5 (EPA, 1990). The frictional velocity is derived from observations of the fastest mile. The emissions expression assumes that the largest wind event between surface disturbances removes all available erodible material. If the surface is disturbed again, additional material becomes available for erosion by the next high–speed wind event.

The frictional velocity is a measure of the wind stress on the erodible surface. The threshold frictional velocity represents the wind shear necessary to begin to move the erodible surface particles. If the frictional velocity exceeds the threshold frictional velocity, wind erosion will occur. The frictional velocity is a function of the material being eroded. For silty clay soils, typical of the material that may be found in sediments, the threshold frictional velocity is 0.64 m/sec (Gillette, 1988). Because of the absence of site–specific data, this velocity will be assumed to be representative of dry, uncrusted reservoir sediments throughout the Columbia Basin.

Mean atmospheric winds are not sufficient to sustain wind erosion. However, wind gusts may quickly deplete a substantial portion of the material available for erosion. The meteorological variable which best reflects the magnitude of the wind gust is the fastest mile. This quantity represents the wind speed corresponding to an entire mile of wind movement which passes the measuring location in the least amount of time. Historical measurements of the fastest mile are available in annual climatological summaries for Kalispell, Spokane, and Yakima (Technical Exhibit A). These data, for the months when the reservoirs would be drafted, represent maximum sustained wind speeds that the dry sediments would experience. Sustained high speed wind events on the order of 1 hour may also be an important mechanism for transporting large amounts of dry lake sediments. The meteorological data base used to develop the wind roses (Figure 2–1) was scanned to determine the highest and 99.9th percentile wind speeds for the Kalispell, Spokane, and Yakima stations. The 99.9th percentile wind represents a wind speed exceeded for only 9 hours per year.

Generally, the reservoirs would be drafted during specific periods of the year (Figure 3–1). The maximum potential for fugitive dust, for each alternative, would be during the months when each reservoir is at its lowest level. Water surface elevations would be different for each alternative. PM_{10} emissions were estimated for all alternatives for the three projects investigated, Lower Granite, Libby, and John Day. The emission estimates used wind data representative of the periods when the water surface elevation will be at its lowest level. The most common drawdown periods for each project are presented in Table 3–1, along with wind data used for those periods (see Technical Exhibit A).

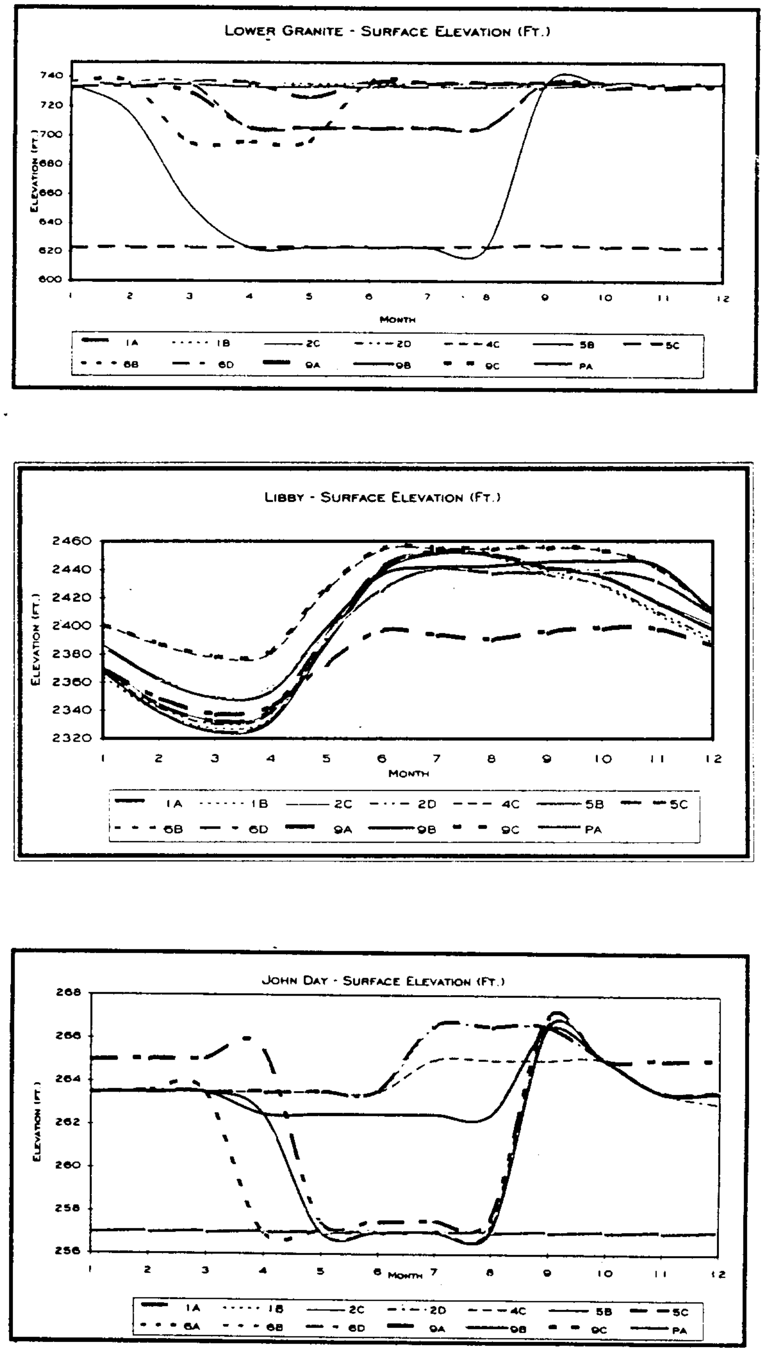

Figure 3–1. Surface Elevations for Lower Granite, Libby, and John Day

Some alternatives have different periods when the water level will be lowest, and the different exposure might result in a higher or lower wind speeds. SOS 5b would draw Lower Granite down to natural river for April through August and represents the largest PM emission rate for this project. Emissions for SOS 5c, year round natural river, would initially resemble those of SOS 5b until the sediments were stabilized.

Wind speeds recorded at some height above the surface must be converted to frictional velocities. Wind speed will decrease logarithmically with decreasing height because of frictional effects. A wind speed may be converted from a value at the measurement height to a reference height of 10 m by using the following expression:

$$u_{10} = u_z * [\ \ln(10/0.002) / \ln(z/0.002)\ ]$$

where z is the measurement height (see Table 3–1, NOAA, 1990) and 0.002 is the assumed roughness height (m).

PM_{10} emissions were estimated for all alternatives for the Lower Granite, Libby and John Day projects. Each alternative was evaluated for three different wind conditions representing the 99.9th percentile and maximum 1–hour wind speed, and the fastest mile. For the John Day project the 99.9th percentile wind speed for many of the alternatives was slightly below the threshold frictional velocity. The wind speed for these cases was increased to produce a small non–negative emission rate.

PM_{10} emissions on a unit area basis are a function of wind speed. Total emissions depend on the amount of exposed area which, in turn, is a function of the surface elevation of each reservoir. The relationship between surface elevation and area of the reservoir

Table 3–1. Wind Data used for Emission Estimates

Location	Kalispell	Spokane	Yakima
Project	Libby	Lower Granite	John Day
Measurement Height (m)	6.07	6.07	10.1
Lowest surface elevations			
Starting Month	March	April	May
Ending Month	April	August	August
Fastest Mile			
(m/sec)	23.2	23.2	21.0
(mph)	52	52	47
Highest 1–hour Wind Speed			
(m/sec)	14.4	18.0	17.5
(mph)	32.2	40.3	39.1
99.9th Percentile Wind Speed			
(m/sec)	12.1	13.0	12.1
(mph)	26.8	29.1	26.8

was developed as part of the input data requirements of the hydroregulation modeling. Reservoir area by surface elevations are presented for Lower Granite, Libby, and John Day in Figure 3–2. The difference in reservoir areas for changing surface elevation is equal to the amount of exposed lake sediments. The area of the exposed sediments divided by the length of the shoreline is equal to the width of the exposed sediments. Shoreline lengths for the Lower Granite, Libby, and John Day projects are 102.0, 60.4, and 245.9 km, respectively (63.4, 224.0, and 152.8 miles).

Predicted PM_{10} emission rates, in units of kg/km, are presented for each alternative, for three projects, and for three different wind conditions, are presented in Figure 3–3. TSP emission rates are equal to twice the PM_{10} emission rates. Lower Granite emissions for SOS 5c would be identical to SOS 5b emissions until the exposed sediments were vegetated or washed away by rains. The emission rates equal to values between the 99.9th percentile and maximum 1–hour wind speeds could be expected to occur every 5 years. Emission rates as high as predicted using the fastest–mile wind speed are possible, but would occur infrequently.

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 speeds 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.

During March 1992, Lower Granite Reservoir was drafted from the minimum operating pool elevation of 733 feet (223.4 m) to an elevation of 697 feet (212.4 m) (Wik et al, 1993). During this exercise a substantial area of shoreline was exposed. The test drawdown elevations resemble the SOS 9c operation. Therefore, emissions during the 1992 drawdown test might be expected to resemble those predicted for SOS 9c (with calls for drawdown to occur during March through May; the 1992 drawdown test occurred only during March). At the level of greatest drawdown the average width of the exposed sediments was 96 m (315 ft). PM_{10} emissions for the drawdown test, following the methodology presented above and assuming a maximum 1–hour wind speed of 16.5 m/sec, were 571 kg/km. However, emissions of this predicted magnitude probably did not occur. The elevation of the reservoir had fallen from 733 feet (223.4 m) to 697 feet (212.4 m) by March 19, the time of the maximum amount of exposed shoreline. The highest wind speeds during the test occurred when the reservoir was being refilled (NOAA, 1992). At the time of the highest winds the reservoir was at an elevation of about 719 feet (219.2 m), creating an average width of exposed sediment of about 33.2 m (109 ft). Using the emission factor derived above, the emission rate for this wind event was about 76.3 kg per kilometer of shore (270.9 pounds per mile). Also, the sediments probably were not dry. Both Lewiston and Spokane recorded precipitation on the day before and the day of the highest winds during March 1992 (Technical Exhibit B).

Emission calculations incorporate a number of assumptions which are intended to result in conservative emission estimates. Many of the assumptions may produce unrealistically large emissions estimates. Table 3–2 presents the assumptions incorporated into the emissions estimates and points out the limitations of the assumptions. Other data used in the emission calculations, such as the representativeness of the wind data, will limit the accuracy of the estimates.

The Hells Canyon Environmental Investigation presented a PM_{10} emission estimate for the Brownlee Reservoir (BPA, 1985). This estimate, 4.22E–8 g/m–sec^2 (0.35 lbs/acre–day) is four to five orders of magnitude smaller than the emissions presented above for the Lower Granite, Libby, and John Day reservoirs. The Brownlee estimate used methods that predated EPA's fugitive dust emission estimate methodology.

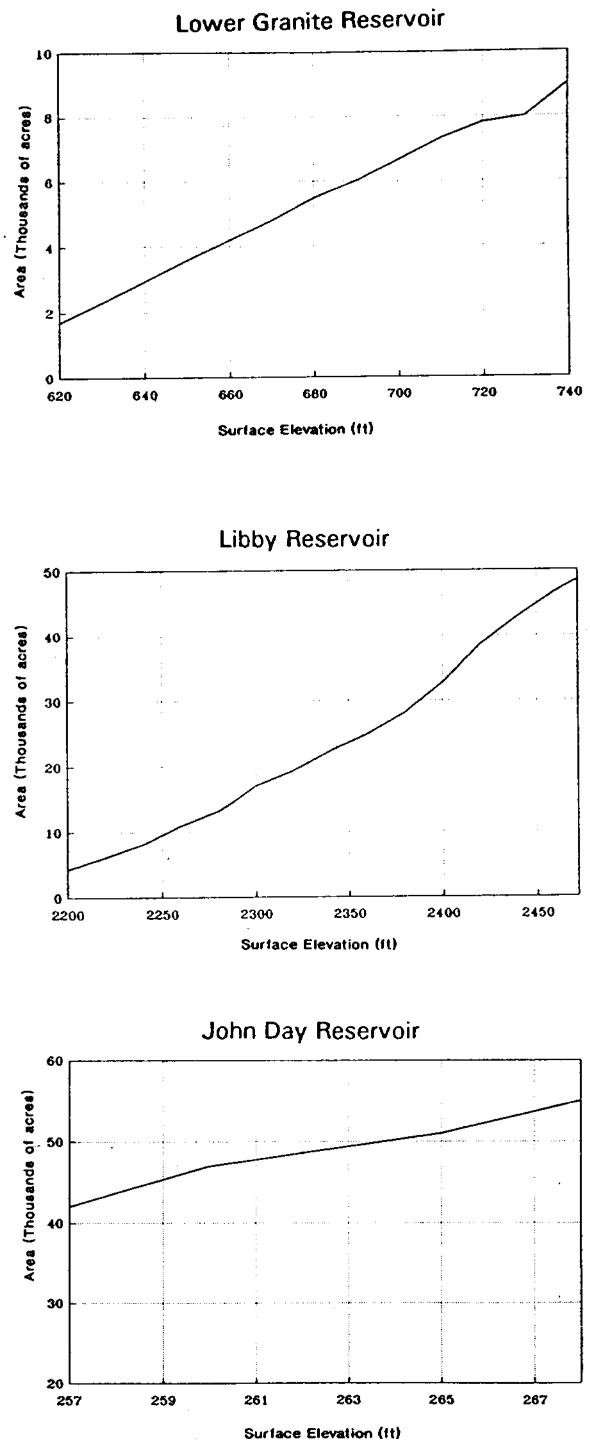

Figure 3–2. Reservoir Areas for Lower Granite, Libby, and John Day

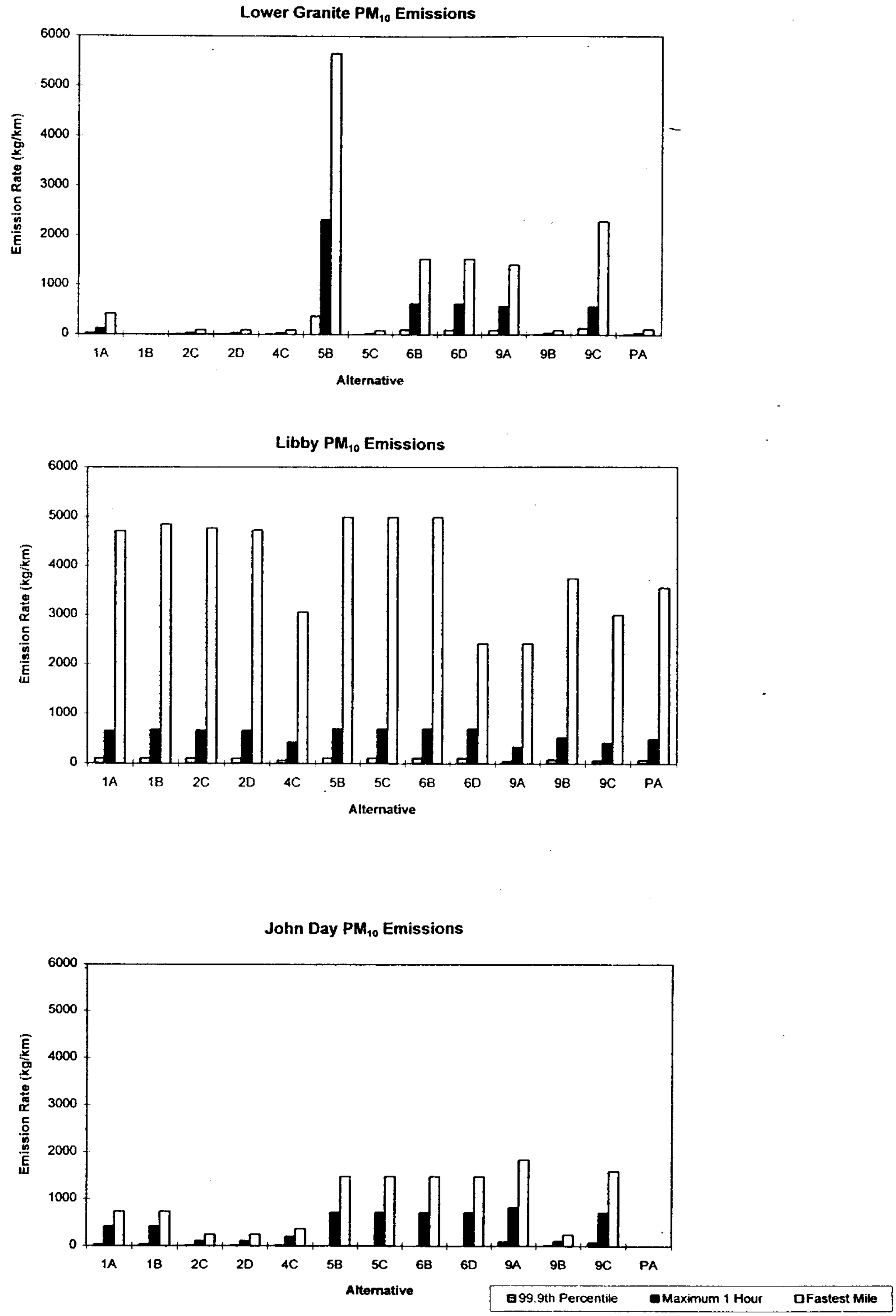

Figure 3–3. PM_{10} Emission Rates for Lower Granite, Libby, and John Day

Table 3–2. Assumptions and Limitations in Emission Rate Calculations

Assumptions	Limitations
The source of the emissions is uncrusted and dry.	A crust will form on the exposed sediments as they dry. Unless the crust is disturbed emissions will be limited.
The sediments dry immediately following drafting.	The sediments may not completely dry for some time. This is especially true for Libby, which would be drafted during March and April. Although only July and October are dryer than March and April at Kalispell, temperatures during these months temperatures are low and sub–freezing conditions are common.
A single wind event will remove all available erodible material.	In reality, previous wind events of lesser intensity will remove some of the material. Later, more intense wind events will remove additional material.
The wind completely removes erodible material from the beach area.	Because the reservoirs follow major valleys, the winds probably blow parallel to the shoreline. In this case, the winds will simply transport the sediment fines down the beach. This material will become available for erosion during the next large wind event.
The emitting surface is smooth and unobstructed.	Areas of rocky lake bottom exist in many places in the reservoirs. Vegetation probably covers much of the shallow water areas. Rain run–off and water draining from the exposed sediments will create rivulets in the sediments.
The beach is of uniform width and slope.	The bottom slope varies from place to place along the reservoir banks, resulting in an uneven beach width.
Successive inundations will replenish material that will be available for wind erosion following drafting.	It is likely that only areas where large amounts of sediments have accumulated will, after the sediments have dried, be subject to wind erosion. Higher areas along the beach that are under water for only short periods will not accumulate enough sediments to result in significant amounts of dust emissions.

3.1.2 Estimated PM_{10} Concentrations

Windblown dust is transported and diluted by the wind. PM_{10} emissions from the exposed shoreline areas were modeled using a standard Gaussian dispersion model and representative meteorological conditions to predict ambient concentrations during the high winds that produced the emissions presented in Section 3.1.1. The methods used to model dust emissions from the Lower Granite, Libby, and John Day reservoir shorelines are presented in this section.

This exercise used the ISCST2 model, which is appropriate for modeling area sources of non–reactive pollutants (EPA, 1986). The model inputs included emissions, meteorological, receptor, and source data. The most common emission rate for all of the alternatives was modeled for each of the three projects investigated (see Figure 3–3). The emissions data used in the modeling is presented in Table 3–3. All emissions are assumed to take place during a 1–hour period. The modeling assumed that plumes of particulate matter are not subject to any vertical motion resulting from buoyancy or momentum. The plumes will stay ground based and will follow the local terrain. The effects of terrain were ignored in the modeling.

The width of the exposed sediments was determined from the change in surface elevation and the length of the shoreline (Section 3.1.1). The shoreline area was divided into a number of adjacent square area sources extending several kilometers in both directions from a central location. Receptors were placed in a straight line perpendicular to the shoreline and spaced every 50 m out to a distance of 5 km (Figure 3–4).

The modeling requires wind speed and direction as input data. The maximum 1–hour wind speed for the period when emissions can be expected was used (Table 3–3). Because the winds were high a D (neutral) stability class was assumed (EPA, 1987). Unlimited mixing was also assumed for the analysis. The wind direction expected for the high wind speed events cannot be determined. Therefore, several wind directions were investigated. The ISCST2 model was run for a wind perpendicular to the shore and nearly parallel to the shore (Figure 3–4). The perpendicular winds will produce the largest concentrations at some distance from the shore area. The nearly parallel winds will result in maximum near–shore concentrations.

PM_{10} emissions resulting from Lower Granite, Libby, and John Day shoreline wind erosion were modeled using the ISCST2 model, representative meteorology, and a straight shoreline configuration. PM_{10} concentrations as a function of distance from the shore were predicted for several wind angles. The emission calculations and modeling are representative of a single event with an assumed duration of one hour. The model predictions were converted to 24–hour and annual average concentrations by multiplying by 1/24 and 1/8760, respectively. The predicted PM_{10} concentrations are presented in Chapter 4.

Table 3–3. Modeling Input Data

Project	SOSs Represented	Width of Beach Area (m)	Wind Speed (m/sec)	PM_{10} Emission Rate (g/m^2–sec)
Lower Granite	6b,6d,9a,9c	71.9	18.0	0.00242
Libby	1a,1b,2c,2d 5b,5c,6b,6d	225.1	14.4	0.000828
John Day	5b,5c,6b 6d,9a,9c	119.4	17.5	0.00166

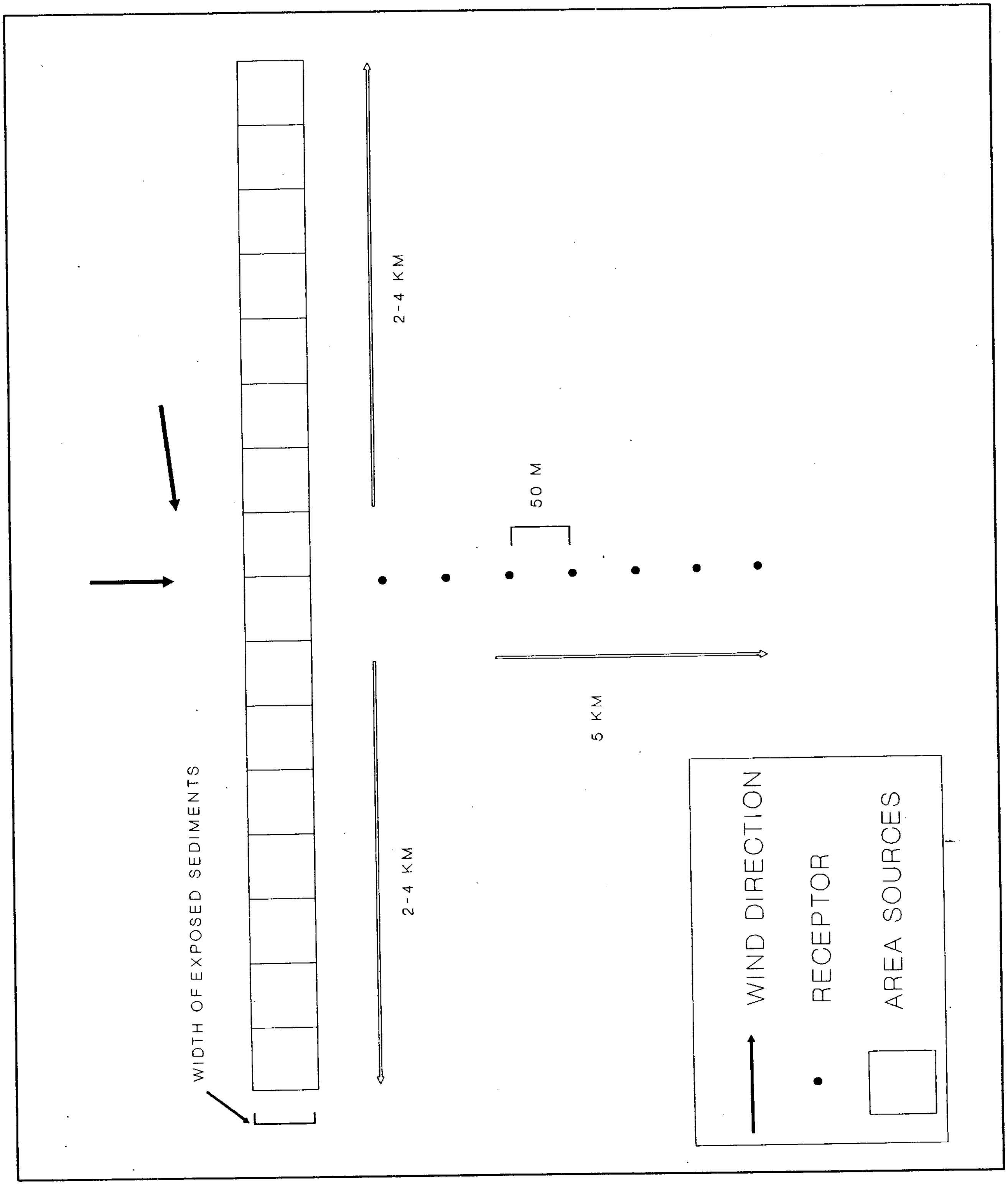

Figure 3–4. Modeling Configuration

3.1.3 Human Health Concerns

3.1.3.1 Exposure Assessment

When reservoir sediments are exposed through drafting, chemicals in those sediments can become airborne. Nearby populations can be exposed to potential health risks by inhaling fine particles. Sediment sampling data are maintained in EPA's STORET database, a national water quality database in which agency and private data can be catalogued. Other sources of sediment data include Battelle Pacific Northwest Laboratory studies of Lower Granite Reservoir sediments (Pinza et al., 1992; Crecelius and Gurtisen, 1985; Crecelius and Cotter, 1986). These databases were reviewed to identify chemicals for potential air quality and human health risks. The review indicated that sediment sampling data for the SOR reservoirs were limited. (In addition, the SOR agencies are aware of no chemical testing data that would pertain to deposition of metals or other chemicals on lands adjacent to the reservoirs.) Lake Roosevelt and Lower Granite were the only reservoirs for which sediment sampling data were both available and indicated a potential for high airborne concentrations, when compared to the Washington State Acceptable Source Impact Levels (ASIL).

The ASIL is the air concentration below which there is no significant health effect. For carcinogenic (cancer–causing) chemicals, the ASIL is an annual average concentration in the air that would increase a person's cancer risk by 1 in 1 million over a lifetime, based on inhalation assumptions from EPA's Region 10 Supplemental Risk Assessment Guidelines for Superfunds (EPA, 1991). The ASIL for carcinogens is an annual average because cancer risks occur as a result of chronic or long–term exposure. ASILs for chemicals that do not cause cancer are based on a threshold concentration below which no adverse health effects occurred in either animal or human studies. ASILs for these chemicals are based on a 24–hour average concentration, because their health effects occur over an acute or short–term exposure period.

The limited sediment data available for the SOR reservoirs precluded a specific and comprehensive evaluation of the potential human health concerns associated with fugitive dust from the reservoirs that might contain hazardous chemicals. Although airborne concentrations of hazardous and toxic chemicals were not estimated, it may be concluded that the potential exists for air concentrations greater than ASILs, especially in the upper reaches of Lower Granite Reservoir and Lake Roosevelt. Based on the sediment concentrations of these chemicals, there are several pollutants of concern, including arsenic and iron. The evaluation did not investigate whether the sediments would actually be exposed. A detailed analysis of wind–generated emissions and concentrations of hazardous and toxic air pollutants would require site–specific data, including sediment concentrations of the pollutants of concern in the areas where they will become exposed, the grain size distribution of the sediments, the volatility of the pollutant versus the potential that the pollutant will remain attached to sediment particles, an evaluation of the smoothness of the exposed sediment surface to determine the roughness height, and representative meteorological data to conduct the dispersion analysis. These data are not currently available. If sediment concentrations of contaminants were large enough, and if the sediments were exposed during drafting, then high speed wind events could result in relatively high air concentrations of these contaminants and pose a potential risk to the health of lake–side residents and of recreationists. The potential for high airborne contaminant concentrations exists for the Lower Granite Reservoir and Lake Roosevelt, and possibly other reservoirs, under certain SOS alternatives. The populations at risk and the consequences of exposure are presented below.

3.1.3.2 Potentially Exposed Populations

The two general population groups most likely to be exposed to dust from reservoir sediments are nearby residents and recreationists. In addition, in recognition of the Federal government's trust responsibility to Indian tribes, the air quality studies considered the potential for adverse effects on tribal populations living near the affected reservoirs. The residential exposure evaluation is protective of workers at the projects because worker exposures are assumed to be of shorter duration (8 hours a day) than exposures of residents (24 hours a day). Therefore, worker exposures were not evaluated separately.

Resident Populations

Most of the areas surrounding the affected reservoirs are sparsely populated. Lower Granite is one of the few reservoirs that has large population centers on its shoreline. The towns of Lewiston, Idaho, and Clarkston, Washington, are at the upper end of the reservoir and have a combined population of approximately 40,000. The remainder of the shoreline is essentially unpopulated.

The shores of Lake Roosevelt are dotted with several small towns, all with populations under 2,000. The total population of the towns around Lake Roosevelt is estimated to be less than 10,000.

Hungry Horse Reservoir has no resident population, as it is surrounded by undeveloped national forest lands and the nearest towns (Hungry Horse and Martin City) are 3 to 5 miles (5 to 8 km) away. Similarly, the U.S. portion of Lake Koocanusa is in the Kootenai National Forest and the Canadian portion abuts lands that are also largely undeveloped. The only towns on the reservoir are Rexford, Montana (population 130) and Newgate and Wardner, British Columbia.

The shoreline of Brownlee Reservoir is mostly undeveloped and has limited access. Weiser, Idaho (population 4,571) and Richland, Oregon (population 181) are the only towns near the reservoir. Dworshak Reservoir is surrounded by undeveloped forest lands. The small town of Ahsahka, Idaho, is the closest population center and is approximately 2 miles (3.2 km) from the dam.

Recreationist Population

Outdoor recreation is a common land use at the reservoirs evaluated in the SOR. Recreational activities at the reservoirs are varied and include boating, swimming, fishing, picnicking, camping, sightseeing, and hiking or walking. The seasonality of recreational use is an important consideration in analyzing exposure to blowing dust associated with reservoir operations. Recreational use occurs year-round but peaks from late spring through early fall. Much of the recreation use during the spring can be directly attributed to the opening of fishing season.

During the summer, the storage projects are generally refilled and held as high as possible to promote and support recreation use. The peak recreation season is from Memorial Day to Labor Day.

Each reservoir has a slightly different visitor usage and characteristics, which are reported in detail in Appendix J, Recreation. Table 3–4 is a summary of baseline annual recreation use for the projects that could experience significant shoreline exposure.

Tribal Populations

The potential for Indian tribal populations to be exposed to blowing reservoir sediments would be greatest where Indian reservations are located near or adjacent to reservoirs that could have significant shoreline exposure as a result of one or more SOSs. As discussed previously, significant shoreline exposure could occur at the storage reservoirs, the lower Snake River reservoirs, or John Day (see Table 3–4). Two of the 14 Indian reservations within the SOR study area are located adjacent to reservoirs in this category; the Spokane and Colville Reservations are both located adjacent to Lake Roosevelt. The combined resident population of these two reservations in 1990 was approximately 8,500 people (Public Sector Information, Inc., 1994).

3.1.3.3 Routes of Human Exposure

An exposure route is a way in which people can be exposed to chemicals from a particular source. Exposure routes depend upon the land uses at or near the reservoir and the ways in which the sediments could be transported through the environment. As discussed in Section 3.1.3.2, land uses at the subject reservoirs are primarily residential or recreational.

Table 3–4. Baseline Annual Recreation Use at Affected Reservoirs

Reservoir	Average Annual Use (in recreation days)
Lake Koocanusa	175,000
Hungry Horse	79,000
Lake Roosevelt	1,805,000
Brownlee	279,000
Dworshak	210,000
Lower Granite	1,530,000
Little Goose	243,000
Lower Monumental	140,000
Ice Harbor	482,000
John Day	2,381,000

Sediment transportation through the environment can occur when sediments are exposed to air and are then blown by the wind. Recreationists were assumed to be at the reservoir shoreline, which was the point of maximum exposure to windblown sediments.

Exposure to windblown particulate matter and chemical contaminants is most likely to occur by inhalation. Although it is conceivable that exposure could occur by ingestion of or by skin contact with windblown dust, these routes were considered to be relatively unimportant compared to inhalation and were not evaluated.

3.1.3.4 Health Risk Factors

The evaluation of risks to public health associated with exposure to the chemicals of concern involves combining information about the relative amount of exposure that would occur under each alternative with information on the toxic effects of each of the chemicals of concern. This section describes the toxic effects of the chemicals of concern identified through the screening process. It first defines carcinogenic (cancer) and noncarcinogenic (noncancer) effects and describes EPA's system for classification of carcinogenic chemicals. The toxic effects of each of the chemicals of concern are then examined.

It is important to note that the following sections describe health effects in general terms and under a variety of situations for the chemicals under evaluation. It does not indicate that these effects are now occurring or are likely to occur under the conditions present or possible at the reservoirs.

3.1.3.5 General Characterization of Toxic Effects

Carcinogenic Effects

Carcinogens are chemicals that are known or suspected to cause cancer in animals or humans. In evaluating toxicities associated with carcinogens, EPA uses a weight-of-evidence classification which is assigned to the chemical based on the extent to which the chemical is thought or known to be a human or animal carcinogen (EPA, 1989). This classification system is based on evidence from animal studies and from studies of humans exposed to the chemical (usually though their occupation). The weight-of-evidence classification system is defined as follows:

- Group A, Human Carcinogen: Sufficient evidence to support a causal link between chemical exposure and cancer in humans
- Group B, Probable Human Carcinogen: B1 - Limited evidence of carcinogenicity in humans; B2 - Sufficient evidence of carcino-

genicity in animals, with inadequate or no evidence in humans

- Group C, Possible Human Carcinogen: Limited evidence of carcinogenicity in animals, and inadequate or no human data
- Group D, Not Classifiable as to Human Carcinogenicity: Inadequate or no evidence of carcinogenicity
- Group E, Evidence of Noncarcinogenicity in Humans: No evidence of carcinogenicity in adequate human or animal studies

Noncarcinogenic Effects

Dust and chemicals that are inhaled can cause direct toxic effects in the lungs or they can be absorbed through the lungs into the bloodstream and have effects on other organs. Effects that last hours to days are considered short-term while effects that last weeks to years are considered long-term. Direct effects on the lungs can be short-term, such as cough and allergic responses (i.e., asthma), or they can be long-term, such as chronic bronchitis (characterized by daily cough and phlegm production that continues for weeks or years). Indirect effects are usually long-term and include skin disease, nerve damage, and kidney damage.

3.1.3.6 Toxic Effects of Specific Chemicals of Concern

Particulate Matter

Particulate matter is the term that is used to describe substances that exist as discrete particles over a wide range of sizes. It includes liquid droplets and solids that come from gaseous emissions and from windblown dust. The portion of total suspended particulates (TSP) that is of most concern for human health is the portion with diameters less than 10 μ, known as PM_{10}. Particles greater than 10 μ are removed in the nasal passages, whereas those less than 10 μ enter the lungs and can be absorbed into the bloodstream (EPA, 1986). The particle itself may cause a tissue reaction (such as pollens that cause an allergic reaction) or it may act as a carrier for toxins (such as heavy metals). In general, there is a greater health risk from exposure to chemicals in the form of fine particles in inhaled air than from ingestion (Lambert et al., 1992).

Particulate matter can cause acute (immediate) respiratory symptoms and may lead to chronic (long-term) lung damage. Acute effects include allergic reactions and irritant effects. Pollens, fungi, and metals such as chromium and beryllium can cause allergic reactions, including the spasm and swelling of airways known as asthma. Respiratory symptoms such as cough and phlegm production can occur from the irritant effects of particulates. Chronic effects include cancer from some chemicals that are inhaled as particulates and lung damage that can occur from repeated episodes of asthma or bronchitis brought on by exposure to particulates. Respiratory illness in childhood has been reported as a risk factor for the development of respiratory diseases in adulthood (Samet et al, 1983).

Several population groups are at increased risk from PM_{10} because of problems with their lung defense mechanisms (Lambert et al, 1992). Infants are at increased risk because their lung defense systems are immature, while the elderly are at increased risk because their lung function is reduced and their defense systems are impaired. Patients with asthma are at risk because their airways are very sensitive to particulates, and patients with emphysema or chronic bronchitis are at risk because of their reduced lung function. Smokers have both impaired defenses and underlying lung damage.

It is difficult to separate the effects of particulates from those of other pollutants because they almost always occur together. However, a study in Utah Valley found that there were increased hospitalizations of children for respiratory illnesses when PM_{10} was high but other pollutant concentrations were low (Pope, 1991). Another study found that children had a higher risk of developing cough and bronchitis when particulate levels were high, even when particulate levels were below the current 24-hour air quality standard of 150 $\mu g/m^3$ (Dockery et al., 1989). However, this study did not find changes in the children's lung function measurements associated with the PM_{10} levels.

There is no clear threshold for adverse health effects from PM_{10} (EPA, 1986). EPA has concluded that long-term effects are not likely to occur from long-term exposure at levels under 80 μg/m^3 (annual average). Based on these findings, EPA set a 24-hour PM_{10} standard of 150 μg/m^3 and an annual standard of 50 μg/m^3.

Arsenic

Arsenic is a component of manufactured metal alloys, electrical devices, glass, wood preservatives, agricultural chemicals, and is also used as a therapeutic agent. The element is distributed widely in natural soils; typical concentrations found in U.S. soils have been between 1 and about 30 mg/kg (Kabata-Pendias and Pendias, 1987). Most arsenic releases to the environment occur as byproducts of metal smelting and refining activities.

Arsenic is readily absorbed via the oral and inhalation routes. The EPA (1984) assumes that, on the average, 70 to 80 percent of arsenic inhaled is absorbed in the respiratory tract. Skin absorption is not significant (EPA, 1984).

Acute exposure of humans to high levels of arsenic has been associated with gastrointestinal effects, nerve damage, and effects on the blood system. Long-term exposure of humans to arsenic can produce toxic effects on the nervous system, skin damage, and damage to heart and blood vessels (EPA, 1984).

Arsenic is classified as a known human carcinogen (Group A) by EPA. Studies of workers in smelters and in plants manufacturing arsenic-based pesticides have shown that inhalation of arsenic is strongly associated with lung cancer and perhaps with some liver tumors (EPA, 1984). The Occupational Safety and Health Administration (OSHA) has set a limit of 10 μg/m^3 for arsenic in workplace air. This standard is designed to protect workers who are exposed to arsenic dust for 8 hours a day. Ingestion of arsenic (such as by populations consuming drinking water with high arsenic concentrations) has been linked to a form of skin cancer and more recently to bladder, liver, and lung cancers (Tseng et al., 1968; Chen et al., 1986).

Iron

Iron is distributed throughout the environment in soils. It is commonly used in industrial processes including mining, iron, and steel manufacturing, and arc welding. It is also one of the most frequently used medical therapeutic agents. Although iron is an essential human nutrient, it can have toxic effects at high doses.

Effects that occur after ingestion of an overdose of iron include intestinal damage, bleeding abnormalities, and liver damage. Health problems that occur after long-term exposure to iron include liver damage, diabetes, and heart damage (Goyer, 1986).

Most inhalation exposures occur in miners or workers in metal industries. These exposures may cause iron particles to become deposited in lungs and can lead to scarring and damage. Dose levels that cause this type of scarring are in the range of 10,000 μg/m^3 (Goyer, 1986). Iron is not considered a carcinogen.

3.2 INDIRECT AIR QUALITY IMPACTS

Many of the SOS alternatives would result in a decrease in the amount of hydroelectric power generated by the Columbia River system. The SOR Power Work Group determined that electricity would have to be purchased from existing sources, or new generating resources would have to be developed to replace the lost generation (see Appendix I for a detailed discussion of generating impacts and replacement power responses). Either type of power supply response would have indirect effects on air quality through emissions from thermal power sources. Purchasing replacement power would involve utilities from the Pacific Northwest, Canada, or California. Each of these regions has a different generating resource mix that includes thermal power to some degree, and that would involve a varying potential for air quality impacts. Acquiring new resources in the Pacific Northwest would also likely involve thermal power; natural gas–fired cogeneration or combustion turbine power plants have accounted for all or nearly all of the recent additions to the power generating capacity of the Pacific Northwest.

One of the consequences of generating electricity from thermal power sources is air emissions. Air pollutant emissions vary considerably for different thermal power technologies. Air quality impacts from various electric power sources were discussed in detail in the Resource Program EIS (BPA, 1993). BPA's recent Business Plan EIS also includes estimates of emissions from a mix of combustion technologies which are summarized below (BPA, 1995).

The evaluation of emissions from thermal power sources makes use of the different resources available in the Pacific Northwest. The SOR Power Work Group assumed that all of the lost power would be replaced by new natural gas–fired combustion turbines, existing combustion turbines, existing coal–fired power plants, and by purchasing power. About 230 MW of power from cogeneration facilities is assumed for all alternatives. Additional replacement power is assumed to come from existing combustion turbines and, if needed, coal–fired plants. Additional power, if required, would be purchased from sources outside the region.

Total emissions for criteria air pollutants were estimated for each SOS alternative using the emission factors presented in Table 3–5. The emission factors presented in Table 3–5 are for controlled emissions. Although CO_2 is not a regulated air pollutant, emissions for this pollutant have been included because of global warming concerns. The emission estimates for the SOS alternatives are presented in Section 4.4.

Table 3–5. Air Pollutant Emission Factors

Pollutant	Emission Factors by Combustion Technology (metric tons per average Megawatt)			
	New Combustion Turbines	Existing Combustion Turbines	Existing Coal–Fired Plants	Power Purchase
SO_2	0.01	0.03	8.63	0.03
NO_x	0.42	5.27	21.56	5.27
CO	0.61	2.02	1.53	2.02
Particulate Matter	0.15	0.03	1.30	0.03
CO_2	3,313	3,542	8,843	3,542

CHAPTER 4

ALTERNATIVES AND THEIR IMPACTS

Chapter 4 describes the results of the air quality impact analysis for the SOS alternatives. Section 4.1 provides a summary of the alternatives. Predicted PM_{10} concentrations resulting from the emission rates developed in Section 3.1 are presented in Section 4.2. Human health concerns regarding elevated PM_{10} concentrations are presented in Section 4.3. Finally, potential indirect impacts due to chemical emissions from thermal plants are summarized in Section 4.4.

4.1 GENERAL DESCRIPTION OF ALTERNATIVES

Seven alternative System Operating Strategies (SOS) were considered in the Draft EIS. Each of the 7 SOSs contained several options, bringing the total number of alternatives considered to 21. This Final EIS also evaluates 7 operating strategies, with a total of 13 alternatives now under consideration when accounting for options. Section 4.1 of this chapter describes the 13 alternatives and provides the rationale for including these alternatives in the Final EIS. Operating elements for each alternative are summarized in Table 4–1. Later sections of this chapter describe the effects of these alternatives on air quality.

The 13 final alternatives represent the results of the third analysis and review phase completed since SOR began. In 1992, the agencies completed an initial effort, known as "Screening" which identified 90 possible alternatives. Simulated operation for each alternative was completed for five water year conditions ranging from dry to wet years, impacts to each river use area were estimated using simplified analysis techniques, and the results were compared to develop 10 "candidate SOSs." The candidate SOSs were the subject of a series of public meetings held throughout the Pacific Northwest in September 1992. After reviewing public comment on the candidate strategies, the SOR agencies further reduced the number of SOSs to seven. These seven SOSs were evaluated in more detail by performing 50–year hydroregulation model simulations and by determining river use impacts. The impact analysis was completed by the SOR workgroups. Each SOS had several options so, in total, 21 alternatives were evaluated and compared. The results were presented in the Draft EIS, published in July, 1994. As was done after Screening, broad public review and comment was sought on 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 1/2 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 13 alternatives have been evaluated through the use of a computerized model known as HYDROSIM. Developed by BPA, HYDROSIM is a hydroregulation model that simulates the coordinated operation of all projects in the Columbia River system. It is a monthly model with 14 total time periods. April and August are split into two periods each, because major changes can occur in stream

Table 4–1. SOS Alternative–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 1b** • Minimum project flow 3 kcfs • No refill targets • Summer draft limit of 5–10 feet	**SOS 2c** Operate on system proportional draft as in SOS 1a **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	**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

KAF = 1.234 million cubic meters MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–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 5c** Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a **SOS 6d** 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 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	**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

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4–1. SOS Alternative–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 Alternative–2

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a **SOS 5c** Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a **SOS 6d** 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 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 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 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a **SOS 5c** Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a **SOS 6d** 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 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.	**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.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4–1. SOS Alternative–3
Actions by Project

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

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

1 kcfs = 28 cms   1 ft = 0.3048 meter

Table 4–1. SOS Alternative–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 Alternative–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 Alternative–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 Alternative–5

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b	**SOS 6b**	**SOS 9a**	**SOS PA**
• 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	Same as SOS 5b	• 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	• 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
SOS 5c	**SOS 6d**	**SOS 9b**	
• Operate to flood control during spring • Refill in June or July and maintain through August • Draft for power production during fall	Same as SOS 5b	• 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	

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4–1. SOS Alternative–6
Actions by Project

	SOS 1	SOS 2	SOS 4
LOWER SNAKE	**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 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 2c** • Operate reservoirs within 1 foot above MOP from April 16 to July 31 • Same as SOS 1a for rest of year **SOS 2d** Same as SOS 2c	**SOS 4c** Same as SOS 2c

	SOS 1	SOS 2	SOS 4
LOWER COLUMBIA	**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 1b** Same as 1a, except no restrictions on 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 2d** Same as SOS 2c	**SOS 4c** Same as SOS 2c, except operate John Day within 2 feet of elevation 263.5 feet Nov. 1 through June 30

KAF = 1.234 million cubic meters MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–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 6d** 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 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 9c** 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

flows in the first and second half of each of these months. The model is based on hydrologic data for a 50–year period of record from 1928 through 1978. For a given set of operating rule inputs and other project operating requirements, HYDROSIM will simulate elevations, flows, spill, storage content and power generation for each project or river control point for the 50–year period. For more detailed information, please refer to Appendix A, River Operation Simulation.

The following section describes the final alternatives and reviews the rationale for their inclusion in the Final EIS.

4.1.1 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 1990–91 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 1990–91, 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.

4.1.2 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 1992–93 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 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.

4.1.3 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).

4.1.4 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.

4.1.5 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.

4.1.6 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 1/2 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 1/2 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.

4.1.7 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. 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.

4.1.8 Rationale for Selection of the Final SOSs

Table 4–2 summarizes the changes to the set alternatives from the Draft EIS to the Final EIS. SOS 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, which was 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. SOS 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 SOS 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

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 SOS2c Final Supplemental EIS Operation – No–Action Alternative	SOS 2 Current Practice SOS2c 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	
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 Balance Impacts Operation** **SOS Preferred Alternative**

Bold indicates a new or revised SOS alternative at Libby for Kootenai River white sturgeon. Such modifications are included in several other alternatives, namely SOS 2d, 9a, 9c, and the Preferred Alternative.

SOS 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 SOS 9a and 9b. Public comment also did not support continued consideration of the SOS 3 alternatives.

SOS 4 originally included 5 options in the Draft EIS. They were similar in operation and impact. In SOS 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 IRC for the Biological Rule Curves and by eliminating SOS 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, SOS 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 1/2 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 1/2 month drawdown strategies (SOS 5a, 6a, and 6c) have been dropped from the Final EIS. However, 2 1/2 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 3 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 3 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. SOS 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. SOS 7b and 7c have been dropped, but SOS 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 1/2–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 or specific projects that are outside the range considered reasonable. Therefore, this alternative has not been carried forward into the Final EIS.

The Preferred Alternative 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 *Idaho 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.

4.2 ESTIMATED WIND–GENERATED PM_{10} EMISSIONS

Following EPA's methodology, PM_{10} emissions were estimated for three projects and all of the SOS alternatives, using representative maximum wind speeds and estimates of the area of exposed sediments. The emission rates were presented in Figure 3–3. Emissions representative of most of the alternatives for each of the three projects studied were modeled to predict PM_{10} concentrations with distance from the shoreline. The emission estimates and the modeling used the maximum 1–hour wind speed expected during the drawdown period. The modeling investigated concentrations resulting from winds blowing directly off the reservoir and perpendicular to the shoreline (90 degrees) and winds nearly parallel to the shore (10 degrees). Perpendicular winds will result in the highest concentrations at some distance from the source. Winds nearly parallel to the shoreline will generate the largest concentrations adjacent to the exposed area. The predicted 1–hour concentrations were converted to 24–hour concentrations by assuming that the winds removed all erodible material in 1 hour. PM_{10} concentrations as a function of distance from the exposed area are plotted for the three projects in Figure 4–1.

PM_{10} concentrations resulting from blowing dust are high for areas immediately adjacent to the source of the dust. The largest concentrations are associated with winds that are nearly parallel to the shore. For these winds a much larger exposed area is contributing to the concentrations immediately adjacent to the beach area. These winds will move the sediment material down the beach in such a manner that PM_{10} concentrations quickly diminish with distance from the beach area. Winds perpendicular to the exposed area will generate higher relative concentrations at some distance from the source. At greater downwind distances more of the exposed surface contributes to the total concentration, but the greater distance also provides greater diffusion. The maximum predicted concentrations adjacent to the exposed area, the distance to a predicted 24–hour concentration less than the AAQS, and the distance to predicted 24–hour concentration equal to 5 $\mu g/m^3$ are presented in Table 4–3.

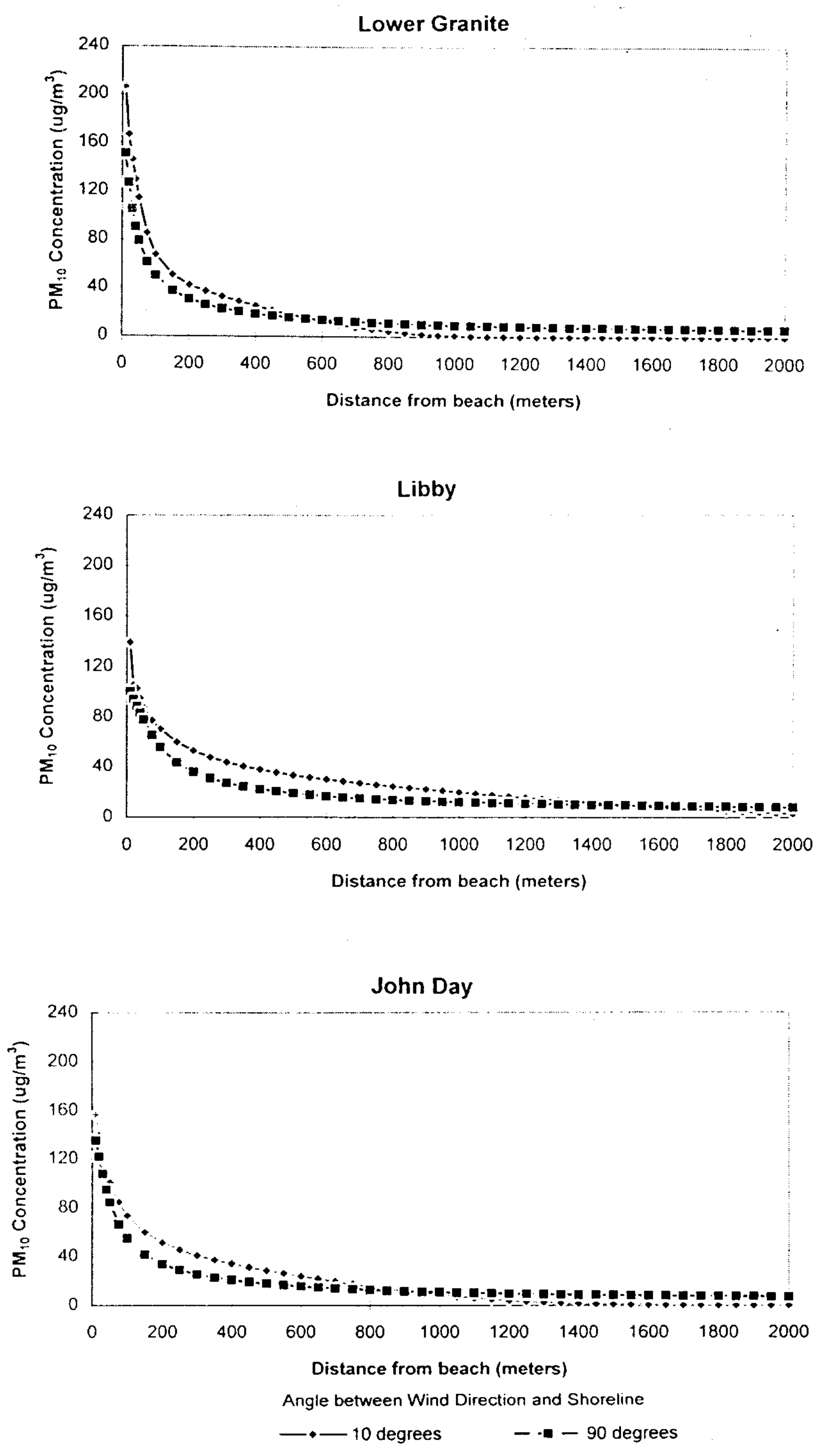

Figure 4–1. PM_{10} Concentrations for Lower Granite, Libby, and John Day

Table 4–3. Maximum Predicted PM_{10} Concentrations

Project	Maximum concentration (μg/m³)	Downwind distance (m) to concentration	
		150 μg/m³	5 μg/m³
Lower Granite	206	30	2900
Libby	139	0	4600
John Day	157	20	3750

Larger concentrations than those presented in Table 4–3 are possible with higher wind speeds. Because the concentrations are predicted with maximum 1–hour wind speeds, faster winds would also be of shorter duration. Concentrations less than the 24–hour PM AAQS occur within 20 to 30 m of the area of exposed sediments. The larger concentrations will be restricted to areas immediately adjacent to the source of the emissions. Winds perpendicular to the shoreline can result in significant concentrations (greater than 5 μg/m³) at distances of about 3 to 5 km from the beach area. The frequency of occurrences of winds strong enough to generate large PM_{10} concentrations is on the order of once or twice in 5 years. Windblown dust is the consequence of high wind speeds, which promote atmospheric dispersion. High PM_{10} concentrations resulting from industrial emissions and wood smoke tend to occur during stagnant inversion conditions. High PM_{10} concentrations resulting from inversion conditions and high wind speeds will occur at different times.

Only the PM_{10} monitoring stations at Lewiston, Clarkston, and Sandpoint are located within 5 km of an SOR reservoir. Significant emissions are most likely to take place during the dry season when the background particulate matter concentrations are also high. The area of exposed lake sediments, the orientation of high wind speeds, and the smoothness of the dry sediments are all unknown factors that contribute to the magnitude of the windblown emissions. It is not possible at this time to predict how wind–generated PM_{10} and TSP concentrations will interact with the Clarkston–Lewiston background concentrations.

Sandpoint, located on the northern side of Lake Pend Oreille, is also a PM_{10} nonattainment area. For most of the alternatives Lake Pend Oreille will be drafted from October to March when the weather conditions are cold and wet. SOS 9a would result in August elevations averaging 5.6 feet (1.7 m) below full. This would expose shallow areas on the eastern side of Lake Pend Oreille. Sandpoint is located near the outlet of the lake where the channel is comparatively narrow and steep. Wind–generated emissions from SOS 9a probably would not affect the Sandpoint nonattainment area. The monitoring program being conducted by the Corps in the Libby area is designed to address the issue of how much particulate matter originating from exposed lake sediments is measured at inland monitoring locations.

Tribal populations living on the Colville and Spokane Reservations would be subject to dust emissions resulting from exposure of the Lake Roosevelt shoreline, which is not one of the three reference reservoirs for which emission calculations were performed. The general physical characteristics (such as the influence of wind direction and proximity to the source) of these emissions would be as described previously in Section 4.2. Emission concentrations near Lake Roosevelt would tend to be less than the potential emissions calculated for Libby, the example storage project included in the calculations, because drafting depth and shoreline exposure for Lake Roosevelt are consistently less than that for Libby in the simulations of the SOS alternatives. Average pool elevation fluctuations for Libby range from about 60 to 130 feet (18 to 40 m), depending upon the SOS, while the range for Lake Roosevelt is from about 30 to 60 feet (9 to 18 m). Based on elevation patterns only, the potential for windblown dust from Lake Roosevelt would be greatest with SOSs 1, 5, 6 or 9c, and would be least under SOS 4c. The summer draft limits included within SOS PA would serve to limit shoreline exposure, and therefore dust emissions, during the dry summer months under this alternative.

4.3 HUMAN HEALTH CONCERNS

Two potential concerns were addressed in the human health component of the air quality analysis. Adverse health effects can occur from high airborne levels of PM_{10}, which consists of particles small enough to bypass the nose and upper airways, enter the lungs, and be absorbed into the bloodstream. In addition to possible health effects from the PM_{10}, health problems from inhalation of chemicals bound to the sediments could occur if the concentrations in the air are high enough.

PM_{10} emissions were estimated using EPA methodologies and maximum wind speeds for all of the SOS alternatives and for three projects, Lower Granite, Libby, and John Day. Representative emissions from these projects were modeled to predict PM_{10} concentrations as a function of distance from the area of exposed sediments. The largest concentrations are located immediately adjacent to the source of the emissions. The concentrations quickly decrease in magnitude with distance from the beach area. Concentrations resulting from winds that are nearly parallel to the shoreline would approach values comparable to background concentrations within a short distance from the source of the emissions. When the winds are perpendicular to the shoreline concentrations approaching background would occur at much greater distances from the beach area. People exposed to the highest concentrations could experience respiratory problems. Concentrations greater than the 24–hour PM_{10} standard (150 $\mu g/m^3$) could cause coughing and phlegm production or worsen asthma and bronchitis conditions in sensitive individuals. The most sensitive individuals would include young children, older adults, smokers, and people with underlying lung problems such as asthma or emphysema. High PM_{10} concentrations are predicted to occur within a short distance from the source of the emissions. Health effects could be exacerbated if the background concentrations were already high.

The Sandpoint nonattainment area is the only area located adjacent to a project reservoir where the background PM_{10} concentrations are already high. Shallower areas of Lake Pend Oreille that would be exposed because of drafting are located at some distance to the east of Sandpoint. And only SOS 9a includes a mid–summer drawdown period for Lake Pend Oreille that would expose much lake bottom. High background concentrations resulting from industrial emissions or from wood smoke would not occur during high wind speed wind events.

Chemicals have accumulated in Columbia River Basin sediments, primarily as a result of emissions from industrial, agricultural, and transportation activities. When these sediments are exposed by reservoir drafting, the chemicals bound to the sediments can become airborne. Although the large particles are filtered out by the nose and upper airways, residents or recreationists near the shoreline could inhale chemical contaminants attached to PM_{10}. The resulting health problems could include cancer or non-cancer effects (such as nerve damage), and would vary depending on which chemical is inhaled.

Lake Roosevelt and Lower Granite Reservoir are the only projects for which chemical sediment concentrations are available, and data for these projects are incomplete. These two projects 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, and Lower Granite receives discharges from industrial operations and municipal wastewater discharges from sources just upstream (including a pulp and paper mill) in the Lewiston, Idaho-Clarkston, Washington area.

Chemical concentrations that had been measured in sediments at Lake Roosevelt and Lower Granite indicate that airborne concentrations greater than the Washington ASILs, which are air quality standards for chemical contaminants that are designed to protect human health, are possible.

A complete analysis of the potential for toxic and hazardous air pollutants resulting from drafting the reservoirs would require site–specific data on meteorological conditions, sediment composition and concentrations of pollutants of concern, water elevation patterns corresponding with high–wind events, and periods of exposure. These data were not reasonably available for the Final EIS analysis, so the chemical dimension of the human health concern has not been explicitly accounted for in this analysis. However, the SOR agencies do not believe that this is a significant information gap that would otherwise change conclusions from the impact analysis. Because any chemical contaminants would be attached to PM_{10} particles, the potential dispersion of chemicals in the reservoir sediments is addressed by considering the dispersion of PM_{10} emissions from the reservoirs. In addition, the analysis does identify the two reservoirs for which the existing sediment sampling data indicate that chemicals in the sediments are most likely to be a concern. Decision makers can apply this knowledge as they evaluate the relative impacts of the SOS alternatives, and especially as they consider the specific impacts of SOS PA.

4.4 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). Additional thermal generation would increase air pollution around the affected thermal plants. Chemical emissions from these power plants 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 power plants that serve the regional are located in Washington, Oregon, and California this impact could occur locally or in other regions.

SOS alternatives that would cause a substantial loss in total annual energy generation could result in two types of responses to replace power supplies. One response 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 power plants, which would result in impacts to air quality. Both cases are described in more detail in Appendix I.

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, 1993). 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 Pacific 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.

Several large coal-fired power plants currently serve the region. There is also a nuclear power plant on the Columbia River in Washington. Each plant is licensed so that operation at maximum capacity will not cause exceedance of any AAQS. No area immediately influenced by emissions from these plants is designated by air pollution control agencies to exceed air quality standards. Therefore, no violations of local air quality standards would be likely to occur as a result of system operations. If power were imported from California, it is possible that air quality there could be affected.

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 Pacific Northwest, Canada, or California. Each of these three sources has a different resource mix that would involve different potential for indirect air quality impacts. Other Pacific 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. Given the diversity of potential choices available for power purchase, it is not possible to specifically predict the source(s) and location(s) of potential air quality effects.

Loss of hydropower must be replaced by power generated by new facilities, existing facilities, purchased from other sources, or a combination of all of these options. The amount of replacement power for each alternative was estimated in BPA's Business Plan EIS (BPA, 1995). The amount of air emissions resulting from generating replacement power for each alternative can be determined from the emission factors presented in Section 3.2 and the amount of power required. The amount of air pollutants emitted for each alternative is presented in Table 4–4. The emissions are projected for two years, 1996 and 2004. By 2004 new combustion turbines and cogeneration plants would be on–line to provide replacement electricity.

Table 4–4. Total Air Pollutant Emissions by SOS

Alternative	Air Pollutant Emissions (thousands of metric tons per year)[a]									
	1996					2004				
	SO	NOx	TSP	CO	CO	SO	NOX	TSP	CO	CO
1a	34	87	5	7	36,295	38	106	6	11	46,807
1b	33	86	5	7	35,774	38	106	6	11	46,443
2c	34	88	5	7	36,907	37	107	6	12	47,279
2d	34	88	5	7	37,193	36	99	6	11	46,289
4c	34	89	5	8	37,524	37	107	6	12	47,575
5b	35	93	5	9	39,733	38	111	6	13	50,355
5c	35	94	5	9	40,199	38	109	6	13	50,469
6b	34	89	5	8	37,641	37	106	6	12	47,950
6d	34	88	5	7	37,037	37	106	6	12	47,340
9a	35	94	5	9	40,853	35	98	6	11	48,850
9b	35	93	5	9	39,932	35	99	6	11	48,042
9c	35	93	5	9	39,824	36	103	6	12	48,869
PA	34	91	5	8	38,612	35	98	6	11	46,836

[a] 1 ton = 907.2 kg

CHAPTER 5

COMPARISON OF ALTERNATIVES

The primary purpose of Chapter 5 is to compare the potential air quality effects across the SOS alternatives. This chapter also includes discussions of potential mitigation measures for the alternatives, cumulative effects, and unavoidable adverse effects.

5.1 DIRECT AND INDIRECT EFFECTS

The primary air quality issues of concern are emissions from exposed dry sediments and emissions resulting from generating replacement electricity. These issues, in relation to the SOS alternatives, are discussed below.

5.1.1 Fugitive Emissions

The air quality analysis has indicated that PM_{10} concentrations immediately adjacent to the exposed sediments could be high, but these short term concentrations would quickly diminish with distance from the beach area. Furthermore, periods of blowing dust would be relatively short, lasting only as long as erodible material is available (on the order of 1 hour). Incidences of blowing dust are highly dependent upon meteorological conditions; dry uncrusted sediments must be exposed to high wind speeds. Sustained wind speeds less than about 9 m/sec (20 mph) may not be enough to remove substantial amounts of dust (Section 3.1). High wind speed events occurring when dry lake sediments are susceptible to wind erosion take place at a frequency of only a few hours per year. Erodible particulate matter is available only if the surface has been disturbed since the previous erosion event. Erodible material deposited on other areas will be available for suspension by other high wind speed events. The angle of the wind with respect to the shoreline helps to determine the downwind dust concentrations. A wind nearly parallel to the shoreline will generate high PM_{10} concentrations immediately adjacent to the exposed area; these concentrations will quickly diminish with distance from the beach area. A wind nearly perpendicular to the shoreline will result in lower initial concentrations which will quickly diminish with downwind distance, but which will also elevate the background concentrations for up to 3 to 5 km from the reservoir.

PM_{10} emissions for three projects, Lower Granite, Libby, and John Day, where the amount of exposed sediments may be most extensive, were estimated in Section 3.1. While other projects will experience exposure of lake sediments, the amount of area exposed will vary depending on the change in surface elevation and the slope of the shore area.

The data necessary to predict windblown PM_{10} concentrations for all of the reservoirs is not reliable enough to be included in this analysis. The amount of PM_{10} emissions is indirectly related to the surface elevation of the reservoirs; lower elevations will expose more sediments which, for the right wind conditions, will result in relatively larger ambient PM_{10} concentrations. The potential for high PM_{10} concentrations can be discussed because the surface elevations of the reservoirs is known.

The hydroregulation model predicted annual average surface elevations of the 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 proportional to the amount of shoreline exposed for that alternative, and is also dependent on other unknown factors such as the slope of the shoreline. 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} concentrations. The differences in the annual average surface elevations by project and alternative are indicated in Table 5–1. Negative values in Table 5–1 indicate lower surface elevations.

There is little or no change in annual average reservoir elevation at the McNary and Chief Joseph projects for all of the alternatives. These projects would not experience increases in ambient PM_{10} concentrations resulting from blowing sediments. Large drawdowns (an annual average of more than 5 feet) are expected for SOSs 5b, 5c, 6b, and 9a for the Ice Harbor, Lower Monumental, and Little Goose projects. Large drawdowns for Lower Granite are expected for SOSs 5b, 5c, 6b, 6d, and 9a. The surface elevation at Dworshak would decrease for SOSs 2d, 9b, and PA. Lower elevations are expected at Brownlee for SOSs 1a, 1b, 9a, 9b, 9c, and PA. Large drawdowns are predicted for Grand Coulee for SOSs 9a and 9b. Lower elevations are expected at Libby for the SOSs 9a and PA, and Hungry Horse for SOS 9a.

Windblown emissions are dependent on wind speed. Three different wind speeds were used in the emissions calculations. Emissions calculated using the fastest mile results 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.

PM_{10} emissions for Lower Granite, Libby, and John Day, for all alternatives, were estimated in Section 3.1 (see Figure 3–3). For Lower Granite the greatest calculated emissions are a result of SOS 5b. Emissions for SOS 5c would equal those of SOS 5b until the exposed sediments were vegetated or washed away by rains. Emissions for SOSs 6b, 6d, 9a, and 9c are considerably less than for SOS 5b. Emissions for the remaining alternatives are small.

The Libby emission factors are actually smaller than those for Lower Granite. However, the exposed areas for Libby are much larger, resulting in higher emission rates for all alternatives. Emissions calculated with the maximum 1–hour wind speed are moderate and are all about the same value.

The predicted John Day emissions are moderate for SOSs 5b, 5c, 6b, 6d, 9a, and 9c. Emissions for the other alternatives are less.

Table 5–1. Change in Average Annual Surface Elevation, by Project and SOS

Project	SOS Alternative											
	1a	1b	2c	2d	4c	5b	5c	6b	6d	9a	9b	9c	PA
John Day	4	4			3	−6	−6	−6	−6	−5		−6	−6
McNary													
Ice Harbor						−96	−96	−32		−32	−1		−1
Lower Monumental						−107	−107	−32		−31	−3		−3
Little Goose						−112	−112	−31		−31	−3		−3
Lower Granite						−112	−112	−30	−30	−30	−2		−2
Dworshak	16	24		−29	31	32	32	32	32	2	−43	−4	−48
Brownlee	−11	−11								−13	−30	−30	−8
Chief Joseph													
Grand Coulee				−2	−2					−41	−18	−8	−9
Albeni Falls					−3					−7	−2	−1	
Libby	−3	−4		−4	1	−3	−3	−3	−3	−63	−10	1	−16
Hungry Horse		−3			25					−53	8	25	7

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. Several project reservoirs are located in areas where nearby monitoring data indicates that the background PM_{10} concentrations are high (Table 2–2). These areas include Ice Harbor (located near Kennewick and Wallula Junction), Grand Coulee (located relatively near Spokane), Albeni Falls (located near Sandpoint), Libby (located near Libby), and Hungry Horse (located near Whitefish). Large background concentrations in the industrial areas such as Spokane will take place during periods of stagnant winds and low–level atmospheric inversions. High wind–generated emissions 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 (Section 4.2). For Lake Pend Oreille the shallow areas are located a considerable distance to the east of Sandpoint. It is not expected that the reservoirs would contribute to an ambient concentrations greater than the AAQS at any of the monitoring locations.

The lake sediments may contain contaminants which, when dry, could become part of the wind-blown emissions. Based on measured sediment concentrations, large concentrations of these contaminants could result in a health threat. Data necessary to rigorously estimate emissions of hazardous and toxic air pollutants resulting from drafting are not available. Alternatives that would expose the greatest amount of sediments in areas where industrial discharges have contaminated the sediments will have the greatest potential for hazardous and toxic emissions.

5.1.2 Emissions from Generating Replacement Electricity

Replacement power would be generated by a mix of natural–gas fired combustion turbines, coal–fired plants, or purchased power. Combustion turbines would be either new or existing facilities. Air emissions from these sources of replacement power were presented in Chapter 4 for the SOR alternatives and two projected years, 1996 and 2004. SOSs 5b, 5c, 9a, 9b, and 9c would result in the greatest amount of air emissions in 1996. By 2004, SOSs 5b and 5c would produce greatest amounts of air emissions. By 2004 SOSs 1a and 1b would generate higher amounts of SO_2; SOSs 1a, 1b, 2c, 4c, 6b, and 6d would produce greater amounts of NO_x; and SOSs 9a, 9b, and 9c would generate greater amounts of CO_2.

If new generating plants are required, it is likely that these units would be natural gas–fired combustion turbines built with emission control devices such as Selective Catalytic Reduction (SCR) for CO and NO_x emissions, advanced low–NO_x combustion units, or 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 construction and air discharge permits. The plants would probably also be subject to Prevention of Significant Deterioration (PSD) regulations and to New Source Performance Standards (NSPS) set forth in 40CFR Part 60 Subpart GG. New facilities would be built only if they comply with all applicable emissions and ambient standards, including the AAQS.

5.2 CUMULATIVE EFFECTS

Having determined the particulate matter and airborne chemical consequences that could result from system operations, thorough consideration of the potential impact on public health and welfare requires addressing other sources in the region which could contribute particulate matter to the ambient air. Since the reservoirs are generally located well away from highly urbanized industrial areas, the major contributing sources are expected to be predominantly rural in nature. The most common such sources include unpaved roads, agricultural tilling, woodsmoke, isolated industrial sources, and off-road recreational vehicles.

Unpaved roads occur near the reservoirs in a number of locations. During periods of dry weather they would contribute significantly to local particulate matter concentrations. Nearby residences that burn wood for heating would also contribute fine particles and some toxic air pollutants. However, the periods when industrial emissions and wood smoke would contribute to air quality problems would not likely coincide with periods when dry lake sediments are likely to become airborne.

In some areas, such as along the lower Snake River reservoirs and John Day, the primary source of particulate matter would probably be agricultural fields.

Lower Granite Reservoir can be used to provide a representative estimation of the magnitude of particulate matter concentrations which could add to reservoir concentrations. Clarkston, Washington and Lewiston, Idaho (on Lower Granite Reservoir) comprise the largest affected urban area with a population of approximately 40,000. There are several industrial sources in the area. The second highest 24–hour and highest annual average PM_{10} concentrations in the Clarkston/Lewiston area, from 1992 through 1994, were 119 and 42.9 $\mu g/m^3$, respectively. This is less than the National AAQS of 150 and 50 $\mu g/m^3$, respectively. PM_{10} concentrations are predicted to be large immediately adjacent to the source of the emissions, and quickly diminish with downwind distance to 24–hour concentrations equal to about 5 $\mu g/m^3$. The resulting annual average concentrations would also be small, less than 1 $\mu g/m^3$. When these concentrations are added to 119 and 42.9 $\mu g/m^3$, the resulting concentrations are still less than the AAQS.

The Lower Granite example is probably typical of potential cumulative effects at other reservoirs. There probably are other, existing sources of particulates near all of the reservoirs where operations could produce blowing dust. (Even at Hungry Horse, where there is a very low level of adjacent development, unpaved roads circle the reservoir and would generate dust.) Reservoir-generated dust would add to the particulates from other sources.

Future conditions with respect to existing sources of particulates and cumulative effects are difficult to predict. Improvements in air quality have been noted in both the scientific and popular literature, although these have typically involved chemical emissions from vehicles and other combustion sources in large urban areas. Future ambient air conditions near the SOR reservoirs will be determined by a variety of offsetting or complementary factors that affect rural areas. Population growth could be expected to increase particulates from woodsmoke, for example, while equipment emission standards and burning regulations would tend to reduce woodsmoke pollution. Overall, the most important determinant of cumulative effects is likely to be changes in agricultural practices or acreage.

5.3 MITIGATION MEASURES

Dust control measures could theoretically be used to mitigate the air quality effects of the SOS alternatives. Dust control methods would decrease the amount of dust generated when reservoir sediments are exposed, but may be impractical for the Columbia River system. Such mitigation methods could include planting vegetation along shorelines so that less shoreline soil is exposed (thus reducing the total dust load when sediments are exposed) or erecting wind barriers along the shoreline in the primary wind direction. For the large reservoirs in the Columbia River system, the cost of these measures would be prohibitive. The technical success of measures such as seeding would also be questionable, and wind barriers would have aesthetic drawbacks. Timing reservoir drawdowns to occur during the months when the ground is frozen or wet would also reduce dust production and in fact, most drawdowns would occur during these months. However, there are many other factors affecting the timing of drawdowns which may take precedence over air quality concerns. Restricting all-terrain vehicle (ATV) and other vehicle use along shorelines during the drawdowns would decrease the amount of dust generated, but could be difficult to enforce.

5.4 UNAVOIDABLE ADVERSE EFFECTS

Unavoidable adverse effects are those effects that would occur regardless of any measures taken to mitigate effects for a given action. Some degree of exposure of sediments in the reservoirs system's storage is unavoidable, as these reservoirs could not be kept full year-round and still meet the authorized project purposes. If reservoir drafting occurs under dry and windy meteorological conditions, sediments would become airborne as particulate matter. Air quality near the reservoirs would be diminished. People near the reservoirs would be exposed to PM_{10} concentrations above background concentrations. In addition, people near the reservoirs could be exposed to any chemicals that are in the sediments and become airborne, unless the sediments can be remediated. No other unavoidable adverse effects related to air quality are expected as a result of the SOS alternatives.

5.5 INCOMPLETE INFORMATION

As described in Section 3.1, the Corps is currently in the process of developing local air monitoring data for the Rexford-Eureka area near Lake Koocanusa. Results from the monitoring program were not available in time for publication in the Final EIS. The monitoring results and any associated revisions to the conclusions of the air quality analysis will be considered in the future as system operations are periodically reassessed.

The Corps air monitoring program at Libby is the only currently active program to address air quality conditions associated with the reservoirs of the Columbia River system. Based on the Libby results and future operating experience with the selected SOS, the SOR agencies may determine that air quality monitoring at additional reservoirs would be appropriate.

CHAPTER 6

LIST OF PREPARERS

The Air Quality Technical Appendix was prepared by Foster Wheeler Environmental Corporation (formerly Enserch Environmental), a consulting firm under contract to BPA. Individuals who contributed to the report are listed in Table 6–1. Contributors are listed by name, education/years of experience, experience and expertise, and role in technical appendix preparation.

Table 6–1. List of Preparers

Name	Education/Years of Experience	Experience and Expertise	Role and Preparation
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CHAPTER 7

GLOSSARY

AAQS: Ambient Air Quality Standard

Acute: Of sudden onset and lasting days to weeks.

AIRS: Aerometric Information Retrieval System

ASIL: Acceptable Source Impact Level

aMW: Average megawatt

Asthma: A chronic respiratory illness in which there is swelling and constriction of the airways causing wheezing and shortness of breath. It is often caused by an allergic response to an inhaled substance.

ATV: All–terrain vehicle

BPA: Bonneville Power Administration

Carcinogen: A chemical that causes cancer in animals or humans.

Chronic bronchitis: A chronic lung disease that lasts for months to years characterized by daily cough and phlegm production. Over time, chronic bronchitis can cause permanent damage to the lungs.

Chronic: Of gradual onset and lasting months to years.

Corps: U.S. Army Corps of Engineers

Detection Limit (DL): The lowest amount that can be distinguished from the normal "noise" of an analytical instrument or method.

EIS: environmental impact statement

EPA: U.S. Environmental Protection Agency

ESA: Endangered Species Act

Exposure: Contact of an organism with a chemical or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut) and available for absorption.

Exposure Route: The way a chemical or physical agent comes in contact with an organism (e.g., by ingestion, inhalation, dermal contact).

Exposure Pathway: The course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., air) or media (in cases of intermedia transfer) also is included.

Exposure Point: A location of potential contact between an organism and a chemical or physical agent.

FWS: U.S. Fish and Wildlife Service

Inhalation: A route of exposure that occurs when airborne substances are inhaled through the nose or mouth into the lungs. Substances can be absorbed into the bloodstream from the lung.

Intake: A measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time (e.g., mg chemical/kg body weight–day). Also termed the normalized exposure rate; equivalent to administered dose.

Long–term: Generally lasting months to years.

NEPA: National Environmental Policy Act

NMFS: National Marine Fisheries Service

Non–detects (NDs): Chemicals that are not detected in a particular sample above a certain limit, usually the quantitation limit for the chemical in that sample. Non–detects may be indicated by a "U" data qualifier.

OSHA: Occupational Safety and Health Administration

PM_{10}: Fine particulate matter; smaller than 10 microns in diameter.

ppm: Parts per million

Respirable: The portion of dust that is small enough (less than ten microns in diameter) to enter the lungs and be absorbed into the bloodstream.

ROSE: River Operation Simulation Experts

SEIS: supplemental EIS

Short–term: Generally lasting days to weeks.

SOR: System Operation Review

SOS: System Operating Strategy

Toxicity: The nature and extent of adverse health effects caused by a substance.

TSP: total suspended particulate

UCL: upper confidence limit

WDOE: Washington Department of Ecology

$\mu g/m^3$: Micrograms per cubic meter

95 percent upper confidence limit of the mean: A statistical method which generates a number that gives 95 percent certainty that the actual mean or average of a group of numbers is below it. Using this number instead of the calculated mean gives an additional protection factor when determining chemical concentrations to which people could be exposed.

CHAPTER 8

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