Columbia River System Operation Review

Final Environmental Impact Statement

Appendix M

Water Quality

BONNEVILLE POWER ADMINISTRATION

US Army Corps of Engineers
North Pacific Division

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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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.

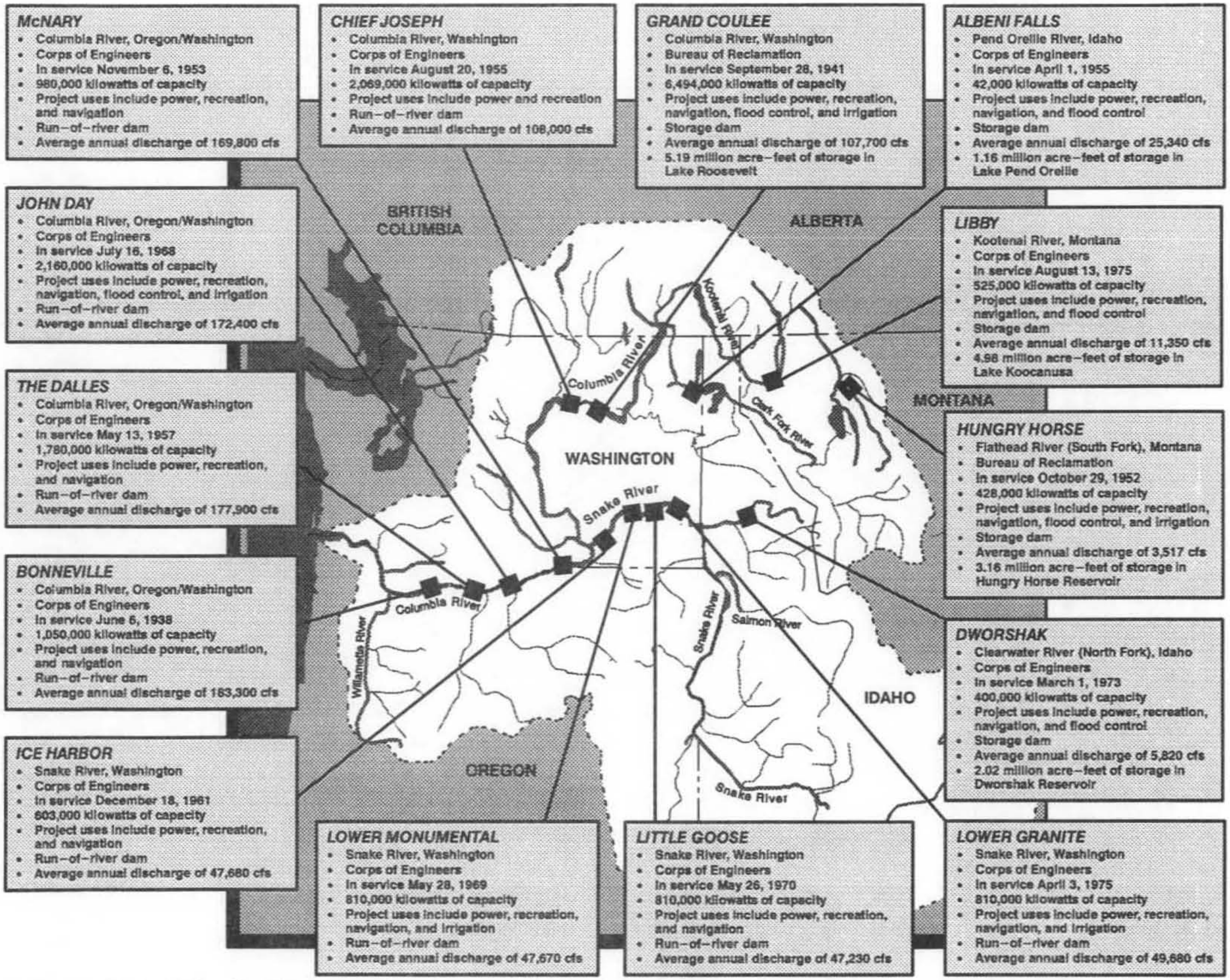
WHAT DO THE TECHNICAL APPENDICES COVER?

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 Water Quality appendix relies on supporting data contained in Appendices H and O. For complete coverage of all aspects of water quality, readers may wish to review all three 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.

SUMMARY

Water is what people everywhere associate with the Pacific Northwest. Every other resource evaluated in the System Operation Review either influences or is influenced by water quality.

Analysis of water quality begins with an account of the planning and evaluation process, and continues with a description of existing water quality conditions in the Columbia River Basin. This is followed by an explanation how the analysis was conducted. The analysis concludes with an assessment of the effects of SOR alternatives on water quality, Chapter 4, and a comparison of alternatives, Chapter 5.

S–1 DEFINITION AND BACKGROUND

S–1.1 Water Quality Issues Raised During Scoping

There is strong support for improved water quality in the Northwest. This was revealed in public meetings, correspondence, and personal communications associated with scoping for the System Operations Review.

Citing the importance of water quality to human health, fish, wildlife, and economic growth, many people sought inclusion of the resource in the SOR. Water quality issues which were raised included:

- watershed conditions;
- pollution from industry, particularly pulp and paper mills;
- discharge of municipal sewage;
- stream siltation;
- elevated water temperature;
- return flows from irrigated land, frequently laden with pesticides and herbicides;
- dissolved gas saturation;
- condition of domestic drinking water.

It was suggested that programs be implemented to educate the public, water users, and natural resource managers about water quality issues. Establishment of a Columbia River Basin Authority for measuring and monitoring water quality was proposed. The use of Canadian treaty water to control pollution was recommended. Water quality studies were requested. Priority was given to maintaining high water quality for anadromous fish and reducing wasteful irrigation practices.

S–1.2 Areas of Controversy

There is some disagreement about the validity and reliability of models used to analyze some 30 water quality parameters. This is primarily due to the insufficiency of information about water quality problems other than temperature and dissolved gas saturation (see discussion below). Predictions about the future condition of water in the Columbia River Basin differed based on speculation about pending regulation, pollution abatement methods, and irrigation practices.

S–2 MAJOR CONCLUSIONS OF THE WORK GROUP

S–2.1 Findings

To a varying degree, all of the SOR alternatives affect water quality. However, the ability to remedy existing and future water quality problems by altering system operations is limited. None of the alternatives evaluated would completely control water temperature, because of physical project limitation. All alternatives call for some spill and, hence, would continue to cause high dissolved gas saturation levels. Lower Snake River reservoir drawdown alternatives would create significant bank and mud flats erosion, although the impacts of sediments resuspended and transported during this operation are not expected to extend beyond McNary Dam. None of the alternatives would create additional dredging for navigation. Many of the alternatives calling from drastic changes in water flow and circulation patterns could affect existing federal permits issued under NPDES and the Clean Water Act.

Predicted water quality impacts are graphically summarized in Figure 5–5 on page 5–17.

S–2.2 Choice Among Alternatives

Adverse impacts on water temperature could be reduced if enough cool water was stored in reservoirs for use in the summer season. Dissolved gas supersaturation problems would not exist if spill could be eliminated entirely. Sediment transport and high turbidity would not occur if reservoir pools did not fluctuate below normal operating range, leaving normally submerged banks exposed to the natural elements. Most water quality problems would not be serious if sufficient flows could be maintained year–round to dilute or assimilate contaminants.

A water quality alternative meeting all these requirements could not be formulated because of the physical properties of structures on the river and conflicts in the requirements of different water users. Although slightly more favorable conditions were observed for water temperature and total dissolved gas in pre–Endangered Species Act operations than in the base case alternatives, only the natural river options produced more visible improvements in those two areas.

The natural river option imposes no restriction on flow and sediment movement and, therefore, eliminates spill during the time window the Lower Snake River reservoirs are drawdown to river bed level. It can still rely on headwater storage projects to provide sustained minimum flows. Increased bank and mud flats erosion and sediment transport, however, would increase turbidity, and nutrients and contaminants concentration in the lower Snake River and further downstream for some period of time. Providing the required bank protection and coping with increased sediment loading could be cost–prohibitive.

Given these considerations, a combination of alternatives built around the natural river option is more likely to be best for water quality. Any such combination would need to take into account impacts to other water users as well. Even within a given alternative, system regulation during extreme flow years may need to be different from that used in an average year, because of variability in water quality data.

S–2.3 Recommendations for Future Study or Referral to Appropriate Agencies

1. A more comprehensive, whole river water quality study of the Columbia River Basin would fill current knowledge gaps and increase the chance of success of future water quality improvement programs. There is a continuing need to know and to closely monitor progress made in protecting and enhancing water quality in the Pacific Northwest.

   The absence of data was particularly acute in the realm of industrial and agricultural pollution. Information about the concentrations and possible movement of trace metals, dioxin, radionuclides, fertilizer, and pesticides is incomplete or missing. The return of water into the river from irrigated agricultural lands is a major concern. Insufficient data made reliable modelling of these problems difficult or impossible. Also needed is a better understanding of the interaction of contaminants and river processes. Recommendations for improving these limitations are given in Chapter 5.

2. Mitigation measures to minimize adverse impacts on fish and aquatic life should include facilities to reduce water temperature and total dissolved gas saturation, where feasible, and new strategies for protecting anadromous fish during periods of high water temperature and high dissolved gas saturation.

3. Since water quality problems are caused by sources both internal and external to the streams, they should be resolved jointly by project owners and operators; relevant state, municipal, and federal regulatory agencies; and the public. Point and nonpoint source and extra–basin pollution, and dredging requirements for navigation need to be taken into account. Education programs are needed to improve public understanding of reservoir operating policies and regional and local issues.

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CHAPTER 1

SCOPE AND PROCESS

1.1 IDENTIFICATION OF WATER QUALITY ISSUES

Because water is the element upon which the river system operates, an assessment of water quality has very broad implication. Water quality issues for analysis in the SOR emerged from three sources:

1. written accounts of known water quality problems in the media or scientific literature;
2. public comment at SOR scoping and coordination meetings;
3. a survey of federal, state, county, and local agencies in the Columbia River Basin.

Once defined, these issues were considered at length by regional technical water quality specialists participating in the SOR Water Quality Work Group.

1.1.1 Known Historical Water Quality Issues

Concern about degradation of water quality in the Columbia River Basin began in the 1930s. Hydropower development, irrigated agriculture, logging, mining, stream channelization, and urbanization were contributing factors. The following abstract from a recent paper by Stober and Nakatani published in Water Quality in North American River Systems, Battelle Press, 1992 summarizes many of the central issues:

"Hydroelectric and agricultural development has changed the quantity and timing of seasonal run-off. Impoundments have modulated temperature extremes in the main stem, delaying the annual thermal maximum below Grand Coulee about 30 days. Warm temperature occurs seasonally at the mouths of tributaries, which may delay the return of adult salmonids to spawning grounds. High spill at dams may supersaturate the river water with air and cause gas bubble diseases in fish.

"Dissolved oxygen levels are adequate in the main stem Columbia River but have been depressed in some tributaries by irrigation withdrawal and returns, and by waste loads from municipal and industrial activities. Specific conductance, nitrate–nitrite, sodium, sulfate, chloride, and temperature in the main stem generally increase downstream. The Snake and Willamette rivers account for the major input of total nitrogen and phosphorus to the Columbia River. Suspended sediment tends to increase in subbasins with logging and agriculture. Seasonal turbidity from suspended sediments has declined in the main stem since the mid–1950s because of impoundments. Toxic chemicals (pesticides, PCBs, and trace metals) have been found in fish of the Columbia River Basin, resulting in at least one recent human health advisory".

1.1.2 Water Quality issues raised by the public and agency coordination.

1.1.2.1 Public Scoping

The SOR Interagency Team conducted 14 meetings throughout the Pacific Northwest during the summer of 1990. During and after these meetings, the public responded in oral testimonies, letters, comment cards, and transcription of small group sessions. The following issues, concerns, and ideas are excerpted from the Comment Summary prepared in January 1991 by the SOR Interagency Team:

- water quality must be part of SOR (Lake Spokane Association, King Hill Irrigation District, Trout Unlimited, U.S. Soil Conservation Service);
- continued support of water quality programs to better educate water users and managers (Riverview Grange);

- mitigate stream siltation and chemical pollution; develop an educational program on the enhancement of water quality in watersheds;
- water quality is important to wildlife;
- water quality and anadromous fish runs are most important concerns;
- the biggest eutrophication problem was at Hanford, when hot water was expelled;
- industrial and non–industrial pollution must be stopped if all of the benefits of the Columbia are to be maintained;
- the priority must be to keep the river clean;
- SOR process needs to include water quality decisions;
- to prepare for twice as many people in the year 2030, a Columbia River Basin Water Quality Authority must be established to measure and monitor water quality;
- the water quality of the Columbia River must be maintained and in some cases improved (Bureau of Indian Affairs);
- no more discharges of radioactive wastes from Hanford and marine effluents; sewage and the like should not be allowed to further pollute the waters;
- system should be managed so as to maintain and enhance water quality and fish and wildlife habitat (University of Montana);
- Libby dam's selective withdrawal system should be used and the [Kootenai] river be kept at optimal temperature for [resident] fishery improvement (Kootenai Fly Fishers);
- ecosystem alteration is irreversible when egg, fry, and smolt exposure to fungal, bacterial, and viral pathogens cannot be mitigated because of inadequate water movement, high water temperatures, and changes in water quality;
- hot water released by Hanford, fertilization, accumulation of pesticides, mining, stripping forests, and other large sources of point pollution harm salmon;
- reservoir drawdown alternatives should include flushing rates over the dam under different drawdown and water retention time conditions (Upper Columbia Tribes);
- water budget and spill plans and other flow regimes have a significant effect on river management;
- good Clearwater River flows are needed for dispersal of effluent from pulp and paper operations: if a conflict develops with maintaining high Dworshak reservoir levels, flows for effluent dispersal should take precedence (Potlach Corp.);
- exposed sand bars and mud flats, undercut cliffs, and eroded banks make Lake Roosevelt dangerous during periods of low water; turbid water makes the lake dangerous during high water (Stevens County Assessor);
- any redirected waters back to the Columbia should be carefully monitored for pollutants as well as temperature, flow changes, or diversion techniques; such clean–up would include getting rid of pesticides and herbicides, phosphate and nitrates, and industrial wastes, especially dioxins from pulp mills;
- stringent habitat, land use, conservation, pollution control, and education programs should be developed within each watershed to mitigate stream siltation, chemical pollution, and flooding;
- fish and wildlife needs should be built in as hard constraints in the long–term plan of operation (U.S. Fish and Wildlife Service);
- consultation with agencies that are mandated by [Montana] state law to administer water management programs needs to be part of the review (Montana Department of Natural Resources);

- agriculture and aquaculture returns are putting an enormous silt and nutrient load [on the Snake River between Milner and Bliss dams] and the dams have blocked much of the rivers natural flushing action (Wood River Resource Conservation);

- point discharge on the system and Canada is still raw sewage;

- use of treaty with Canada should also incorporate pollution control along the Columbia River (Lake Spokane Protective Association);

- study as to why the algae is taking over the Snake River (King Hill Irrigation District).

There were additional public comments during the 14 SOR Mid–Point Review Public Meetings held in the fall of 1992. Sixty–six written testimonies and 136 comment sheets were received from the public. Issues raised at these meetings included the need to maintain high water quality to protect anadromous fish, and increased water conservation to limit wasteful irrigation practices.

1.1.2.2 Agency Water Quality Letter Survey of Professionals

The water quality work group conducted a limited letter survey of regional government agencies involved in water quality. Respondents were asked to identify and rank 20 contaminants and physical parameters from a list of 50. The list included the following groups: conventional parameters, toxic chemicals in water and sediments, semi–volatiles, nutrients, bacteria, and radionuclides. Seven river reaches were considered:

1. International border to Grand Coulee Dam (Columbia)
2. Grand Coulee Dam to Snake River confluence (Columbia)
3. Snake River confluence to Bonneville Dam (Columbia)
4. Snake River
5. Yakima River
6. Willamette River
7. Bonneville Dam to the Pacific Ocean (Columbia)

The most important parameters from the list of 50 were ranked from 1 to 20, most to least important. The resulting weighted averages are summarized in Table 1–1. Responses to the letter survey were very limited but generally reflected a consensus of water quality specialists representing several agencies.

1.1.2.3 Water Quality Work Group Scoping

As indicated above, the water quality problems in the Columbia River Basin are quite diverse. The system operation review explores a range of strategies based on the manipulation of river flows and the water surface elevation in project reservoirs. Dissolved gas saturation, water temperature, and turbidity issues can be addressed, at least partially, by these strategies. Other water quality problems are either remotely or not at all related to hydropower operations. Information required to make the connection between system operations and water quality in those cases may also be unavailable.

Water conditions required by various river users differ and sometimes conflict. Meeting the needs of anadromous fish, for instance, can be at the expense of resident fish, recreation, navigation, flood control, and power. The design of an alternative satisfying all these requirements is impossible. Instead of attempting to create a "water quality alternative" the group decided to assess the water quality implications of alternatives designed to meet other objectives. They also formulated reservoir operating rules for improving water quality or preventing its degradation.

Table 1-1. Top Twenty Water Quality Parameters

< ..... river reaches ..... >

Reach 1 Border to Grand Coulee	Reach 2 G. Coulee to Snake Riv.confl	Reach 3 Snake R. to Bonneville	Reach 4 Snake R.	Reach 5 Yakima	Reach 6 Willamette River	Reach 7 Bonneville to Ocean
1 DIOX/FUR	DISSGAS	PESTICIDES	TEMP	TEMP	DIOX/FUR	DIOX/FUR
2 DISSGAS	PESTICIDES	DISSGAS	TSS	PESTICIDES	PCB	PESTIC.
3 Cd	Hg	DIOX/FUR	DISSGAS	TURB	TEMP	PCB
4 Pb	TEMP	TEMP	PESTICIDES	DDT	PESTICIDES	Al
5 Hg	Cd	Pb	TOTPHOSPH	TSS	Cu	TEMP
6 AS	DIOX/FUR	Hg	TURB	TOTPHOSPH	Pb	DDT
7 Zn	As	As	SOLPHOSPH	TKN	Hg	DISSGAS
8 PCB	Pb	PCB	AMMONIA	AMMONIA	Zn	Cd
9 Cu	Al	VOC	DIOX/FUR	DISSGAS	TOTCOLIFOR	Hg
10 PESTICIDES	Zn	Cd	BOD	SOLPHOSPH	DDT	TSS
11 Al	Cu	TURB	TKN	BOD	CHLOROPHEN	BOD
12 Be	Se	Al	DDT	FECALCOLT	TSS	CHLOROP.
13 Cr	TURB	Cr	TOTCOLIFOR	Hg	TURB	Cu
14 Fe	Ce-137	Se	Ph	Ph	BOD	Cr
15 Ba	Ba	Cu	FECALCOL	Pb	pH	Pb
16 Ni	Be	Zn	TOC	TOTCOLIFOR	TOTPHOSPH	As
17 Ag	Cr	ADSORORG	Hg	Cd	Al	Zn
18 TOTPHOSPH	Fe	Ba	Pb	VOC	As	VOC
19 Se	Ni	Be	Cd	Cu	Ba	TOTCOLIF.
20 TEMP	Ag	Fe	VOC	Zn	Be	TURB

Notes:
(1) ranking is by order of importance, as perceived by the professional agencies surveyed. 1 is most important; 20, least important;

(2) standard chemistry symbols are used whenever applicable (See Chemistry Symbols in Part 7.0, Glossary of Terms and Acronyms). Other abbreviations/acronyms are as follows in their order of appearance in the table: DIOX/FUR= dioxin/furan, DISSGAS= dissolved gas, TOTPHOSH= total phosphorous ammonia, TEMP= water temperature, TUR= turbidity, ADSORORG = adsorbable organic, TSS = total suspended sediments, TKN= total Kjeldahl nitrogen, SOLPHOSP= soluble reactive phosphorous, BOD= biochemical oxygen demand, TOTCLIFOR – total coliform bacteria, TOC= total organic carbon, VOC= volatile organic compounds, FECALCOL= fecal coliform, CHLOROPHEN = chlorophenol.

The limited quantity, fragmentary nature, and quality of information can also be a serious handicap in describing and predicting water quality. The most critical deficiency is in data that address interactions between water quality problems and river operations. Additionally complicating the study of Columbia River Basin water quality is the large number of river systems involved. Each of these systems contains major reservoirs with unique characteristics. Analytical tools or models for addressing contaminants such as trace metals, radionuclides, and nutrients in this variety of settings need more calibration data to be reliable.

Water entering the study area from Canada and the upper Snake River basin compounds these problems. While originating outside the geographical scope of SOR analysis, the condition of these flows has a cumulative effect on water quality in the lower reaches of the river. Loss of the spring freshet and added flows during other seasons in particular were cited in many ways in which dams have changed conditions in the lower Columbia. Although not described in detail, the impacts of the entire reservoir system, both in the U.S. and Canada, on the habitat in the lower river were provided in this water quality appendix. A compilation of papers on impacts of the hydro system on the lower Columbia River can also be found in the anadromous fish technical appendix.

These limitations were also identified:

(1) only the broad, basinwide picture on the main stem Columbia/Snake Rivers was assessed, exclusive of any other tributaries;

(2) very little information is available linking contamination from point source pollutants such as pulp and paper plants and nuclear reactors to mainstem water quality;

(3) groundwater quality conditions and their relation to system operations could not be predicted;

(4) the areas downstream from Libby and Hungry Horse Dams were not modeled for water quality because of a lack of data; and

(5) daily variations of water quality parameters could not be predicted with the information provided by the hydroregulation model used in the System Operation Review.

Because of these limitations, quantitative analysis was confined to three parameters, dissolved gas saturation, water temperature, and sediments (turbidity). Other parameters which affect water quality, while important to overall environmental quality, were evaluated qualitatively. Sediment–associated nutrient and contaminant loads due to erosion were assessed quantitatively, but input data was so limited that model results had to be evaluated qualitatively. They should be reassessed during the next round of the SOR after sufficient data has been collected.

1.1.3 Areas of Controversy

There is disagreement about the validity and reliability of models used to analyze some water quality contaminants. Three major water quality conditions affected by system regulation ––water temperature, dissolved gas saturation, and suspended sediment –– can be modeled with reasonable accuracy. Other parameters could only be assessed qualitatively.

There are also differences of opinion about water quality in the future. They revolve around predictions about future legislation (re–authorization of the Clean Water Act) and advances in pollution control techniques and irrigation practices.

1.2 DEVELOPMENT PROCESS OF WATER QUALITY APPENDIX

Preparation of the Water Quality Appendix is a cooperative effort between the three lead agencies for SOR and other agencies and organizations with representatives on the water quality work group (see List of Preparers). The appendix is intended to provide an accurate picture of water quality conditions under existing conditions and those which would be produced by the implementation of a range of alternatives.

Interagency staff members performed the multitude of analyses needed to evaluate the relative merits of the proposed alternatives. They were guided by suggestions and assessments by the general membership of the work group and other interested parties. Outside contractors were also retained to assist with specific analysis and report writing.

Water quality work group members have demonstrated knowledge and experience that encompassed many aspects of water quality. They started meeting about once a month since mid–1991, and undertook numerous research and writing assignments.

1.2.1 Development of the Work Group

Interagency staff members were nominated by agency heads on the basis of current responsibilities in the field of water quality. Other work group members were invited after referrals disclosed interest in and knowledge about water quality. This included people associated with universities, private citizen groups, Indian tribes, and federal and state agencies. Representatives of the following agencies and groups were regular and continuing participants:

- U.S. Corps of Engineers
- U.S. Bureau of Reclamation
- Bonneville Power Administration
- U.S. Geological Survey
- U.S. Environmental Protection Agency
- National Marine Fisheries Services
- U.S. Soil Conservation Service
- Lake Roosevelt Water Quality Council
- Citizen For a Clean Columbia
- Oregon Department of Environmental Quality

Representatives from Portland State University (Civil Engineering Department), Environment Canada, Washington Department of Community Development, the Corps of Engineer's Hydrologic Engineering Center and Waterways Experiment Station, and U.S. Fish and Wildlife Service were occasional participants.

Many other state agencies and private citizens have asked to be included on the mailing list for minutes of meetings and other documents. This includes Oregon, Idaho, and Montana water quality specialists; coordinators of the Lower Columbia River Bi–State Program; and Corps of Engineers research institutions (Hydrologic Engineering Center, Davis, CA and Waterways Experiment Station, Vicksburg, MS).

1.2.2 Coordination with Other Work Groups

Since water is central to virtually every other resource involved in the SOR, close coordination with other work groups was essential. The water quality group routinely coordinated its activities with the anadromous fish, resident fish, irrigation, navigation, cultural resources, recreation, hydropower, and wildlife work groups. Input for and results from water quality models had to be available and consistent with information sought and generated by these other work groups.

Examples of information exchanges included impacts on water quality from irrigation return flows, data regarding ship movement, effects of water temperature, dissolved gas saturation, and turbidity on anadromous and resident fish, effects of sediment build–up and river bank erosion on cultural sites, and information about water transparency and purity for recreation.

A joint meeting was held with the anadromous and resident fish work groups to determine the nature and extent of their water quality objectives. Meetings with the anadromous fish group were also held to coordinate methodologies for predicting dissolved gas saturation.

Regulated flow data for each SOR alternative were obtained from the river simulation work group and the economics group provided methods for assessing water quality benefits. There was a continuous exchange of information about the content, format, and style of this document with National Environmental Policy Act guidance group. Sustained liaison was maintained between project managers and work groups on budgeting, scheduling, and overall coordination.

1.3 SCREENING ANALYSIS

More than 90 alternatives were initially developed by SOR work groups to address a full range of system operation possibilities. Some were extreme, providing for a single interest at the expense of other considerations. Others attempted to achieve some compromises to accommodate a number of resources.

Screening analysis was a rough, first–cut assessment to eliminate extreme alternatives from further consideration. Screening permits the grouping similar alternatives for full–scale analysis.

1.4 SELECTION OF ALTERNATIVES

Initial screening was useful in establishing how the system would respond to operations optimizing conditions for single resources. It helped identify alternatives that could solve specific problems, but would also negatively affect too many other water users.

Public comment on the results of screening analysis was then solicited at a series of meetings. The most promising alternatives in terms of predicted impacts on and potential acceptance by all water users were retained for a more complete, full–scale analysis. Many were combined with other variations to form alternatives with broader but generally compatible goals and objectives.

Full–scale analysis was a more detailed evaluation using state–of–the–art modeling to rate the relative merits of the various alternatives and rank them in terms of effects on water quality. The performance of each alternative was assessed both quantitatively and qualitatively based on predicted water temperature, dissolved gas saturation, and, when applicable, sediment transport.

The results of the water quality evaluation were combined with the results of other SOR other work groups and composite ratings were calculated for use in the selection of the recommended alternative(s).

1.5 FULL–SCALE ANALYSIS

To comply with the National Environmental Policy Act, full–scale assessment of all environmental effects associated with the implementation of each alternative was required. This included a "systematic, interdisciplinary approach which will ensure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision–making". Environmental indices were developed to characterize the relative significance of the predicted impacts.

Three different mathematical models were used to predict how each strategy would affect water temperature, dissolved gas saturation, sediment transport, and other water quality parameters. This process is described in detail in Chapters 3 and 4 of this document.

CHAPTER 2

WATER QUALITY IN THE COLUMBIA RIVER BASIN TODAY

2.1 INTRODUCTION

The Columbia River watershed encompasses a 259,000–square–mile area shared by two nations and six States (Figure 2–1). The river begins in British Columbia, Canada and flows through the states of Washington, Idaho, and Oregon to the Pacific Ocean. Its major tributaries are the Kootenay, Pend Oreille, Spokane, Snake, Yakima, Deschutes, and Willamette.

Other states and provinces located in the watershed are Alberta, Canada, Wyoming and Montana. There are several small and large rivers that enter into these tributaries. Each state has its own water quality standards, and management and monitoring programs. The waterways within the watershed are also regulated by several federal, state, tribal, and local agencies, each having responsibilities for water rights, allocation, flows, and operation of the system.

Compared with other regions in the nation, water in the Columbia River Basin is still relatively clean. Concern about the permanence of this advantage, however, has been growing. Population growth, mining, logging, agriculture, and industry have created and are continuing to create significant problems. Columbia River dams have been associated with the production or exacerbation of chemical, physical, and thermal pollution.

2.2 ACTIVITIES AFFECTING WATER QUALITY

Dams and Hydropower

The major purpose of dam construction on the Columbia was to prevent flooding and produce electricity. In most cases, irrigation, navigation, and recreation were secondary benefits. Dams impound water and can sharply reduce river velocity. As a result, sediment will either settle on the bottom of the reservoir or remain suspended in the reservoir's water column, potentially affecting turbidity and concentrations of contaminants in the reservoir or downstream. Sediment transport downstream of dams is affected because natural river processes replace the suspended sediment that was removed by the upstream dams.

Water released over spillways and heating (solar and geological) can also increase gas levels which can cause gas bubble disease in fish. Gas bubble disease can kill fish and may cause behavioral disorders. Fish tolerance to elevated gas pressure varies with fish species, life history stage, water temperature, hardness, depth, and length of exposure.

Water temperature is also affected by dams. After a stream is impounded, more of its water surface area becomes exposed to solar radiation, precipitations, evaporation, and wind effects. At the microclimatic level and depending on local conditions and mesoscale meteorological elements, new lakes may have some influence over weather and climate. Creation of large deep reservoirs normally causes stratification or layers of water with different physical and chemical properties. Dams can radically change the temperature and gas pressure of the water released downstream, impacting the aquatic ecosystem.

Flow releases from reservoirs are regulated by a series of operating rule curves designed to ensure that the dams perform their authorized functions. Actual releases, however, depend on run–off conditions. Generally, more water is stored and released during a high flow year than during a low flow year, resulting in different impacts on water quality in reservoirs and areas downstream from the dams. More flows also means higher potential for spill. As most of the Columbia and Snake River is now a series of stair–step impoundments (see Figure 2–2), the water moving downstream does not circulate sufficiently to rid itself of gas entrainment at the upstream dams. As a result, dissolved gas supersaturation created by spill at one dam will often stay at or above that initial saturation level as the water flows toward the ocean.

Dam operational measures could result in downstream scouring, increased gas supersaturation, decreased dissolved oxygen in deeper water, increased turbidity, and resuspension of contaminated fine sediments. Upstream impacts may include decreased water volumes and flows, increased temperatures, decreased dissolved oxygen concentrations, increased pollutant concentrations, and altered mixing of outfall discharges. These effects could result in violations of water quality standards.

Fisheries

Development of the dams and hydroelectric projects on the Columbia and Snake rivers has altered natural flows in those streams. Part of the natural spring run–off which juvenile salmon and steelhead relied on to make their outmigration to the ocean is now stored in reservoirs for use in drier parts of the year. To speed up fish travel time, the Northwest Power Planning Council established a water budget, a volume of water set aside for fish. It is released from upriver storage dams during the spring run (April 15 – June 15) to create an artificial freshet.

The original water budget amounted to a total of 4.03 million acre–feet –– 2.39 million acre–feet at Priest Rapids Dam and 1.64 million acre–feet at Lower Granite Dam. Since its inception in late 1982, the water budget has been increased several times. In 1993, the water budget provided by Dworshak Reservoir for the Lower Snake River was about 1.1 million acre–feet, and the water budget provided by the upper Columbia River reservoirs was about 6.45 million acre–feet. Release of this water augments flows in the main stem Columbia and Snake Rivers, and generally benefits water quality as well.

To reduce fish mortality at dams located along the juvenile migration routes, the Council's original Fish and Wildlife Program also called for an interim measure known as "spill for–fish–passage". Accordingly, sufficient water was spilled to keep the fish away from the turbines and to guarantee at least a 90 percent fish passage survival rate at each dam. Other performance criteria such as Fish Passage Efficiency (percent of fish passing a dam through a route other than the turbines) have also been used.

In 1989, a Fish Spill memorandum of agreement was signed between Bonneville Power Administration and several state, federal, and Indian Tribes fishery agencies specifying more finite spill percentages of the outflows at Lower Monumental, Ice Harbor, John Day and The Dalles Dams. These percentages, expressed in percent of daily average project outflows, were respectively 70, 25, 0, and 10 percent for the spring (April–May); and 70, 25, 20, and 5 percent for the summer (June–August). At Bonneville Dam, the Corps of Engineers spilled nightly 53 percent of the project outflow in the spring, and 41.5 percent of the project outflow in the summer.

Although spill for–fish–passage has been discontinued at Lower Monumental Dam, following completion of permanent fish bypass facilities at that project in 1992, it is likely to continue at other projects for some time. In the mid–Columbia River reach between Wells and Priest Rapids Dams, the mid–Columbia Public Utility District (PUD) dams continue spilling the amount required in their FERC licenses during June–August. This varies from about 2 to 20 percent of daily average project outflow.

Agriculture

Approximately seven million acres of farmlands were irrigated in the Columbia River Basin in 1990 (Columbia Basin Project Expansion Draft EIS, USBR). This included 3.3 million acres in Idaho, 0.4 in Montana, 1.9 in Washington, and 1.3 in Oregon. These figures were expected to remain fairly steady over the next 30 years. Water diverted for irrigation evaporates or transpires, seeps into the ground, or runs off the end of fields, eventually returning to the river or tributaries as a point or non–point source of pollution.

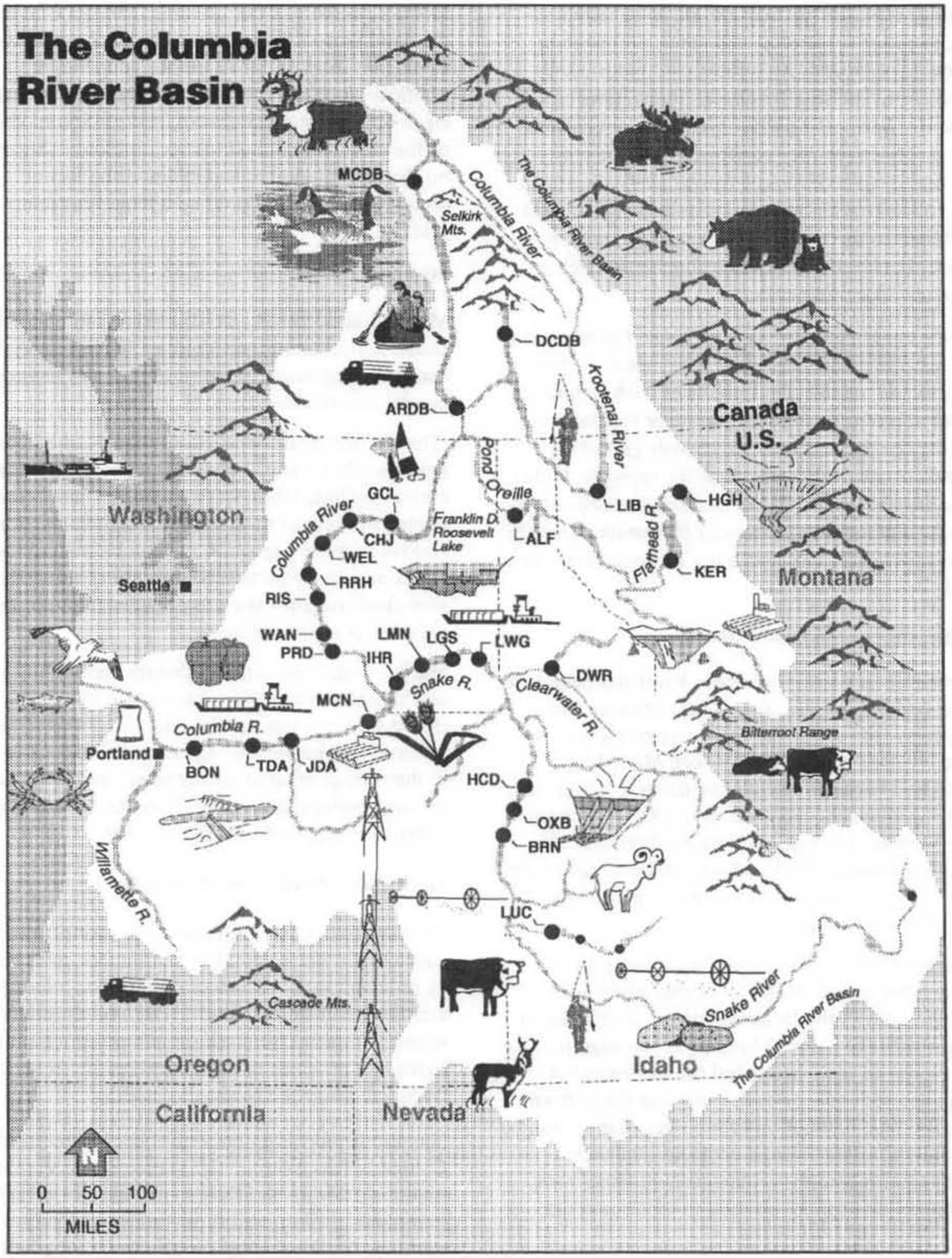

Figure 2–1. The Columbia River Basin

Irrigation return flows may elevate water temperatures, increase suspended sediments, and contain fertilizers, pesticides, herbicides, and natural salts leached from the soil. Irrigation return flows are frequently warm and polluted and can enter rivers, lakes, and groundwater supplies. High concentrations of phosphorous and nitrogen may cause small lakes to choke with aquatic weeds and algae. Dead plants sink to the bottom where they are broken down by bacteria, a biochemical process which consumes dissolved oxygen.

Livestock grazing adjacent to rivers and streams can have a significant impact on stream water quality. Poor grazing management practices destroy riparian habitat adjacent to streams and other vegetation necessary to prevent erosion. Heavily grazed watersheds usually exhibit less holding capacity; higher than normal spring run–off causes increased velocities and sedimentation. Streams that would normally run year–round can become dry or intermittent as a result.

Navigation and Transportation

Transportation on the Columbia River has been vital to the economy of the area. Wheat growers and many industries along the river depend on it to transport their products to market. Many large vessels and barges travel up and down the river daily requiring channels deep enough for them to navigate. Most of this traffic is between Portland, Oregon and Lewiston, Idaho where sufficient navigation draft has been maintained and dams are equipped with adequate navigation locks.

Dredging to maintain navigation channels, mostly between the mouth of the Columbia River and Portland, affects the hydrology of the river channel and disturbs the channel bottom. It can also increase the velocity of the current and the movement of suspended sediments, which can scour the bottom and shoreline. Disruption of the river channel can be detrimental to the riverine ecological balance. Dredging also disturbs sediments containing toxic substances that can be harmful to plants and animals.

The possibility of accidental spills from barges, other vessels, and trains running parallel to the river exists. Most are small spills of gasoline, diesel, or oil but the cumulative effect on the river's ecology may be significant. Larger, more serious spills require notification of the proper authorities and immediate clean–up measures. Because of the size and velocity of the river, containment is very difficult. Depending on the type of material spilled and the location, sections of the river could be affected for many years.

Mining

Mining has occurred extensively in Columbia River Basin. It has diminished significantly in recent years because of economic conditions and new environmental regulations.

The environmental effects of mining can be both long and short term. Erosion from soil disturbance creates sedimentation in rivers and streams. Some mining operations divert water from streams for various purposes; return flows can be polluted with toxins and heavy metals. Separation of minerals sometimes requires the use of chemicals and metals harmful to aquatic systems.

Mining in streams can also disturb stream bottoms and shoreline vegetation. Mines that have been closed for years can continue to affect streams when precipitation passes through mine tailings or cavities in the tailings created during mine operation. A restored water table can cause contaminated groundwater to resurge into nearby streams.

Timber and Wood Product Industry

The timber industry, extremely important to the economy of this region, has been under close scrutiny in recent years because of impacts to watersheds and fish and wildlife habitat. The wood product industry has also been criticized because of contaminated by–products and chemicals produced and discharged into the rivers and streams.

Numerous pulp and paper mills are located in the Columbia River Basin. The standard process often requires chlorine bleach. By–products of this process include dioxin and furans which are known carcinogens. Dioxin and furans have a long half life, which means they can remain in a riverine environment for several years.

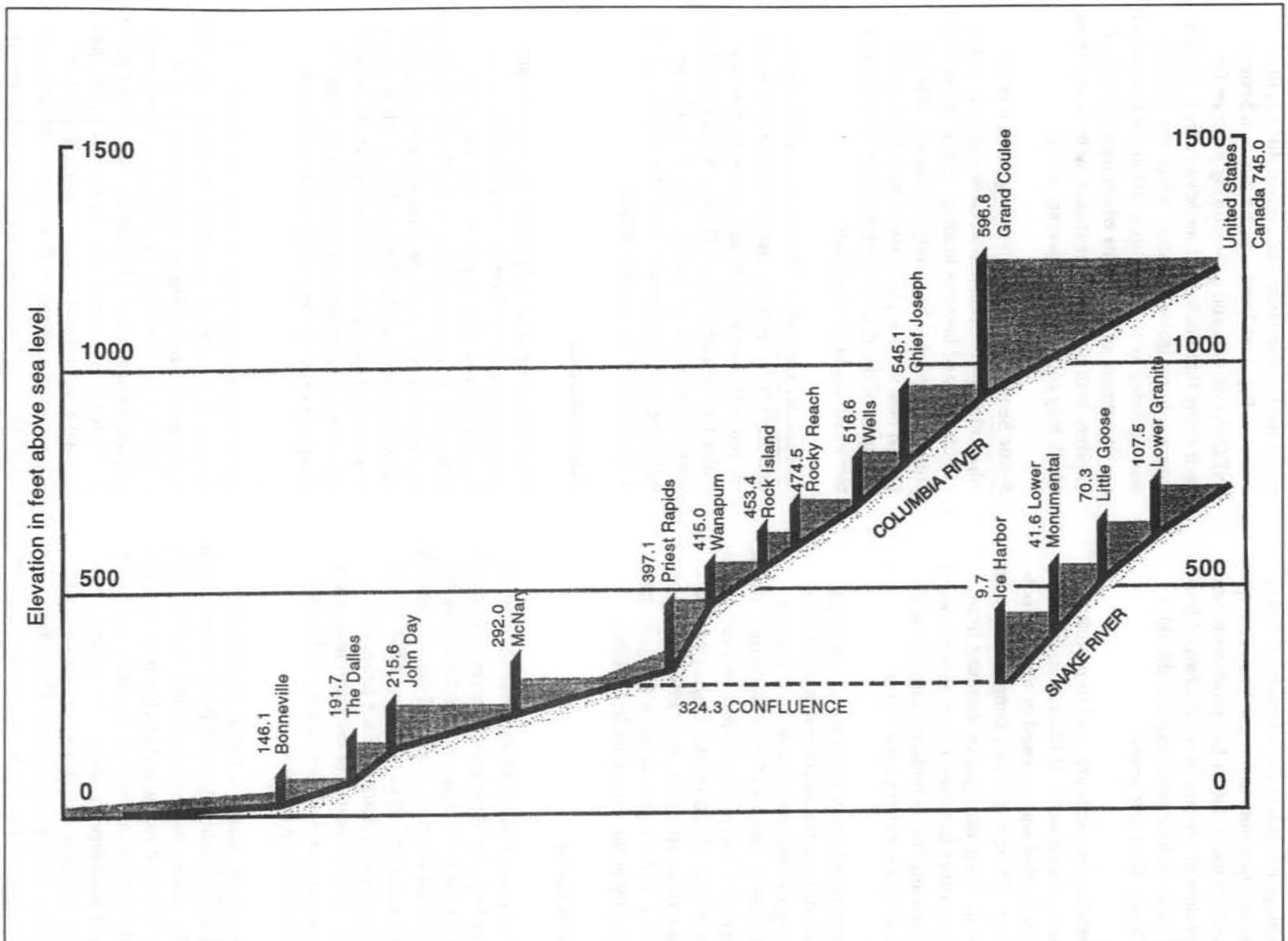

Figure 2–2. US Columbia River and Lower Snake River Dams (Showing River Miles)

New technology minimizes the emission of dioxin and furans, and new laws and regulation are requiring pulp mills to use it. Other by–products harmful to the environment are still being discharged into the river. These include other organic chlorides, acids and bases, fibre and resins.

Several harmful chemicals are used to produce plywood and pressed wood. If these chemicals are not properly treated and disposed of they can pollute the river. There are a few examples of streams and reservoirs being damaged by dumping from pulpmills and other factories. Lower summer water levels, by reducing the assimilative capacity of the streams, may make matters even worse.

Harm to watersheds from logging and associated road construction in the Northwest is well documented. Logging impacts streams and rivers by increasing erosion, temperature, and altering stream morphology. New logging techniques and recognition of the detrimental effects of past logging practices are reducing these effects to some extent. Nevertheless, logging is still a major factor in the degradation of water quality in the Columbia River Basin.

Urban Development

Urban development has increased over the past 50 years, spreading over thousands of acres of wetlands and affecting the natural geology. Wetlands are not only valuable habitat for a variety of fish and wildlife, but also act as natural sinks collecting, filtering and biodegrading organic detritus. Each town, city, home, and business located in the basin may affect the river's water quality depending on its location and type of treatment systems.

Sewage Treatment plants – Before the Federal Water Pollution Control Act (FWPCA) Amendments of 1972, the wastes discharged into the river by cities and towns were not monitored as closely as they are today. Although the majority of the cities and towns treated their discharged wastes, some organic compounds and inorganic chemicals were still entering streams. After Congress passed the Clean Water Act, section 303 required the states to develop instream water quality standards, and section 404 required National Pollutant Discharge Elimination System (NPDES) permits and a monitoring program for each entity that discharged wastewater from a point source into navigable streams. When the FWPCA was amended in 1977, Sections 307 and 402 required pre–treatment of pollutants which pass through or interfere with municipal treatment systems and those which may contaminate sewerage sludge.

Septic Sewage Systems – Septic systems located adjacent or near rivers and streams can be a source of nutrient, and bacteria loading. Septic systems are normally regulated by county ordinances. It is not known how many septic systems contribute to the pollution of the river's watershed, but their cumulative effect could be significant.

Stormwater run–off – The Environmental Protection Agency has recently determined that stormwater run–off from industry and municipalities is a major contributor to the pollution. Regulations have been adopted that require industry and cities to minimize and, if necessary, treat stormwater before it enters rivers, lakes, and streams.

Other Industries

Other industries that may affect the basin's water quality indirectly or directly are aluminum, food processing, and nuclear power. The aluminum industry is a major employer in the Pacific Northwest and requires very large amounts of electrical power. With the closure of the Trojan plant, nuclear power is a relatively small source of energy at the present time but could be more significant in the future if safety concerns can be satisfactorily addressed.

When industries are located near or adjacent to the river or its tributaries, industrial discharges can affect water quality depending on the type and level of treatment. For example, large nuclear power plants require large amounts of water for the cooling process. If this water is released into the river at higher than normal temperatures it could adversely affect the ecosystem. Accidental spills of radioactive material could also adversely affect the river's water quality.

PCBs in Water and Sediments

Polychlorinated Biphenyls (PCBs) are part of a group of synthetic organic chemicals known as chlorinated hydrocarbons. From 1929 to 1977, PCB–containing products were manufactured in large quantities because of their stability, and flame–retardant and heat–transfer properties. They were and still are widely used in motors, electrical equipment, electromagnets, pumps, cutting oils and some household appliances.

The properties which made PCBs attractive for use also made them an environmental and health liability. They are persistent, can concentrate their toxicity in the food chain, and are widespread, occurring everywhere in the world. PCBs accumulate at an average level of 2.3 ppm in human fatty tissue and an average of 1.2 ppm in human breast milk.

PCBS are stringently regulated under the Toxic Substances Control Act (TSCA) with strict labeling and disposal requirements. Since the TSCA's passage in 1976, the nation's industries have been phasing out existing PCBs. These efforts have concentrated on removing high level PCBs in the dielectric fluids of electrical transformers and capacitors, and in industrial machinery. Because transformers and capacitors tend to fail catastrophically, TSCA requires soil around a high level PCB spill to be removed for disposal as a hazardous waste. Many pieces of totally enclosed PCB–containing equipment such as household or industrial/commercial appliances still remain in service. Others have been buried in landfills. EPA's Virtual Removal program is intended to remove PCBs completely from service before they can escape to the environment. In the long term, this effort should prove less costly than treatment of contaminated areas that would result from future leakage of this equipment.

During the last decade, the Corps of Engineers conducted an aggressive PCB removal and replacement program to eliminate the risk of PCB releases at its dams on the Columbia and Snake Rivers. All of the transformers at these dams are now classified and labeled as non–PCB, as are the oil circuit breakers. For example, at Bonneville Dam, the last 12 oil circuit breaker bushings which might contain small amounts of PCBs are scheduled to be replaced by the end of 1995. There are no PCB capacitors in use at the dam. No PCB or PCB–contaminated equipment is in service at McNary Dam, nor at any of the Corps' Snake River dams.

Due to historical practices associated with their use, PCBs may have leaked or spilled into the soil or been transported into bodies of water. They can be expected in Columbia mainstem reservoirs because of contributions from tributaries and discharges from industrial sources, wastewater treatment plants and landfill leachates.

Monitoring of sediment, fish tissues and water during the Oregon–Washington Bi–State Study detected PCBs in several locations below cities in the study area, in rivers, ports and in the Columbia River estuary. Other monitoring programs, such as those associated with Lake Roosevelt and the Columbia River Integrated Environmental Monitoring Program (CRIEMP), detected PCBs and other persistent industrial pollutants in the bottom sediment of the Columbia on both sides of the interstate border. Additional monitoring is needed throughout the basin to delineate hot spots and conduct risk assessments. These sediment quality data should be entered into the National Inventory of Contaminated Sediment Sites and Sources, managed by the EPA Office of Science and Technology. Associated fish contamination data should be entered into the same national data base.

Under extreme river operations scenarios, there may be a risk of resuspension of sediment laden with PCBs, metals, pesticides if contaminated areas are disturbed. Most of the anticipated effects will fall within a range associated with current operations. However, the timing and duration of these effects may vary or be displaced seasonally due to changes in spill programs. The general lack of data on location and distribution of toxic substances such as PCBs does not allow accurate prediction of health effects or changes to chemical quality of the water. This must be remedied through a long term collaborative monitoring effort for these substances. During the May 1992 drawdown test in Lower Granite pool, samples taken contained no PCBs.

2.3 RESPONSIBLE AGENCIES AND GROUPS

2.3.1 Federal, State, and Local Agencies

The major federal agencies authorized to operate the dams and control the river for power and flood control are the U.S. Army Corps of Engineers and the Bureau of Reclamation. The Bonneville Power Administration works closely with these two agencies, with authorization to market and distribute the power generate at federal Columbia River Basin dams.

Other federal agencies responsible for land use activities and recreation on the river are the National Park Service (NPS), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), and U.S. Forest Service (USFS). The federal agency responsible for water quality within the river basin is the U.S. Environmental Protection Agency (EPA). Agency responsibilities often overlap, requiring close coordination to protect the resource.

There are several state, county, tribal, and local government agencies also responsible for the various activities on the river. The responsibility for water quality and associated land use practices, in most cases, flows from Federal to State, and State to county and local government.

Numerous efforts in the Basin include monitoring activities. These activities cover an array from water column chemistry to riparian condition to watershed land uses to fish surveys and even to some macro−invertebrate surveys. Major monitoring objectives of water quality monitoring in EPA and State water quality programs are :

- **comprehensive status and trends**
  problem identification/trends
  emerging problem characterization
- **watershed assessments**
  urveillance/screening
  regulatory decision making
  water quality−based control development
  investigation of cause−effect relationships
- **program effectiveness**
  compliance
  public information and education
  evaluation of measures and projects.

An example of comprehensive multi−agency basin-wide monitoring directly related to the operation of the Columbia River system is the Columbia and Snake Rivers Dissolved Gas Monitoring Program. This Program, in operation since the mid−1970s at Corps projects, was expanded to cover other non−Corps dams in 1984. The network currently consists of 33 automated stations located in the forebay and tailwater areas of most mainstem dams, with satellite linkage between the various measurement sites and the ground receive stations in Boise, Idaho and Portland, Oregon (Figure 2−3). Its objective is two−fold: 1) to provide the water quality data needed to adjust spill at Columbia and Snake River mainstem dams; and 2) to check for compliance with existing state water quality standards.

Uncompensated total dissolved gas (TDG) saturation, which can cause lethal gas bubble disease in fish, is the primary water quality parameter monitored by agencies operating the Columbia River dams. Water temperature is also monitored because of its critical impact on fish and aquatic life. To relate these two parameters to project operations, data on the spill itself are also routinely collected. As such, the dissolved gas monitoring program is very much an integral part of water management.

Daily monitoring of dissolved gas saturation and water temperature is carried out during the juvenile fish migration season, April through October. Major participants include the Corps of Engineers (COE), U.S. Bureau of Reclamation (USBR) and the mid−Columbia County PUDs (Chelan, Douglas and Grant). During high run−off years, emphasis is usually on TDG saturation and spill. During low run−off years, the emphasis shifts to water temperature and powerhouse releases. The TDG data are maintained in the Corps North Pacific Division's Water Quality Data Base and are widely disseminated to project owners and other agencies through the Columbia River Operational HydroMet System (CROHMS).

2.3.2 Citizen Involvement Organizations and Programs

In addition to government agencies, many citizen involvement groups are active in promoting, managing or implementing water quality programs in the Columbia Basin. Some of these groups are indicated below, a list that is not exhaustive.

Washington

State–wide organizations include Citizen Lake Monitoring Project (Washington Department of Ecology), Washington State University Cooperative Extension Water Quality program, and the Washington State Lake Protection Association. More localized organizations and programs are listed below:

Adopt a Stream Foundation: A citizen training program under which people "adopt" a watershed. Participants are trained to assess the watershed, monitor the conditions, and take local action based on their findings.

Citizens for Clean Columbia: Based in Colville, an advocacy organization involved in the Lake Roosevelt Forum. Provides education programs.

Clark County Water Resources Council: Advocacy group dedicated to encouraging people to monitor, improve and advocate for water quality resources. Activities include streamwalk, stream stewardship, lake monitoring, and storm–drain monitoring.

Clark County Cooperative Extension: Stream watch program under which trained volunteers assist in educational and organization programs related to the dynamics of stream water quality.

Environmental Information Center: Provides information to citizen groups and students. Also sponsors streamwalks and other monitoring activities. A program of the Clark County Public Utilities.

Lake Roosevelt: Lake Roosevelt Water Quality Council will be developing a citizen monitoring program.

Northwest Rivers Council: An organization designed to protect the natural values of rivers in Washington, Oregon, Idaho and Montana. Has been instrumental in establishing the Oregon Rivers Council and Idaho Rivers United. Main focus is water quantity. Major activities include sponsorship of an annual conference advocacy, citizen involvement in policy groups and provision of technical information.

Idaho

Idaho Water Resources Research Institute manages the streamwalk program for Idaho. Also, is involved in citizen education and training programs which include Streamkeeper and Project WET.

Idaho Department of Fish and Game manages a public involvement program designed to protect and restore fish habitat. Also very involved in water quality education.

Idaho Rivers United: An advocacy organization which also has a citizen monitoring program. Sponsors student monitoring program.

Kootenai Environmental Alliance: Located in Northern Idaho, organization has advocacy role as well as monitoring activities. Interested in policy development within the community.

North Idaho Lakes Coalition: A coalition of lake associations. Major activities include advocacy and monitoring the water quality in northern Idaho lakes.

Northwest Water Watch: Patterned after the WSU Cooperative Extension Bay Watches Program, trains citizens and teachers in all aspects of water ecology. Trained volunteers volunteer 50 hours to work on a water related environmental issue.

Sawtooth Workshop: Trains the public, teachers and agency staff how to gather and use environmental information. Course is designed to empower participants to understand issues and take action.

Students on the Snake: A student monitoring program which sponsors five high school programs along the Snake River from Lewiston down.

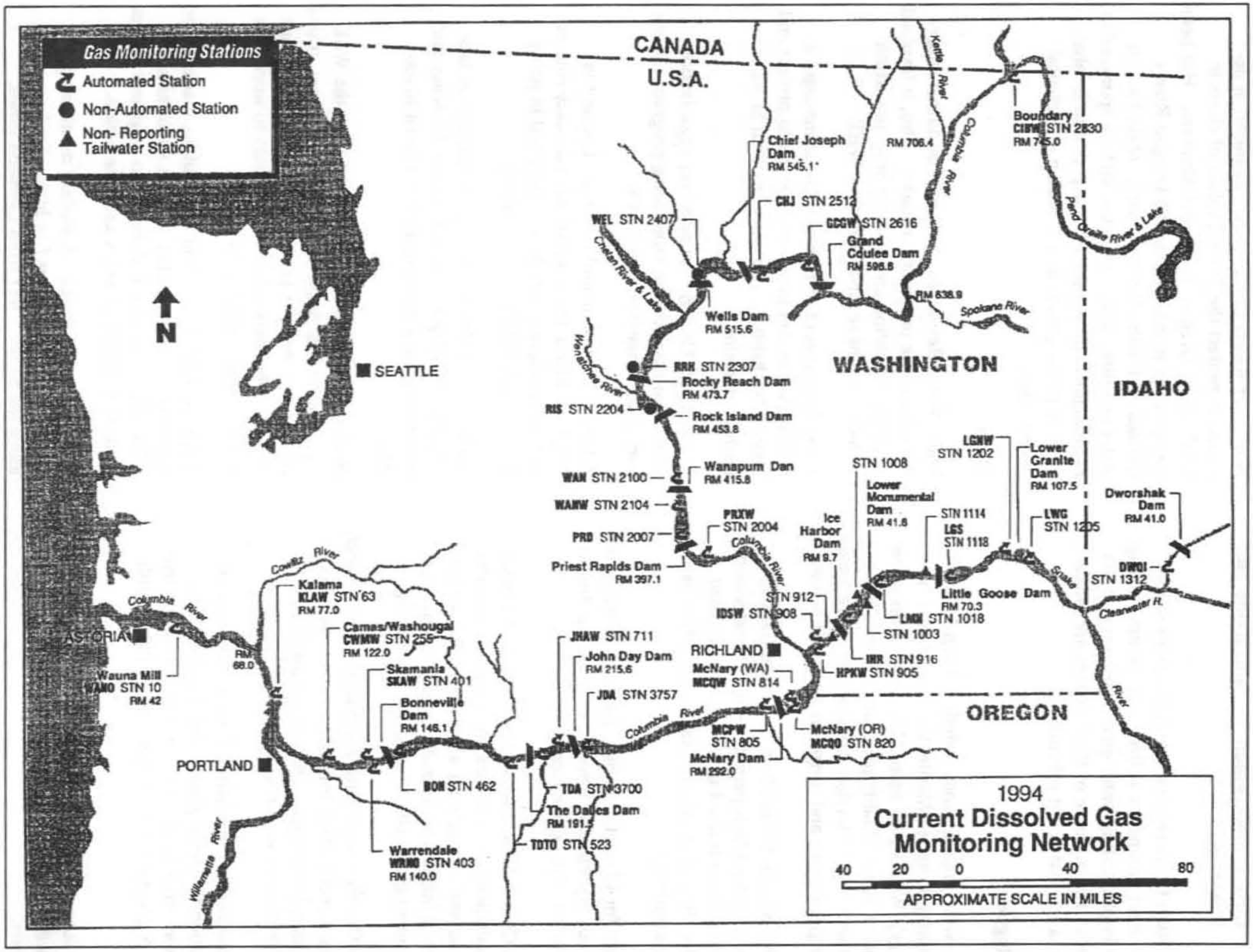

Figure 2–3. 1994 – Location of Dissolved Gas Monitoring Stations

Oregon

Citizen Lake Monitoring: A state sponsored program which is managed by Portland State University. Involves and trains citizens in lake monitoring.

Governors Watershed Enhancement Board: A statewide grant program which provides funding to citizen groups and others to improve or protect watersheds.

River Network: A national organization, based in Portland, which provides assistance to citizens concerned about rivers. Has a data base of information on technical assistance, a newsletter, and documentation of successful restoration projects.

FAUNA (Friends and Advocates of Urban Natural Areas): An umbrella organization to provide assistance and support to local citizen groups in the greater Portland area. Sponsors forums and conferences to train and inform citizens.

Metropolitan Greenspaces Program: Provides a regional approach in protecting natural resources in the four county area surrounding Portland area. Created the greenway corridors for animals, plants and people.

NW Environmental Advocates: An advocacy organization based in Portland. Provides boat rides to educate concerned citizens about the Columbia and Willamette. Recently published two maps, under their River Watch program, entitled: Toxic Waters, and Columbia River− −Troubled Waters.

Oregon Rivers Council: An advocacy organization working to affect national policy on the protection and restoration of rivers. Involved with other northwest states on hydro intervention issues.

Urban Streams Council: A new organization consisting of FAUNS, Greenspaces, and the multitude of groups monitoring local streams and rivers. Focus is on the Tualatin and Willamette Rivers.

Saturday Academy: An educational program that includes a National Science Foundation program to monitor the Tualatin River.

2.4 LAW, REGULATIONS, AND PROGRAMS RELATED TO WATER QUALITY

Clean Water Act (CWA)

The Federal Water Pollution Control Act, better known as the Clean Water Act (CWA), is rooted in older water pollution control legislation such as the Refuse Act (1899) and the Water Pollution Control Act (1948). Its objective is "to restore and maintain the chemical, physical and biological integrity of the Nation's waters" and two goals were specified. The first is to attain a level of water quality which "provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water." The second is to minimize the discharge of pollutants into navigable waters.

CWA Water Quality Standards. The 1972 amendments (Section 303c) require the states to establish water quality standards for all water protected by the CWA. Renewable every three years, these standards identify the uses of each water body and water quality criteria which must be met to protect the designated (beneficial) use or uses. Section 305b imposes reporting requirements. Each state must submit biennial reports to the EPA assessing the extent to which its waters support beneficial uses, identifying point and non−point sources of pollution, and recommending actions to improve water quality.

CWA Non−point Source Management Plans. The CWA mandates several broad water quality planning programs to reduce the pollution of surface waters. Section 319 addresses pollution from diffuse sources such as agriculture (excluding irrigation return flows), mining, forest practices, construction, urban run−off, ground water seepage, and hydrologic modifications (such as dams and reservoirs).

Each state prepares a non−point management plan for submittal to the EPA. It includes information similar to that in the 305b water quality report but is delves more deeply into non−point source issues.

Non−point sources of pollution are generally addressed with Best Management Practices (BMPs). These are physical, structural, or managerial practices that prevent or reduce surface and ground water pollution. Examples of water quality BMPs are: bio–filtration strips, swales, stream fencing, detention and infiltration techniques, oil/water separators, and waste abatement programs. Monitoring is conducted by a variety of agencies to assess the implementation and effectiveness of these management practices.

CWA Point Source Discharge Permits. The discharge of pollutants from point sources into waters of the U.S. without a permit is prohibited by the CWA. Points sources are usually municipal and industrial wastewaters, non–contact cooling waters, storm waters discharged into water from outfall pipes or ditches, or combined sewer overflows.

Under Section 402 of the CWA, National Pollutant Discharge Elimination System (NPDES) permits are issued by either the EPA or states to which it has delegated the authority. Many states also issue permits for waste discharges not covered by the NPDES program.

Discharge permits specify effluent limitations which must be monitored and the types of data which must be reported. Instream as well as wastewater or storm water monitoring may be required. There are approximately 1,500 NPDES permits in the Idaho, Oregon, and Washington portions of the Columbia Basin.

Dredged or fill materials discharged into water are regulated by Section 404 of the CWA. Discharges now also include those incidental to excavation activities. Most permits for this activity are issued by the U.S Army Corps of Engineers but the EPA plays an active role in evaluating these impacts and may inspect 404 permits in emergency situations. Applicants for 404 permits must also provide certification from the appropriate State agencies that the project will not violate State water quality standards.

CWA Oil Spill Prevention. The CWA (Sections 311 and 308) controls the discharge of oil into or upon waters of the U.S., adjoining shorelines or contiguous zones. Certain facilities must have Spill Prevention Control and Countermeasure (SPCC) plans if a spill could enter waters of the U.S. in harmful quantities. Both the CWA and the Oil Pollution Act of 1990 use the same implementing regulations.

Safe Drinking Water Act

This legislation protects public water supplies including groundwater aquifers which draw from surface waters.

National Environmental Policy Act of 1970 (NEPA)

This legislation requires the Federal government to undertake activities in a manner which protects the environment. When "significant" environmental effects can be expected to be produced by an activity, an environmental impact statement (EIS) must be prepared. The definition of "significant" is carefully defined. NEPA is intended to be used as a decision–making tool by Federal agencies.

Alternatives for achieving the proposed action are developed in the environmental impact statement and the effects of implementing each alternative are assessed. A detailed description of National Environmental Policy Act requirements is given in the environmental impact statement for Columbia River System Operations.

Rivers and Harbors Act of 1899

This legislation focuses exclusively on navigable waters. Section 9 regulates the construction of bridges, causeways, dams or dikes. Section 10 addresses the obstruction of navigable waters by wharves, piers, excavations and fills. The U.S Army Corps of Engineers issues most authorizations, many of which are nationwide general permits. Section 10 permits that involve discharge (intended or incidental) must be certified under Section 401 of the CWA by the appropriate State agencies.

The U.S. Coast Guard, part of the Department of Transportation, is responsible for some permits under the Rivers and Harbors Act. Bridges over navigable waters are an example of Coast Guard permit.

Coastal Zone Management Act (CZMA)

This statute created a voluntary program to protect coastal resources, including the Great Lakes. To receive Federal funding, states must develop programs for regulating land and water uses associated with coastal development. These enforceable policies must also include measures for resolving conflicts among competing uses. Both Oregon and Washington have Federally approved Coastal Zone Management Programs. The Act was amended and re–authorized in 1990. Water pollution control programs and a requirement to address non–point source pollution affecting coastal water quality were incorporated.

Executive Order 11988 (Flood Plain Management)

The purpose of this directive is to avoid, where practicable alternatives exist, the short and long term hazards associated with floodplain development on human health and safety, and environmental impacts to fish and wildlife and their habitat.

Federal Water Project Recreation Act

The Policy of this act states that Federal agencies in planning navigation, flood control, reclamation, hydroelectric, or multipurpose water resource projects, must consider the potential outdoor recreational opportunities and fish and wildlife enhancement that the projects might afford.

Executive Order 11990 (Protection of Wetlands, 1977)

Agencies, in carrying out their land management responsibilities, are to take action which will minimize the destruction, loss, or degradation of wetlands, and take action to preserve and enhance the natural and beneficial values of wetlands.

Fish and Wildlife Coordination Act

The objective of this Act is to provide that wildlife conservation receive equal consideration and be coordinated with other features of water resource development plans. The Act states that whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, controlled or modified for any purpose by any entity, of or permitted by the federal government, the entity shall first consult with the United States Fish and Wildlife Service, and with the head of the agency exercising administration over wildlife of that state.

Executive Order 12088 (Federal Compliance with Pollution Control Standards,1978)

This presidential order delegates to the head of each agency the responsibility for ensuring that all necessary actions are taken for the prevention, control, and abatement of environmental pollution. Executive Order 12088 gives EPA authority to conduct reviews and inspections for the purpose of monitoring federal facility compliance with pollution control standards. Also, each agency shall submit a semi–annual plan to the Office of Management and Budget for the control of environmental pollution. The plan shall indicate methods of improvement in the design, construction, management, operation, and maintenance of federal facilities, and shall include cost estimates.

2.5 WATER QUALITY STANDARDS

Idaho, Oregon, Washington

The EPA and States of Idaho, Oregon, and Washington have established surface water criteria or water quality standards applicable to the Columbia River Basin. This discussion focuses on the State standards because they are the same as or more stringent than the Federal criteria, and are legally enforceable. The codes, rules, and regulations for these state standards are voluminous, so only selected highlights of the standards are presented in this document. All three states have established a policy of antidegradation and beneficial uses for their surface waters, which precludes the discharge or introduction of any toxic or hazardous materials that result in significant deleterious effects.

Idaho's beneficial uses are domestic and agricultural water supply, cold–water and warm–water biota, salmonid spawning, primary and secondary contact recreation, and special resource water. All except warm–water biota have been designated as beneficial for the Brownlee, Oxbow, Hells Canyon, and Dworshak reservoirs, North Fork of the Clearwater River, and the Snake River downstream of Brownlee (Source: Bureau of National Affairs, Inc. (BNA), 1991).

In a four–level water quality classification system that ranges from AA (extraordinary) to C (fair), the State of Washington has classified the Columbia River from Grand Coulee Dam downstream to the Pacific Ocean and the Snake River as Class A (excellent). Beneficial uses are water supply (domestic, industrial, agricultural); stock watering; fish and shellfish rearing, spawning, and harvesting; wildlife habitat; recreation (primary contact); and commerce and navigation (BNA, 1991).

Oregon defines various portions of the Columbia and Snake rivers as beneficial for public and private domestic supply, industrial water supply, irrigation, livestock watering, anadromous fish passage, salmonid fish rearing, salmonid fish spawning, resident fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, aesthetic quality, hydropower, and commercial navigation and transport (BNA, 1991).

A total dissolved gas standard of 110 percent saturation at ambient atmospheric pressure is the maximum level for acceptable total dissolved gas set by the three States (BNA, 1991). Each State has, however, different thermal criteria.

Idaho specifies the criteria in relation to specific use categories. The most restrictive use criterion is for salmonid spawning, with maximum water temperatures set at 55°F (13°C) with daily averages no greater than 48.2°F (9°C).

Oregon allows no water temperature increases in the Columbia River, outside of an assigned mixing zone, when the stream water temperature is at or above 68°F (20°C). When the river is 67.5°F (19.7°C) or less, the Oregon standard dictates that no more than a 0.5°F (0.28°C) increase is allowed due to a single–source discharge. No more than a 2°F (1.1°C) increase is allowed by all sources when the stream is 66°F (19°C) or less.

In Washington, no increase over 68°F (20°C) due to human activity is allowed. In addition, no increase over 0.3°C (0.54°F) is allowed from Priest Rapids Dam (river mile, RM 309) to Grand Coulee Dam (RM 595) when the stream is naturally over 68°F (20°C). In the lower Columbia River and Snake River above the Clearwater River (RM 139.3), no increase over 0.3°C (0.54°F) caused by human activity can occur from a single source, or no increases over 1.1°C (2°F) from all activities when the stream is over 68 F (20°C). In the Snake River below the Clearwater River, the 1.1°C (2°F) restriction is dropped in favor of no temperature increase exceeding $t = 34/(T+9)$°C where t = change in temperature and T = background temperature.

Idaho and Washington specify that turbidity shall neither exceed 5 nephelometric turbidity units (NTU) over background levels when the background level is 50 NTU or less nor have more than a 10 percent increase when background is more than 50 NTU. Oregon simply specifies the 10 percent increase criterion (BNA, 1991).

Minimum dissolved oxygen standards vary for each State. Idaho has specific criteria below existing dams. From June 15 to October 15, these criteria require at least 6.0 milligrams per liter (mg/l; 30–day mean), 4.7 mg/l (7–day mean minimum), 3.5 mg/l (instantaneous minimum), and 6 mg/l or 90 percent of saturation (whichever is greater) for slamonid spawning uses. Oregon specifies at least 90 percent of saturation for portions of the Columbia mainstem, and Washington specifies at least 8 mg/l for Class A waters (BNA, 1991).

Fecal coliform and pH standards vary among states, use classifications, and river system reaches. Typically, pH is restricted to levels between 6.5 and 8.5 pH units. Fecal coliforms must be less than 100 organisms/100 ml.

Montana

Montana water quality regulations are similar to the other Pacific Northwest states; water quality criteria are based on beneficial uses. For major water bodies such as the Kootenai and Flathead Rivers, the classification is B–1, with a few minor exceptions. Waters classified as B–1 are suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

There are also numerical criteria associated with the B−1 classification.

- Dissolved oxygen must not be reduced below 7.0 mg/l.
- Induced pH variation must be less than 0.5 unit between pH 6.5 and 8.5, with no change outside this range, and natural pH above 7.0 must be maintained.
- The maximum turbidity increase is 5 NTU above natural background.
- For temperature, a 1°F maximum increase above naturally occurring water temperature is allowed between 32 to 66°F (0 to 18.9°C). With temperatures between 66°F (18.9°C) and 65°F (19.2°C) discharge is not allowed that will increase temperature above 67°F (19.9°C). Where natural water is 66.5°F (19.2°C) or greater, no increase greater than 0.5°F (0.3°C) is allowed. A maximum 2°F per hour decrease below naturally occurring water temperature is allowed when water is above 55°F (12.8°C), and a 2°F (1.1°C) maximum decrease below naturally occurring water temperature is allowed when the naturally occurring water temperature is between 32 to 55°F (0 to 12.8°C).
- For bacteria, when the water temperature is above 60°F (15.6°C), fecal coliforms must neither exceed 200 organisms per 100 ml nor may 10 percent of the total samples during any 30−day period exceed 400 organisms per 100 ml.
- Also, the numerical Federal water quality criteria and national primary and secondary drinking water criteria are incorporated by reference in state laws.

2.6 WATER QUALITY STUDIES

2.6.1 General Studies

Water quality studies and monitoring conducted on the Columbia River and its tributaries over the past 20 years have been generally limited to temperature, dissolved oxygen, total dissolved gas saturation, and sedimentation. Little work has been done on toxins, heavy metals, pesticides, herbicides, and nutrients. In short, work conducted in the past provides an incomplete picture of the system's water quality.

Ongoing and more recent studies conducted by the United States Geological Survey, Environment Canada, Washington State Department of Ecology, Oregon State Department of Environmental Quality, and the British Columbia Ministry of Environment have provided good scientific data, but are limited to specific locations within the watershed.

The Environmental Protection Agency and the states conduct water quality monitoring programs to establish status and trends, and to assess watersheds. Water column data routinely collected include dissolved oxygen, temperature, fecal coliform, conductivity, nutrients, turbidity, pH, and water flow. Various stations also collect more site−specific contaminants of concern. For public water systems supplying communities of year−round residents, Safe Drinking Water Act regulations require monitoring of coliform, turbidity, inorganics, organics, and radionuclides. At sites with surface water components, monitoring for potential surface water chemical, physical and biological impacts is required. Land practices, surface water, and ground water are monitored under various projects, many of which emphasize riparian areas.

The U.S. Geological Survey (USGS) has a fixed station monitoring network throughout the basin. For Idaho, stations were established cooperatively with the State and USGS. In Oregon and Washington, the State instream network sites are different than the USGS stations. Parameters monitored include dissolved oxygen, temperature, fecal coliform, conductivity, nutrients, turbidity, pH, metals, major anions and cations, suspended sediments, and water flow.

Monitoring by the U.S. Forest Service includes traditional water column chemistry, aquatic and riparian habitat parameters, and BMP (Best Management Practice) implementation and effectiveness. The type and intensity of monitoring depends on the specific National Forest and Ranger District and the particular issues of concerns. Some forests have long–term trend stations on major streams as they leave the forest. The Region 6 Stream Survey Program surveys parameters such as pool/riffle ratio, amount of woody debris, substrate characterization, and extent of riparian cover.

The U.S. Army Corps of Engineers monitors the water quality at its reservoirs. Routine parameters include flow, temperature profiles, conductivity, nutrients, turbidity, Secchi transparency, dissolved oxygen, pH, and dissolved gas. Sediment sampling is conducted in selected locations to assess sediment contaminants of concern. The Corps has begun sampling bed sediments to assess dioxin concentrations at a few reservoir locations. The Corps also conducts some biological monitoring in its reservoirs and some groundwater quality monitoring.

For its reservoirs, the U.S Bureau of Reclamation monitors temperature profiles, dissolved oxygen profiles, dissolved gas, chlorophyll a, Secchi transparency, and a range of inorganics including nutrients and metals. The Bureau also routinely monitors irrigation drain water and works with local Soil and Water Conservation Districts and Irrigation Districts to monitor effects of their activities.

Many of the Tribes in the Basin are routinely collecting water column chemistry data, primarily in conjunction with fisheries management efforts. Typical parameters include temperature, dissolved oxygen, turbidity, and conductivity.

Myriad site–specific monitoring activities are being conducted in the basin in conjunction with research, planning, regulation, and restoration efforts. A sampling of these types of efforts in Table 2–1.

Table 2–1. Site–Specific Studies in the Columbia Basin

Project	Participants
Lower Columbia River Bi–State Study	WA, OR, Pulp & Paper Indust. USGS, Ports
National Water Quality Assessment (NAWQA)	USGS
Middle Snake River	EPA, IDEQ
Lake Roosevelt Study	EPA, WA–DOE Local, USGS
Tualatin Basin TMDL	OR–DEQ, OR–AG, ODFW, USGS, OGI OSU, PSU
S. Fork Salmon River TMDL	IDEQ, USFS
Columbia Basin Dioxin TMDL	EPA/states
National Bioaccumulation Study	EPA
Hanford Superfund	EPA, WA–DOE
Clean Lakes Projects	States
Irrigation Drainage Program	USDI
Effects of Chlorinated Compound on WA birds	USFWS
EIS for Channel Deepening Project	COE

Table 2–1. Site–Specific Studies in the Columbia Basin – CONT

Project	Participants
Long Term Management Study	COE/NMFS
Columbia River Long–Term Biological Monitoring	NMFS
Willamette River Basin Study	ODEQ/USGS, Industries
Columbia River Estuary Turbidity Maximum	LMER UW Fisheries Res.Inst.
GIS Inventory of Wetlands in Columbia Estuary	CREST
Sediment Yield Location Maps, Western States	SCS

In summary, data needed to provide a reliable prediction on the impacts of proposed system regulation on many water quality parameters are missing. A good balance of common constituents (at least for total phosphorous and nutrients) is possible, and there are good data on indicator bacteria concentrations, pH, and specific conductance (Fretwell, M.O, USGS, 1992, personal communication). Temperature data are also quite good for the sampling stations, but not good enough to fully evaluate the effects of impoundments. There is almost no information on organic contaminants and poor data on trace metals.

Many ad hoc studies have assessed water quality in short river reaches for short time periods. Other reaches have received little or no attention. There is information to answer generic questions about almost any river system but data for quantitative answers to site specific question is often unavailable. Answers to questions about the water quality effects of dams and reservoirs, pulp mills, and agriculture are examples.

2.6.2 Specific Water Quality Studies

Lower Columbia River Bi–State Water Quality Study

The 1990 Washington and Oregon Legislatures appropriated funds for an interstate study of water quality in the lower Columbia River. The funds were used to identify and study water quality problems in the Columbia River below Bonneville Dam. Additional funding was provided by the Washington and Oregon public ports, and the pulp and paper industry.

The study, a "reconnaissance survey", is a broad–brush look at the water quality of the lower river. It was designed to answer some general questions about possible problems, and to help decide which contaminants and locations warrant further study. It was not detailed enough for human health risk assessments, nor to present a complete picture of water quality in the lower river.

EPA Study for Northwest Power Planning Council

In 1992 Region 10 of the Environmental Protection Agency (EPA) responded to a request from the Northwest Power Planning Council to lead an interagency study of the water quality in the Columbia River Basin. Members of the Columbia River Water Management Group's Water Quality Committee actively participated in this effort. The first part of the study consists of a compilation of existing water quality information, determination of additional information needs, and development of a study plan for collecting additional information. The short study report is intended to be one of the many efforts to improve communication and coordination between the water quality agencies and fish restoration entities in the Columbia Basin. Better communication was found to be crucial at this time, given the Endangered Species Act listing of salmon species and the mounting concerns over the traditional water quality parameters of temperature and sediment.

Water Budget Environmental Assessment

In September 1982 the Northwest Power Planning Council (Council) requested the Corps of Engineers' assistance in analyzing the proposed water budget, which is part of the Council's Fish and Wildlife Program. The Program establishes a total water budget of 4.64 million acre-feet (Maf) to be divided into 3.45 Maf at Priest Rapids Dam and 1.19 Maf at Lower Granite Dam. The intent of the water budget is to provide improved transportation flows for juvenile anadromous fish during their journey downstream to the Pacific Ocean.

As a result, studies were undertaken by the Corps to identify the impacts of alternative methods of operation for the water budget, and their impacts on operation for other project purposes. The environmental assessment evaluates the nonpower impacts of the water budget at Dworshak Dam and Reservoir. Seven alternatives were considered, and impacts on the following water use considerations assessed:

- physical (water and air quality),
- biological (aquatic and terrestrial community),
- cultural (land use, recreation, aesthetics and human interest, cultural status, manmade facilities and activities),
- ecological (food web).

The Bonneville Power Administration (BPA) also prepared an environmental assessment of "Proposed Power System Changes to Implement the Water Budget", including marketing impacts. A finding of no significant impact (FONSI) was issued in January 1983 for two of the alternatives evaluated.

The nonpower environmental impacts of the water budget at the Libby project were also assessed. A FONSI for Libby was issued in July 1983. Consequently, preparation of an environmental impact assessment was not required.

An environmental investigation was conducted by a contractor for BPA in 1984 to assess water budget impacts on the operation of the Idaho Power Company's projects --Brownlee, Oxbow, and Hells Canyon. The Hells Canyon Environmental Investigation looked at existing surface and groundwater quality in the study area, potential impacts on water quality, and additional studies required to evaluate water budget impacts.

Lake Roosevelt Study

Lake Roosevelt is the reservoir created by the construction of the Grand Coulee Dam on the Columbia River in 1941. It is the largest lake in Washington and the sixth largest in the United States. Despite its importance, there has been no comprehensive assessment of the Lake Roosevelt's physical, chemical, biological, and hydrological processes in the past. To fill this knowledge gap, citizen groups and responsible State and Federal agencies decided in 1992 to form the Franklin D. Roosevelt (FDR) Water Quality Council. The Council includes management, technical, and citizen's committees. Its major goals are to clean up the lake by preventing pollution from Canada and the United States, determine the impacts of past pollution, and prepare a water quality management plan.

The FDR Water Quality Council has obtained funding to conduct studies and prepare a work plan, fund citizen participation, and hire a Project Director. The work plan was finalized in March 1992 and an integrated assessment study began in July 1992. The initial focus was on evaluating existing data and sampling sediment and fish tissue for metals and toxic contaminants in the reservoir. Reservoir nutrients and watershed sources of pollution will be more thoroughly monitored in later years.

Regardless of the progress made on controlling pollutants originating in Canada, American entities are expected to continue identifying and addressing the lake's water quality problems. This includes include Washington Ecology, EPA, and groups such as the Lake Roosevelt Water Quality Forum, the Lake Roosevelt Water Quality Council, the Citizen for a Clean Columbia, and the Lake Roosevelt Coordinating Committee.

Kootenay River Basin Water Quality Status Report

In 1992 and 1993, a coalition of agencies involved in the Kootenay River Basin formed the Kootenay River Network (KRN). The KRN is composed of Federal, provincial, state, tribal, industrial and citizen group representatives. Approximately 90% of the land in the Basin is government–owned or managed. Several of the participating entities funded a contractor to prepare a Water Quality Status Report. The Report documents the history of pollution sources and activities affecting water quality, fish and recreation in this international watershed (it covers 80% of the Basin in British Columbia, Idaho and Montana above Kootenay Lake). The white sturgeon and bull trout, both considered for listing as threatened or endagered, are present in the Basin.

2.7 DESCRIPTION OF EXISTING CONDITIONS

2.7.1 Reach–by–reach Description

The Basin's existing water quality conditions will be separated into five major reaches and the following parameters will be discussed: toxicants, heavy metals, turbidity, dissolved gases, temperature, nutrients, pH, sediments, bacteria and radionuclides.

The major reaches are: Origination in British Columbia, Canada to Grand Coulee Dam; Coulee Dam to the Snake River Confluence; Snake River; Snake River Confluence to Bonneville Dam; and Bonneville Dam to the Pacific Ocean. In addition, water quality conditions at Libby and Hungry Horse reservoirs, which are also covered by the Columbia River System Operation Review, will also be described.

Figure 2–4, originally prepared by B.C. Hydro, is a three–dimension illustration of the Columbia River and its major tributaries, including locations and elevations of all existing dams.

Good usable water quality data is generally limited to specific locations, and data available from most of the long term monitoring programs, with the exception of temperature and dissolved gas data, is either outdated or unreliable. Because of this, much of the material within this section will be based on professional judgment of the contributing preparers or generalizations. The need for additional monitoring is discussed elsewhere in this Appendix.

Libby Water Quality

The Kootenai River in Montana was impounded by Libby Dam in March 1972 to form Lake Koocanusa. Below Libby Dam, the Kootenai River flows back into Canada to Kootenai Lake, which flows into the Columbia River. Water quality data were collected downstream of Libby Dam by the USGS before and after dam construction. In general, the construction of Libby Dam reduced discharge extremes, increased overall water discharge temperatures, decreased summer discharge temperatures, and decreased nutrient levels in the Kootenai River downstream of the dam (Whitfield and Woods, 1984). Damming of the Kootenai River also increased the pH of the river, although seasonal changes were observed and were proportional to depth of discharge.

Water quality data collected from October 1984 to September 1985 approximately 0.7 mile downstream from Libby Dam, reported pH values from 7.9 to 8.5; water temperatures from 37 to 61°F (2.5 to 16.0°C); dissolved oxygen from 87 to 113 percent saturation; low nutrient concentration (generally <0.1 mg/l, N and <0.01 mg/l P); and low total organic carbon (<2.0 mg/l) (USGS, 1986).

Although highly productive (eutrophic) conditions were predicted for Lake Koocanusa, turbid conditions and physical limnological factors caused low algal productivity (McKim et al., 1976). In addition, Canadian municipal and industrial sources substantially reduced nutrient loading into Lake Koocanusa during the late 1970s. Sediments in Lake Koocanusa are calcareous and low in organic matter, have a silty loam or loam texture, and serve as a phosphorus sink (Iskandar and Shukle, 1981). Combined with the reduced nutrient loading, this may contribute to the low productivity of the lake. During spring snow melt run–off, substantial quantities of suspended sediment are discharged to the Kootenai River downstream of the dam (Ciliberti, 1980).

In 1973, game fish populations were adversely affected by high gas supersaturation levels at least 5 to 6 miles downstream of the Libby Dam (May, 1973). Total gas supersaturation levels of up to 130 percent were observed in some areas of the river (May, 1973). Since Unit 5 began operation in 1984, no spill has been necessary and gas supersaturation levels have generally been below 110 percent.

There were problems associated with contaminants (metals and organochlorides), but these have not been fully investigated with regard to effects on fish. Nutrients have also been mentioned as a concern for Libby Reservoir and the Kootenai River.

A recent report (Knudson, 1994) documents the effects of land and water use activities, especially hydropower operations, logging, mining, and untreated or poorly treated municipal and industrial (pulp mill) wastewater on fish, recreation and in–stream water quality. These activities degraded water quality and habitat in the 1960's and 1970's but were brought under control during the 1980's. An expanded monitoring program is needed to measure the long term effectiveness of the control program. Monitoring and enforcement programs in the Kootenay River Basin are hampered by differences in water quality criteria and standards across the international boundary.

The Kootenai Tribe of Idaho's Environmental Management and Fisheries Departments have been conducting water and sediment quality studies on the Kootenai River and its tributaries. This was prompted by concerns arising from the white sturgeon recovery efforts, and the apparent trophic collapse of the Kootenai River ecosystem. Although few negative water quality impacts have been reported to date, the data collection effort is likely going to continue for some time.

Hungry Horse Water Quality

Hungry Horse Reservoir was created in 1953 with the completion of Hungry Horse Dam on the South Fork of the Flathead River, approximately 4 miles from the confluence with the main stem, which subsequently empties into Flathead Lake. Water quality data collected in 1978 indicated that the reservoir is oligotrophic; i.e. low in nutrient input and primary productivity (May and Weaver, 1987).

Surface water temperatures vary widely in Hungry Horse, ranging from frozen (32°F (0°C) in winter to over 73.4°F (23°C) in late summer. The reservoir thermally stratifies in summer (typically June through September) but is isothermal (no temperature gradient) in spring and winter. The water volume in the preferred thermal range for cutthroat trout (50 to 60.8°F (10 to 16°C) is greatest in spring and fall (May and Fraley, 1986).

Downstream, hypolimnetic discharges from Hungry Horse have lowered the summer water temperatures and raised the winter water temperatures in the Flathead River from historical levels (Beattie et al., 1988). Cold water released from the deep layers of the reservoir reduces trout growth in the South Fork and mainstem Flathead Rivers to a fraction of pre–dam levels. The Northwest Power Planning Council has called on Bonneville Power Administration and the Bureau of Reclamation to begin actions aimed at installing a temperature selective withdrawal facility at Hungry Horse Dam. This should minimize instances of large, rapid and detrimental temperature fluctuations in the Flathead River.

The dissolved oxygen levels in Hungry Horse Reservoir have been consistently above biologically optimal levels of 7 mg/l, typically in the range of 8 to 10 mg/l. The pH (in 1985) ranged from 7.4 to 8.9, with the majority of values between 7.8 to 8.5 units. Specific conductance ranged between 110 to 150 umhos/cm, on the lower end for productivity (May and Fraley, 1986).

Reach 1, Origination to Grand Coulee Dam

The Columbia River begins in Central British Columbia about 400 miles above the city of Castlegar, British Columbia. Major tributaries in this reach are the Kootenay, Pend Oreille, and Spokane River. Lake Roosevelt, created by Grand Coulee Dam, begins below the Canadian Border near the town of Northport, Washington. There are several small towns located on the river in British Columbia. Major industry within this reach is mining, timber, agriculture, hydropower, tourism, and pulp mills. The Hugh Keenleyside Dam in British Columbia is also located in this reach. The purpose of this dam is flood control.

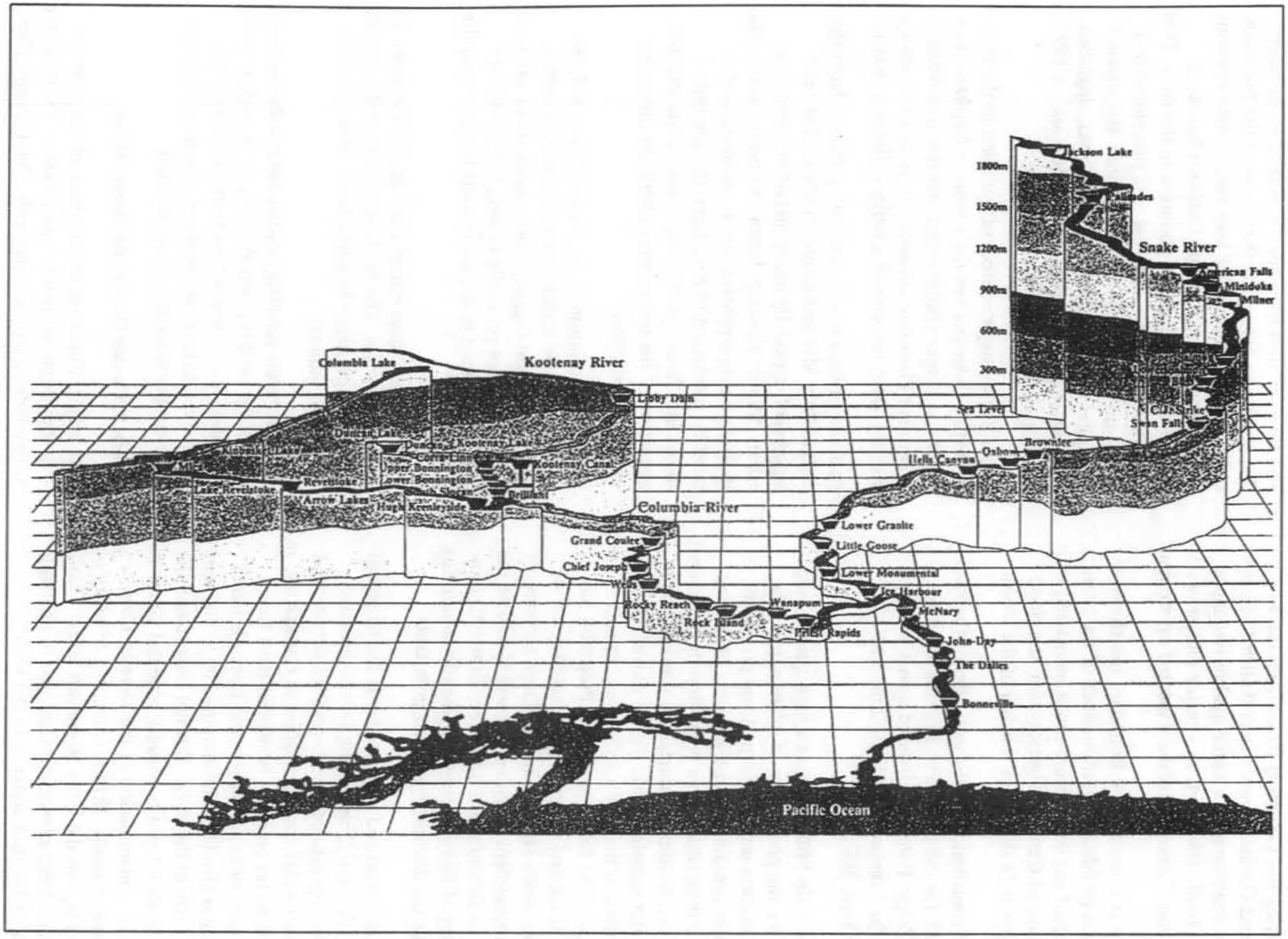

Figure 2–4. The Columbia River and its Tributaries

Water entering the Columbia River from the Kootenay and Pend Oreille Rivers meets British Columbia Ministry of Environment's water quality standards. The Pend Oreille River acts as a major diluter of pollution from Canadian industry located up stream.

Monitoring at International Boundary has shown a dissolved gas problem at certain times of the year. Total dissolved gas supersaturation is associated with the operation of Canadian hydropower and flood control projects in the upper reaches of the basin.

The major contributors to the pollution of the river in this reach for the past 30 to 40 years has been from the Celgar Pulp Mill, located near Castlegar, B.C., and the Cominco Lead and Zinc smelter located in Trail, B.C.

The Celgar Pulp Mill produces a high quality pulp necessary for the production of white paper. The bleaching process used in the past has produced by–products containing large amounts of dioxin, furans, and fibre which have been directly discharged into the river. Studies conducted by Canadian and United States scientists have shown dioxin/furans contamination in the rivers sediments, aquatic invertebrates, and fish. The Celgar Pulp Mill has been upgrading and expanding its facilities during the past few years and has installed new technology and water treatment facilities that will eliminate the discharge of dioxin/furans and fibre. British Columbia Ministry of Environment is presently monitoring the mill for the discharge of other pollutants.

The Cominco lead and zinc smelter is the largest of its type in the world, employing several hundred people. Past operations have been very detrimental to the river's water quality. Studies in Canada and in the United States on Lake Roosevelt have found large amounts of heavy metals and trace elements. The plant has also been discharging 300 to 400 tons of slag per day in the river. This not only scours the river bed, it also deposits harmful material. Since the discovery of contamination of the river by Cominco, Environment Canada, British Columbia Ministry of Environment, and the Lake Roosevelt Water Quality Council have been pressuring Cominco to eliminate discharges of harmful material to the river.

The three entities have also been conducting scientific studies to determine the extent of the pollution and how it is affecting the lake and riverine environment. Over the past 2 years Cominco has taken several steps to eliminate pollution to the river. They have developed an automated spill prevention and clean–up program, constructed ponds and covered stockpiles to prevent erosion to the river, upgraded their water quality treatment facilities, and by 1995 will stop discharging slag into the river.

Other not so major sources of pollution to the river in British Columbia are the Cominco fertilizer plant which discharges phosphorous and the Trail Sewage Treatment Plant that occasionally dumps raw sewage into the river, because of a faulty collection system.

Past and present studies indicate pollution from the Celgar Pulp Mill and Cominco Metals has been significant, especially heavy metals and trace elements. Studies showing dioxin and furans in fish also indicate a major problem area, but more studies must be conducted to determine the amount of dioxin and furans in the deeper sediments and how operation of the system may distribute the toxins into the food chain.

Sources of pollution in the United States to Lake Roosevelt come mainly from old and new mines, agriculture, and logging. The magnitude or extent of pollution is not presently known, but studies are being conducted in the watersheds to determine the impact.

The Spokane River enters Lake Roosevelt about 50 miles down river. The Spokane River's water quality is affected primarily by agriculture, urban development, and industry.

More accurate scientific studies have probably been conducted on this reach than any of the other reaches. More studies and a long term monitoring program need to be developed and conducted to complement the work already completed.

Reach 2, Coulee Dam to the Snake River

The major tributaries to this reach of the river are the Okanogan, Wenatchee and Yakima rivers. There is one federal dam in this reach, Chief Joseph Dam, and several mid–Columbia Public Utility District's dams. These are Wells, Rocky Reach, Rock Island, Wanapum, and Priest River Dams. This reach is a major agricultural area producing a variety of food products for animals and human consumption.

There are two large and several smaller irrigation projects within this reach that drain directly or indirectly into the river or its tributaries. The major projects are the Columbia Basin project which extends from Banks Lake to the confluence of the Snake River, and the Yakima Project that extends from northeast of Yakima to the confluence of the Snake River. Irrigation return flows containing nutrients, sediments, and pesticides may impact the water quality of this reach considerably. Other impacts are sedimentation from irrigated farmland and erosion caused by cattle and sheep.

Dams in this reach are operated for flood control, power, and irrigation, and their impacts on water quality are relatively minor compared to pollution problems caused by agriculture and other sources. Some of the larger cities located in this reach may also directly or indirectly impact the rivers water quality. If any of them are discharging directly into the river, they would be required to have a 402 NPDES permit, which is regulated by the State of Washington.

Hanford Sub–Reach

In 1943, the U.S. Atomic Energy Commission committed 560 square miles of land in Eastern Washington to the production of radioactive materials for defense purposes. As part of this operation, discharge and disposal of toxic wastes were made to various underground storage sites on the reservation. A total of nine nuclear reactors were also put in service between 1944 and 1987, some of which discharged their cooling water into the Columbia River. For national security reasons, access to specific information on operational and waste disposal practices at Hanford was limited to only those directly involved for many years. Studies on the long–term potential environmental impacts of the operation also have generally not been made public. Because of the reservation's proximity to the Columbia River, any leakage of storage tanks would drain toward the 44 miles of the Hanford. This explains the high interest shown by the public in identifying and characterizing the wastes that are onsite.

Since 1957 the Hanford sub–reach of the Columbia River has been monitored for various contaminants discharged to the River directly or through springs. In addition, some 700 wells, approximately 140 in the near–river area, are monitored quarterly for tracking plumes of contaminants and radionuclides. So far, no impacts were directly observed on the Columbia River water quality as a result of the Hanford operation.

Analyses made in 1988 revealed low levels of long–lived radionuclides at most locations along the Hanford shoreline. Most of these radionuclides were also found in sediment samples. The levels detected are, however, thought to be far below a health hazard or danger to public health and safety.

The mission of Hanford is now changing from nuclear materials production to clean–up and restoration. The U.S. Department of Energy is committed to phasing out liquid radioactive waste discharge to Hanford soils by 1995. Under the current Superfund action spearheaded by the U.S. Environmental Protection Agency a thorough survey of springs along the River was conducted in 1991. Monitoring activities to assess a broad range of radionuclides and hazardous substances are scheduled to continue for a few more years.

More studies of the river and its tributaries need to be conducted in this reach, and the Hanford subreach.

Reach 3, Snake River

The Snake River originates in western Wyoming, flows through Idaho, and enters the Columbia River near Pasco, Washington. The major use of Snake River water is for barge traffic, recreation, power, and irrigation. Dams that may affect water quality on the Snake River are Brownlee, Oxbow, Hells Canyon, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and Dworshak Dams. Dams higher up in the system probably do not directly affect Columbia River's water quality.

Eight long term water quality monitoring sites are located on the Snake River. Monitoring dates range from 1975 to 1992 and are located at Burbank, WA; Ice Harbor, WA; Lower Monumental, WA; Little Goose, WA; Lower Granite, WA; Lower Granite at river mile 120, WA; Anatone, WA; and Weiser, Idaho (see Figure 2–1). The primary parameters measured at these locations were water temperature, specific conductance, dissolved oxygen, and pH. Most of these stations were only sampled once or twice per year and, in most cases, not every year.

The United States Geological Survey has a long term monitoring station on the Clearwater River at Spaulding, Idaho. They also sample for water temperature and specific conductance, suspended sediment, turbidity, total Phosphorous, dissolved oxygen, and pH.

The spill over the dams in the lower Snake River has increased dissolved gas saturation, although pre–dam conditions might have also experienced supersaturation. Total dissolved gas saturation levels in the lower Snake River are influenced by flow from the Clearwater River (including releases from Dworshak) as well as the middle Snake River, and typically range from 105 to 110 percent saturation in Lower Granite forebay during the spring in high flow years. Saturation levels successively increase downstream through the Little Goose, Lower Monumental, Ice Harbor, and McNary forebays when all projects are spilling. Installation of spillway deflectors at Lower Granite, Little Goose, and Lower Monumental dams has reduced the levels of total dissolved gas supersaturation associated with spillway discharges. However, maximum supersaturation ranging from 110 to 140 percent has still been observed for extended periods during high flow events. This exceeds the state standard and federal criteria of 110 percent saturation (Corps of Engineers, 1984–92).

Water storage capacity at the four lower Snake River reservoirs is very limited and retention time is approximately 8 to 20 days, depending on the flows. Therefore, thermal stratification (vertical temperature gradients decreasing from top to bottom) is rare, but during some low flow years, stratification may occur for short periods and range up to 7°F (3.9°C). In general, however, the maximum difference is about 4°F (2.2°C). Temperatures are generally lower during the spring of a high flow year, but they increase in July or August.

Vigg and Watkins (1991) have further characterized temperature in the Snake River as follows:

"Mean water temperature in the lower Snake during 1985–89 was above 70°F (21°C) from 17 July to 19 August; considerable annual variation occurred with temperatures exceeding 70°F (21°C) from 10 July to 14 September in individual years. Based on an analysis of 1938 to 1966 USGS data, the effect of the hydropower system and other anthropomorphic (human–caused) changes on temperature in the Columbia River became apparent in the mid–1950s; the major effect has been shifting temperature maximums so that warmer temperatures occur later in the year (EPA and NMFS, 1971; Crawford et al., 1976). The most significant changes have been above the confluence of the Snake and Columbia rivers. Pre–dam (1955 to 1958) water temperatures were high (greater than 72°F (22°C)) in the lower Snake River during mid–July to late August (FWPCA, 1967). Other human–caused watershed disruptions (e.g., defoliation [loss of riparian vegetation] and water diversion) probably elevated maximum temperatures over historic levels in the Snake River Basin (for example, irrigation–associated influences increased river temperature 6°F (3.3°C) to 7°F (3.9°C) between Parker and Kiona in the Yakima River (FWPCA, 1967)".

The Snake River has a significant effect on the hydrology and water quality of the Columbia River because of the respective volumes of water involved. Large amounts of sediments are transported from the Snake River into the Columbia. If these sediments contain large amounts of contaminants, such as hydrocarbons, pesticides, nutrients, and organochlorines, impacts could be significant.

Commerce or transportation of goods and services to and from the Columbia River up the Snake River to Lewiston, Idaho is very important to the economy of the area. Barging requires dredging of navigation channels deep and wide enough for safe navigation. Dredging can have a significant impact on the hydrology, water quality, and aquatic ecology of the river. Commerce can also pollute the river's water with gas and oil spills and accidental spills of various contaminants from barges.

Agriculture in the drainage basin has an impact on water quality. It is known to contribute large amounts of sediments to the river and other chemicals used for farming. Water quality conditions for other parameters in the middle Snake River have been summarized as follows (Idaho Department of Health and Welfare, 1982).

"The Snake River trend stations have historically recorded escalating concentrations of bacteria, nutrients, and suspended sediment as the river flows from Marsing to Weiser. A current comparison of water quality between Marsing and Weiser cannot be determined due to insufficient data at Marsing; however, the Snake [River] at the Weiser station continues to reflect consistently high nutrients and sediment. Bacterial densities exceed criteria for primary contact recreation (May–September) at Weiser. Subsequent decreases in bacteria and suspended sediment are observed below Hells Canyon Dam, after the river has passed through Brownlee, Oxbow, and Hells Canyon Reservoirs. Nutrients continue to be of concern below the dam accompanied by occasional low dissolved oxygen [concentration] levels. Toxaphene residues, in concentrations associated with reduced growth and reproductive failure, have been detected in fish taken from the Snake River at Weiser and Hells Canyon Dam".

The report also states that non–point source inputs from irrigation returns and grazing areas are the principal pollution problems in the reservoir complex. The EPA has classified the middle Snake River as having marginal water quality (receiving moderate or intermittent pollution) (BPA,1985).

In summary, the waters of the lower and middle Snake River are degraded; the waters are high in bacteria and nutrients, resulting in high productivity. Water temperatures are somewhat elevated and depleted of dissolved oxygen in certain areas. Although not well documented, it is likely that organic residuals associated with pesticide and herbicide applications are also present. All of these observations are consistent with the quality of irrigation return water, which constitutes a high percentage of the middle Snake River flow.

Clearwater River Water Quality

Data for the Clearwater River System are limited, although studies are being conducted that may provide useful information. A major human–induced effect on the Clearwater System is Dworshak Reservoir. This storage reservoir is deep (600 feet in the forebay) and narrow; consequently, the lake thermally stratifies every year with a thermocline at approximately 40 to 50 feet. Deep water (below 40 to 50 feet) temperatures remain consistent throughout the year at about 39°F (4°C) to 41°F (5°C). Retention time in the reservoir is about 1 year. The reservoir has been characterized as oligotrophic (i.e., low in productivity and nutrient limited).

The USGS station at Spaulding, Idaho, a National Stream Quality Accounting Network station, provides data on other water quality parameters. Data from the most recent available year are consistent with the oligotrophic characterization of the reservoir and indicate exceptional water quality that is low in dissolved solids and devoid of inorganic contaminants.

Reach 4, Snake River Confluence to Bonneville Dam

There are three large dams, one irrigation project and several smaller streams that empty into the Columbia River in this reach. The dams are McNary, John Day, and The Dalles Dams. The Umatilla Irrigation Project is located near McNary Dam. Water quality data for this reach is minimal with the exception of temperature and dissolved oxygen at Umatilla and McNary Dam.

Agriculture in the drainage basin of the river has an impact on water quality, but sufficient data is not available to quantify its impact, if any. Because this reach is below the confluence of the Snake River, dam and reservoir operation and maintenance may have a measurable effect on the distribution of sediments and other contaminants to the Columbia River.

In conclusion more work needs to be done in this reach to determine existing and operational impact on water quality.

Reach 5, Bonneville Dam to Pacific Ocean

Bonneville Dam is the last major downstream dam on the Columbia River. Major tributaries in this reach are the Willamette, Lewis, and Cowlitz Rivers. Portland, Oregon and Vancouver, Washington are the largest cities in this reach along with several smaller towns. Commerce traffic is heavy in this reach and industrial and urban discharges numerous.

The latest water quality study for this reach was a reconnaissance survey commissioned by the Lower Columbia Bi–State Water Quality Program. The study was designed to answer general questions regarding possible water quality problems and to determine further study needs in different locations.

The study looked for heavy metals, bacteria, pesticides, PCB's, dioxin and furans, and other conventional pollutants. With the exception of radionuclides, all contaminants were found in either the river's water column, sediments, benthic communities, or many species of fish. The majority, with the exception of organic contaminants in the water column, exceeded state and federal water quality criteria.

Contaminants were found downstream from Portland, Vancouver, St. Helens, Kalama, Longview, and Wauna. They most likely came from sewage treatment plants, pulp mills, barges and ships, marinas, and other large and small businesses. Contaminants found in the river have a detrimental impact, not only on water quality but to the aquatic flora and fauna living in or next to the river. Further studies need to be conducted to determine the severity and source(s) of the pollutants.

Recent investments in pollution abatement by lower Columbia River industries include $38 million by Boise Cascade Corporation at its pulp mill in St. Helens and $18 million by James River Corp at Wauna. Both mills converted from chlorine to chlorine dioxide for bleaching pulp in white paper production. This is expected to substantially reduce chlorine discharges and the trace amounts of dioxin which accompany these discharges.

The impacts of the ocean tide can be felt as far upstream as the Bonneville Dam. Salinity intrusion (salt content of 2 parts per million or more) also affects the lower 20 to 30 miles of the Lower Columbia River. The extent of the intrusion largely depends on the combination of tidal range, river morphology, and streamflow. Based on survey data, a maximum tidal range of 6.9 feet combined with a low streamflow of 110,000 cfs pushed the distance of intrusion to about 25 miles up–river. This distance was reduced to about 20 miles when the maximum tidal range was 9.2 feet and the streamflow reached 182,000 cfs (McConnell et al., 1979). Operations of the dams above Bonneville Dam may play an important role in distributing the contaminants downstream into the estuary, and limiting salinity instrusion upstream.

Materials dredged from the federal navigation channel along the main stem of the Columbia River consists of clean medium and fine sands. Physical analyses of the dredged areas show little change in characteristics over the last 60 years. Because the material dredged is defined as a coarse grain material, is low in organic content, and comes from a high energy environment removed from known contaminant sources, the material dredged from the main ship channel meets exclusive criteria described in the Clean Water Act [40 CFR 230.60 (a), (b),].

Maintenance dredging is coordinated through a public process, and a water quality certification is issued by the States of Oregon and Washington. Both states include provisions regarding allowable mixing zones for impacts related to turbidity and dissolved oxygen. Meeting the criteria has not been a problem in the past because of limited turbidity increase at the dredging or disposal sites. Further, any water quality impacts associated with dredging are temporal in nature, lasting only as long as the operation.

The factors affecting total dissolved gas saturation in the Columbia River are similar to those described earlier for the lower Snake River. When spilling is minimal (September through March), the saturation level is near normal (100 percent). However, total dissolved gas concentrations increase to as much as 140 percent during heavy spill from April through August.

Lower Columbia River water temperatures vary seasonally and have a recorded range from 31°F (−0.5°C) to 75°F (24°C). Winter temperatures (December to March) range from 32°F (0°C) to 48°F (9°C), and from March and June, water temperatures rise to about 58°F (14°C). By August, the river usually warms to its annual maximum average of 68°F (20°C).

Based on the most recent USGS State Water Resources Data Reports, concentrations of dissolved oxygen are relatively high, ranging from approximately 70 to 135 percent saturation, with a mean saturation of 105 percent. Other previous studies have also shown that the pH value generally ranges from 6.4 to 8.5 pH units (Corps, 1977). Fecal coliform bacteria, expressed as Most Probable Number (MPN), have recently ranged from <1 to 120 colonies per 100 ml. Typically, MPN values have been under 40 colonies per 100 ml.

While the Willamette River is not included in the System Operation Review, this major tributary of the Columbia has been a major consideration in regional concerns about water quality for many years. National attention was claimed by Willamette River cleanup efforts in the late 1960s and 70s. Recently, however, new concerns about the river's condition have materialized. In addition to pollution from Portland's combined sewer outflows during storm events, high levels of dioxin and some deformed fish have been found below pulp mills in the Willamette Valley.

Columbia Slough

The Columbia Slough is an 18−mile canal which parallels the Columbia River from Fairview Creek in East Multnomah County to Kelley Point Park in North Portland. It is considered one of the most polluted water bodies in Oregon. Until 1948, the slough was regularly flushed by the Columbia River. It was plugged during the Vanport flood of that year when sand filled pipes under the levee at Marine Drive and NE 17th Avenue.

The City of Portland has committed $125 million to eliminate the flow of raw sewage into the slough during storms. But toxic waste from adjacent industries, including serious concentrations of heavy metals, will remain on the bottom of the slough. Pollutants include arsenic, chromium, lead, mercury, and chemicals such as toluene, polychlorinated biphenols, and dioxin. Leaching from the St. Johns landfill and from contaminated groundwater are additional problems. One proposed remedy is to remove the plug and flush the slough but questions have been raised about the impacts of such an operation on Willamette and Columbia River water quality.

2.7.2 Water Quality Concerns by Subbasin

Problems identified for the subbasins are summarized in Table 2−2, as directly excerpted from a 1992 EPA's letter report to the Northwest Power Planning Council. As most of them are not well quantified, the list does not indicate how strong the evidence is nor how widespread the problem may be. The lack of understanding is especially true with respect to the combined or cumulative effects of these problems. Temperature and sedimentation are clearly the most commonly identified problems. It should be noted that Table 2−2, Water Quality Concerns by Subbasin, was based on best professional judgment, not on hard data.

Table 2–2. Water Quality Concerns by Subbasin
(Source: EPA's letter report to NPPC, 1992)

Subbasins	Water Quality Problems	Data Gaps
Basin–wide General	Temperature, sedimentation dissolved gas, dioxin PCBs, groundwater	Metals, pesticides
Columbia River /estuary	Temperature, PCBs, dioxins, furans, pesticides, metals, bacteria	Industrial organics radionuc.
Mainstem below Bonneville Dam	Temperature, PCBs, dioxins, pesticides, metals, bacteria, DO, TSS	fluoride
Willamette River	Temperature, PCBs, dioxins, furans, metals, nutrients, pesticides, DO, pH, sedimentation, bacteria	radio–chemicals chemicals
Coast Fork Tributaries	Nutrients, DO, pH, sedimentation, temperature, bacteria, mercury (Cottage Grove Reservoir), flows	
Coast Range	Bacteria, DO, algae, nutrients, pH, sedimentation	
Clackamas	Bacteria, metals	
McKenzie	Organics, metals	
Molalla/Pudding	Nutrients, DO, pesticides, sedimentation, temperature, bacteria, oil & grease, TSS	
Middle Fork Santiam/Calapooia	Bacteria, organics	
Tualatin	Nutrients, algae, DO, bacteria, pH, sedimentation, metals, organics, TSS, pesticide	Sediment contaminants
Sandy River	sedimentation, DO	temperature
Grays River	sedimentation, habitat alteration	
Elochoman River /Germany Creek	sedimentation, habitat alteration	
Kalama River		temperature, sedimentation
Washougal River	metals, nutrients, sediments, DO, temperature, bacteria, oil, grease, ammonia, pH, chloride	temperature
Lewis River	nutrients, sedimentation, DO, temperature, bacteria, ammonia	temperature
Cowlitz River	total dissolved gasses, sedimentation, TSS, DO, bacteria, temperature, (Longview ditches: organics, metals, DO, bacteria, oil & grease)	temperature
Mainstem, Bonneville to Priest Rapids:	total dissolved gases, temperature, dioxins, furans, pesticides, PCB's, metals,	metals, PCBs, fluoride

Table 2–2. Water Quality Concerns by Subbasin – CONT

Hood River	pesticides, nutrients, sedimentation, bacteria, oil & grease, aquatic weeds, TSS	
Deschutes River	temperature, DO, sediments nutrients, bacteria, aquatic weeds	pesticides
John Day River	temperature, sedimentation, nutrients, DO, pH, bacteria, aquatic weeds, habitat alt.	metals pesticides
Umatilla River	temperature, sedimentation, pH, DO, nutrients, pesticides, bacteria, aquatic weeds	metals
Wind River		impaired spawning area
Big White Salmon	temperature, bacteria	temperature
Klickitat River	cold temperature, sediments, DO, bacteria	temperature
Walla River	temperature, sedimentation, nutrients, pesticides, salinity, TSS, DO, bacteria	metals
Mainstem Snake, mouth to Hells Canyon	temperature, sedimentation total dissolved gases, algae nutrients, DO, organics	pesticides
Tucannon River	temperature, bacteria, TSS	
Palouse River	sedimentation, nutrients, temperature, bacteria, oil & grease, pH, metals, DO, ammonia	
Clearwater River	temperature, sedimentation, metals, habitat alteration, metals, pesticides, nutrients, DO, priority, organics, bacteria, oil & grease, ammonia	metals nutrients, sediments, habitat alteration
Grande Ronde R.	temperature & sedimentation, nutrients, BOD, DO, pH, habitat alteration, bacteria	metals
Salmon River	temperature, habitat alteration, sedimentation pesticides, ammonia, DO,metals & low pH (Panther Creek), nutrients	metals habitat alteration sediments
Imnaha River	temperature, habitat alteration, sedimentation	
Snake Mainstem above Hells Canyon Dam	temperature, sedimentation DO, pH, nutrients, bacteria algae, ammonia, pesticides	pesticides
Burnt River	temperature & sedimentation, nutrients, DO, BOD, pH, loss of cover	metals
Payette River	temperature, eutrophication (Cascade Reservoir), sedimentation, pH, DO, nutrients	metals
Owyhee/Malheur Rivers	temperature, sedimentation, pH, DO, nutrients, trace elements (As, HG), pesticides, algae, flow	
Boise River	temperature, coliform bact., turbidity, nutrients, DO, pH, BOD, flow, sedimentation, oil & grease	metals
Mainstem, Priest Rapids to Chief Joseph	total dissolved gases, dioxins, furans, pesticides, temperature, metals	PCBs, trihalomethane diss. gas

Table 2–2. Water Quality Concerns by Subbasin – CONT

Yakima River	temp. (passage & rearing), pesticides, sediments, DO, ammonia, pH, nutrients, algae, bacteria, chloride, metals, priority organics	metals
Crab Creek	temperature, sedimentation, nutrients, pH, bacteria, ammonia	pesticides
Wenatchee River	temperature, pesticides, sedimentation	metals
Entiat River	temperature	
Lake Chelan	pesticides, metals, ammonia, nutrients, bacteria	
Methow River	temperature, sedimentation	
Okanogan River	temperature, sedimentation, pesticides, DO, pH,	DO, pH nutrients
Mainstem, Chief Joseph to Canadian Border	metals, dioxins, furans (LK.,Roosevelt), bacteria (Nespelem R.)	dissolved gas
Kootenai River	total dissolved gases,	sediments
Clark Fork River	metals, sedimentation, habitat alteration	sediments pH, nutrients
Flathead River	temperature, too cold, reduced productivity, total dissolved gases	sediments nutrients
Pend Oreille/Spokane River	metals (Zn, Cd), PCB's, DO, pesticides, nutrients, pH, sedimentation, ammonia, TSS, nutrients, temp. bacteria, chloride, aquatic weeds	DO, sediments nutrients

2.8 BASINWIDE STATUS OF WATER QUALITY

Water quality parameters which can be affected by reservoir regulation are discussed in general terms in Exhibit A. The status of some of the most important of them, including trends, is given in Exhibit B. This material is entitled "Columbia River System Operation Review, Historical and Current Water Quality Conditions", June 1993, and was prepared by Ebasco Environmental. Figure 2–5 is a graphic summary of water quality concerns in the area covered by the Corps' North Pacific Division.

Dramatic improvement in water quality conditions in the Columbia River Basin is not expected in the near–term. Many current and proposed reservoir operations have an adverse effects. This includes spill to improve fish passage and reservoir drawdown. Both of these measures are intended to promote the recovery of salmon; determining their effectiveness could require years of monitoring.

Controlling point and nonpoint source pollution -- municipal and industrial wastes, soil erosion, return flow from agricultural lands -- is also a long–term endeavor. It depends primarily on the actions of state and federal regulatory agencies. The Corps of Engineers, Bonneville Power Administration, and the Bureau of Reclamation have little direct control over these sources of pollution except to providing flows to dissipate serious discharges when they occur. Because water quality problems are caused by sources both internal and external to the streams, they should be resolved jointly by all interested and affected parties.

Continuation of current system operations is not expected to affect water quality in the Columbia River Basin to any appreciable extent. Such an assumption, however, is not an assured possibility. Public opinion, expressed both nationally and regionally, indicates dissatisfaction with the emphasis on traditional benefits, power generation, flood

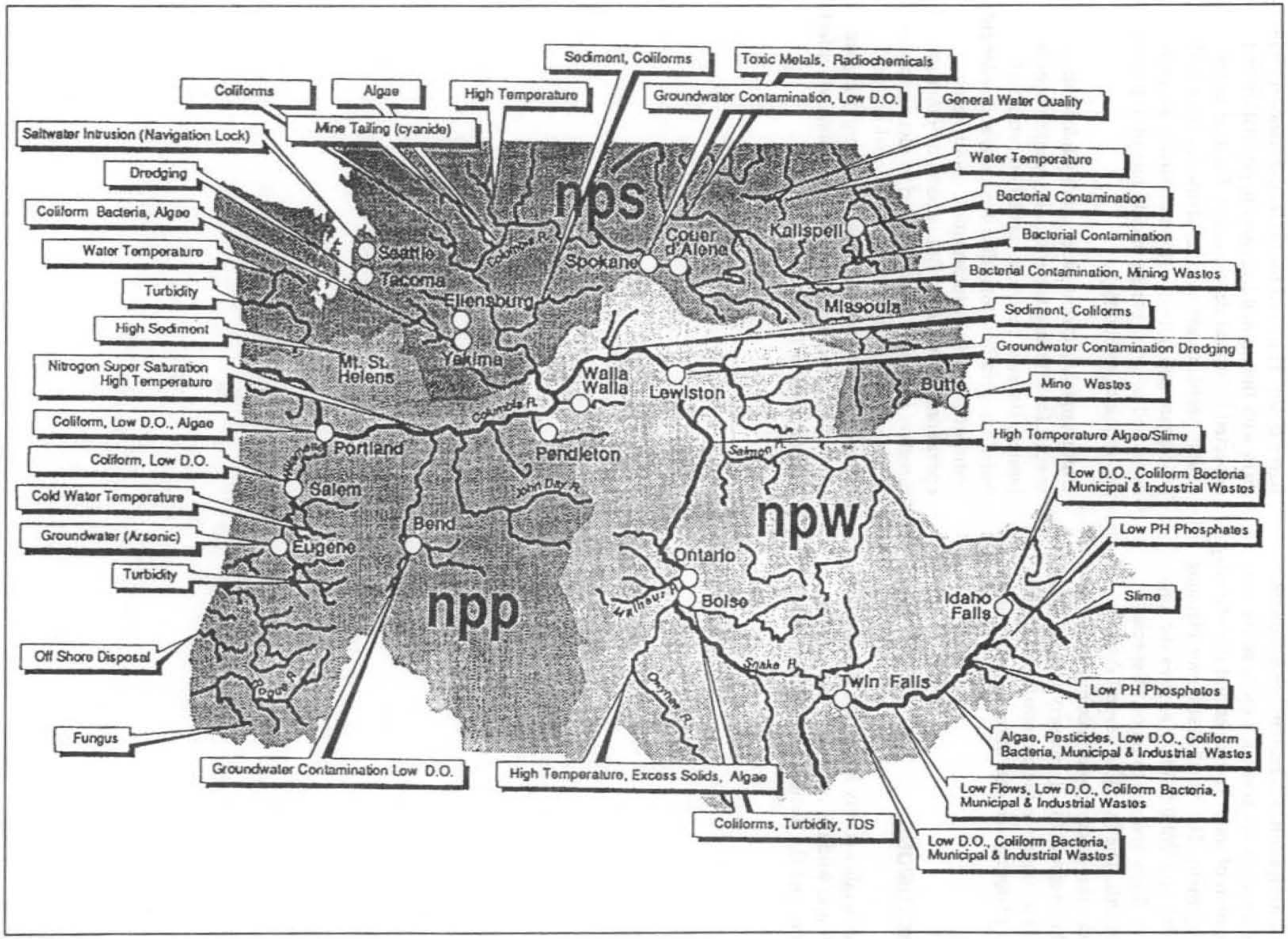

Figure 2–5. US Corps of Engineers North Pacific Division's Water Quality Concerns

control, and navigation. Recreation, environment, and fishery interests are seeking a more active role in the allocation of water resources and day–to–day water management. The Northwest Power Planning Council's Fish and Wildlife Plan requires the augmentation of flows and construction of special facilities for fish. The listing of several salmon species under the Endangered Species Act has required the preparation of recovery plans. This is another major change in the circumstances under which river planning and operation occurred in the past.

2.9 CONCLUSIONS

Good water quality is very important to human health, fish and wildlife, recreation, the aquatic environment, and the economy of the Columbia River Basin. The need for protective measures will grow with the normal increases in population and expected industrial development. Because water quality problems are diverse, stemming from both in–stream and out–of–stream sources, all interested and affected parties should join in to provide the required solution(s).

Unfortunately, current water quality information needed for effective water quality management is limited. Because reservoir regulation can affect water temperature, total dissolved gas, and sediment transport, important information about system operations was secured. But impacts on other parameters also need to be assessed to identify cumulative and synergistic effects. Additional holistic water quality studies and long term monitoring are needed to determine how river operations will affect water quality in the future.