THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Pacific Northwest Region

Second National Water Assessment by the U.S. Water Resources Council

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Foreword

The Water Resources Planning Act of 1965 (Public Law 89-80) directs the U.S. Water Resources Council to maintain a continuing study of the Nation's water and related land resources and to prepare periodic assessments to determine the adequacy of these resources to meet present and future water requirements. In 1968, the Water Resources Council reported the results of its initial assessment. The Second National Water Assessment, a decade later, provides a comprehensive nationally consistent data base for the water resources of the United States. The results of the Second National Water Assessment were obtained by extensive coordination and collaboration in three phases.

Phase I: Nationwide Analysis

The Council member agencies researched, analyzed, and prepared estimates of current and projected water requirements and problems and the implications of the estimates for the future.

Phase II: Specific Problem Analysis

Regional sponsors, one for each of the 21 water resources regions, surveyed and analyzed State and regional viewpoints about (1) current and future water problems, (2) conflicts that may arise in meeting State and regional objectives, and (3) problems and conflicts needing resolution.

Phase III: National Problem Analysis

The Council conducted this final phase in three steps: (1) An evaluation of phases I and II, (2) an analysis that identified and evaluated the Nation's most serious water resources problems, and (3) the preparation of a final report entitled "The Nation's Water Resources--1975-2000."

The final report of the Second National Water Assessment consists of four separate volumes as described below. These volumes can assist Federal, State, local, and other program managers, the Administration, and the Congress in establishing and implementing water resources policies and programs.

Volume 1, Summary, gives an overview of the Nation's water supply, water use, and critical water problems for "1975," 1985, and 2000 and summarizes significant concerns.

Volume 2, Water Quantity, Quality, and Related Land Considerations, consists of one publication with five parts:

Part I, "Introduction," outlines the origin of the Second National Water Assessment, states its purpose and scope, explains the numerous documents that are part of the assessment, and ident-

ifies the individuals and agencies that contributed to the assessment.

II, "Water-Management Problem Profiles," identifies ten general water problem issues and their implications and potential consequences.

Part III, "Water Uses," focuses on the national perspectives regarding existing ("1975") and projected (1985 and 2000) requirements for water to meet offstream, instream, and flow-management needs. State-regional and Federal perspectives are compared.

Part IV, "Water Supply and Water Quality Considerations," analyzes the adequacy of fresh-water supplies (ground and surface) to meet existing and future requirements. It contains a national water budget; quantifies surface- and ground-water supplies, reservoir storage, and transfers of water within and between subregions; describes regional requirements and compares them to supplies; evaluates water quality conditions; and discusses the legal and institutional aspects of water allocation.

Part V, "Synopses of the Water Resources Regions," covers existing conditions and future requirements for each of the 21 water resources regions. Within each regional synopsis is a discussion of functional and location-specific water-related problems; regional recommendations regarding planning, research, data, and institutional aspects of solving regional water-related problems; a problem-issue matrix; and a comparative-analysis table.

Volume 3, Analytical Data, describes the methods and procedures used to collect, analyze, and describe the data used in the assessment. National summary data are included with explanatory notes. Volume 3 is supplemented by five separately published appendixes that contain data for the regions and subregions:

Appendix I, Social, Economic, and Environmental Data, contains the socioeconomic baseline ("1975") and growth projections (1985 and 2000) on which the water-supply and water-use projections are based. This appendix presents two sets of data. One set, the National Future, represents the Federal viewpoint; the other set, the State-Regional Future, represents the regional sponsor and/or State viewpoint.

Appendix II, Annual Water Supply and Use Analysis, contains baseline water-supply data and baseline and projected water withdrawal and water-consumption data used for the assessment. Also included are a water adequacy analysis, a natural flow analysis, and a critical-month analysis.

Appendix III, Monthly Water Supply and Use Analysis, contains monthly details of the water-supply, water-withdawal, and water-

consumption data contained in Appendix II and includes an analysis of monthly water adequacy.

Appendix IV, Dry-Year Conditions Water Supply and Use Analysis, contains both annual and monthly baseline and projected water-withdrawal and water-consumption data for dry conditions. Also, a dry conditions water-adequacy analysis is included.

Appendix V, Streamflow Conditions, contains detailed background information on the derivation of the baseline streamflow information. A description of streamflow gages used, correction factors applied, periods of record, and extreme flows of record, are given for each subregion. Also included is the State-Regional Future estimate of average streamflow conditions.

Volume 4, Water Resources Regional Reports, consists of separately published reports for each of the 21 regions. Synopses of these reports are given in Volume 2, Part V.

For compiling and analyzing water resources data, the Nation has been divided into 21 major water resources regions and further subdivided into 106 subregions. Eighteen of the regions are within the conterminous United States; the other three are Alaska, Hawaii, and the Caribbean area.

The 21 water resources regions are hydrologic areas that have either the drainage area of a major river, such as the Missouri Region, or the combined drainage areas of a series of rivers, such as the South Atlantic-Gulf Region, which includes a number of southeastern States that have rivers draining directly into the Atlantic Ocean and the Gulf of Mexico.

The 106 subregions, which are smaller drainage areas, were used exclusively in the Second National Water Assessment as basic data-collection units. Subregion data point up problems that are primarily basinwide in nature. Data aggregated from the subregions portray both regional and national conditions, and also show the wide contrasts in both regional and national water sources and uses.

The Second National Water Assessment and its data base constitute a major step in the identification and definition of water resources problems by the many State, regional, and Federal institutions involved. However, much of the information in this assessment is general and broad in scope; thus, its application should be viewed in that context, particularly in the area of water quality. Further, the information reflects areas of deficiencies in availability and reliability of data. For these reasons, State, regional, and Federal planners should view the information as indicative, and not the only source to be considered. When policy decisions are to be made, the effects at State, regional, and local levels should be carefully considered.

In a national study it is difficult to reflect completely the regional variations within the national aggregation. For example, several regional

reviewers did not agree with the national projections made for their regions. These disagreements can be largely attributed either to different assumptions by the regional reviewers or to lack of representation of the national data at the regional level. Therefore, any regional or State resources-management planning effort should consider the State-regional reports developed during phase II and summarized in Volume 4 as well as the nationally consistent data base and the other information presented in this assessment.

Additional years of information and experience show that considerable change has occurred since the first assessment was prepared in 1968. The population has not grown at the rate anticipated, and the projections of future water requirements for this second assessment are considerably lower than those made for the first assessment. Also, greater awareness of environmental values, water quality, ground-water overdraft, limitations of available water supplies, and energy concerns are having a dramatic effect on water-resources management. Conservation, reuse, recycling, and weather modification are considerations toward making better use of, or expanding, available supplies.

CONTENTS

Illustrations

Physiography

Description

The Pacific Northwest Region occupies about 270,884 square miles[1] of the northwestern corner of the conterminous United States (Figure 17-1). The region includes all of the Columbia River Basin in the United States and those basins in Oregon and Washington draining into the Pacific Ocean, the Straits of Georgia or Juan de Fuca within Washington, and that part of the Great Basin lying in Oregon. The region encompasses all of the State of Washington, most of Oregon and Idaho, that part of Montana west of the Continental Divide, and the portions of Utah, Wyoming, and Nevada that are drained by tributaries of the Columbia River (Figure 17-1). Nearly half of the region is classified as forestland. Rangeland, pasture, and other agriculture covers 30 percent of the land, while 11 percent is used as cropland. Present land use is shown in Figure 17-2. Fifty-five percent of the region's area is federally owned. Private ownership accounts for nearly 40 percent. The remaining 5 percent is under State, county, and municipal ownership.

Geology

Although a variety of rock types occur in the region, the predominant types are those of volcanic origin. More than half of the region is underlain by lava flows, pyroclastics, or sedimentary rocks composed of volcanic materials. Other rock types found in the region include granitic, metamorphic, and consolidated sedimentary rocks.

The Coast Range consists principally of marine sandstones and shales together with basaltic volcanic rocks and related intrusives. Drowned valleys provide many harbors, and the drowned lower course of the Columbia River offers a route through the Coast Range. Soils on the sedimentary strata range from sandy loams to clays, while the soils on the volcanic rocks vary from lateritic loams to clay loams. Ground-water yields are best in dune and beach sands along the coast and in certain alluvial deposits.

Alluvial, lake, glaciofluvial, and glacial deposits underlie the floor of the Willamette Valley-Puget Sound Trough, which is located between the Coast Range and the Cascade Range. Soils include recent alluvial sediments, loams developed on older alluvial deposits, and soils developed on the sedimentary and volcanic rocks of the flanking mountains and the hills rising from the valley floor. Wells drilled into the alluvial and glacial deposits have moderately large to very large yields.

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[1]This is the sum of the areas of counties used to approximate the hydrologic area of the region. Land use and other socioeconomic data are related to this area. The drainage area in the United States within the hydrologic boundary is 277,340 square miles.

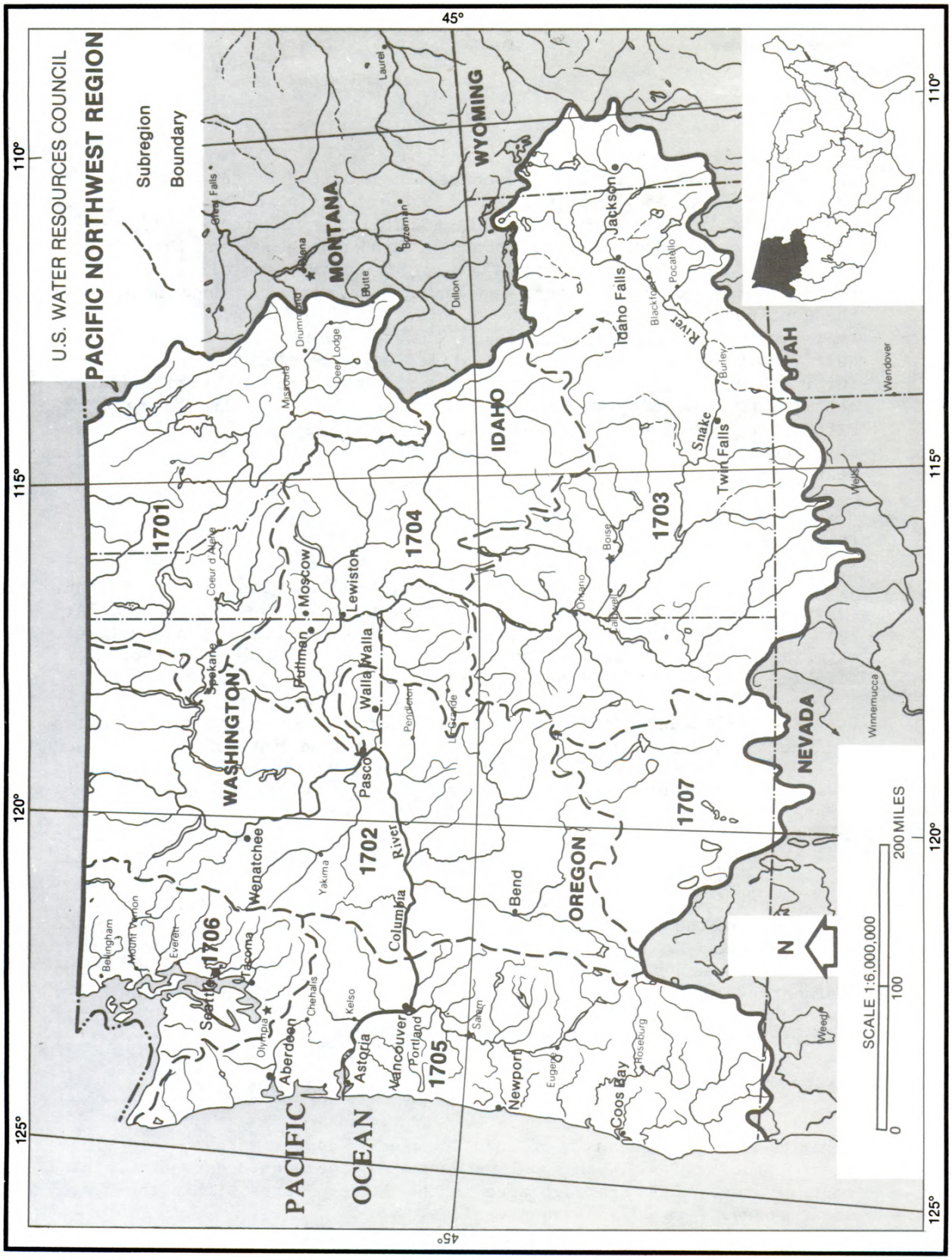

Figure 17-1. Region Map

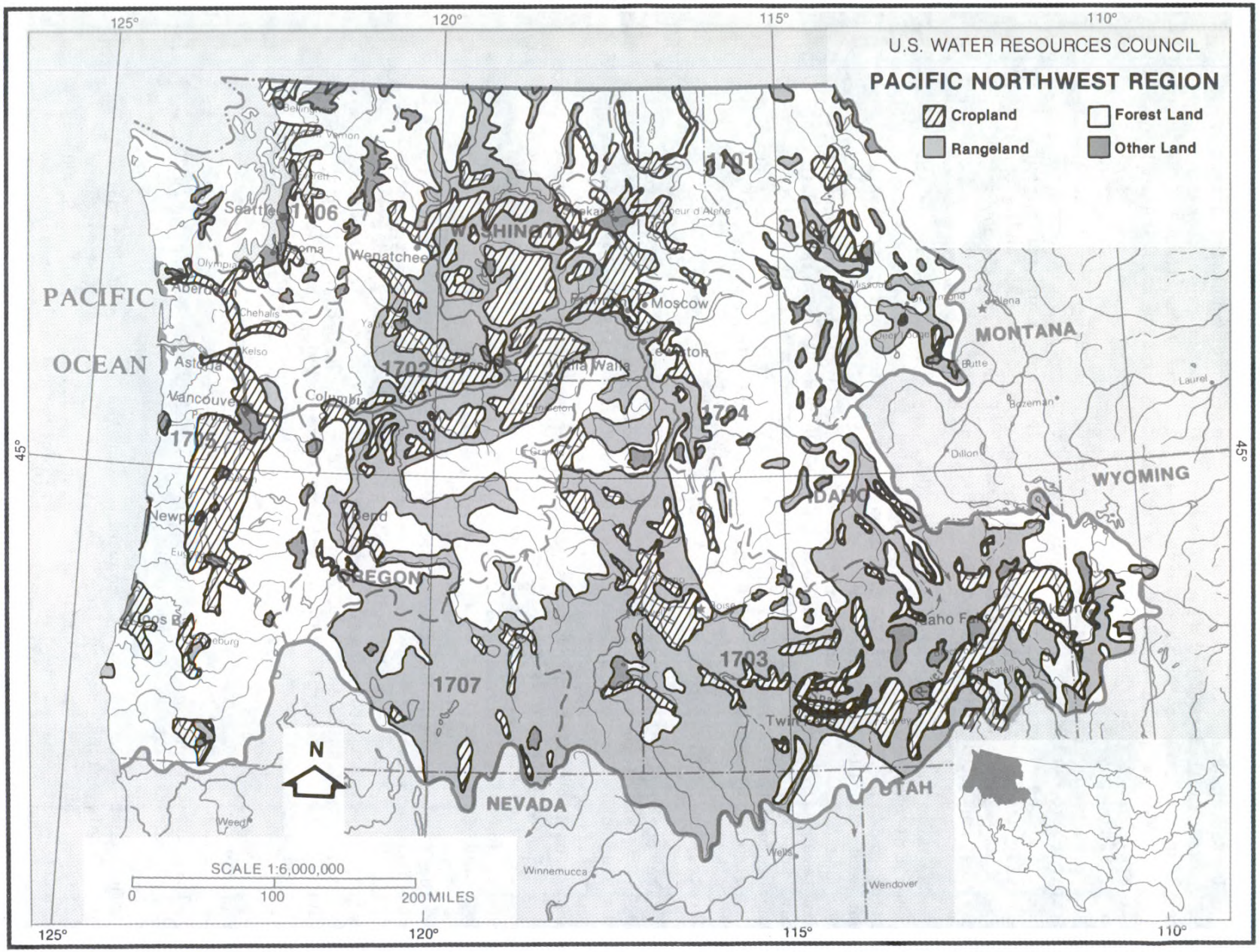

Figure 17-2. Present Land Use

The Cascade Range consists of a very rugged group of mountains carved from folded, faulted, and uplifted older igneous and metamorphic rocks and some younger volcanic rocks which have remained relatively unaltered. The younger rocks are porous and highly permeable, and streams draining such areas are characterized by high base flows.

The Columbia Plateau, located east of the Cascade Range, consists of volcanic rocks overlain by varying thicknesses of loess, glacial outwash, lake silts, and other materials. The loess soils are deep and fertile but are easily eroded. Many of the formations are highly porous and store large volumes of water where saturated. Much of the area is, however, semiarid, and little water is available for recharging aquifers.

The Blue Mountains, including the Wallowa Mountains, lie to the southeast of the Columbia Plateau. They consist of a core of older crystalline, volcanic, and consolidated sedimentary rocks surrounded by younger lavas and pyroclastic rocks. Soils include colluvium, sandy loam, clay loam, and clay. The younger rocks are generally higher in porosity and permeability than the older rocks. The Oregon Closed Basin, which covers southcentral and southeast Oregon, comprises a high lava plateau with numerous basins and ranges formed by block faulting. Soils include alluvial and wind-blown silts in the uplands and wind-blown sand and silt, clay, and sometimes peat in the basins. Most of the rocks are moderately to highly porous and permeable.

The Snake River Plain extending from southeastern Oregon across southern Idaho into western Wyoming is an extensive volcanic plateau containing both older and younger rocks. In some areas, the basalt surface is virtually unweathered, and little residual soil has developed. In other areas, wind-blown silt provides a permeable, highly fertile soil. On the older rocks, the soils range from gravelly, sandy loams to clay loams. The younger basalts are moderately to highly porous and permeable. The area is, however, semiarid and receives most of its water from surface runoff and ground-water inflow from basins flanking the plateau.

The Northern Rocky Mountains, occupying the northeastern portion of the region, consist of consolidated sedimentary rocks and metamorphic rocks. Soils formed on granitic rocks have low fertility, while those developed on metamorphic rocks are moderately fertile. Some wind-deposited soils and certain soils developed on glacial deposits have high fertility. Alluvial and outwash deposits in the valleys store and yield large amounts of ground water.

Topography

The physiographic provinces making up the region and their principal physical characteristics are as follows:

The Coast Range is a group of mountains along the Oregon and Washington coast with elevations ranging from 2,000 to 4,000 feet. At the northern end of the Coast Range are the Olympic Mountains standing 4,000 to 8,000 feet above sea level. The highest peaks bear perpetual snowbanks and

several small glaciers. Streams draining the Coast Range are short and have steep gradients.

The Willamette Valley-Puget Sound Trough, lying between the Coast Range and the Cascade Range, is between 30 and 50 miles wide and about 350 miles long. For the most part, it is below 1,000 feet in elevation.

The Cascade Range is a rugged group of mountains running north and south through Oregon and Washington. The main crest of the Cascades lies at about the 5,000-foot elevation, while several volcanic peaks of the range rise above 10,000 feet.

Immediately east of the Cascade Range and covering southcentral Washington and northcentral Oregon is the Columbia River Plateau. The plateau slopes gently from an elevation of about 4,000 feet around its borders to 350 feet along the gorges of the Columbia and lower Snake Rivers. The plateau is dissected by streams and, in the northern part, by deep, vertical-walled coulees.

To the southeast of the Columbia River Plateau and extending from the extreme southeast corner of Washington to Central Oregon are the Blue Mountains and the associated Wallowa Mountains. Peaks in the Blue Mountains proper have elevations of 7,000 to 9,000 feet, while in the Wallowa Mountains, the highest peaks exceed 10,000 feet in elevation.

The Oregon Closed Basin, occupying southeast and southcentral Oregon, consists of a plateau interrupted by fault block mountains and by fault troughs. The general base elevation is 4,000 feet, and peaks reach from 6,000 to 9,000 feet.

The Snake River Plain, which extends from southern Idaho to western Wyoming, is an arcuate downwarp 30 to 60 miles wide and about 400 miles long. It descends gently from an elevation of about 6,000 feet above sea level at its east end to about 2,200 feet on the west.

The northern Rocky Mountains occupy a large area in western Montana and Wyoming, in northern, central and eastern Idaho, and in northeastern Washington. The principal ranges in the group have a north-south orientation. Between the ranges are long, narrow valleys in which the principal streams are located. Elevations rise from 2,000 feet in the lowest valleys to over 12,000 feet on some of the peaks.

Climate

A considerable variety of climate occurs within the region because of variations in topography and elevation. Location near the coast or at some distance inland is another important factor, and the parallelism of the coastline and mountain ranges enhances the effect. Thus, the Cascade Range serves to divide the region into two broad climatic subregions: the mild, comparatively wet west and the drier east, with more extreme temperatures.

The heaviest annual precipitation in the conterminous United States

occurs on the western slopes of the Coast and Cascade Ranges. It exceeds 200 inches in the Olympic Mountains. From the crest of the Coast Range, annual precipitation decreases to about 35 inches in the Willamette Valley-Puget Sound Trough and then increases to 100 inches or more along the crest of the Cascade Range. About two-thirds of the year's total precipitation falls from October to March. East of the Cascade Range in central Oregon and Washington, precipitation decreases rapidly to 10 inches or less in the valleys and plateaus. Mountain areas have a total of 40 to 50 inches. The Snake River Plain receives from 6 to 15 inches of annual precipitation, with 40 or more inches occurring near the tops of the higher mountains along its southern edge. In the northern Rocky Mountains, annual precipitation ranges from 10 to over 70 inches. At the higher elevations, much of the precipitation falls as snow. Maximum snowpacks, occasionally 20 to 30 feet deep, are generally found at elevations above 5,000 feet. Heavy snowpacks on many of the highest mountains have formed some glaciers.

West of the Cascade Range, winters are milder and summer days cooler than at locations of similar elevation east of the mountains. January temperatures average 36° F in low-lying areas west of the Cascades as compared to 32° F in the warmest valley areas east of the mountains. The corresponding July temperatures are 62° F and 76° F. The average length of the frost-free growing season varies from over 240 days in parts of the coastal area to 200 days in interior valleys and 160 days or less on the plateaus. Diurnal and seasonal ranges of temperature east of the Cascades are greater than the corresponding values west of the mountains. Likewise, the areas east of the Cascade Range are characterized by greater extremes of temperature than the areas to the west.

People and the Resources

Introduction

Basic to an identification of the region's problems with respect to water and related land resources is an analysis of the region's economic, social, and environmental factors that influence and, in turn, are influenced by those problems. Estimates and projections of population, economy, water supplies, water requirements, and other factors were prepared as explained elsewhere in the National Assessment Report.[1] Those estimates and projections are referred to as the National Future (NF). Alternative regional projections were prepared, or extracted from information already available; these projections are consistent with State or regional perceptions and are referred to as the State-Regional Future (SRF). Differences between the SRF and NF projections and the implications of such differences are discussed at the end of this section. All data presented are taken from the NF unless stated otherwise.

Population

In the 25 years from 1975 to 2000, the region's population is projected to increase 13 percent from 6,703,000 to 7,589,000, thereby increasing the density of population from about 25 to about 28 persons per square mile. During the same period, the Nation's population is projected to increase 24 percent with the density of population growing from 61 to 76 persons per square mile. In the next 25 years, therefore, the region's population growth rate is projected to be substantially below the national average. In terms of population density, the region will continue to be relatively sparsely populated.

Slightly more than 70 percent of the population lives in the Seattle and Portland metropolitan areas located in subregions 1706 and 1705, respectively. Subregions 1704 and 1707, the areas with the lowest populations, are expected to experience little change in population.

Economy

Total employment in the region is projected to increase 27 percent from 2,642,000 in 1975 to 3,345,000 in the year 2000. Total earnings, in constant 1975 dollars, are expected to increase 129 percent from $30.9 billion to $70.8 billion. Per capita income, also in constant 1975 dollars, is projected to increase 107 percent from $5,934 to $12,272. In the 25-year period, total employment in the Nation is projected to increase by 34 percent, a rate much higher than the 27 percent projected for the region. The increase in total earnings for the Nation, projected at 140 percent, is also greater than the 129 percent increase projected

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[1] See Volume 3, Analytical Data.

for the region. With respect to per capita income, the projected national average of $12,319 for 2000 is higher than the regional projection, although the rate of increase is less than that for the region.

The region, like the Nation, depends on noncommodity industries for a major part of its earnings. Included in noncommodity industries are government, wholesale and retail trade, services, contract construction, transportation, communications, public utilities, finance, insurance, and real estate. In 1975, this group of industries (designated as "other" on Table 1) accounted for 73 percent of all regional earnings. That percentage is expected to rise to 78 percent by the year 2000.

Manufacturing accounted for 22 percent of the region's earnings in 1975. The major items manufactured were wood products, transportation equipment (excluding motor vehicles), and food products. Total earnings from manufacturing are projected to increase 107 percent in the 25-year period. The corresponding increase nationally is 113 percent. About 5 percent of the total regional earnings in 1975 was attributed to agriculture. With a projected increase in agricultural earnings of only 13 percent for the 25-year period, such earnings will make up only 2.3 percent of the regional total in 2000. For the Nation as a whole, a 16 percent increase is projected for agriculture earnings in the 25-year period. Projected increases in selected earnings for the region are given in Table 17-1.

Table 17-1.--Pacific Northwest Region earnings--1975, 1985, 2000
(million 1975 dollars)

Earnings sector	1975	1985	2000
Manufacturing	6,814	9,383	14,125
Agriculture	1,453	1,427	1,647
Mining	150	167	198
Other	22,501	32,633	54,870
Total	30,918	43,610	70,840

To summarize, both earnings and per capita income in the region are expected to more than double in the 25-year period, 1975 through 2000. The increased earnings are expected to come principally from noncommodity industries and from manufacturing. The manufacture of wood products, transportation equipment, and food products will continue to play a major role in the regional economy. In projected rate of economic growth, however, the region will place below the national average.

Natural Resources

The basic natural resources of the region are high-quality land and water and certain mineral deposits in sufficient quantities to be of economic significance. Timber, fish, and wildlife are important resource products. The mountains, forests, rivers, and lakes, together with the wildlife and fish life they support, combine to provide outstanding recreation and esthetic values, and constitute a significant natural resource.

The land area in the region totals some 171.0 million acres, of which almost 50 percent is classified as forestland, while 31 percent is used as pasture, rangeland, and other agriculture, and 19.2 million acres or 11 percent consist of cropland. About 6.2 million acres of cropland, over 32 percent of the total, are irrigated. Land in pasture but tilled in regular rotation is included under cropland. The cropland base of 19.2 million acres will be slightly reduced by the year 2000. Urban land totaled 1.06 million acres in 1975.

Pasture and rangeland comprise about 51 million acres which provide about 7 million animal unit-months of livestock grazing. About 19 percent of the rangeland is in good condition, 44 percent is in fair condition, and the balance, 37 percent, is in poor condition.

Forestland covers over 85 million acres, of which about 80 percent is classified as commercial forests. These commercial forests contain a significant portion of the Nation's saw-timber volume. The value of the resources, however, extends beyond the provision of wood. The forests are the principal vegetative cover protecting the slopes of the mountains which produce most of the region's runoff. They also provide shelter for elk, deer, and other big game and, east of the Cascade Mountains, provide much of the summer range for cattle and sheep. Table 17-2 lists land uses in 1975.

Table 17-2.--Pacific Northwest Region surface area and 1975 land use

Surface area or land-use type	1,000 acres	Percentage of total surface area
Surface area		
Total	173,366	100.0
Water	2,329	1.3
Land	171,037	98.7
Land use		
Cropland	19,159	11.1
Pasture and range	51,008	29.4
Forest and woodland	85,041	49.1
Other agriculture	1,289	0.7
Urban	1,055	0.6
Other	13,485	7.8

Minerals

The mineral resources of the region play an important role in the regional economy and provide a vital source of raw materials for its industry. The principal domestic sources of antimony, manganese, nickel, olivine, pumice, silver, and vermiculite are found in the Pacific Northwest. Mineral resources requiring water for processing include metals, nonmetals, and fuels. Metals requiring water for processing are copper, lead, zinc, silver, gold, manganese, nickel, tungsten, and uranium. Water is also required for processing nonmetallic products including fluorspar, magnesite, sand and gravel, stone, vermiculite, and phosphate rock.

Coal is the principal mineral fuel occurring in the region. Closely related industrial operations requiring water for processing and cooling purposes include refineries for aluminum, cement, copper, and steel.

Agriculture

Agriculture products exported from the region include grain, grass seed, potatoes, fruits, hops, beet sugar, vegetables, nuts, peppermint, berries, and some dairy products. Beef is an important product in many localities. Irrigation is a key factor in the region's agriculture, particularly in the precipitation-deficient areas east of the Cascade Range. Earnings from agriculture amounted to $1,453 million in 1975, representing about 5 percent of total earnings. Although the land base currently devoted to cropland is expected to slightly decline by the year 2000, agricultural production is projected to increase due to an expected increase in irrigated land and to significant improvements in yield. Agricultural earnings in 2000 are projected to be 13 percent greater than those for 1975. Expected agricultural land use changes are listed in Table 17-3.

Table 17-3.--Projected changes in cropland and irrigated farmland in the Pacific Northwest Region--1975, 1985, 2000
(1,000 acres)

Land category	1975	1985	2000
Total cropland----------	19,139	19,086	18,927
Cropland harvested---------	12,037	12,357	13,231
Irrigated farmland---------	6,186	7,424	7,759

Energy

By the end of 1975, the region had a total electric power generating capacity of 28,272 MW (megawatts) made up as follows:

Hydroelectric	22,323 MW
Fossil fueled	3,962 MW
Nuclear fueled	1,990 MW

Total electric energy generation in 1975 amounted to 137,838 gWh (gigawatt-hours) of which about 93 percent was generated by hydroelectric power plants. Nuclear-fueled plants produced about 2.4 percent, and fossil-fueled plants accounted for about 5 percent. Annual generation is expected to almost triple by the year 2000 reaching 408,621 gWh. Nuclear-fueled plants are projected to produce about 58 percent of the total. Hydroelectric plants are projected to produce about 38 percent and fossil fueled plants about 4 percent. Two nuclear powerplants are currently in operation.

By the year 2000, 10 such plants are projected. The principal fossil-fueled plants currently in operation number four; two additions are projected. The projections are listed in Table 17-4.

Table 17-4.--Pacific Northwest Region electric power generation--1975, 1985, 2000

(gigawatt-hours)

Fuel source	1975	1985	2000
Fossil----------	6,292	9,732	17,813
Nuclear----------	3,310	44,907	235,145
Conventional hydropower----	128,236	134,472	155,663
Total generation---------	137,838	189,111	408,621

Most of the region's hydroelectric energy potential has been developed. A few major sites still exist, but development of the sites is likely to be opposed by environmental interests. As more steam electric plants are built, the existing hydroelectric plants will be used increasingly for peaking rather than for base load.

Navigation

A 40-foot deep, 600-foot wide channel provides deep-draft navigation on the Columbia River from its mouth to Vancouver, Washington, and to Portland, Oregon. A 15-foot deep channel continues upstream from Vancouver to the navigation locks at Bonneville Dam. Upstream from Bonneville Dam, slackwater navigation is available on the Columbia River to the pool behind McNary Dam and then up the Snake River to the City of Lewiston. Deep-draft port and terminal facilities on the Columbia River are located at Portland, St. Helens, and Astoria in Oregon and Vancouver, Kalama, and Longview in Washington. There is navigation for some distance upstream from Portland on the Willamette River. Waterborne commerce on the lower Columbia River, which amounted to 28 million short tons in 1965 and 39 million tons in 1975, is projected to reach 44 million short tons in 2000, according to regional estimates. Port facilities are generally adequate for existing deep-draft navigation, but will need to be expanded and improved to accommodate the projected additional traffic. In 1967, the upbound and downbound cargos moving through the McNary Lock were 429,069 and 1,574,726 short tons, respectively. The corresponding totals for 1970 were 532,013 and 1,755,950 tons. Upbound cargo on the Snake River is projected to increase from 471,000 to 740,000 short tons over the period from 1980 through 2000, according to regional estimates.

The Strait of Juan de Fuca and the connecting channels provide natural deep-water access, permitting unrestricted vessel size, from the Pacific Ocean to the many bays and estuaries in Puget Sound. Foreign and domestic coastwise waterborne commerce increased by 50 percent between 1952 and 1966.

Continuation of that trend would raise such commerce to 60 million tons in the year 2000. There are, in all, some 32 active port districts in Puget Sound. The coastal areas in Washington and Oregon, exclusive of Puget Sound, have four deep-draft harbors and some 14 shallow-draft harbors. The inland navigation is outlined in Figure 17-3.

Environment

The natural resources of the region, which are many and varied, offer a wide range of outdoor recreation opportunities. Their extensive use by residents of the region as well as by visitors has given tourism an important place in the region's economy.

Water resources providing recreation opportunities include lakes, ponds, reservoirs, glaciers and snowfields, rivers, creeks, springs, and the ocean with its ebb and flood tides. The lakes of the region number in the thousands and are widely distributed. A total of 260 major lakes and small reservoirs over 100 acres in size have been inventoried in regional studies. The mountain lakes are the most numerous. Many such lakes found in the alpine country provide opportunities for sightseeing, camping, and fishing. Mountain ranges containing large numbers of alpine lakes include the Rockies, Cascades, and Selkirks. The lowland lakes, farm ponds, oxbow lakes, and city park lagoons, are important suppliers of water-based recreation activities for urban populations because of their general location, easy access, and usable topography. Almost 200 reservoirs with storage capacities of at least 5,000 acre-feet provide over 1.2 million surface-acres of water. Scattered throughout the region, they provide a wide range of opportunities for water-related recreation. Water locked in its solid state as ice or snow is also important to outdoor recreation. The high scenic peaks of the Cascade and Rocky Mountains contain over 80 percent of the remaining examples of the ice age glaciers left in the conterminous United States. During summer, the glaciers and snowfields contribute to streamflow and provide opportunities for sightseeing and outdoor photography. In winter, the extensive snowfields in the mountains provide opportunities for skiing, sledding, snowmobiling, and snow camping.

The numerous rivers of the region are generally of high quality. Some of them are of national significance because of their wild, scenic, or recreation character. According to regional estimates, some 400 miles of streams have been designated under Federal law as wild and scenic rivers, while about 2,300 miles have been recommended for study for such designation. Studies on some of the streams have been completed while others are in progress and some are yet to be initiated. There are, in addition, some 7,000 streammiles that may have potential and should be studied to determine their value as State or national rivers. The free flowing rivers or segments thereof provide a wide range of outdoor recreation opportunities including fishing, float boating, motor boating, swimming, hunting, sightseeing, photography, and nature study. The

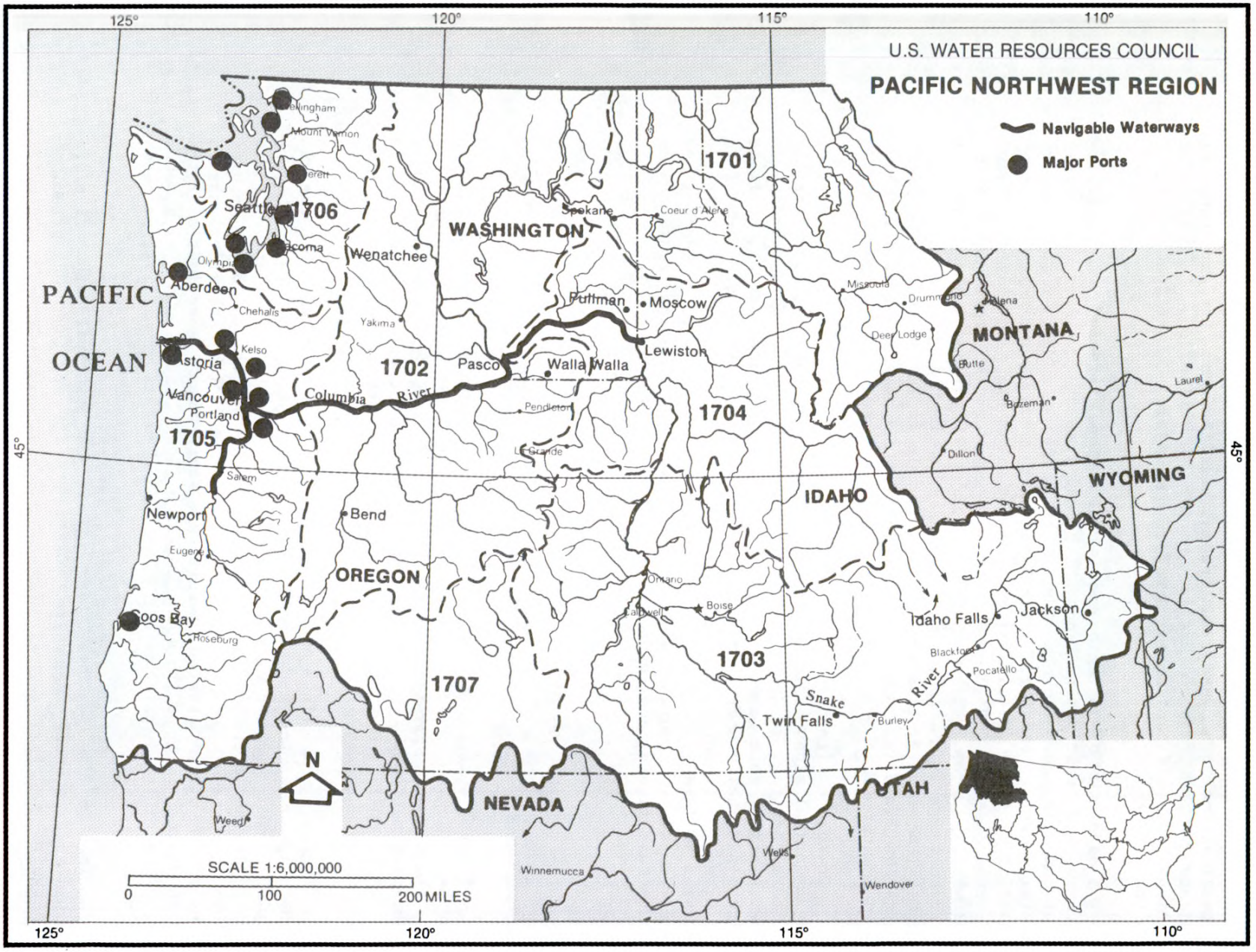


Figure 17-3. Navigation System

estuarine areas of rivers are of special significance to the environmental balance between fresh and salt water. The region has 7,270 miles of nationally significant streams for fish and wildlife, more than 23 percent of the national total.

A major part of the region consists of national forests, parks, wildlife refuges, and other public lands which fall into the category of natural environment areas. They provide extensive opportunities for sightseeing, hiking, hunting, fishing, boating, canoeing, mountain climbing, and rock hounding. Within the natural environment areas are federally designated wilderness areas. There are 27 such wilderness areas aggregating 5.2 million acres. They constitute about 36 percent of the National Wilderness System. Additionally, 105 areas have been identified by governmental land management services for possible inclusion in the National Wilderness Preservation System. Five endangered species of wildlife have been identified.

In common with the rest of the Nation, the region has a number of archeological sites and sites associated with the history, tradition, or cultural heritage of Nation, State, or local areas. Examples include Fort Clatsop, Fort Vancouver, and Marcus Whitman national areas; heritage sites; national historic sites; State areas such as Champoeg State Park in Oregon, Fort Columbia in Washington, Fort Casey in Washington, Cataldo Mission in Idaho; and numerous sites relating to prehistoric Indians and their culture. Figure 17-4 shows the locations of national parks, wild and scenic rivers, and important recreation rivers.

Surface Flows

Present outflow, as modified by reservoir operations, in the Pacific Northwest Region is 255,270 mgd. Total available streamflow estimated for the region is approximately 266,566 mgd. Figure 17-5 gives the present subregion outflows. It should be noted that the closed basin approximated by subregion 1707 has no outflow and that water received as precipitation is lost through evapotranspiration and other consumption.

Highest streamflows occur in winter west of the Cascade Range and generally in spring and summer east of it. Their total exceeds the regional mean from November through June. August and September are generally the months of low flow on both sides of the Cascades. The high flows in streams west of the Cascade Mountains, which generally occur in winter, as already stated, result from storm runoff sometimes assisted by snowmelt. East of the mountains high flows in the principal streams occur generally in spring or early summer and result primarily from snowmelt.

Flows in the Columbia River and in the principal tributaries are regulated by storage reservoirs. Usable storage capacity of the principal reservoirs and regulated lakes exceeds 55 million acre-feet including

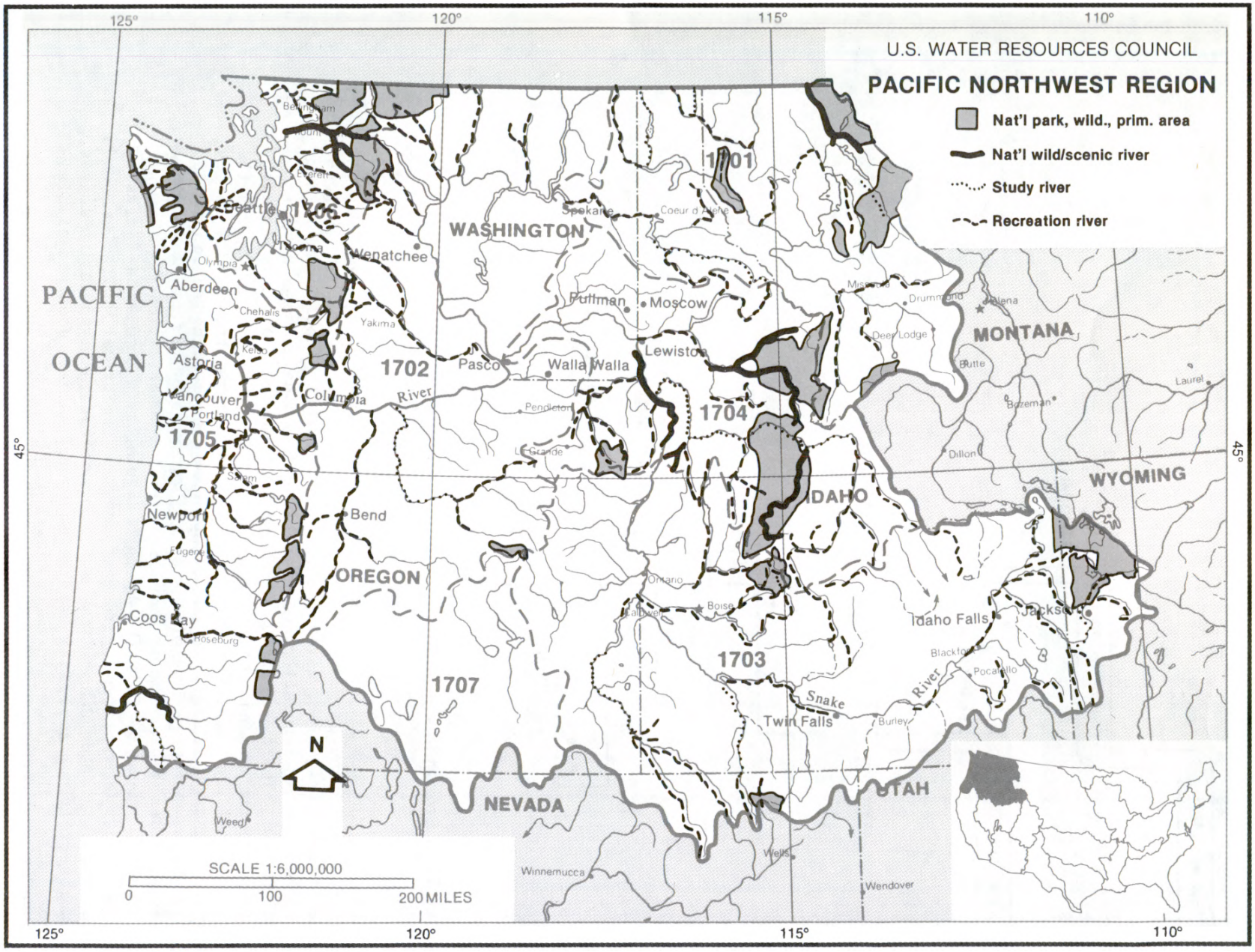


Figure 17-4. Environmental Resources

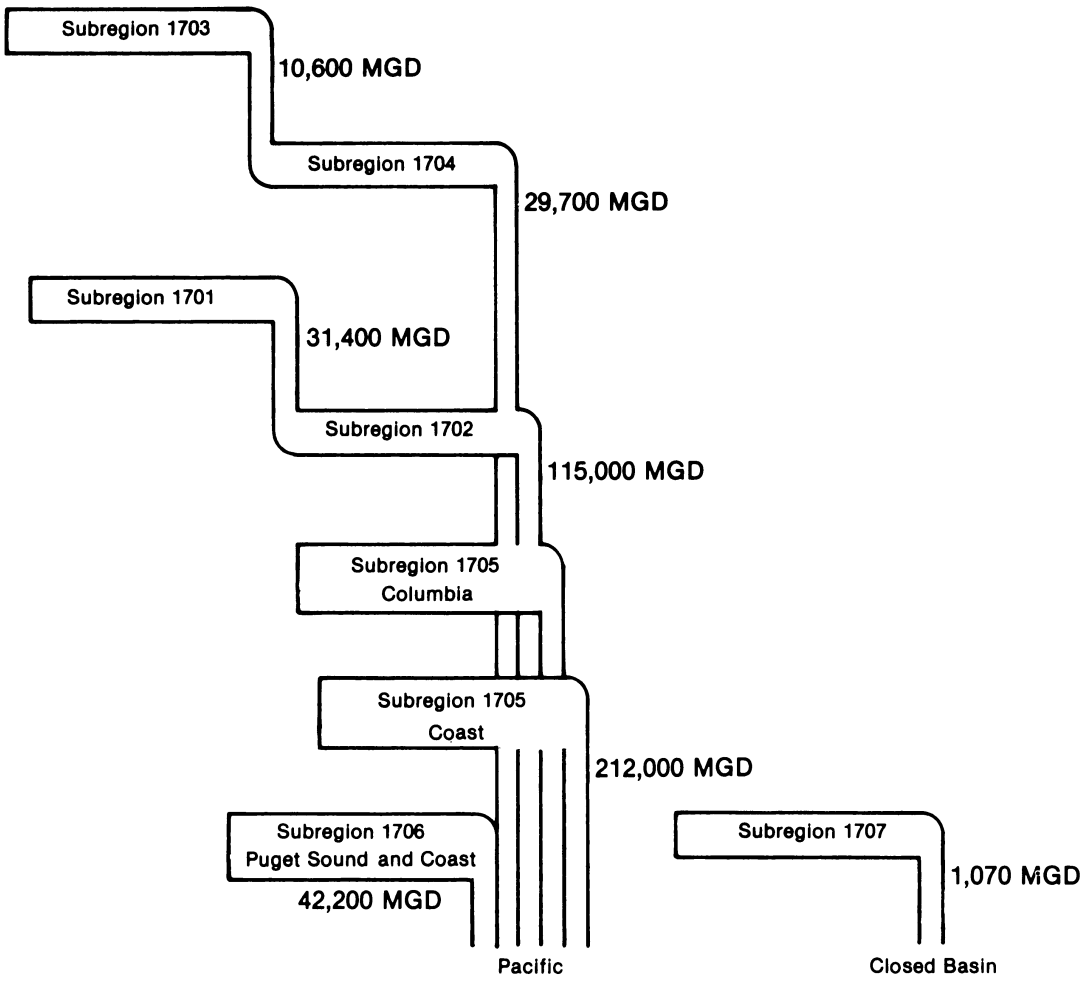


Figure 17-5. Streamflow

reservoirs in Canada. Many of the reservoirs are multipurpose. Their main functions provide for flood control, recreation, hydroelectric power generation, irrigation, navigation, municipal water supply, and fishery enhancement. Flow regulation has generally reduced peak flows and increased base flows. There are many legal restrictions and other constraints to flow regulation and stream management. The most important are the international treaties, such as the Boundary Waters Treaty with Canada signed on January 11, 1909, and the treaty with Canada signed on January 17, 1961, for cooperative development of the water resources of the Columbia River. Other restrictions include Federal authorization requirements on Federal dams, Federal Energy Regulatory Commission licenses, the Northwest Coordination Agreement between electrical utilities, and water rights granted under State laws. Except for the evaporation losses from reservoir surfaces, flow regulation by reservoirs does not significantly alter the long-term mean annual discharge of the stream system.

Ground Water

Ground water is an essential element in the assessment of the water resources of the region. Not only are large quantities of water for a variety of uses obtained from wells and springs, but also a large part of the surface-water supply is maintained by discharge from aquifers, especially during periods of fair weather when the flow of many streams is composed mostly or entirely of ground-water discharge.

Only in coastal areas does any significant quantity of ground water (excluding evapotranspiration) leave the region that does not appear as a component of stream discharge. Thus, the streamflow value for each subregion includes the ground-water component, except in subregions 1705 and 1706 where part of the ground water discharges directly into the Pacific Ocean or Puget Sound.

Although use of ground water does not add to the total available supply, it does offer opportunities for management by augmenting minimum streamflows and increasing firm supplies by drawing water from underground storage during dry periods and replacing the ground water by natural or artificial recharge during periods of excess runoff.

Ground water can be obtained in most of the region. However, the quantities obtainable from a well may range from a few gallons to many thousand gallons per minute. Also, the depth to which a well must be drilled to obtain a ground-water supply may range from a few feet to more than a thousand feet. The great differences are related chiefly to differences in geology, quantity of precipitation, topography, and drainage.

About 42 percent of the region is underlain by aquifer units with low porosity and permeability that will generally yield only small supplies of ground water. These units are, however, confined mainly to thinly populated areas where water needs are comparatively small and surface water supplies are plentiful.

West of the Cascade Range, the major aquifers are chiefly sand and gravel in alluvial and glacial deposits. Many wells with yield capacities ranging from 20 to 2,000 gallons per minute have been drilled in these deposits in subregion 1706 and in the Willamette, Cowlitz, Chehalis, and other river valleys.

In the plateaus of central and eastern Washington, northcentral and northeastern Oregon, and westcentral Idaho, basalts of the Columbia River and Snake River Group are the most widespread major aquifers. They yield up to 2,000 gallons per minute and more to wells. Recharge from direct precipitation is generally small, but some areas receive additional recharge from streams draining adjacent mountain areas or from irrigation seepage. Over large areas of the plateaus, however, recharge is entirely from scanty local rainfall. This limits the quantity of ground water that can be obtained.

Alluvial deposits are important aquifers along the Columbia River downstream from Grand Coulee Dam; in the Spokane, Okanogan, Yakima, and Walla Walla River Valleys; and in the Ephrata-Moses Lake and Pasco areas. Alluvial deposits are also major aquifers in valleys in northern Idaho and Montana and in such places as the Rathdrum Prairie, and the Bitterroot, Flathead, Kootenai, and similar valleys. Volcanic rocks, sedimentary strata, and valley alluvial deposits are important aquifers in southcentral and southeastern Oregon and in southwestern Idaho, but they have been developed only at a few places. Extensive aquifers underlie the Snake River Plain and more ground water is withdrawn in that area than in any other part of the region. Basalt is the major aquifer in the eastern Snake River Plain, but alluvial deposits are important near the Snake River and in tributary valleys. The major productive aquifers in the region are outlined in Figure 17-6.

Water Withdrawals

Withdrawals of fresh water from ground-water and surface-water supplies in the region totaled 37,495 mgd in 1975. Irrigation was by far the major use accounting for 33,181 mgd or about 88 percent of the total. Withdrawals for manufacturing were next in magnitude with a total of 2,324 mgd or close to 6 percent of the regional total. Other identified uses were steam electric generation, public lands, domestic, and mining. Figure 17-7 shows the relative magnitude of withdrawals for principal uses.

Projections for the year 2000, with respect to fresh-water withdrawals from surface sources, show reductions of about 10 percent for irrigation and about 51 percent for manufacturing uses below the corresponding values for 1975. Domestic use is expected to increase by 19 percent.

As a result of reductions, total withdrawals in 2000 are expected to drop 10 percent below the 1975 value to 33,852 mgd. Irrigation will continue to be the dominant use of water, taking up 89 percent of all withdrawals of surface water. Manufacturing use, which accounted for 6 percent of the withdrawals in 1975, will make up only 3 percent of the total in 2000. A comparison of the projected withdrawals in 2000 is given in Figure 17-7. Ground-water withdrawals in 1975 totaled 7,348 mgd, or 20 percent of total withdrawals. No projections are available for ground-water withdrawals in 2000. Saline-water withdrawals in 1975 amounted to 131 mgd.

Water Consumption

While total withdrawals of water are expected to increase from 1975 to 1985 and decline by 2000, the quantity of water lost through evapotranspiration, or otherwise consumed and not returned to the stream or ground water, is projected to increase. Total consumptive use of water in 1975 was 11,913 mgd. This is projected to rise to 15,196 mgd by the year 2000, with most of the increase occurring by the year 1985.

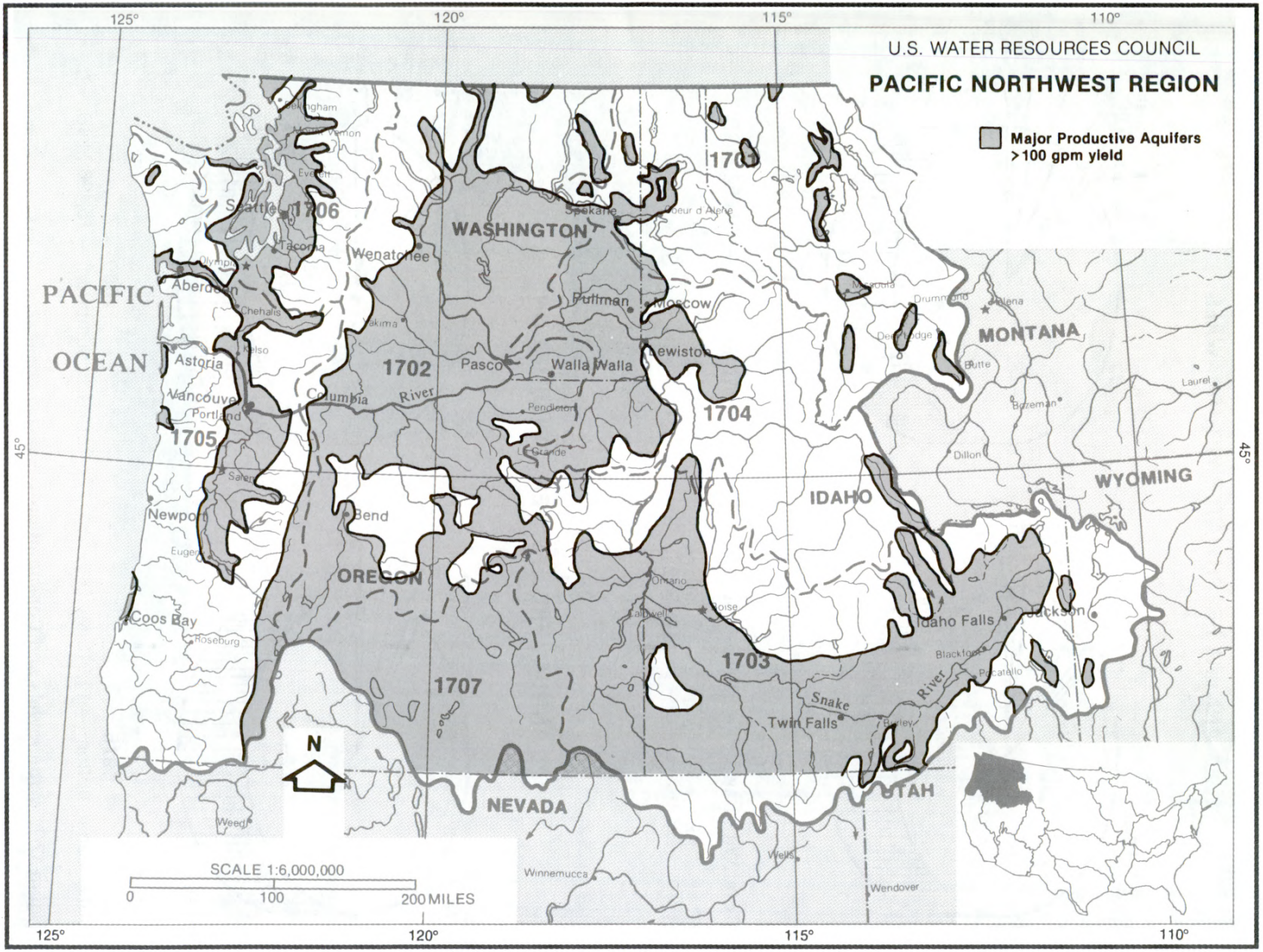
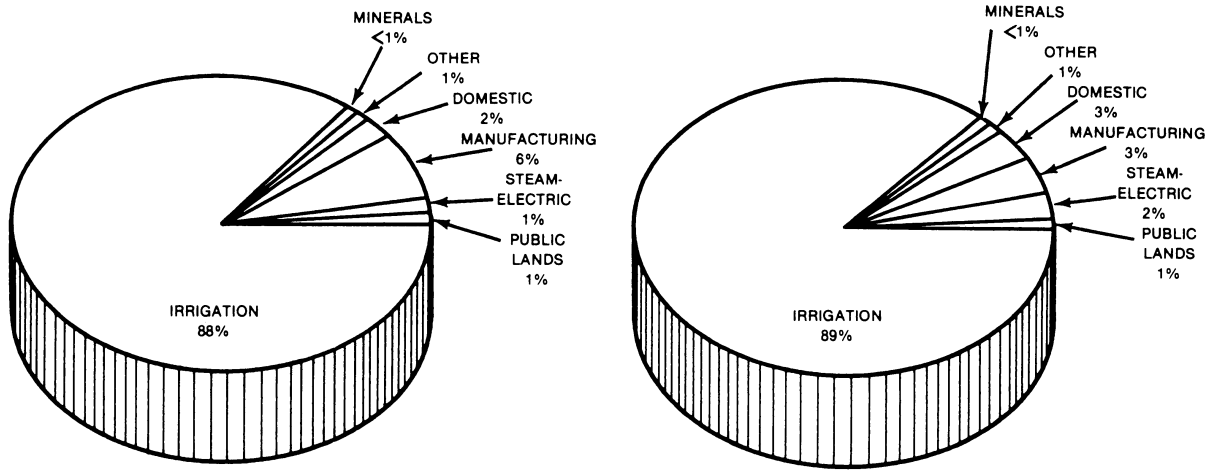


Figure 17-6. Major Aquifers

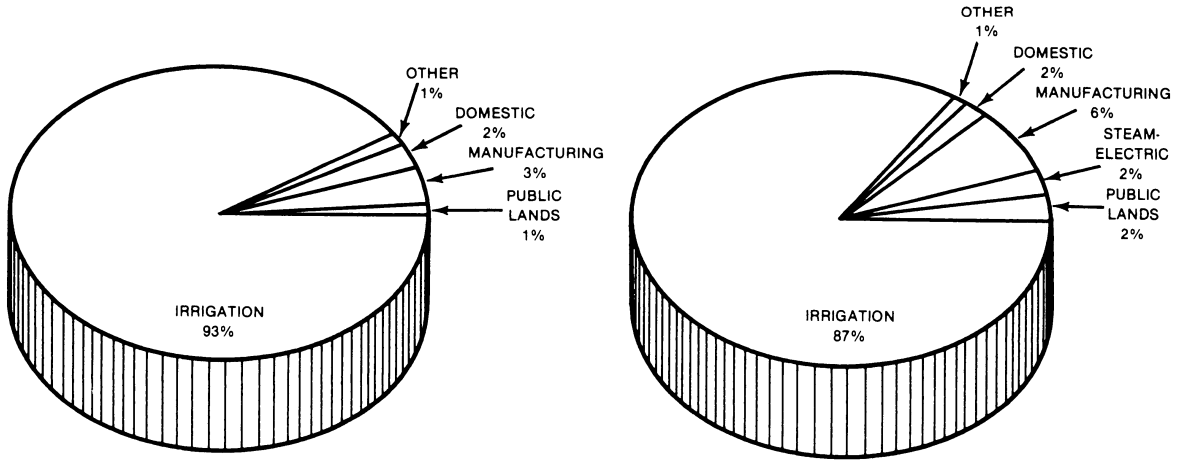
ANNUAL FRESHWATER WITHDRAWALS



1975
Total Withdrawals — 37,495 MGD

2000
Total Withdrawals — 33,852 MGD

ANNUAL FRESHWATER CONSUMPTION



1975
Total Consumption — 11,913 MGD

2000
Total Consumption — 15,196 MGD

Figure 17-7. Withdrawals and Consumption

Crop irrigation used 11,026 mgd in 1975, or 93 percent of total consumption for that year. By the year 2000, consumption for irrigation will be 13,213 mgd or about 87 percent of total consumption. Manufacturing, the second largest consumptive use, is expected to more than double from 325 mgd in 1975 to 880 mgd in 2000. The largest rate of increase in consumption will occur in steam electric use, in which the level of consumption in 2000 is expected to be more than 26 times the 1975 level. Figure 17-7 graphically illustrates annual fresh water consumption by the various uses in 1975 and 2000, respectively.

Instream Uses

Instream uses of water provide for stream resource maintenance and serve fish life, water quality, hydropower, navigation, recreation, esthetics, and other needs. Offstream uses of water, especially those involving consumptive depletions, necessarily conflict with instream uses. In 1975, four of seven subregions experienced seasonal conflicts between instream and offstream uses. Such conflicts are expected to increase in the future. The critical months generally are July and August, although conflicts could occur in almost any month. It is projected that conflicts of this nature will be most acute in subregions 1702, 1703, 1704, and 1705 in 1985; in the year 2000 the critical conditions would be most likely in subregions 1701, 1706, and 1707.

Water Supply and Demand

Annual regional outflow averages 255,270 mgd. The total available streamflow is about 266,556 mgd. The consumptive use in 1975 was estimated at 11,913 mgd or about 4.5 percent of the total annual supply. The projected consumptive use in the year 2000 is 15,196 mgd, or about 5.7 percent of the annual supply. Thus, the total regional supply is large in comparison with the regional consumptive requirements.

In spite of the large total supply, water is not always available where and when it is needed. Extreme variations occur in both the areal distribution and timing of runoff. Consequently, the average discharge is not the usable supply. Even with storage, the total mean discharge is not usable because of natural losses as well as seasonal and year-to-year variations. In most streams, the minimum year of discharge provided only about 60 percent of the average annual flow; also, the mean of the minimum 5 consecutive years supplied only about 75 percent of the average. Some large streams produce minimum-year flows as low as 25 percent of the long-term average.

Irrigation, which is by far the major use of water in the region, requires the diversion, conveyance, and application of water to crops. Lands suited to irrigated agriculture, particularly in the plateau country, are often at considerable distance, both vertical and horizontal, from streams with adequate supplies of water. Usability of the water is often severely limited by the economic costs required to develop the supplies.

Comparative Analysis

Table 17-5 provides a summary of data and compares the National Future (NF) and State-Regional Future (SRF) estimates of streamflows and water needs in the Pacific Northwest Region. Only limited SRF data comparable to NF data is available for projections to 1985 and 2000; therefore, no real comparison between the two is possible.

Table 17-5.--Socioeconomic and volumetric data summary: the Pacific Northwest Region

Category	1975		1985		2000	
	NF	SRF	NF	SRF	NF	SRF
SOCIOECONOMIC DATA (1000)						
Total population	6,703	6,783	6,991	8,089	7,589	9,780
Total employment	2,642	2,440	2,958	2,931	3,345	3,607
VOLUMETRIC DATA (mgd)						
-Base conditions-						
Total streamflow	266,556	NE	266,556	NE	266,556	NE
Streamflow at outflow point(s)	255,270	239,570	251,905	NE	251,291	NE
Fresh-water withdrawals	37,495	37,493	38,098	NE	33,852	NE
Agriculture	33,253	33,253	34,725	NE	30,063	NE
Steam electric	260	260	203	NE	580	NE
Manufacturing	2,324	2,324	1,321	NE	1,132	NE
Domestic	804	804	863	NE	957	NE
Commercial	274	274	282	NE	307	NE
Minerals	118	118	141	NE	167	NE
Public lands	190	190	262	NE	332	NE
Fish hatcheries	272	272	301	NE	314	NE
Other	0	0	0	NE	0	NE
Fresh-water consumption	11,913	11,905	14,610	NE	15,196	NE
Agriculture	11,098	11,098	13,448	NE	13,315	NE
Steam electric	13	13	104	NE	344	NE
Manufacturing	325	325	501	NE	880	NE
Domestic	210	210	220	NE	238	NE
Commercial	55	55	56	NE	60	NE
Minerals	18	18	19	NE	27	NE
Public lands	190	190	262	NE	332	NE
Fish hatcheries	0	0	0	NE	0	NE
Other	0	0	0	NE	0	NE
Ground-water withdrawals	7,348	7,348	NE	NE	NE	NE
Evaporation	2,014	1,915	2,055	1,915	2,083	1,915
Instream approximation						
Fish and wildlife	214,004	214,004	214,004	214,004	214,004	214,004

NE - Not estimated.

Problems

The water and related land resources of the region are of sufficient quantity and quality to provide for the social and economic needs of the people without degrading the quality of the natural environment. Nevertheless, there are existing and emerging problems with respect to those resources, which, if left unresolved, would limit their uses and thereby contribute to the impairment of social, economic, and environmental values. The problems generally relate to water and land-use conflicts, water quantity and quality, flooding, erosion, fish and wildlife habitat, intergovernmental jurisdicational conflicts, and Federal Reserved Rights.

Pollution

Water quality in the region is generally good, but certain pollution problems of varying severity exist which damage fisheries and create undesirable public health and esthetic conditions.

Water quality in the Columbia River is generally excellent. Turbidity is near zero, and dissolved oxygen ranges from about 12.5 mg/l (milligrams per liter) in winter to 10 mg/l in the summer. Dissolved solids are low, about 115 mg/l. Coliform count is very low, about 500 counts/100 ml. There is, however, some increase in coliform count below Portland. Klesiella and pseudomonas bacteria have also been found in Columbia and Snake River water samples. Point sources and land runoff both contribute to this increase, but the count is still significantly lower than observed with uncontrolled runoff in the past.

The potential exists, however, for increasing enrichment of Columbia River waters. This process, coupled with thermal and other effects of impoundments, pose the threat of algal production and severe water quality degradation. Urban, manufacturing, mining, and agricultural waste loads contribute to the enrichment. The problem already exists in Brownlee Reservoir on the Snake River as well as in certain tributary streams, and a number of other Snake and Columbia River reservoirs are beginning to exhibit similar characteristics.

The natural water temperature regime of the Columbia River has been altered by the construction and operation of the series of impoundments on the stream system. The impoundments have increased both the area and duration of exposure of streamflow to thermal influences and increased the thermal inertia of the stream through the increase in stream depth. Thermal effects of these changes have been the reduction of average summer temperatures, increase in average winter temperatures, and a shift in the annual temperature cycle. However, the surface waters of stratified reservoirs have been characterized by higher temperatures in summer than had occurred in the natural stream in preimpoundment times. Changes in the thermal regime conflict with the temperature requirements of certain phases of the life cycle of resident cold water fish and thereby adversely affect those species. The general increase in water consumption presents possible problems in subregion 1703. The projected depletions for the year 2000 will increase the existing stresses on the Snake River.

Brownlee Reservoir is experiencing excessive algal growths, anaerobic decomposition of organic material deposited at the reservoir bottom, and constant oxygen deficiency. The oxygen deficient, nutrient-rich outflows from the reservoir cause major water-quality problems downstream. In recent years, floating aquatic slimes, stimulated by the high nutrient concentrations, have appeared in the lower reaches of the Snake River. The aquatic growths interfere with boating, fishing, and other recreation activities.

Certain estuaries on the Oregon coast, including Coos Bay, Yaquina Bay, and Tillamook Bay, are subject to water-quality degradation, principally with respect to dissolved oxygen and bacterial contamination. Domestic sewage, livestock wastes, and wastes from pulp and plywood mills are the principal factors responsible for the degradation. In Coos Bay and Yaquina Bay, water-quality degradation also occurs when dredging activities free oxygen-demanding organic deposits resulting from pulp and paper waste discharges. Toxic products of decomposition are also released, at times, from bottom deposits.

Water quality in subregion 1706, which includes Puget Sound and the rivers emptying into it, is generally excellent. Limited areas, however, are subject to poor circulation and high pollutant loads. In the Duwamish River estuary, for example, dissolved oxygen and intense algal blooms occur during the low autumn runoffs. Urban development of the lowlands along the eastern shore of Puget Sound results in high coliform count in the adjacent waters of the sound and the Nooksack, Skagit, and Duwamish Rivers. Industrialization around Puget Sound also presents serious local problems because of hazardous materials discharged into the sound.

Waste heat from steam electric power generation will increase from 66 trillion Btu's per year in 1975 to 1,655 trillion Btu's per year in 2000 as steam plants are installed. However, waste heat discharged to the Columbia River will be reduced when Public Law 92-500 is implemented, and recycling will be used by all plants except for a few located on the coastlines of subregions 1705 and 1706. Total heat discharged to fresh water by power generation facilities will be reduced from 23 trillion Btu's in 1975 to about 2 trillion Btu's in 2000; however, heat discharged to saline water will increase from 0 to 421 trillion Btu's/year. Heat from manufacturing will be reduced by about 102 trillion Btu's.

Erosion and Sedimentation

Erosion affects cropland, rangeland, and forestland in many parts of the region. The most severe erosion problem occurs in the Palouse River Basin, in which some 1.3 million acres of fertile agricultural lands are affected. Sheet, gully, and bank erosion of the rich loess soil combine to produce the greatest soil loss and highest sediment yield in the region.

Bank erosion on coastal streams reduces the extent of agricultural lands and causes sedimentation of estuaries. The sedimentation reduces

still further the limited areas of high biological productivity in estuaries, thereby adversely affecting fish life, both resident and anadromous, and other biota.

Of the seven subregions, subregion 1704, in which the Palouse River Basin is located, has the highest sheet erosion rate sediment yield for cropland: the projected erosion rates for 1985 and 2000 are 13 tons/acre/year. The corresponding average regional erosion rate projected for 1985 and 2000 is 4 tons/acre/year. The highest erosion rate for forests and rangelands occurs in subregion 1707, the Oregon Closed Basin, in which the estimated erosion rate for 1975 is 4.0 tons/acre/year.

Flooding

All of the subregions experience flood problems in varying degrees of severity. The most severe flood problems are encountered on several of the larger streams flowing into Puget Sound and the Rogue and Umpqua Basins in subregion 1705. Damages from flooding in 1975 amounted to about $126 million for the region of which about 33 percent occurred to urban property and 53 percent, to agricultural property. Between 1975 and 2000, flood damage to urban property is projected to increase by 45 percent with damages to agricultural lands going up by only 6 percent. For the region as a whole, the projected increase in total flood damages of 25 percent is slightly below the 26 percent increase estimated for the Nation. In 1975, flood damages in subregion 1705 amounted to $43 million, or more than one-third of the regional total. A projected 38 percent increase in damages between 1975 and 2000 is the highest projected increase rate for the region.

Water Quality

If the total water supply in the region in an average year were distributed evenly to all parts of the region and adjusted to seasonal demands, the supply would probably be sufficient to meet all requirements. The natural supply is, however, not so distributed. Many parts of the region are virtually arid while others enjoy a surplus of water. Natural streamflows are high during certain seasons, but they can be extremely low in others, even on streams which have high annual flows. Also, annual flows are subject to drastic variations from year to year; the minimum-year flows on some large streams is as low as 25 percent of the mean annual flows. Thus, the principal water supply problem in the region as a whole is the severe maldistribution of the resource, geographically, seasonally, and annually.

Intensifying the problem of seasonal maldistribution is the conflict in timing between water supplies and water uses. The season of high offstream water use coincides with that of low streamflows. The problem is further compounded by conflicts between uses, particularly between offstream and instream uses. To resolve the problem of seasonal maldistribution, the flows in many streams are regulated through the use

of storage reservoirs. Continued development of storage would improve flow regulation and further resolve the problem of seasonal shortages. However, many of the available reservoir sites are located in the headwaters of streams and are important wildlife habitat areas. Development of such sites, therefore, conflicts with other uses of the land.

In addition to the physical problems of getting water when and where it is needed, legal and institutional problems also affect the supply. Legal problems generally relate to water rights under State laws, Federal laws, treaties, and other agreements. Institutional problems generally consist of conflicting jurisdiction over water within each level of government and between the various levels of government.

Thus, in spite of the large annual supply of water in the region, water requirements in many areas are not adequately met largely because supplies are not naturally or legally available when and where they are required.

Water Surface

For subregions 1705 and 1706, the current and projected water surface demands for recreation use exceed the presently available resources. The two subregions contain the bulk of the region's population but are among the lowest of the several subregions in fresh-water surface areas. The marine waters adjacent to the two subregions are, however, available to absorb certain types of boating and other water-related activities. The vast acreage of marine water in Puget Sound, in subregion 1706, offers almost unlimited opportunities for boating and fishing. Large numbers of nonresidents are attracted to those waters and the adjoining fresh-water lakes each year, and Puget Sound is aptly regarded as the boating capital of the Northwest. In subregions other than 1705 and 1706, available surface waters are more than adequate to satisfy all current and future recreation requirements.

Other

Jurisdictional conflicts over water and related land resources is a major problem in many parts of the region. In a single watershed, some 20 separate local general purpose governments, some 70 other local taxing districts, another 70 local nontaxing districts, and several State and Federal agencies may make or influence water resources policy. Conflicts between these jurisdictions inhibit orderly planning and management of water and related land resources.

Federal reserved lands and Indian reservations occupy a major portion of the region's land area. Of the water originating on those lands or passing through or by them, the Federal Government and Indian tribes claim, under the Reservation Doctrine, the right to use, on those reserved lands, such amounts as may be deemed necessary to fulfill the purposes for which the lands were reserved. Until such time as the amounts claimed

are quantified, the legal status of all waters originating on or passing through or by them is in doubt. Since most of the water supply produced in the region originates on Federal lands, the continued availability of much of the region's water for use outside reserved lands is in doubt.

Individual Problem Areas

Ongoing studies and programs adequately address those water and related land resources problems that are clearly recognized and well understood with respect to their characteristics, the nature and extent of their effects, the interests affected, the alternatives available for their resolution, and their respective costs and benefits. These problems can be related to existing institutional arrangements.

Not adequately addressed are those water and related land resources problems that are complex, that cover wide areas both in terms of geography and disciplines involved, that generate effects that are widespread and often nonquantifiable, and to which solutions are not immediately discernible. These problems cannot be related directly to existing institutional arrangements.

Four areas were identified as having severe water and related land resources problems not being adequately addressed in ongoing studies and programs. The problem areas are:

Coastal Problem Area in Oregon

Puget Sound Problem Area in Washington

The Snake River Problem Area in Idaho, Oregon, and Washington

The Columbia River Problem Area in Oregon and Washington

Their locations are indicated in Figure 17-8a. Problems affecting them relate to Federal and Indian reserved rights, water use conflicts, land use conflicts, intergovernmental jurisdictional conflicts, water quality degradation, and minimum perennial flows. Water use conflicts occur principally on the Columbia and Snake Rivers and involve primarily irrigation, hydropower, and fish life uses. The principal land use conflicts occur in coastal and estuarine areas where the conflicts are essentially between preservation and development. The problem areas and the problems affecting them are described on the following pages. Figure 17-8b presents a tabulation of problem issues by subregion.

Problem Area : The Oregon Coast

Description

This problem area includes the entire coastal drainage of Oregon with the exception of the Umpqua and Rogue River Basins. Its total area of about 7,000 square miles is made up of Clatsop, Tillamook, Lincoln, Lane, Coos, and Curry Counties and parts of Columbia, Lane, and Douglas Counties. Its coastline of about 500 miles includes 14 major estuaries having a combined surface area of about 41,000 acres. The estuaries produce

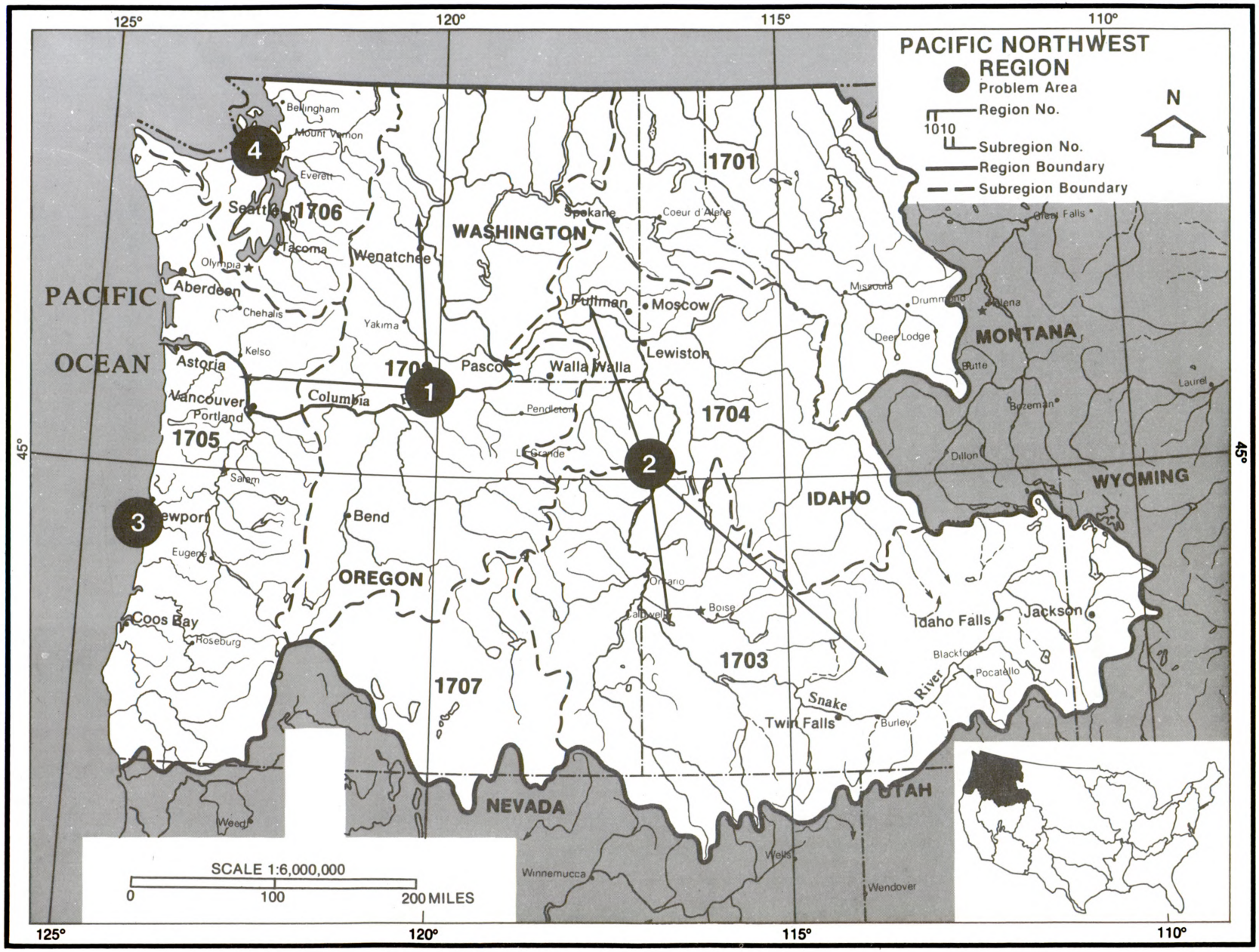


Figure 17-8a. Problem Map

PACIFIC NORTHWEST REGION (17)

PROBLEM MATRIX

Problem area		Problem issues O= Identified by Federal Agency Representatives X= Identified by State-Regional Representative													
		Water quantity				Water quality				Related lands					
No. on map	Name	Fresh surface	Ground	Marine and estuarine	Surface/depth	Fresh surface	Ground	Marine and estuarine	Surface/depth	Flooding	Drainage	Erosion and sedimentation	Dredge and fill	Water related use conflicts	Other
Subregion 1701	Clark Fork-Kootenai	O				O						O			O
Subregion 1702	Upper/Middle Columbia	O	O			O				O	O				O
Area 1	Columbia River	X				X								X	X
Subregion 1703 and 1704	Upper Central Snake														
	Lower Snake	O				O				O		O			O
Area 2	Snake River	X				X								X	X
Subregion 1705	Coast-Lower Columbia	O				O		O		O	O		O		O
Area 3	Oregon Coast					X		X		X		X	X	X	X
Subregion 1706	Puget Sound	O				O		O		O		O	O		O
Area 4	Puget Sound				X	X		X		X		X		X	X
Subregion 1707	Oregon Closed Basin	O				O									O

Figure 17-8b. Problem Matrix

clams, oysters, and crabs for recreation and commercial uses. Estuarial mud flats, waters, and marsh vegetation provide important migration and wintering grounds for waterfowl as well as habitat for shore birds and furbearing animals. Coastal lands are generally rugged, since they are part of the Coast Range. About 70 percent of the area is commercial forest. The lumber and wood products industry, tourism, and commercial fishing are the principal economic activities. Agriculture is of minor significance, economically. The population, which is concentrated along the coastal highway, totals about 150,000. The principal population center, Coos Bay-North Bend-Eastside, has a population of about 23,000. The other major centers of population are: Astoria, 10,700; Newport, 5,800; Tillamook, 4,200; Seaside, 4,000; and Lincoln City, 3,700.

Problems

Some unwise urban and industrial development and agricultural and forestry practices have adversely affected fish and wildlife habitat within and adjacent to estuaries. Developments have removed bank vegetation, channelized streambeds, removed gravel and bottom materials in spawning channels, introduced domestic and industrial wastes and road materials in damaging concentrations, and dredged and filled shellfish and marsh areas in the tidal zones, thereby reducing habitat. Agricultural practices have contributed to water quality degradation. Man and his activities have also adversely affected beaches and dunes, lakes, scenic and wilderness areas, critical wildlife habitat, and other unique resources of the Oregon coastal zone.

Certain estuaries, notably Coos Bay, Yaquina Bay, and Tillamook Bay, are affected by water-quality degradation, principally low dissolved oxygen and high bacterial contamination. Domestic sewage, livestock wastes, and wastes from pulp and plywood mills are the factors principally responsible for the degradation.

Overbank flooding occurs on the lower reaches of most of the coastal streams at least once a year. The resulting inundation and bank erosion reduces the dairy and agricultural production and causes estuarine sedimentation. Such sedimentation further reduces the limited areas of high biological productivity in estuaries, thereby adversely affecting fish life, both resident and anadromous, as well as other biota.

The forest products industry is one of the largest single factors that have adversely affected the natural coastal environment. Poor logging practices of the past have contributed to the degradation of water quality and wildlife habitat in the region as a whole. In contrast, coastal dredging programs are relatively limited in their adverse effects. Dredging for navigation purposes in the Columbia River estuary, Coos Bay, and Yaquina Bay is carefully controlled and monitored to minimize damage to fish and wildlife habitat. Degradation could be particularly severe in Coos and Yaquina Bays, where oxygen-demanding organic deposits are present in certain areas.

Adverse Effects

Persistence of water-quality degradation in bays and estuaries will continue to curtail biological production in those bodies of water and reduce commercial and recreational fishing. Apart from the loss of food and recreational value, the reduced fishing activities will cause moderate to severe economic losses to coastal communities.

Losses to the dairy industry and agriculture will continue if overbank flooding on the lower reaches of coastal streams is not resolved. Since agriculture is not a major economic activity on the coast, losses to agriculture will not have a significant impact on the coastal economy. However, the dairy industry losses and the sedimentation of estuaries and associated wetlands which result from flood-caused erosion will have significant economic effects through the reduction in habitat and consequent loss of fish and wildlife, including waterfowl. Losses would accrue to both commercial and recreational fisheries.

Dredging in the Columbia River estuary and in Coos Bay and Yaquina Bay makes navigation possible with consequent economic benefits to communities on those estuaries as well as to others in the interior. Dredging, however, affects fishery habitat and degrades water quality, and land disposal of dredged material can affect wildlife habitat. Indiscriminate dredging and disposal practices would reduce fish and wildlife production, but to date, the moderate cumulative effects cannot be determined. Also, it should be mentioned that dredged material has created wildfowl habitat. Reduction in fish and wildlife production has adverse economic and social impacts on coastal communities, but the extent of the adverse effects cannot be determined on the basis of the available data.

The development and use of land adjacent to estuaries for residential, commercial, industrial, and agricultural purposes continue to damage the limited estuarine areas existing in Oregon. The resulting loss in biological production will continue to curtail both commercial and recreation fishing and thereby cause economic losses to coastal communities. Scenic and esthetic values will also be lost through the drainage and land-fill activities associated with development. Loss of production areas in estuaries will lead to a reduction in food fish. Effects of land development and use on estuarine ecosystems and other estuarine values are severe, but current knowledge of Oregon estuaries is inadequate to fully evaluate the economic, social, and environmental consequences.

Problem Area : Puget Sound

Description

The Puget Sound problem area lies in northwestern Washington bounded on the north by Canada, on the east by the Cascade Range, on the west by the Olympic Mountains, and on the south by a series of low hills. The principal feature of the area is Puget Sound, a 2,500-square-mile

inland sea located in the center of the area. The major rivers in terms of flow are the Skagit, Snohomish, Nooksack, Puyallup, Elwha, Nisqually, Green, Skokomish, Stillaguamish, and Cedar Rivers. Forests cover 76 percent of the land area; cropland covers 7 percent. Puget Sound is the most populous area in the region. Over 2 million people live in a narrow belt along the east side of Puget Sound. Puget Sound is nationally recognized for its scenic and recreation values, water transportation, and for the production of fish, shellfish, and other marine resources. The problem area is relatively large, including 13 counties or parts of counties. The principal cities and their populations are Seattle, 503,000; Tacoma, 156,000; Everett, 53,000; Bellingham, 41,000; Bremerton, 37,000; and Olympia, 25,000.

Problems

The Puget Sound area has outstanding scenic and recreation values which could be impaired through improper development. The area also has important fishery resources, both salt water and fresh water, and wildlife resources. The conservation and enhancement of these resources depends on the choices made with respect to their management. Parts of the eastern shoreline of Puget Sound developed rapidly in the past and now form the metropolitan centers of the area. Development of the area continues, and navigation activity is expected to increase substantially as Alaskan oil becomes available for shipment. While demands on estuarine and adjacent shorelands for developmental purposes as well as for recreation and fish and wildlife production continue to increase, the State Shoreline Management Act, complemented by the Federal Coastal Zone Management Act, has established a process to define acceptable uses of the shoreline and shorelands.

There is a distinct need to expand the current baseline studies, now limited to the marine environment and associated shorelines of Northern Puget Sound, utilizing the existing criteria and standards established by the State. This would provide continuity in coverage and scope to all areas of the sound, Hood Canal, and the Strait of Juan de Fuca. It would also allow scientific and factual identification of priority areas suitable for development or preservation and guide the location of environmentally acceptable, water-oriented commerce and industry, including oil transportation and transfer facilities.

Jurisdictional conflicts over water and related land uses constitute a major problem in the Puget Sound area. In a single watershed, some 20 separate local general purpose governments, some 70 other local taxing districts, another 70 local nontaxing districts and several State and Federal agencies may make or influence water resources policy. Orderly planning and implementation with respect to water and related lands are often hindered by conflicts among the many jurisdictions involved. This problem is not unique to Puget Sound but is statewide in application, such subdivisions having been created by the Washington State Legislature over the years. The problem of proliferation of such units is not being seriously addressed, but it should be noted that this is purely an internal

State problem, that no meaningful State-Federal agency study could be productive, and that only study and action by the State Legislature can resolve the problem.

The problem area contains large areas of national forest and other federally reserved lands as well as tribal lands in the Skokomish, Squaxin Island, Nisqually, Puyallup, Muckleshoot, Port Madison, Port Gamble, Tulalip, Swinomish, Lower Elwha, and Lummi Indian Reservations. Waters originating on those lands or flowing through or by them fall within the Reservation Doctrines under which the Federal Government and Indian Tribes claim to reserve the right to appropriate such waters as may be required to serve all needs on those lands. Amounts so appropriated could have a major impact on existing water rights and on the availability of water for future non-Federal, non-Indian uses. The amounts have not been identified and there are currently no plans for identifying them. Until the extent of Federal/Indian water rights is known, the water available for other uses cannot be established, thus inhibiting the orderly planning of the subregion's water and related land resources. The State of Washington emphasizes that Congress alone can resolve this problem and urges Congress to take immediate steps to do so by thorough study and expeditious action.

Adverse Effects

Intensive development of coastal lands and islands in the Puget Sound without sound basis for approval could severely impair the environmental resources of the area, while the increasing use of estuarine waters for commercial navigation could adversely affect the management of some of those resources. In addition to the scenic and esthetic values of Puget Sound and its numerous islands, the resources include anadromous fish, resident fresh-water fish, marine fish, shellfish, and waterfowl. Marine fish and shellfish are particularly susceptible to pollution and siltation resulting from development and intensive use of estuarine lands and waters. Marine fish and shellfish are harvested for commercial and recreational purposes, and any damage to those resources would therefore result in both economic and social losses. Unless the multigovernmental jurisdictional conflicts with respect to water and related land resources are resolved, the orderly planning for those resources to satisfy social, economic, and environmental needs will be inhibited, thereby jeopardizing the unique assets of the Puget Sound area. Delay in quantifying Federal Reserved Rights will inhibit orderly planning of the area's water and related land resources.

Problem Area : The Snake River

Description

In terms of discharge, drainage area, stream length, and water use functions served, the Snake River is the principal tributary stream in the Columbia River system. Its average annual flow of 36 million acre-

feet represents 20 percent of the Columbia River discharge at its mouth. Its drainage area of 109,000 square miles covers 89 percent of the State of Idaho, nearly 20 percent of Oregon, 14 percent of Wyoming, 5 percent of Washington, and parts of Nevada and Utah and represents nearly 40 percent of the entire Columbia River drainage. Of the total stream length of 1,000 miles, some 80 miles lie in Wyoming, 530 miles within Idaho, and 140 miles within Washington. Of the remaining 250 miles, 230 miles form part of the Idaho-Oregon border, while 20 miles form part of the Idaho-Washington border.

The Snake River serves all water-use functions, including irrigation, recreation, navigation, fish and wildlife, power, and waste disposal. Irrigation is by far the major out-of-stream use. This use takes place mainly in Idaho where the river skirts the Snake River Plain along its southern edge. Irrigation use is intensive, and return flows may be diverted more than once before the river leaves the plain and enters the canyon where it forms the Idaho-Oregon border. Commercial navigation is limited to the lower reaches of the river. Hydroelectric power is generated at a number of multipurpose dams in several reaches of the river. Fish and wildlife and recreation functions are served throughout the stream system. Important anadromous fish runs occur on the middle and lower reaches of the Snake River.

Problems

Brownlee Reservoir experiences excessive algal growths, anaerobic decomposition of organic material deposited at the reservoir bottom, and constant oxygen deficiency. The oxygen-deficient, nutrient-rich outflows from the reservoir cause major water quality problems downstream. In recent years, floating aquatic slimes, stimulated by the high nutrient concentrations, have appeared in the lower reaches of the Snake River. The aquatic growths interfere with boating, fishing, and other recreation uses.

Legislation that created the Hells Canyon National Recreation Area provides a high level of protection to the shorelands in the free-flowing reaches of the Snake River in Idaho and Oregon below Hells Canyon Dam. The legislation specifically provided, however, that the creation of the recreation area would not establish any flow requirement that would conflict with future upstream depletions. Excessive upstream depletions could, therefore, impair the use of the Hells Canyon reach of the Snake River for navigation, fish life, and recreation.

Conflict could develop between upstream consumptive uses and downstream nonconsumptive uses on the Snake River. Upstream consumptive uses include flow depletions resulting from food and fiber production in Idaho. Downstream nonconsumptive uses include power generation, recreation, and fish and wildlife uses. Irrigation continues to expand in Idaho, and the availability of land suitable for irrigation will not limit continued growth. Since this issue involves the Federal Government and the several States sharing, in part, the middle and lower reaches of the Snake, a policy solution appears most appropriate. Evaluations of the scope and

impact have been completed as a part of Columbia River and Tributaries study, the Snake River Level B studies, and the Idaho State Water Plan, but there is no overall agreement on the best solution.

A related potential conflict on the Snake River is conflict between hydroelectric power and other instream uses of water. The establishment of minimum instream flows to serve fish life, navigation, recreation, and water quality might require releases at power dams which, during periods of low energy demand, may exceed turbine requirements. The energy value of the excess water released to maintain instream flow levels would thereby be lost to the power-generating system. However, potential energy losses would be relatively minor compared to economic losses that would accrue from constraints on peaking capability and system operations. Hydroelectric powerplants pose another problem to recreation, fish life, navigation, and water quality uses of the river. Operation of those plants for peaking purposes would increase changes in flows and fluctuations at the dams.

Adverse Effects

Nonresolution of the issue of the maintenance of minimum perennial streamflows will intensify pressure on instream uses of water, particularly fish. The land base exists for expanding irrigated agriculture, and such expansion will continue to take place subject to the availability of water supply and the markets for agricultural products. The Idaho State Water Plan has identified solutions to this issue, but they have not been implemented. Thus, the dilemma still exists: whether to develop and gain recognizable economic benefits or to leave water for environmental considerations.

Any increase in withdrawals of water from the upper Snake River during low-flow periods for irrigation and other consumptive uses will reduce flows in the middle and lower Snake River and thereby reduce energy production at power dams in those reaches of the river. The four Federal dams on the lower Snake River have a total installed capacity of 1,485 megawatts and an ultimate capacity of over 3,000 megawatts. The three privately owned hydroelectic power dams on the middle Snake River have a total installed capacity of 1,120 megawatts. Expansion of irrigation, in addition to causing reduction in energy produced at power dams, will also add to the energy load for pumping. At the time the original power studies were made, pumping had not become an acceptable practice in the Snake River Basin. Therefore, the issue of upstream development opposed to downstream power production exists, and in an energy-short period such conflicts are magnified.

Power operations at the Idaho Power Company's hydroelectric plants immediately upstream from the Hells Canyon National Recreation Area also affect flows through the reach. Fish life and commercial navigation, as well as fishing and recreation boating, are affected by the fluctuations.

The middle Snake River, the only free-flowing reach of the river below Brownlee pool, provides habitat for important resident and anadromous fish species and offers outstanding scenic and recreation values. As a designated wild and scenic river, it has national as well as regional importance. Unless the problem of enrichment of the Snake River is resolved, the algal blooms and attendant deoxygenation characterizing Brownlee Reservoir will probably be repeated in the reservoirs below Brownlee, including the four Federal reservoirs in the lower Snake River. Such a development would have a severe impact on the anadromous fish runs on the Snake River, including the runs on the Salmon River. Those runs have national as well as regional significance. Flow fluctuations resulting from peaking operations at hydroelectric plants would create hazards to recreation and navigation as well as interfere with fish life.

Increased withdrawals of water in the upper Snake River during low-flow periods for irrigation and other consumptive uses would reduce flows and affect water quality in the middle Snake River. Some 67 miles of the river have been classified under the Wild and Scenic Rivers Act for the purpose of preserving the unique characteristics of Hells Canyon. The Hells Canyon National Recreation Area legislation recognized this problem and dealt with it decisively in Section 6:

> "Section 6. (a) No provision of the Wild and Scenic Rivers Act (82 Stat. 906), nor of this Act, nor any guidelines, rules or regulations issued hereunder, shall in any way limit, restrict, or conflict with present and future use of the waters of the Snake River and its tributaries upstream from the boundaries of the Hells Canyon National Recreation Area created hereby, for beneficial uses, whether consumptive or nonconsumptive, now or hereafter existing, including, but not limited to, domestic, municipal, stockwater, irrigation, mining, power, or industrial uses.
>
> "(b) No flow requirements of any kind may be imposed on the waters of the Snake River below Hells Canyon Dam under the provisions of the Wild and Scenic Rivers Act (82 Stat. 906), of this Act, or any guidelines, rules, or regulations adopted pursuant thereto."

Problem Area : The Columbia River

Description

The Columbia River drains about 259,000 square miles of which about 40,000 square miles lie in the Canadian Province of British Columbia and the balance in the United States. All of Idaho and parts of Montana, Washington, Wyoming, Utah, Nevada, and Oregon lie within the U.S. portion of the drainage. Characterizing the drainage area are rugged mountains, interspersed with valleys and large plateaus. The principal tributaries include the Kootenai, Clark Fork-Pend Oreille, Spokane, Snake, and Willamette Rivers. The climate is characterized by cold, wet winters

and hot, dry summers. Precipitation varies widely, ranging from less than 12 inches per year in eastern Washington and southern Idaho to more than 100 inches per year in some of the mountain areas. The flow regime of the Columbia River is based principally on snowmelt, with low flows occurring in winter and high flows in spring and summer. The average annual runoff of the Columbia River at the mouth is about 180 million acre-feet for the 50-year period from 1897 to 1946 (Columbia-North Pacific Region Framework Study). Modified mean monthly discharge at The Dalles, Oregon, ranges from 122,000 cfs in October to 244,000 cfs in May (C-NP Framework Study). Major reservoirs have also been developed on the Columbia River and its principal tributaries. They serve the functions of power generation, flood control, irrigation, navigation, municipal and industrial water supply, and recreation. In addition to resident fish species, the Columbia River system supports the following anadromous fish species: steelhead trout, coho salmon, spring chinook salmon, fall chinook salmon, sockeye salmon, and shad.

Problems

One of the emerging water-supply conflicts on the Columbia River system is that the depletion of flow for irrigation use results in loss of energy at downstream hydroelectric plants. The conflict occurs on the Columbia River and its principal tributary, the Snake River. Irrigation continues to expand, and land will not be a limiting factor in future growth. Flow depletion resulting from such expansion could significantly reduce energy production at Federal and non-Federal hydroelectric power plants on the Columbia and lower Snake Rivers. Flow depletions also conflict with fish and wildlife requirements, especially when combined with flow restrictions resulting from hydroelectric power operations.

Another emerging conflict is that between hydroelectric power and other instream uses. The establishment of minimum instream flows to serve fish life, navigation, recreation, etc., on the Columbia and Snake Rivers might require power dam releases which, during periods of low energy demand, may exceed generating requirements. Energy value of the excess water released to maintain instream flow levels would thus be lost to the power-generating system. As the cost of energy from alternative sources increases, so would the value of energy foregone to maintain instream flow levels. Operation of hydroelectric power plants to serve peak loads could cause rapid changes in flows below the dams, thereby adversely affecting fish life, recreation, and navigation.

Severe water-quality degradation of the Columbia River waters could result from algal production resulting from increased enrichment and changes in thermal climate. Urban, manufacturing, mining, and agricultural waste loads contribute to this possibility. The problem already exists in Brownlee Reservoir on the Snake River, where nutrient-rich waters support prolific algal growths which, in turn, cause low dissolved oxygen and anaerobic decomposition. Some smaller tributaries also are affected by the problem.

The natural, predevelopment water temperature regime of the Columbia

River has been altered by the construction and operation of the series of impoundments on the stream system. Impoundments have increased both the area and duration of exposure of streamflow to thermal influences and also increased the thermal inertia of the stream through the increase in water depth. The thermal effects of these changes have been the reduction of average summer temperatures, the increase in average winter temperatures, and a shift in the annual temperature cycle. However, the surface waters of stratified reservoirs have been characterized by higher temperatures in summer than had occurred in the natural stream before impoundment. Changes in the thermal regime conflict with the temperature requirements of certain phases of the life cycle of resident cold-water fish and some anadromous fish and thereby adversely affect those species.

Adverse Effects

Increased withdrawals of water for consumptive purposes, particularly irrigation, will reduce flows in the Columbia River and thereby curtail the energy produced at hydroelectric power dams located on that river. There are six Federal power dams on the Columbia River with a total existing capacity of 10,569 megawatts and an ultimate capacity of 21,035 megawatts. There are, in addition, five power dams on the Columbia River owned by public power authorities. Expansion of irrigation, in addition to causing a reduction in energy produced at power dams, will also increase the energy requirements for pumping. The resulting difference between energy capability and load will have to be made up from alternative sources, principally thermal sources. The economic value of the energy lost will increase with the cost of alternative sources of energy. The effect of the energy loss would, therefore, be significant. In addition to increased thermal generation required to offset hydropower losses due to irrigation water withdrawals, the alternative of additional reservoir storage in the Columbia River system should be considered and evaluated.

If left unresolved, the emerging conflict between hydroelectric power generation and other instream water uses will damage some of those water use functions, particularly fish life. About 450 miles of the Columbia River, from Chief Joseph Dam to the tidal reach, are involved. Nine dams are located within the reach; four are Federal power dams, and the rest are public power dams. Operation of Chief Joseph Dam and Grand Coulee Dam, both located upstream of the 450-mile reach, will also affect flow conditions and, hence, the other water-use functions within the reach. Any damage to the anadromous fishery will adversely affect recreational and commercial fishing as well as the Indian fishing. The salmon has a special significance to the Indian tribes in the region, and the right to fish for salmon is recognized in Indian treaties with the Federal Government.

Failure to control the eutrophication of impoundments on the Columbia River system will deplete oxygen levels in the river and thereby adversely affect the fishery resources and recreation use of the river. Degradation of the thermal regime will damage the fishery habitat directly and also affect it indirectly through the reduction of the waste assimilation

capacity of the river. The anadromous fish runs of the Columbia River have national as well as regional importance. They support a commercial fishery, an extensive sports fishery, and an Indian fishery. Damage to the anadromous fishery resources of the Columbia River will, therefore, have both an economic effect and a social effect. Flow fluctuations resulting from peaking operations at hydroelectric plants might create hazards to recreation and navigation and might interfere with fish life. Recently identified water-quality and other related problems should be addressed and implemented soon in order to expedite compliance with statutory water-quality goals.

Summary

The region in general has a large supply of water. The supply, however, is not equally distributed throughout the year or throughout the region. In some areas, the maldistribution of surface supplies is compensated for by the presence of ground-water supplies at depths and quantities that satisfy requirements. In many areas, however, particularly in the valleys east of the Cascade Range, the lack of surface- and ground-water supplies causes seasonal shortages of water, particularly for irrigation.

Inadequate surface supplies also cause conflicts between competing uses, particularly between those uses which require water to be withdrawn from streams and those which require the water to remain within the stream. Irrigation is the principal offstream use. Fish life, recreation, hydroelectric power, and navigation are the principal instream uses. Irrigation is essential to agriculture because of the lack of precipitation during the summer growing season. On the other hand, the streams need to have sufficient flows during summer to maintain the high water quality required by the salmonoid fishery, a resource unique and valuable to the region. Conflicts also exist between hydroelectric power and the anadromous fishery. On some streams, flow regulation by means of reservoirs has rectified the seasonal imbalance of water supply. The potential exists for expanding storage, but many of the storage sites are in prime wildlife habitat or have high scenic and esthetic values, and the development of storage would thus conflict with other values.

Both surface-water and ground-water supplies are generally of good quality and can be used for most purposes. Increased treatment of municipal and industrial effluents has improved quality on certain streams which previously had pollution problems. Major remaining problems are those associated with enrichment of streamflow. Nutrients causing the enrichment generally come from nonpoint sources. Other water quality problems relate to sedimentation and estuarine pollution.

While certain areas are short of water, other areas, including the area west of the Cascade Range, which contains the bulk of the region's population, have ample supplies to meet all requirements. A number of scenic rivers both east and west of the Cascade Range have sustained flows of high-quality water and provide outstanding fishery habitat. Numerous lakes and reservoirs, together with the marine waters along the coast of Oregon and Washington, provide adequate surface waters for boating, fishing, and other water-based recreation.

Flows in the Columbia River and in the middle and lower Snake River are regulated by a system of dams, primarily for the purpose of hydropower generation, flood control, irrigation, and navigation, but also for fish life and recreation. There are conflicts between some of the uses, and they will tend to intensify with time, thereby increasing the constraints on the operation of the system of dams.

Land resources in the region are generally adequate to meet projected requirements, particularly for agriculture and outdoor recreation. Valleys, benches, plateaus, and rolling hills provide extensive lands suitable for a wide variety of agricultural crops. The range in climatic conditions characterizing the region adds to that variety. Extensive rangelands provide for stock farming, while the slopes of the many mountain ranges provide forestland. Lands used for recreation extend from ocean beaches to alpine meadows and snow-covered peaks and from deserts to rain forests. The region's land and water resources, together with the fish and wildlife resources they support, provide the region with many types of outdoor recreation throughout the year.

The major land-use conflicts in the region are those between development and conservation uses. The conflicts are particularly severe in coastal and estuarine areas where the preservation of scenic and esthetic values and fish and wildlife habitat conflicts with the development of docks and marinas and industrial and residential buildings. In intermediate and headwater areas, the development of storage sites and the conversion of rangeland to irrigated cropland conflict with the preservation of wildlife habitat, including migration routes and winter range.

The region's population and economy are projected to grow, but at a lower rate than the national growth rate. The water and related land resources are adequate to provide for that growth without causing any significant change in the quality of the overall environment. However, in areas of water deficiency, water shortages and competition for available supplies will intensify. Likewise, the conflicts between preservation and development, particularly in coastal areas, will grow more acute.

Conclusions and Recommendations

Resolution of water and related land resources problems identified in this analysis requires the joint efforts of Federal, State, and local governments, and public and private universities and other organizations having specialized knowledge or interest in resolving those problems. The joint efforts would involve planning studies, data collection, and research on water and related land resources. It would also involve the examination of and possible modifications to legal and institutional arrangements relating to those resources.

Federal Role

In the joint efforts to resolve problems, the Federal agencies should continue to take the lead with respect to those problems in which they have statutory responsibilities or the specialized knowledge needed to deal with them. In other areas, they should concede leadership to the States. The Pacific Northwest River Basins Commission, as a Federal-State entity, should coordinate the efforts of Federal and State agencies where necessary. Coordination by the commission would be most appropriate on those problems which are complex or involve conflicts in use and which dictate a multiobjective, multidisciplinary approach, particularly in comprehensive planning.

Current activities by Federal agencies to resolve existing problems should be continued and the efforts intensified where necessary. Included is the fisheries engineering research program undertaken by the U.S. Army Corps of Engineers, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service. The program is intended to mitigate damages caused to anadromous fish by the impoundments on the Columbia and Snake Rivers. Also included are studies on the management of those impoundments, within the context of certain instream and offstream uses, currently undertaken by the Bonneville Power Administration, the Bureau of Reclamation, and the Corps of Engineers. Among other ongoing Federal agency activities that need to be continued are the flood control studies of the Corps of Engineers and the erosion control programs of the Soil Conservation Service.

In addition to continuing existing activities, Federal agencies should take leading roles or otherwise participate in special studies, data collection, and research in connection with coastal and estuarine problems and water allocation problems on the Columbia and Snake Rivers. They should also take steps to identify and quantify Federal and Indian reserved rights and help States deal with nonpoint sources of pollution that cause water quality problems on the Snake River.

Planning

The problem areas identified have already been subject to Level B studies or studies of similar scope. No new Level B studies are, therefore, recommended.

Data and Research Recommendations

Oregon Coastal Area

Collect required data on the Columbia River Estuary and other estuaries on the Oregon Coast to fill gaps that exist in the current data base. Inventory and map habitat types and extent. Investigate food chain problems and production, water chemistry including pollutant impacts, hydraulics of estuaries, sedimentation patterns, and human use of resources.

Puget Sound Area

Initiate data development program similar to that proposed for the Oregon coastal area. Initiate steps for early quantification of Federal and Indian reserved rights.

The Snake River

Continue to collect necessary basic data to help identify available water supplies and opportunities for augmenting supplies and improving flow regulation. With this information, refine existing criteria and procedures of water allocation, upgrade and bring up to date existing plans and water allocations for the Snake River, promote new actions as appropriate, and determine interstate relationships and impacts as appropriate.

The Columbia River

Collect data and develop a procedure for allocation of water resources on a similar basis to that recommended for the Snake River.

Institutional Arrangements

Take steps to improve cooperation between the various levels of government having statutory responsibilities over water and related land resources.

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[1] The Washington staff of the Federal agencies was augmented by field office staff who participated with Washington offices or through the Regional Study Teams.
[2] Several States had representatives on more than one Regional Study Team. Contributions of those not named were greatly appreciated.

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The United States Water Resources Council
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The purpose of the Council is to encourage the
conservation, development, and utilization
of water and related land resources
on a comprehensive and coordinated basis
by the Federal government,
States, localities, and private enterprises
with the cooperation of all
affected Federal agencies,
States, local government, individual
corporations, business enterprises,
and others concerned.