WESTWIDE STUDY REPORT
ON

Critical Water Problems Facing the Eleven Western States

United States Department of the Interior
April 1975

WESTWIDE STUDY REPORT
ON

Critical Water Problems Facing the Eleven Western States

UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

BUREAU OF RECLAMATION
Gilbert G. Stamm, Commissioner

FOREWORD

To:
The President
Water Resources Council
The Congress

This is my report on the critical water problems facing the 11 Western States, summarizing the results of the Western U.S. Water Plan Study initiated in 1969. Authorization for that study was provided by the Congress in the Colorado River Basin Project Act (Public Law 90-537) in September 1968. The act directed the Secretary of the Interior to conduct reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the 11 Western States lying wholly or in part west of the Continental Divide.

Western water resources programs generally have not fully addressed the needs and desires of the people of the Nation's highest growth-related region; instream flow requirements and Indian water needs are still being identified and quantified. Water requirements in the Western States have increased at phenomenal rates in recent years and pressures have mounted to develop the vast natural resources of the West while at the same time providing greater safeguards for the national environment and more water for fish and wildlife, recreation, and a general quality of life.

Since the passage of the act, new national priorities have emerged. Satisfaction of national energy and food and fiber needs, emerging land-use policies, and the need for adequate programs to enhance the environment place new demands on planning for development of the resources of the Western States. Development of the West's energy mineral reserves, timber, and other food and fiber resources for national use may conflict with other national priorities, but the development of these resources is increasingly urgent.

While Public Law 90-537 directed that my report and recommendations be completed no later than June 30, 1977, it was determined that in light of pressing needs and priorities, the assessment of critical water supply problems must be accelerated. The report contains the results of this accelerated interagency State-Federal effort. It has been prepared in such manner as to provide the information necessary to assist the Federal Government in making decisions on policy, funding, and action programs for development of the West's resources. However, the report itself does not serve as the document upon which any specific authorization for study or request for funding is based.

Problems identified as having high priority are those related to the needs for water for mineral and energy resources development, municipal and industrial water services, water supplies necessary to satisfy the objective of Indian self-determination, and water and plans for the maintenance and improvement of the quality of the environment. In determining possible solutions to these and other future water needs, emphasis has been given to total water management, including water reuse and recycling and improvement of water system efficiency.

This report provides valuable information on all aspects of water and related land resources in the 11 Western States. Conclusions have been reached and recommendations drawn. It is an important and valuable document for those people interested in the proper use and care of our valuable natural resources.

ROGERS C. B. MORTON
Secretary, United States
Department of the Interior

ACKNOWLEDGMENT

The Westwide Study represents the joint efforts of representatives of the 11 Western States, commissions representing regional and national interests, nongovernmental organizations, and the Federal Government. All those involved helped to make possible the valuable contribution of the Westwide Study.

Participants were organized into three groups whose functions are discussed in the introduction of this report. The three groups are the Advisory Committee, the Management Group, and the Implementation Group.

Participating in the Advisory Committee were representatives from:

Arizona
California
Colorado
Idaho
Montana
Nevada
New Mexico
Oregon
Utah
Washington
Wyoming

Pacific Northwest River Basins Commission
Missouri River Basin Commission
Colorado River Commission of Nevada
Colorado River Board of California
Arkansas-White-Red Basin Inter-Agency Committee
Upper Colorado River Commission
Pacific Southwest Interagency Committee

National Water Resources Association
Western States Water Council
League of Women Voters
Sierra Club
National Association of Counties
Four Corners Regional Commission
International Boundary and Water Commission (U.S. Section)
Izaak Walton League of America
American Farm Bureau Federation
AFL-CIO
Natural Resources Council of America
National Tribal Chairman's Association
Water Resources Congress
U.S. Chamber of Commerce
National Congress of American Indians
National Association of Conservation Districts
Western Systems Coordinating Council
American Water Works Association
Wildlife Management Institute
Rocky Mountain Center on Environment
National Grange
Trout Unlimited

Participating in the Management Group were representatives from:

Water Resources Council
Department of Agriculture
- Economic Research Service
- Forest Service
- Soil Conservation Service

Department of the Army
- Corps of Engineers

Department of Commerce
Environmental Protection Agency
Federal Power Commission
Department of Health, Education and Welfare
Department of Housing and Urban Development
Pacific Northwest River Basin Commission
Department of the Interior
- Bureau of Indian Affairs
- Bureau of Mines
- Bureau of Sport Fisheries and Wildlife
- Bureau of Outdoor Recreation
- Geological Survey
- Office of Saline Water
- Bureau of Land Management
- Bureau of Reclamation
- National Park Service
- Bonneville Power Administration

Department of Transportation

Participating in the Implementation Group were field counterparts of the participating Federal agencies, representatives of the 11 Western States, the Pacific Northwest River Basins Commission, and consultants.

Primary responsibility for decisions rested with the Department of the Interior in consultation with the Water Resources Council and other Federal agencies. The Bureau of Reclamation of the Department of the Interior was the lead agency for the study and preparation of this report for printing was done through the facilities of the Bureau of Reclamation.

CONTENTS

CONTENTS–Continued

CHAPTER III – ASPECTS OF THE FUTURE

CHAPTER IV – WESTWIDE PROBLEMS

CONTENTS–Continued

CONTENTS–Continued

CHAPTER V – REGIONAL PROBLEMS

CONTENTS–Continued

CHAPTER VI – STATE SPECIFIC PROBLEMS

CONTENTS–Continued

CONTENTS—Continued

CONTENTS—Continued

CONTENTS—Continued

CONTENTS–Continued

CONTENTS—Continued

CONTENTS—Continued

CONTENTS—Continued

CONTENTS—Continued

LIST OF FIGURES

LIST OF FIGURES—Continued

LIST OF TABLES

LIST OF TABLES—Continued

LIST OF TABLES–Continued

LIST OF TABLES–Continued

Figure I-1. **Westwide Study Area.**

CHAPTER I
STUDY PURPOSE, HISTORY AND APPROACH

INTRODUCTION

Investigations for the Western U.S. Water Plan – or Westwide Study as it is commonly called – were undertaken under the authority of the Colorado River Basin Project Act (Public Law 90-537), passed by Congress on September 30, 1968. Titles I and II of this Act related specifically to planning and directly concerned the Westwide Study.

Arizona, southern California, southern Nevada, and portions of Mexico are largely dependent on the Colorado River for fresh water as are major portions of the four Rocky Mountain States of Wyoming, Utah, Colorado, and New Mexico. The Congress recognized this reliance and called in Title I of the legislation for "the provision of additional and adequate water supplies for use in the Upper as well as the Lower Colorado River Basin." A 1922 Compact specifies amounts of water to be allocated to Upper and Lower Basin States, but seldom during the past 40 years has the annual runoff in the Colorado River been sufficient to meet the Compact allocations.

Title II of the Act directed that the "Secretary of the Interior shall conduct full and complete reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the Western United States. Such investigations shall include the long-range water supply available and the long-range requirements in each water resource region of the Western United States." The Congress had defined the West as the 11 States lying wholly or in part west of the Continental Divide. (See Figure I-1.)

Progress reports on Westwide Study activities were called for biennially beginning in June 1971, with a final reconnaissance report to the President, Congress, and Water Resources Council due not later than June 30, 1977. The Secretary of the Interior assigned leadership in this planning effort to the Bureau of Reclamation and established a resident study management team in Denver, Colorado, composed of representatives of several Federal Departments, Bureaus, offices, and agencies. The study effort has been strongly based on participation of many agencies and organizations of Federal and State Governments and private groups. Policy guidance has been received from a Department of the Interior group in Washington.

In order to better coordinate the Westwide Study effort with other water and related resource legislation and to be responsive to current national goals and objectives, it was determined that the study should be completed by July 1, 1974. This accelerated and redirected study effort identifies and recommends specific future studies to provide needed solutions to the critical water problems facing the 11 Western States. It does not present a general plan.

STUDY PURPOSE

The development of adequate information upon which to base future significant decisions relative to the water and related resources of the 11 Western States has been a goal of this study effort. A determination and an assessment of the critical water related resource problems for the study area have been made through a cooperative interagency endeavor. This report presents the results of that effort. An objective has been to provide a meaningful report on the identified problems and to set forth alternative studies and viewpoints. An effort is made in this report and the Executive Summary to reflect the views of the wide variety of interests participating in the study.

Future Federal water resources planning must be governed by legislation enacted by Congress and by policy contained in the Principles and Standards approved by the President on September 5, 1973,[1] as they may be modified. This report does not formulate plans; rather, it recommends levels and areas of future Federal involvement in water and related land resources planning which, if undertaken, would be governed by current legislation and administrative policy. State and local entities will participate through parallel or accompanying studies as appropriate.

This report takes into consideration the views of the States and of a broad group of other participating interests in the study. However, the report itself will be the report of the Secretary of the Interior in response to Congressional directives and administrative requirements. It consists of three documents: The Report, The Executive Summary, and The Official Comments. The official comments are a compilation of the official reviews on the first two documents.

---

[1] Federal Register, September 10, 1973, Vol. 38, No. 174, Part III, Water Resources Council, Water and Related Land Resources, Establishment of Principles and Standards for Planning.

This report is intended to provide both quantitative and qualitative information on critical aspects of water and related land resources in the 11 Western States. Urgent resource problems have been dimensioned, conclusions have been reached, and recommendations drawn. Followup responsibility rests with the decision-makers – the President, the Congress, the Governors, and the State legislatures – to determine how, where, and when to translate the findings of the Westwide Report into viable action programs.

STUDY HISTORY

The Colorado River Basin Project Act was the consummation of many years of effort and controversy. The States of the Colorado River Basin were concerned with developing means to provide additional water supplies for use within their Southwest region. Importation of water on a large scale was viewed by many interests in the Southwest as necessary to avoid catastrophe, but the Pacific Northwest, the "obvious" source for importation into the Colorado, feared that such a course would prejudice its own future welfare and growth. The result of this impasse was a compromise under which the Central Arizona project and certain other projects desired by Colorado River Basin interests were authorized in the 1968 Act with two provisions:

1. For a 10-year period from the date of the Act, no effort would be made to plan for importation of water from drainages outside the Colorado River Basin States.

2. By June 30, 1977, the Secretary of the Interior must investigate and report on water supply availability and water needs for each of the water resource regions of the 11 Western States and on sources and means of augmentation of the water supplies available for the Colorado River Basin, other than from the Pacific Northwest.

In enacting the Colorado River Basin Project Act, Congress recognized a tumultuous history of water scarcities in parts of the West, and set about building a formula to do something about it.

The specific information requested by Congress included:

1. Estimates of both the long-range water supplies available and the long-range water requirements for each water resource region of the 11 Western States.

2. Results of full and complete reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the Western United States.

3. Results of the studies of possible means of augmentation of the natural water supplies of the Upper and Lower Colorado River Basins from sources within the Basin, including weather modification, desalting, water conservation, and geothermal.

4. Results of the studies of possible means and sources of augmentation from sources outside the Basin in the States of Arizona, California, Colorado, and New Mexico, particularly northern California.

5. Recommendations for such feasibility studies as are warranted of sources and means of augmentation.

Thus, it was evident that the Westwide Study was to be a multiagency, multidisciplinary effort; involve the 11 Western States; and accommodate the newly evolving planning concepts and values.

The Plan of Study

To accomplish this, an ad hoc committee composed of representatives from interested Federal agencies and States was formed in November 1970 and charged with developing a plan of study. This committee was composed of representatives of the 11 Western States, the Federal agencies involved in water resource development, the Water Resources Council, and other commissions and councils.

Several key decisions faced this ad hoc committee, the most difficult of which was defining the proper scope for the study. Of importance to the determination of scope were two major qualifications: (1) the study would be reconnaissance, or Level B, in character, and (2) it would cover only those resources and activities that affected the availability and requirements for water. Another decision was that the study effort must take full advantage of all previous studies, Federal and non-Federal, and that in essence the Type I Framework studies would constitute the initial base for Westwide planning. Due to the Westwide Study's comprehensive nature, every water planning activity in the West – past or present – Federal, State, or private – should contribute. With this background the original Plan of Study was developed which identified the additional information and investigations required. The Plan of

Study was made a part of the first biennial progress report presented to Congress in June 1971.

However, concern was soon expressed that the scope of the Study as conceived at that time was too broad, more than could be accomplished. In July of 1971, the House Appropriations Committee, in reporting out the "Public Works for Water and Power Development and Atomic Energy Commission Appropriation Bill, 1972," stated:

> "* * * It is requested that a revised plan be developed for Committee approval which limits investigation to the essential elements required to meet study objectives of assessment of water needs and development of plans to meet these requirements * * *"

An intensive review and reevaluation of the scope of the Plan of Study in light of the request of the Appropriations Committee was undertaken during the first half of FY 1972. The reexamination was conducted by the involved Federal agencies and by the affected 11 Western States. It consisted of reviewing in detail the Type I Framework reports and ongoing programs for the Western river basins and identifying, item by item, the additional work necessary to: (1) determine water availability and water requirements, and (2) develop an array of alternative plans at the reconnaissance level (Level B) to meet future water requirements to the year 2020 with emphasis on year 2000.

As a result of the reexamination, some work items in the original Plan of Study were transferred to ongoing programs, some items were eliminated, some modified, and others added. The Plan of Study as modified in March 1972 was considered the minimum additional work required to meet the directives of the Colorado River Basin Project Act of 1968.

Study Organization and Accomplishments

During the period of time from September 1970 to January 1973, the overall study effort advanced from an organizational phase to implementation. The already established basic organization for the accomplishment of the Study provided much toward this effort. The Department of the Interior group considered key policy and criteria after other interests had opportunity to contribute. Primary responsibility for decisions rested with the Department of the Interior at the Washington level in consultation with the Water Resources Council and other Federal agencies.

The Advisory Committee was composed of representatives from the fields of natural resources having direct ties to the 11 Western States. This committee reviewed and advised on the adequacy of standards, criteria, and assumptions used in the conduct of the Study. The Committee held seven meetings from March 1971 to December 1973 which provided a forum for exchange of ideas and public involvement at the policy level. Participating in the Advisory Committee were representatives from:

States of:

Arizona	New Mexico
California	Oregon
Colorado	Utah
Idaho	Washington
Montana	Wyoming
Nevada	

Pacific Northwest River Basins Commission
Missouri River Basin Commission
Colorado River Commission of Nevada
Colorado River Board of California
National Water Resources Association
Western States Water Council
League of Women Voters
Sierra Club
National Association of Counties
Four Corners Regional Commission
International Boundary and Water Commission (U.S. Section)
Izaak Walton League of America
American Farm Bureau Federation
AFL-CIO
Natural Resources Council of America
National Tribal Chairman's Association
Arkansas-White-Red Basin Inter-Agency Committee
Upper Colorado River Commission
Pacific Southwest Interagency Committee
Water Resources Congress
U.S. Chamber of Commerce
National Wildlife Federation
National Congress of American Indians
National Association of Conservation Districts
Western Systems Coordinating Council
American Water Works Association
Wildlife Management Institute
Rocky Mountain Center on Environment
National Grange
Trout Unlimited

As initially organized, the Management Group had responsibility for overall management and coordination of the Study. It was to be composed of membership from the 11 Western States, all interested Federal agencies, and certain commissions and councils; however, active participation was primarily by resident Federal agencies. A total of some 20 Federal agencies were involved in the Westwide Study; 10 from within the Department of the Interior. Those participating were as follows:

Water Resources Council
Department of Agriculture
  *Economic Research Service
  *Forest Service
  *Soil Conservation Service
Department of the Army
  *Corps of Engineers
Department of Commerce
  *Environmental Protection Agency
Federal Power Commission
Department of Health, Education and Welfare
Department of Housing and Urban Development
Pacific Northwest River Basins Commission
Department of the Interior
  *Bureau of Indian Affairs
  *Bureau of Mines
  *Bureau of Sport Fisheries and Wildlife
  *Bureau of Outdoor Recreation
  *Geological Survey
  *Office of Saline Water
  *Bureau of Land Management
  *Bureau of Reclamation
  National Park Service
  Bonneville Power Administration
Department of Transportation

*Resident member agency – based in Denver, Colorado.

The Implementation Group included the field counterparts of the participating Federal agencies, representatives of the 11 Western States, the Pacific Northwest River Basins Commission, and consultants. This group was originally responsible for assembling and comparing necessary basic data, identifying water needs and available water resources, and initiating the development of alternative plans to satisfy all water needs for States and water resource regions.

In this early phase, new procedures on multiobjective planning were developed and tested, various programs and studies were initiated to provide data and information on augmentation possibilities, with special emphasis on means to augment the flows of the Colorado River, and interagency, interdisciplinary planning teams were organized on a state-by-state basis and assigned a wide variety of tasks. State-Federal Study Teams in existence in the northwest States were also formed in the other States. These teams provided information needed by the Westwide Study effort to insure that local views of water needs and requirements and the desired future characteirstics of the local areas were provided. Completed and on-going State water plans complemented this effort and provided much useful information. One of the Study's basic guidelines has been to take account of and balance local, State, regional, and national interests; thus it was important that the study effort have specific and authoritative knowledge of State objectives and desires.

The various teams from the Westwide Management Group and the State-Federal Study Teams compiled substantial planning information and additional planning tools and techniques. The Management Group worked on plan formulation, techniques to gather and make best use of the needed water and land statistics, development of an environmental inventory, creation of information on the various schemes to augment the natural flows of the Colorado River, and development of a range of unit consumptive water requirements.

REDIRECTION OF THE WESTWIDE STUDY

New national priorities have emerged since passage of the authorizing legislation for Westwide. Satisfaction of national energy and food and fiber needs and emerging land use policies, together with the protection and enhancement of the environment, place new demands on planning for development of the resources of the Western States. Development of the energy mineral reserves, timber, and food and fiber resources for national use often conflicts with other national priorities. But need for these resources is pressing.

Questions surrounding the decisions for use of these vital resources must necessarily receive first attention. Sound fiscal management dictates that available water and related land resources planning capability be applied to problems of highest priority. In this overall context, the Westwide Study was administratively redirected in January 1973 to the objective of identifying by July 1, 1974, only the most pressing and immediate water and land related study needs.

The Westwide Study effort was basically centralized and scoped to provide:

1. Assessment of data from completed and ongoing studies on water, land and related resources and the possibility of these data being used in studies to determine solutions for priority demands.

2. Identification of the water supplies and requirements for the 11 Western States and the nine water resource regions within those states.

3. Recommendations for further detailed studies (Level C) for areas facing the most critical water-related problems.

4. Identification of the need and recommendations for any future Level B studies.

Level C is defined as program or project detailed studies to support authorization or implement a plan of action. These multiobjective studies which are needed in the subsequent 10- to 15-year period, are to implement findings, conclusions, and recommendations of framework studies and assessments and regional or river basin Level B studies. Level B is a reconnaissance level evaluation of water and land resources, on a regional or river basin basis, prepared to resolve complex multidisciplinary problems with a 15-25 year time frame identified in framework and assessment Level A studies. These multiobjective studies are to involve Federal, State, and local interests and will identify and recommend action plans and programs.

Reassessment and redirection of the overall Westwide effort was necessary to complete the study in the reduced time period imposed. Resource inventories and plan formulation studies were discontinued and problem assessment studies were stepped up.

Factors Affecting Redirection

Of far-reaching influence is the changing attitude toward population and economic growth. Growth affects resource needs and the environment largely through the economy. Awareness is growing that disparity in growth between urban and rural areas is accompanied by changes in the quality of life; an acceleration of the depletion of domestic and international resources; greater pressure on the environment; fewer social options; and greater dependence on continual rapid technological developments to solve these problems. If present patterns continue, these problems will grow, irreversibly forcing changes in the current way of life. Slower growth means time, resources and additional options: Time to gain the knowledge needed; time to redress the mistakes of past growth; resources to implement the proper solutions and more choices in a future way of life.

New approaches to water and related land resource planning have evolved beginning in December 1968 with the increase in discount rate announced by the Water Resources Council and with the recently approved Principles and Standards. This new multiple-objective approach has brought into question many of the water plans completed or in progress. Reevaluation and reformulation of many of these plans will be required.

Another important factor influencing Federal water planners in recent years has been the increasing activity of States in resources planning. In years past, many of the Western States relied heavily on Federal agencies to plan their water and related resources developments. Now they are building staffs, formulating State water plans, and participating to a much greater degree in the planning process. This is a desirable trend which calls for new working arrangements between the States and Federal water resource agencies.

The recently coined phrase "energy crisis" is rapidly becoming a byword in today's conversation. The facts of today's United States energy picture speak for themselves. More energy has been consumed in the past 30 years than in all history before 1940. One of the most critical trend lines is the continuing increase in per capita energy consumption in the United States. Even if current United States birth rates approaching zero population growth are maintained, the high-energy life style is expected to put new demands on all energy resources. In the United States, overall energy consumption may triple by the year 2000.

The environmental concerns of recent years, which receive major emphasis in the National Environmental Policy Act of 1969, have a major impact on planning. This Act requires that Federal agencies take environmental factors into full account in all their planning and decision-making. Much of the current concern over aspects of the environment has sprung from a negative reaction to the degradation inflicted on the natural surroundings. But there is a positive side to the struggle for environmental quality, and it too has been an important consideration in the Westwide Study effort. The planner and the decisionmaker must thoroughly consider and document the probable consequences of their planning and decisions on environmental values.

A part of the overall environmental picture important to the water planner is the water quality control program set forth in the Federal Water Pollution Control Act, as amended, which has led to the establishment of State water quality standards throughout the Nation. Every project that stores, diverts, or otherwise changes the natural flow of a river or stream is affected by the requirements of water quality considerations, be they for fish, esthetics, or the maintenance of set standards. In recognition of this close relationship, Congress in that Act authorized the Water Resources Council to prepare water resource plans for river basins throughout the Nation. In the West, this action could be considered as a duplication of the initial Westwide charge.

The potential effects of all of these rapid and unprecedented changes and how to accommodate them in the planning of water and related resources development are the major concerns of Federal, State and private interests involved in resource planning. The Westwide Study has been focused within the framework of these changes to provide information on where additional high priority study effort is needed to bring forth solutions to the water problems facing the West.

Defining Critical Problems

One of the most difficult assignments in the redirected study was establishing a basis for defining the most critical water and related problems. Recognizing that there are interdependencies among the categories, the order of priority in establishing this criticality from the national viewpoint was determined as (1) Municipal and Industrial Water Supplies; (2) Energy Development; (3) Environmental Protection and Enhancement; and (4) Agriculture and other Developmental Programs.

Issue papers were requested from the State-Federal Study Teams on water and related problems believed at the field level to be of a critical nature. Also, the teams were asked to prepare a report by States which summarized the critical issues and made recommendations consistent with the revised study objectives. Concurrently, action was initiated by the Management Group on the following items: (1) Additional issue papers were prepared on problems thought to be critical; (2) A screening and summarizing of problems submitted by others were completed; (3) Original investigative work on specialized problems such as energy was undertaken; and (4) The reports by States, the framework studies, and other available data were screened and evaluated.

The most critical water and water-related problems were defined and an assessment made of what should be done about them. Issues were grouped on a substantive basis and the result was a list of problems by States which were judged to be critical. Many of these problems occurred in more than one State on both a regional and a Westwide basis. Therefore, a consistent approach for considering State problems as a part of a regional or Westwide problem was developed. Through this process, a set of water-related problems, including functional, institutional, and social problems was established. These were discussed with the States, Advisory Committee and other interests. From these discussions and further review and analysis, a final list of critical problems, requiring further study or new studies in the near time frame, was developed. Recommendations for additional study have been made for most identified problems. Where study is needed in the 1976 to 1980 time frame, recommendations are made for agency participation, range of funding, and level of study effort.

Report Organization

The remainder of this report is divided into six additional chapters. Chapter II, The Westwide Situation, provides an assessment of the present setting on water and land resources, population, economy, environment, minerals and energy. Chapter III, Aspects of the Future, examines various important factors which will influence water planning in the Westwide area with emphasis on year 2000. Chapter IV, Westwide Problems, discusses critical problems that are common to most of the 11 Western States. Chapter V, Regional Problems, presents critical problems that affect large geographic areas involving two or more States. Chapter VI, State Specific Problems, sets forth critical problems, more closely identified with individual State conditions. In the latter three chapters, various approaches to problem resolution are discussed, conclusions drawn, and recommendations made for supplemental or new studies were considered appropriate. Chapter VII, General Observations, synthesizes and consolidates the multitude of conclusions and recommendations.

This report is supported by a number of working documents and unpublished material on file. Working documents with a limited distribution to study participants include:

- Augmentation Potential through Weather Modification
- Consumptive Water Requirements for Public Lands Administered by the Bureau of Land Management
- Definition of terms
- Guidelines for Planning Ground-Water Management
- Indian Reservations in the Eleven Western States
- Land Resource Base
- Outdoor Recreation Needs
- The Role of Ground Water in Resource Planning in the Western United States
- Socioeconomic Characteristics
- Wild and Scenic Rivers, Streams and Stream Systems
- Wilderness, Potential Wilderness, Research Natural Areas and Natural Landmarks

CHAPTER II
THE WESTWIDE SITUATION

INTRODUCTION

This chapter illustrates the existing planning setting for the Westwide Study area. It is a landscape, an insight on the people of the West; their economy, the natural resources, the environment, and the land and water resources. It provides a basis or setting from which "the tomorrows" and associated resource problems will evolve.

To begin this chapter, the population of the West is examined. This examination is followed by a discussion on the economy, including the very important setting for energy development, the natural environment, the land resource base, and the West's water supply.

THE PEOPLE

Population of the 11-State Westwide Study area totaled 33,735,000 in 1970, about 16 percent of the Nation's total. Distribution of Western residents is not uniform, it occurs principally in the belts from San Francisco south to San Diego, the Front Range of the Rocky Mountains in Colorado, the Willamette-Puget Sound corridor in Oregon and Washington, Wasatch Front in Utah, and Central Arizona. The major metropolitan centers occurring within these belts – Los Angeles, San Francisco, San Diego, Denver, Seattle, Portland, Salt Lake City, and Phoenix – account for the bulk of the West's people – and the bulk of the historical population increases.

Over the 50-year period from 1920 to 1970, the population growth rate for the 11 Western States has been higher than that for the entire United States. Table II-1 presents the population totals for each Westwide State by decades.

Population has historically moved from rural to urban areas, resulting in increasing population densities in the larger communities and a decrease in inhabitants per square mile in the rural areas. Although the average density per square mile is only slightly more than 28 people in the 11 Western States, the majority of inhabitants reside in more congested, metropolitan areas. In fact, based on United States Census figures, the Westwide area has a greater percentage of inhabitants in metropolitan areas (defined as a city and contiguous area containing more than 100,000 people) than does the Nation. Table II-2 presents a breakdown of metropolitan and nonmetropolitan populations for each Westwide State and the Nation. Figure II-1 shows the metropolitan percent for each Westwide State and locates the major urban regions.

Less than 1 million of the West's inhabitants, not quite 3 percent of the total, reside on farms. Even so, 17 percent of the population is located in rural areas.

Table II-1.—*Population by State, 1920-1970 (thousands)*

State	Year					
	1920	1930	1940	1950	1960	1970
Arizona	334	436	499	750	1,032	1,772
California	3,427	5,677	6,907	10,586	15,717	19,953
Colorado	940	1,036	1,123	1,325	1,754	2,207
Idaho	432	445	525	589	667	713
Montana	549	538	559	591	675	694
Nevada	77	91	110	160	285	489
New Mexico	360	423	532	681	951	1,016
Oregon	783	954	1,090	1,521	1,769	2,091
Utah	449	508	550	689	891	1,059
Washington	1,357	1,563	1,736	2,379	2,853	3,409
Wyoming	194	226	251	291	330	332
Westwide total	8,902	11,897	13,882	19,562	26,924	33,735

Source: Statistical Abstract of the United States, 1971, U.S. Department of Commerce, No. 11, p. 12.

Table II-2.—*Metropolitan and nonmetropolitan populations by State, 1970 (thousands)*

State	Populations		
	Metro-politan	Nonmetro-politan	Total[1]
Arizona	1,320	452	1,772
California	18,639	1,314	19,953
Colorado	1,671	536	2,207
Idaho	148	565	713
Montana	0	694	694
Nevada	416	73	489
New Mexico	316	700	1,016
Oregon	1,281	811	2,091
Utah	822	238	1,059
Washington	2,394	1,015	3,409
Wyoming	0	332	332
Westwide total	27,007	6,730	33,735
United States	144,313	58,923	203,235

[1] Numbers may not total due to rounding.
Source: The Commission on Population Growth and the American Future, 1972, Vol. 5, *Population, Distribution, and Policy*, pp. 162-167.

Table II-3 indicates the distribution of minorities by State. Spanish people make up 13 percent of the total population of the West. Five percent of the West's population are black and 1 percent are Indian as compared with national percentages of 11 for black and 0.4 for Indian.

Of special concern because of their geographical restrictions are the inhabitants of the 172 Indian reservations located in the 11 Western States. While all States have at least one reservation, the majority are concentrated in the Pacific Northwest and Southwest portions of the Study area.

Domestic water use is directly related to the number of inhabitants of the region. Individual household water consumption in the West is 13 percent higher than the rest of the country. When commercial and industrial uses are added, per capita consumption is 30 percent higher than the balance of the Nation. Because of the arid climate and the need for irrigation, total per capita water consumption in the West is 16 times greater than the other portions of the Nation.

THE ECONOMY

The Westwide area can be best described as having a strong, rapidly growing industrialized economy. The higher than normal rate of population growth fed by continuing rapid inmigration has provided an ever-increasing demand for all consumer goods, food, construction activity, and services. The strength of the economy over the last two decades is indicated by the high growth rates of most industries. However, the higher than national growth rate masks some pockets of depressed economic activity as revealed by a higher than national rate of unemployment in 1970 resulting in a lower family income than the rest of the Nation. At the same time, however, per capita income was about equal to the national levels with a smaller percentage of individuals receiving less than poverty level income. This section enumerates some of the significant economic resources of the Westwide area. The economy is described in terms of employment and industrial output impinging upon the population.

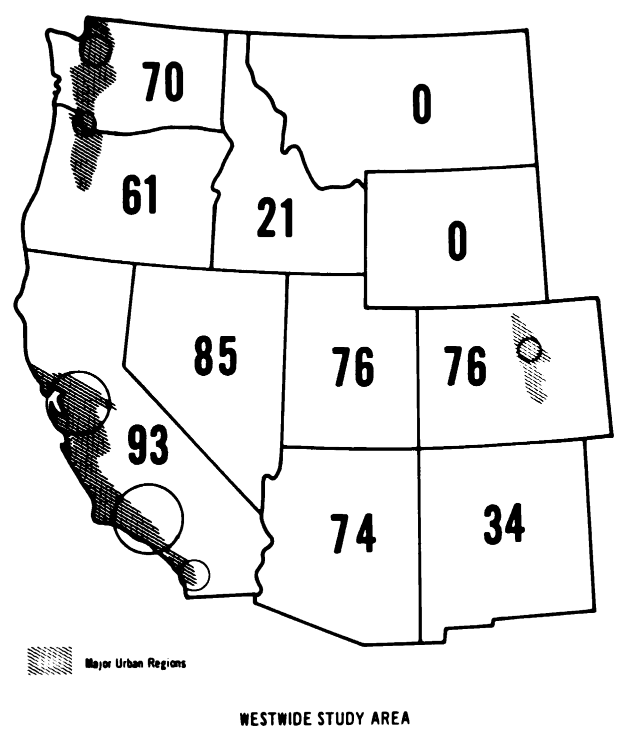


Figure II-1. Percent of State population residing in metropolitan areas and major urban regions – 1970.

Table II-3.—*Socioeconomic characteristics for Westwide (1970 census data)*

DEMOGRAPHIC

Westside and Nation	Population															
	Total	Rural						Total[1]		Percent rural	Minority groups[2]					
		Farm	Nonfarm	Farm*		Nonfarm*		Rural*	Urban		Spanish	Indian	Negro	Other	Total minority	Percent minority
				White	Other race	White	Other race									
Arizona	1,770,900	23,273	339,546	31,151	14,807	247,471	69,390	362,819	1,408,081	20	333,349	95,812	53,344	16,796	499,301	28
California	19,957,715	184,875	1,635,124	233,844	14,392	1,499,854	71,909	1,819,999	18,137,716	9	3,101,589	91,018	1,400,143	700,941	4,592,750	23
Colorado	2,207,259	85,989	385,188	102,379	1,395	363,495	3,917	471,177	1,736,082	21	286,467	7,182	66,411	19,467	379,527	17
Idaho	712,567	93,708	231,759	101,648	2,154	217,361	4,304	325,467	387,100	46	18,476	6,687	2,130	4,948	32,241	5
Montana	694,409	82,129	239,936	85,054	3,306	214,995	18,610	322,065	372,344	46	7,771	27,130	1,995	2,241	21,536	3
Nevada	488,738	7,716	85,801	9,172	1,038	78,267	5,040	93,517	395,221	19	27,142	7,933	27,762	4,866	67,703	14
New Mexico	1,016,000	37,487	267,808	42,591	9,467	203,021	50,216	305,295	710,705	30	407,286	72,788	19,555	7,842	507,471	50
Oregon	2,091,385	102,185	586,689	130,936	2,173	547,064	8,701	688,874	1,402,511	33	34,577	13,510	26,308	19,488	93,883	4
Utah	1,059,273	179,662	26,293	30,666	2,036	166,901	6,356	205,955	853,314	19	43,550	11,273	6,617	9,457	70,897	7
Washington	3,409,169	111,826	820,846	138,751	2,796	771,039	20,080	932,672	2,476,497	27	70,734	33,386	71,308	53,420	228,848	7
Wyoming	332,416	31,263	100,276	34,065	1,031	93,497	2,946	131,539	200,877	40	18,551	4,980	2,568	1,844	27,943	8
Westwide	33,729,831	940,113	4,719,266	939,863	54,595	4,402,965	261,469	5,659,379	28,080,488	17	4,349,492	371,699	1,678,141	841,310	7,240,642	21
United States	203,212,877	8,292,150	45,586,707	–	–	–	–	53,878,857	149,334,020	26	–	792,730	22,580,289	2,089,932	–	–

Sources:

[1]"General Social and Economic Characteristics—United States Summary"—Table 142. Correction note on page 1-359 to classify rural populations into farm and nonfarm.
[2]State totals are those appearing in state reports. Westwide aggregate of states. "General Population Characteristics—United States Summary"—Table 48.
*"Farm" and "Nonfarm" populations characterized by "White" and "Other Races" do not agree with "Rural" total because of incorrect classification by farm-nonfarm residence.

Personal Income

Personal income is one of the most comprehensive and suggestive measures available to gage the overall business and economic activities in a region. It reflects the current income received by individuals from all sources. The personal income measure in an overall sense provides a reliable guide to a region's changing market and income patterns.

Total personal income increased in the Westwide area 103 and 106 percent from 1950 to 1960 and 1960 to 1970, respectively. Per capita income for the same periods increased 46 and 66 percent respectively.

Expansion of the region's per capita income has generally paralleled the average income growth at the national level.

Table II-4 shows total and per capita income by States and reveals the more important centers of economic activity. ("Current dollars" as used in the statistical abstract means actual amounts unadjusted for price changes.) The States of California, Colorado, Oregon, and Washington contain the bulk of the industrial and business activity of the West.

Nevada experienced the most rapid increase in total personal income between 1950 and 1970 (666 percent) closely followed by Arizona (530 percent). Wyoming had the slowest growth in total personal income showing only 122 percent for the 20-year period. The most rapid increase in per capita income came about in Arizona (166 percent) with Wyoming recording the least change for the 1950 to 1970 period.

Table II-5 indicates the percentage of population in each State which in 1970 received less than poverty level income. As indicated, the percent for the Westwide population is less than for the Nation as a whole. In addition, the median family income is given for each State and the percentage of families with less than poverty level income. The family income for New Mexico is significantly lower than most of the other States.

The table also draws a comparison between the level of income received by Indians and income received by the total Westwide population. For the entire area, the median family income in 1970 was $9,126 while Indian families most frequently received less than half that amount ($4,293).

Employment

Employment in the Westwide area has been increasing at a rate about double that for the United States as a whole. Total employment in the Westwide area increased from 7,345,000 in 1950 to 13,128,000 in 1970, or about 79 percent. During the same period,

Table II-4.—*Total and per capita personal income by State – 1950-1970 (current dollars)*

State	Total personal (billions of dollars)			Per capita (dollars)		
	1950	1960	1970	1950	1960	1970
Arizona	1.0	2.7	6.3	1,331	2,032	3,542
California	19.8	43.0	89.8	1,852	2,708	4,469
Colorado	2.0	4.0	8.3	1,487	2,273	3,751
Idaho	0.8	1.2	2.3	1,295	1,850	3,206
Montana	1.0	1.4	2.3	1,622	2,037	3,381
Nevada	0.3	0.8	2.3	2,091	2,856	4,544
New Mexico	0.8	1.8	3.1	1,177	1,888	3,044
Oregon	2.5	4.0	7.8	1,620	2,235	3,700
Utah	0.9	1.8	3.4	1,309	1,968	3,210
Washington	4.0	6.7	13.7	1,674	2,349	3,993
Wyoming	0.5	0.7	1.1	1,669	2,261	3,420
Westwide	33.6	68.1	140.4	1,718	2,529	4,162
United States	226.2	398.7	797.1	1,496	2,216	3,910

Source: Statistical Abstract of the United States, 1971, U.S. Department of Commerce, No. 497, p. 314.

total United States employment increased from 57,457,000 to 78,600,000, or about 37 percent.

Table II-6 presents the work force by States and percent unemployed in 1970. Washington experienced the greatest unemployment rate (7.9 percent) with Arizona and Colorado having the lowest (4.2 percent) which about equaled the United States average (4.1 percent). The unemployment rate, 6 percent in 1970, for the Westwide area as a whole was substantially above the national rate. Table II-7 shows numbers of workers employed by industry and also by occupation. Manufacturing accounted for the largest single employing industry and professional, technical, and managerial workers dominated the occupations in which workers engaged.

The size of the Indian labor force is compared in table II-8 with the total number of workers in each State. As shown the unemployment rate among Indians is in excess of 45 percent, indicating a serious social problem among this minority group. Part of this problem may stem from the insufficient educational levels achieved by Indian workers.

Industry Earnings

During the period 1950 to 1969, total annual earnings of industries in the Westwide area have increased 159 percent or about 2-1/2 times from $37,526 million in 1950 to $97,075 million in 1969. This is "real" growth measured in terms of constant 1967 dollars to exclude the distortion of inflation, and amounts to an annual compound growth rate of about 5-1/8 percent. Industry earnings of the 11 Western States are shown in table II-9 by State totals and by basic industries. Total industry earnings for the United States during this time increased from $258,748 million to $554,912 million, or 114 percent, which reflects an annual compound growth rate of about 4-1/8 percent.

Earnings of agriculture in the Westwide area declined slightly (4 percent) from 1950-1969, while for the United States the decline was about 17 percent. The general decline in agricultural earnings was largely offset in the Westwide area by an increase for both Arizona and California. This reflects an increase in the acreage, production, and price of high-value irrigation

Table II-5.—*Family income by State, 1970*

State	Family income		
	Median[1]	Percent less than poverty[2]	Median Indian[3]
Arizona	9,187	11.5	2,774
California	10,732	8.4	2,500
Colorado	9,555	9.1	4,500
Idaho	8,381	10.9	7,250
Montana	8,512	10.4	4,250
Nevada	10,692	7.0	2,700
New Mexico	7,849	18.5	2,260
Oregon	9,489	8.6	6,700
Utah	9,320	9.1	4,500
Washington	10,407	7.6	5,586
Wyoming	8,943	9.3	4,200
Westwide	9,126	–	4,293
United States	9,590	10.7	–

Source: [1]"General Social and Economic Characteristics—United States Summary"—figure 76 on page 1-357.
[2]State percentages are those appearing in State reports. U.S. Calculated from table 139, "General Social and Economic Characteristics—United States Summary."
[3]1967 Estimates for Reporting Tribes, U.S. Dept. of Commerce, E.D.A., Federal and State Indian Reservations, and E.D.A. Handbook, January 1971.

Table II-6 —*Employment by industry by State, 1970*

Westwide and Nation	Civilian labor force[1]	Employment by industry[2]				
		Agriculture, forestry, and fishery	Mining	Construction	Manufacturing	Other (primary services)
Arizona	640,000	24,605	18,986	46,673	95,958	427,833
California	7,992,168	233,850	34,379	404,350	1,614,687	5,197,424
Colorado	862,133	38,093	14,232	54,668	120,5811	598,202
Idaho	271,593	33,406	3,869	16,628	37,827	165,721
Montana	260,649	32,726	5,877	15,674	23,626	166,705
Nevada	208,996	4,786	3,714	16,266	10,357	162,682
Bew Mexico	342,482	15,352	17,943	23,774	21,832	243,936
Oregon	837,078	42,465	1,379	45,324	167,035	522,642
Utah	399,162	14,360	11,545	20,665	55,018	276,974
Washington	1,338,518	54,769	2,193	75,515	266,875	833,711
Wyoming	129,577	12,286	11,087	8,511	7,939	83,566
Westwide	12,951,570	506,698	125,204	728,048	2,421,735	8,679,396
United States						
16 years old and older	79,801,605	2,840,488	630,788	4,572,235	19,837,208	48,672,880
14 and 15 years old	1,315,625					
United States total	81,117,230					

Source: 1970 Census of Population "General Social and Economic Characteristics"
[1] United States Summary, Table 112.
[2] United States Summary, Table 114.

crops which, in an economic sense, characterize agriculture in these States.

Earnings of the mining industry in the Westwide area increased about 65 percent during the period (1950-1969), while increasing only 11 percent for the United States. Earnings from mining actually declined slightly in Montana, Idaho, and Washington, while increases from 50-100+ percent were experienced in California, Arizona, and Colorado.

The increase in total construction in the West was reflected by a gain in earnings of 68 percent during the period (1950-1969). This is considerably less than the rest of the Nation which posted an increase of 120 percent. Arizona and Nevada experienced the most rapid growth in construction with earnings in 1969 being four times those of 1950.

Earnings of the manufacturing industry in the Westwide area have trebled during the period (1950-1969), while doubling for the United States. Among the 11 Western States, California and Washington experienced the most dollar growth in earnings from manufacturing and together account for over 80 percent of the total.

Transportation, communication, and public utility earnings more than doubled over the period (1950-1969) compared to the national increase of 82 percent. Growth in these industries was fairly uniform for the 11 Western States.

Wholesale and retail trade earnings more than doubled from 1950 to 1969. The rate of growth was about 30 percent higher than the rest of the Nation. Over the period (1950-1969) the earnings from finance, insurance and real estate activity increased 183 percent

Table II-7.—*Employment by occupation by State, 1970*

	Civilian labor force		Employment by occupation[3]							
								Laborers		
Westwide and Nation	No.[1]	Percent unem-ployed[2]	Professional technical manage-mental	Sales workers	Clerical and kindred	Craftsman foreman and kindred	Opportunity including transporta-tion	Except farm	Farm workers	Service workers include household
Arizona	640,000	4.2	160,920	47,833	105,421	85,793	83,346	29,737	17,947	83,058
California	7,992,168	6.3	1,998,856	595,877	1,479,679	968,435	1,025,683	308,133	162,217	945,810
Colorado	862,133	4.2	227,076	63,513	154,465	102,957	97,722	33,385	32,131	114,527
Idaho	271,593	5.2	60,028	16,745	34,155	32,815	36,833	13,870	29,224	33,771
Montana	260,649	6.2	59,966	15,535	35,330	31,022	26,910	11,386	28,465	35,994
Nevada	208,996	5.4	48,386	11,350	33,463	26,229	18,242	7,513	3,683	48,839
New Mexico	342,482	5.7	92,496	20,674	53,072	42,910	39,411	14,517	12,373	47,384
Oregon	837,078	7.0	188,211	58,637	129,109	102,646	116,650	47,709	31,016	104,767
Utah	399,162	5.2	99,949	26,565	69,870	55,044	51,040	16,181	11,715	48,202
Washington	1,338,513	7.9	319,161	91,034	215,293	179,705	161,406	64,821	41,344	160,299
Wyoming	129,577	4.8	32,364	6,712	18,175	16,903	15,140	5,327	11,061	17,707
Westwide	12,951,570	6.0	3,287,413	954,475	2,328,032	1,644,459	1,672,383	552,579	381,176	1,640,358
United States										
16 years old and older	79,801,605	4.1	17,719,963	5,443,318	13,745,144	10,608,010	13,453,985	3,426,546	2,379,545	9,777,088
14 and 15 years old	1,315,625	42.3								
Total	81,117,230	4.7								

Source: 1970 Census of Population "General Social and Economic Characteristics"
[1] United States Summary, Table 112.
[2] Calculated from United States Summary, Tables 112 and 113.
[3] United States Summary, Table 113.

Table II-8.—*Comparisons between Indian and statewide averages for selected economic factors by State, 1970*

State	Size of labor force		Labor force unemployed		Average education level	
	State[1]	Indian[2]	State	Indian	State[1]	Indian[3]
	(Number)		(Percent)		(Grade)	
Arizona	640,000	39,363	4.2	43.0	12.1	8.3
California	7,992,168	1,701	6.3	48.3	12.3	9.4
Colorado	862,133	652	4.2	46.3	12.3	8.0
Idaho	271,593	1,744	5.2	39.3	12.1	NA
Montana	260,649	6,172	6.2	46.6	12.2	8.8
Nevada	208,996	1,418	5.4	35.0	12.3	7.7
New Mexico	342,482	9,265	5.7	64.7	12.4	5.5
Oregon	837,078	941	7.0	25.8	12.2	9.0
Utah	399,162	NA	5.2	NA	12.3	NA
Washington	1,338,513	4,570	7.9	32.7	12.3	8.8
Wyoming	129,577	1,057	4.8	45.6	12.2	NA
Westwide	13,282,351	66,883	6.0	45.3	–	–

Source: [1]Data assembled for the Westwide Report.
[2]Bureau of Indian Affairs Labor Statistics for the Albuquerque, Billings, Portland, Sacramento, and Window Rock Area Reservation. Does not reflect Indian labor statistics for areas off the reservations.
[3]1969 Estimates for reporting Tribes, U.S. Department of Commerce, Economic Development Administration, Federal and State Indian Reservations, an EDA Handbook, January 1971.

compared to the United States average of 165 percent. Activity in Arizona and Nevada showed the fastest growth, increasing about five times over the two decades.

Services were the second highest gains with earnings in the 11 States increasing 234 percent from 1950 to 1969. This compares to the national average of 183 percent for the same period. All States of the region showed significant increases with Nevada posting the largest rate of gain, 658 percent.

The largest increase in earnings is the Westwide area occurred in the local, State, and Federal government sectors. The Westwide growth of 254 percent was slightly higher than the national average of 215 percent for the period 1950 to 1969.

California is noteworthy by having 63 percent of the total industry earnings of the 11 Western States in 1969. By industry, California's share was 50 percent of agriculture, 28 percent of mining, 51 percent of construction, 69 percent of manufacturing, 63 percent of transportation, 63 percent of trade, 67 percent of finance, 66 percent of services, and 62 percent of Government. Fifty-nine percent of the Westwide inhabitants resided in California in 1970.

Recreation and Tourism

A substantial amount of reasonably reliable data is readily available for many basic industries. Unfortunately, little research has been done in the field of recreation economics. Consequently, such detailed and reliable data are not readily available for the recreation-tourism industry in the West. Since recreation-tourism obviously is a major industry in each of the 11 Western States, some general observations are in order. It is generally recognized that tourism-recreation is the second, third, or fourth leading industry in each Westwide State. Further, historic trends and economic analysis suggest that it is probably the fastest growing major industry in the West.

The National Travel Expenditure Study, based in part on the 1972 National Travel Survey by the Bureau of the Census, provided estimates of travel spending of residents of the United States to destinations within the States, but 100 miles or more away from home. This study showed, for example, that California received nearly $4.1 billion; more travel income than any other state in the Nation. Also, visitors to Nevada spent more per person per day than in any other of the

Table II-9.—*Earnings by selected industries by State*

11 Western States—by States and totals

State	Industry									
	Agriculture forestry and fishery	Mining	Construction	Manufacturing	Transportation communication & public utilities	Wholesale and retail trade	Financial insurance & real estate	Services	Government	State total
Arizona										
1950	211	73	86	78	100	125	44	152	187	1,148
1959	191	103	233	311	176	416	119	303	440	2,292
1969	234	185	335	744	257	699	230	659	931	4,274
California										
1950	1,741	219	1,667	4,351	1,742	4,594	1,202	3,041	3,364	21,920
1959	1,813	270	2,653	9,821	2,618	6,946	2,033	5,490	6,274	37,918
1969	1,886	325	2,438	15,162	4,357	10,318	3,407	10,401	12,536	60,830
Colorado										
1950	278	56	164	290	211	460	93	256	336	2,146
1959	221	108	271	539	306	688	187	461	639	3,421
1969	270	129	377	908	437	1,012	314	844	1,344	5,635
Idaho										
1950	236	33	67	111	82	177	26	80	91	903
1959	220	25	82	183	93	218	40	123	170	1,154
1969	265	30	105	268	107	269	60	213	278	1,595
Montana										
1950	360	61	72	90	117	199	28	96	118	1,140
1959	200	53	86	125	133	228	49	142	200	1,214
1969	227	56	99	176	146	262	62	207	324	1,558
Nevada										
1950	44	17	29	21	42	65	11	82	57	369
1959	28	22	61	39	65	126	27	237	130	737
1969	31	35	131	69	118	228	66	622	316	1,616
New Mexico										
1950	145	78	96	54	72	159	32	111	189	936
1959	138	146	151	106	131	270	68	265	420	1,695
1969	150	143	143	131	154	311	86	395	646	2,159
Oregon										
1950	309	10	208	778	261	602	118	320	276	2,882
1959	241	10	220	975	316	720	155	447	481	3,566
1969	204	13	341	1,424	441	1,036	263	762	884	5,368
Utah										
1950	110	72	82	138	113	214	36	98	188	1,053
1959	66	93	118	273	155	300	69	182	330	1,586
1969	68	109	129	389	196	405	98	335	652	2,383
Washington										
1950	432	18	318	973	361	880	204	469	815	4,470
1959	314	14	400	1,594	434	1,135	301	714	1,118	6,024
1969	397	15	614	2,614	652	1,650	501	1,302	2,116	9,861
Wyoming										
1950	109	54	45	34	72	100	15	41	89	559
1959	92	73	74	51	76	108	20	68	107	670
1969	66	103	62	54	81	117	28	97	185	794
Total—Westwide										
1950	3,975	691	2,834	6,918	3,173	7,665	1,809	4,746	5,710	37,526
1959	3,524	917	4,349	14,017	4,503	11,155	3,068	8,432	10,309	60,277
1969	3,798	1,143	4,773	21,939	6,946	16,307	5,115	15,837	20,212	97,075
Index										
1950	100	100	100	100	100	100	100	100	100	100
1959	89	133	153	203	142	146	170	178	180	161
1969	96	165	168	317	219	213	283	344	354	259
Total—United States										
1950	23,597	5,145	15,483	74,818	21,131	48,940	10,911	28,904	29,818	258,748
1959	17,042	5,149	21,853	107,255	27,392	63,500	18,110	45,245	50,221	355,767
1969	19,571	5,701	34,064	161,427	38,558	91,116	28,933	81,704	93,839	554,912
Index										
1950	100	100	100	100	100	100	100	100	100	100
1959	72	100	141	143	130	130	166	157	168	138
1969	83	111	220	216	182	186	265	283	315	214

50 States. Table II-10 summarizes some of this travel expenditure data for the 11 Western States.

Agricultural Production

The Westwide area makes an important contribution to agricultural production in the United States. About one-half of the annual domestic consumption of wheat, noncitrus fruit, vegetables, beans and peas, rice, potatoes, and barley is produced in the West. (See fig. II-2.) Additional information on the West's cropland is presented subsequently in this chapter.

Energy Development

Electric utility use comprises about 24 percent of the total primary energy used. Residential and commercial, industrial, and transportation account for the remainder with industrial being the largest. United States total energy consumption is about 200 kWh per capita per day or five times the world average. In 1970, the sources of energy in the United States were 41 percent from petroleum, 35 percent from natural gas, 22 percent from coal, and about 2 percent from hydropower and nuclear. In the Westwide area, in 1972, sources of energy were 49 percent fossil fuels, more than 46 percent hydropower, nearly 2 percent nuclear, and 3 percent other including gas turbine and geothermal. Only about one-half of this energy potential is converted into useful work while the other half is rejected predominantly through heat dissipated into air and water.

The present energy situation is characterized by short-term dislocation of energy resources; increasing costs of production; increased environmental requirements; delays in powerplant and energy plant construction· natural gas shortages, possible electric power shortages, gasoline, diesel, heating oil and residual fuel shortages; mid-East oil cutbacks and inefficient or unnecessary use of energy resources.

Efforts to develop new energy resources have intensifed environmental concerns. As a result, overall energy impacts on air, water, and land are closely scrutinized especially in the Western United States.

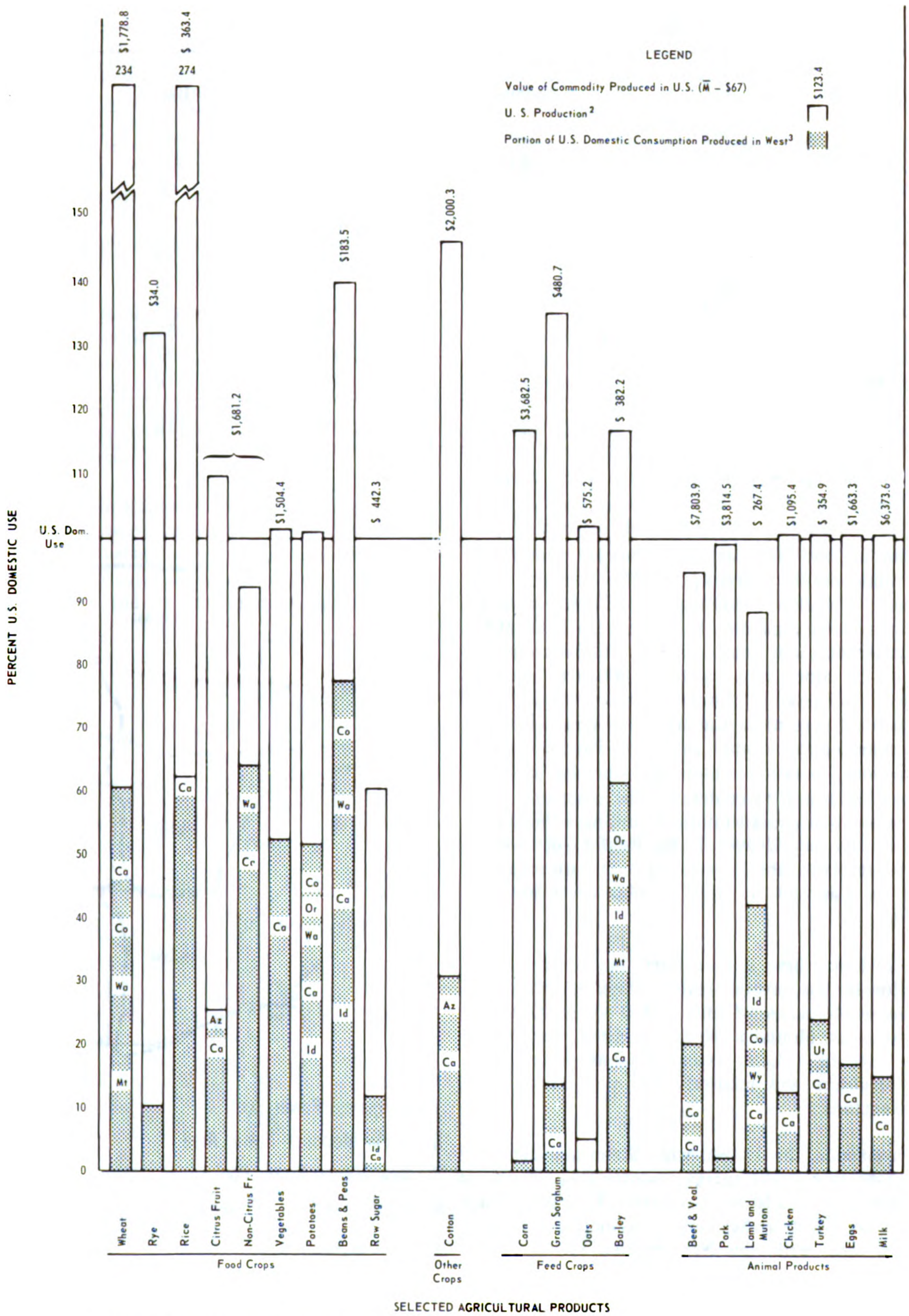
The Westwide area is served by an interconnected group of investor owned, public non-Federal, and Federal utilities. These utilites have formed a group, the Western Systems Coordinating Council, to study common problems, interchange information, and perform other functions as needed. Much of the information on electrical energy has been taken from data developed by that Council. The Western Systems Coordinating Council's area is shown on figure II-3 and is approximately the same as the Westwide area. Table II-11 shows the 1972 powerplant capacity by State.

The transmission of electrical power from mine-mouth plants or the transportation of coal to load-center

Table II-10.—*1972 United States domestic travel expenditures, by State visited 1972 (millions)*

State visited	Expenditure						
	Transportation	Lodging	Food	Entertainment	Gifts	Incidentals	State totals
Arizona	200.2	125.9	144.0	37.1	2.1	109.7	619.1
California	1,787.4	607.7	814.1	219.1	18.6	647.9	4,094.8
Colorado	288.8	140.1	175.1	44.1	2.4	131.2	781.8
Idaho	72.4	24.0	46.9	13.3	1.2	38.6	196.4
Montana	67.1	32.7	37.8	11.4	0.7	31.6	181.5
Nevada	81.9	134.5	201.1	26.4	1.0	80.9	525.9
New Mexico	90.8	36.2	75.8	20.8	1.2	59.8	284.7
Oregon	212.2	61.4	117.2	27.0	2.3	81.3	501.5
Utah	146.7	34.4	65.1	16.7	1.3	48.4	312.7
Washington	296.9	72.0	147.3	32.1	3.0	92.1	643.5
Wyoming	47.3	30.8	34.1	10.3	0.3	29.1	152.1
Westwide	3,291.7	1,299.7	1,858.5	458.3	34.1	1,350.6	8,294.0

Source: 1972 National Travel Expenditure Study Summary Report — December 1973 by United States Travel Data Center, Washington, D.C.



Source: [1] 1972 OBERS Projections, Volume 5, United States Table 5.
[2] Computed from 1972 OBERS Projections, Volume 1, Table C-3.
[3] Computed from unpublished OBERS Agricultural Base Data - December 1, 1971, Natural Resource Division of Economic Research Service, USDA.

Figure II-2. ***Production and value of agricultural commodities.***

Table II-11.—*Powerplant capacity by type by State, 1972*

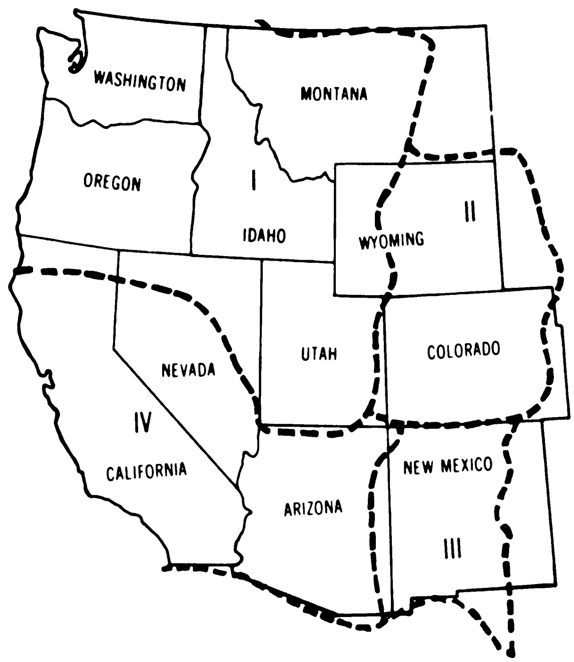
State	Powerplant type				
	Fossil	Nuclear	Hydro	Other[1]	Total
Arizona	2,254	–	1,366	409	4,029
California	20,849	510	7,765	1,397	30,521
Colorado	2,173	–	664	68	2,905
Idaho	10	–	2,230	7	2,247
Montana	312	–	1,542	20	1,874
Nevada	2,212	–	1,340	99	3,651
New Mexico	3,672	–	24	60	3,756
Oregon	184	–	5,587	–	5,771
Utah	771	–	191	51	1,013
Washington	1,743	860	13,090	27	15,720
Wyoming	1,618	–	217	10	1,845
Westwide	34,798	1,370	34,016	2,148	73,332

[1] Includes gas turbine, geothermal, internal combustion.

powersites are options available. The current trend is to utilize mine-mouth powerplants. The storage and movement of coal and cooling water for select sites both involve large capacities. For instance, a 1,000-MW power generation unit consumes 3 to 5 million tons of coal annually along with up to 15,000 acre-feet of water using wet cooling towers. At the present time, more than 60 percent of the Westwide area's electric power consumption occurs along the Pacific Coast. Major power generation centers are generally located close to the large load centers on the coast and the inland population concentrations found near Phoenix, Salt Lake City, and Denver. In the Pacific Northwest, major powerplants are hydroelectric and are located east of the Cascades on the Columbia River and its tributaries.

In contrast to these concentrated major load and population centers, several Western States have present total power demands of only 1,000 to 2,000 MW. Some, such as Montana, Wyoming, Utah, and New Mexico and, to a lesser extent Arizona, have large energy resources and relatively low population and energy demands.

For convenience, the 11 Westwide States area can be divided into three basic energy resource areas: Northwest, Southwest, and Rocky Mountains. For discussion purposes, the Western Systems Coordinating Council areas are used with the New Mexico Power Pool considered as part of the Rocky Mountain area. The Northwest resources are essentially hydrobased with plans for immediate development of nuclear power.



I - Northwest Power Pool
II - Rocky Mountain Power Area
III - New Mexico Power Pool
IV - Pacific Southwest Power Area

Source Western Systems Coordinating Council

Figure II-3. General electric powerload areas.

The Southwest is dependent on coal, oil, and gas reserves with a fossil-fired power generation base. There is some use of geothermal resources. The Rocky Mountain area has the most diverse resource base with coal, oil, oil shale, and uranium reserves. Synthetic oil and gas products from coal and oil shale conversion are under present or pending development. Coal conversion to pipeline quality gas or to oil and liquid products is now under pilot plant development. Oil shale pilot development has been under intensive study for several years.

There were energy shortages in the Pacific Northwest in late 1973 resulting from delays in constructing electric powerplants and from extremely low runoff. These shortages caused curtailment in interruptible load and may recur, depending on water conditions, load growth, and extent of progress in construction of thermal electric plants.

Power shortages in California have resulted in requests for voluntary conservation and curtailment of electric load. These shortages are caused by increasing demands, by difficulty in obtaining suitable fuel for powerplant use, and by delays in constructing and licensing fossil- and nuclear-fired powerplants. Waste heat disposal of power generation and industrial processing imposes an increasing demand on water resources.

The Western States contain most of the United States' undeveloped energy resources including strippable coal, oil shale, and uranium reserves (fig. II-4). Over 70 percent of the country's strippable coal reserves are found west of the Mississippi. All low-sulfur subbituminous coal and lignite resources and one-half of the bituminous coal containing less than 1.5 percent sulfur are concentrated in this area. Oil shale found in the Green River Formation in Colorado, Utah, and Wyoming has been estimated to contain about 1.25 trillion barrels of oil. Physical, economic, and environmental conditions will determine how much oil can actually be extracted. It is presently anticipated that at least 600 billion barrels of oil can be extracted.

Several unit trains and one major slurry pipeline which move coal to large capacity powerplant sites are located in the area. Large unit trains now originate in Colstrip, Montana, and Gillette, Wyoming, to move large tonnages of coal to distant locations. One unit

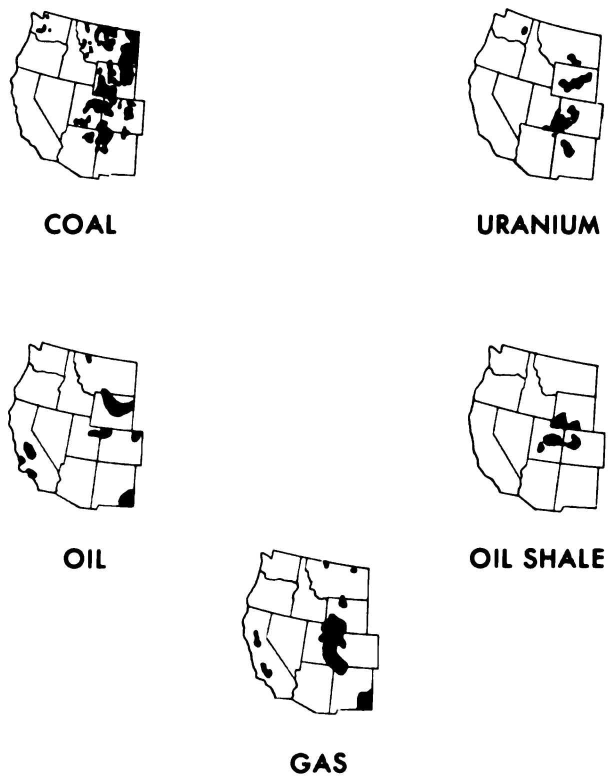


*Figure II-4. **Distribution of mineral energy reserves in the West.***

train presently hauls 1,000 tons of coal every 60 hours to supply a large capacity powerplant in Colorado. Other trains are already scheduled to deliver western coal to the Midwest and southern portions of the country.

The 275-mile Black Mesa coal-slurry pipeline supplying Mohave Powerplant in Nevada moves the equivalent of 160 railcars of coal daily. It represents another potential use of water for transportation and processing. In some cases, slurry pipeline transportation of coal may deliver coal energy at a lower cost than unit trains or even electric transmission lines. After the 50/50 water-coal slurry solution is separated, the water can be purified and used for processing and cooling on site. The amount is not sufficient for the usual powerplant requirements.

In summary, electric power generation and primary energy resource production are important in the Westwide area. Rapidly increasing demands for all types of energy and the greater utilization of the available coal, oil shale, and uranium resources in the West have major impacts in the Westwide area including significant water demands in water-short areas.

NATURAL ENVIRONMENT

In a land area where the altitude varies from more than 14,000 feet above sea level to 248 feet below, where rainfall varies from more than 100 inches per year to less than 1, where temperatures vary from more than 120°F to minus 50°F, where there are both glaciers and boiling hot springs, the world's tallest trees and the barest of desert lands, the largest and deepest canyons, the purest water and the most mineralized, the most natural and the most intensively developed areas, it is impossible to describe the "environment" in a few pages. Rather, this section will focus on significant environmental aspects which affect or are affected by water resource conservation and development.

The material presented is organized in accordance with the classes or components of environmental quality described in the Principles and Standards for Planning Water and Land Resources that were promulgated by the Water Resources Council. This is consistent with the approach to consideration of environmental quality aspects followed during the conduct of the Westwide Study.

The general natural history regions of the West have been described by the National Park Service in order to develop preservation and interpretation plans. These regions are illustrated in figure II-5. These regions include areas with similar geologic histories, structures and landforms, climates, soils, vegetation, and animal life. The characteristics of each region are described in a 1970 report prepared by the National Park Service.

Without describing the various regions, it does appear that they are as distinct today as they were in the early parts of the 20th century. Changes have occurred, however, that are significant. Entire rivers, certain river reaches, lakes, estuarine areas, and specific tracts of land have been altered. Even though the range of certain species of plants and animals has decreased or expanded with development of the West, the structure and operation of most major natural regions (ecosystems) remain basically unchanged.

Open Space and Greenbelts

Even with the population of about 34 million in 1970, there are large expanses of open space with room to roam for both westerners and easterners. More than 320 million acres of National Forest lands, public domain lands, and wildlife refuge areas receive multipurpose management which allows open space, outdoor recreation experiences. Other lands and waters managed as a part of public and private water resource developments contribute greatly to satisfaction of open space recreation needs.

Despite this large expanse of open land for the area's largest population centers, accessible open space is at a premium. Open areas once available within or adjacent to metropolitan centers are disappearing rapidly. Public lands including wilderness areas adjacent to metropolitan areas, experience heavy usage. This intense use both degrades the areas and reduces the quality of the outdoor experience received.

About 2.3 million acres are managed by counties, cities, and park and recreation districts for outdoor recreation. These parks meet more of the recreation needs for more people than the relatively vast acreages of nonurban recreation areas. Greenbelts along streams in urban areas are becoming one of the most important opportunities for creating open space and recreation areas. Such space creates buffer areas that break up urban development concentrations and lessen flood damage. More and more water and land are being dedicated for this purpose and greenbelts are being considered in many water development projects.

Lakes, streams, and appurtenant lands developed in connection with water development projects serve important recreational functions in urban areas such as Denver, Colorado; Sacramento, California; and Boise, Idaho. As land values increase, and competition for

Source: Based upon Fenneman's (1928) Physiographic Divisions of the United States

Figure II-5. Natural resource regions.

available water intensifies, it is becoming more and more difficult to acquire and maintain water-related park areas in urban settings.

Streams and Stream Systems

The Wild and Scenic Rivers Act (P.L. 90-542) declares a national policy that "* * * certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations." The purpose of the Act is "* * * to implement this policy by instituting a national wild and scenic rivers system, by designating the initial components of that system, and by prescribing the methods by which, and standards according to which, additional components may be added to the system from time to time."

During the Westwide Study, an effort was made to list all reaches of streams that have significant, identified free-flowing values in the 11 Western States. In addition to the sources listed above, official reports of State and Federal agencies and official correspondence to the agencies responsible for study and administration of the National Wild River System were used to develop the list. A summary of this effort is presented in table II-12.

Five streams in the Western States with a combined total mileage of 508 stream miles were included as so-called instant wild rivers in the National Wild and Scenic River System with the passage of P.L. 90-542. That Act listed 14 additional rivers under Section 5a for immediate study to determine if any of the designated 1,126 stream miles should be made a part of the National System. In addition, the Secretaries of Interior and Agriculture have designated 2,398 miles of stream as candidates for further study as called for under Section 5c of the Act.

The State of Oregon has designated 496 miles of river as scenic waterways under State law and the State of California has designated 830 miles of river for preservation or study through a law dated December 20, 1972.

Table II-12.—*Number and mileage estimates of existing and potential wild, scenic, and recreational rivers and other rivers with identified free-flowing values by State, 1972*

State	Number and mileage of rivers													
	Federal 3a[1]		Federal 5a[1]		Federal 5c[1]		State system[2]		Framework studies[3]		Other sources[4]		State total[5]	
	No.	Miles	No.	Miles	No.	Miles	No.	Miles	No.	Miles	No.	Miles	No.	Miles
Arizona	–	–	–	–	–	–	–	–	12	1,595	1	32	13	1,627
California	1	110	–	–	6	680	17	830	16	1,426	10	634	50	3,680
Colorado	–	–	–	–	–	–	–	–	18	1,332	75	2,193	93	3,525
Idaho	2	257	5	510	2	273	–	–	52	2,270	39	978	100	4,288
Montana	–	–	2	375	3	350	–	–	11	656	6	458	22	1,839
Nevada	–	–	–	–	–	–	–	–	9	1,035	1	15	10	1,050
New Mexico	1	56	–	–	–	–	–	–	2	208	15	531	18	795
Oregon	1	85	1	75	2	398	7	496	60	2,733	8	277	79	4,064
Utah	–	–	–	–	1	110	–	–	16	1,395	9	338	26	1,843
Washington	–	–	6	166	3	275	–	–	96	2,976	12	211	117	3,628
Wyoming	–	–	–	–	4	312	–	–	3	267	18	799	25	1,378
Westwide	5	508	14	1,126	21	2,398	24	1,326	295	15,893	194	6,466	553	27,717

Source: Western United States Water Plan Working Document—Wild and Scenic Rivers—November 1972.
[1] Refers to rivers identified under sections of Public Law 90-542, as amended.
[2] Streams listed in California Senate Bill 107 approved by the Governor, December 20, 1972. Streams established under Oregon Law (ORS 390.805 to 390.925).
[3] Streams identified for study of free-flowing value in Type I and II Comprehensive Framework Studies.
[4] Streams identified as having free-flowing value in official correspondence or reports.
[5] Total mileage figures may not add from left to right because of adjustments to exclude duplicate reaches listed under two or more columns.

The framework studies conducted in the West identified 295 separate reaches of streams totaling 15,893 miles as having significant free-flowing values. One hundred ninety-four stream reaches totaling 6,466 stream miles have been suggested for consideration in future studies by other reports and correspondence from State, Federal, and nongovernmental agencies.

Thus, more than 500 stream reaches having a combined total of more than 20,000 miles have either been designated as part of the existing system, identified for future study, or suggested for further consideration. Additional discussions of the planning process necessary to implement the wild and scenic river program as well as discussions about conflicts on stream reaches are provided in subsequent chapters.

Complementing the effort to identify and preserve from intensive development those streams with outstanding free-flowing qualities is the effort to maintain adequate minimum flows in all important streams for fish and wildlife, recreation, and water quality. Several States, including Oregon, Washington, Idaho, Colorado, and California, are actively involved in determining or establishing instream flow needs. Their efforts range from preliminary studies of such needs to extensive systems of established minimum flows such as in Oregon. A knowledge of instream water needs is necessary to interpret the potential impacts of water development on streams and ecosystems and to establish flow criteria adequate to maintain present or acceptable aquatic environments.

Lakes and Reservoirs

The many natural lakes in the West, together with attendant facilities, enhance environmental quality through fish and wildlife, aesthetic, and recreational uses. The variations in altitude, scenic setting, water quality, and aquatic life serve a variety of uses and enjoyment. With the development of the water resources of the West, thousands of manmade ponds and reservoirs further increase the availability of water-based recreation for the public.

Approximately 1 percent of the total area of the West is covered by water and the majority of this area is in natural and manmade lakes. Table II-13 lists the water area by State.

Examples of the outstandingly attractive lakes in the West are Jackson Lake in Wyoming, Lake Chelan in Washington, Crater Lake in Oregon, and Lake Tahoe in California and Nevada.

Public recreational use of all types of lakes and reservoirs has increased dramatically during the past decade. One Federal agency reported that during 1972 some 56.2 million visitor-days of use were recorded at the 1.7 million acres of water surface included in

Table II-13.—*Water surface area by State (1,000 acres)*

State	Total acres of water surface area		
	Total of areas, each under 40 acres in size	Total of areas, each over 40 acres in size	Total
Arizona	13	214	227
California	201	1,156	1,357
Colorado	72	256	328
Idaho	40	560	600
Montana	198	926	1,124
Nevada	15	417	432
New Mexico	2	151	153
Oregon	216	533	749
Utah	38	1,621	1,659
Washington	133	686	819
Wyoming	109	452	561
Westwide	1,037	6,972	8,009

Source: State-Federal Study Team reports (unpublished)

projects managed as a part of its program. This usage amounted to more than 30 visitor-days for each acre of surface water available.

Beaches and Shores

A comprehensive survey of the beaches and shores in the West was not completed under the Westwide Study. It was recognized, however, that those beaches and shores along the Pacific Coast, those surrounding certain lakes and reservoirs, and those along major streams contribute many benefits to environmental quality.

The shallow shoreline area of most water bodies is the major contributor to the productivity for most aquatic organisms. This zone serves as the major spawning and nursery area for many sport and commercial fish species as well as the source of organisms on which they depend for food.

Beaches and accessible shoreline areas are the most heavily used portions of the coastal area and of lakes and reservoirs. Swimming and fishing are concentrated there and users must pass through shoreline recreational access points to enjoy the water areas.

Within most of the Westwide Study area, there is adequate shoreline for public recreation; however, full utilization for recreation is not possible because of insufficient public access. The lack of access stems from two causes – physical and institutional or legal restrictions. Physical restrictions typically include natural barriers such as cliffs, or manmade barriers such as railroad rights-of-way. Institutional or legal restriction involves land use ownership problems. Access is often limited due to residential, business, or industrial development along the shoreline. For safety and other reasons, some large military reservations, atomic energy sites, and municipal water supply reservoirs are closed to recreation access. Also access to shoreline areas is often prevented by landowners because of liability responsibilities or fear of vandalism.

The more than 1,293 miles of shoreline along the Pacific coast serve an invaluable purpose for swimming, sunbathing, collection of sellfish, and general recreation. The beaches of larger reservoirs in the Southwest, such as Lake Mead in Nevada and Arizona, are heavily used and space during a holiday weekend is at a premium.

Wilderness, Primitive, and Natural Areas

On September 3, 1964, Congress enacted Public Law 88-577, the Wilderness Act "* * * to establish a National Wilderness Preservation System for the permanent good of the whole people, and for other purposes." Passage of the Act immediately classified as National Wilderness Preservation System, 8,226,593 acres of National Forest lands west of the Mississippi River. The Act also required the Secretary of Agriculture to review each area within the National Forests, which was at that time classified as primitive, as to its suitability or nonsuitability for preservation as wilderness. These Primitive Area reviews, with recommendations, are reported to the President who in turn makes recommendations to the Congress with respect to designation as Wilderness or other reclassification. The Act also directed the Secretary of the Interior to conduct similar studies of areas 5,000 acres or more in size which have wilderness characteristics within the National Park System and the National Wildlife Refuge System. All of these studies are to be completed within 10 years after the enactment of the Act.

In the Westwide area, there were 62 legislatively established wildernesses within the National Forests on July 1, 1973. These areas contained a total of about 10 million acres and include 54 areas placed in the system by the 1964 Act. Eleven Primitive Areas and one other area (Scapegoat) have been added since passage of the

Act. Of those areas reviewed, 11 areas (totaling 1.7 million acres) await action by Congress. The Forest Service is conducting reviews on the 11 remaining Primitive Areas. These total about 2.4 million acres. The 10.7 million acres of established wilderness plus these 4.1 million acres amount to 14.8 million acres which the Forest Service is currently managing as wilderness. Within the National Wildlife Refuge System, Congress has acted to designate 25 units of wilderness, covering 103,435 acres. Study is in various stages of completion on the remaining areas in the system, comprising nearly 28.5 million acres that must be studied for suitability or nonsuitability as wilderness.

Lands administered by the Bureau of Land Management are not covered by the Wilderness Act although areas having primitive value may be set aside either by withdrawal or other authority and managed to maintain the same quality as lands in the Wilderness Act. The Bureau administers about 175 million acres of land in the West. The Bureau of Land Management has classified 9 primitive areas in roadless and undeveloped areas, and has recently inventoried 152 areas for possible designation as primitive areas.

Most uses which were well established in primitive areas or wildernesses before passage of the act are generally allowed to continue. Permitted activities include ingress and egress to State and private property, application of the existing mining laws with certain restrictions until December 31, 1983; recreation in undeveloped surroundings; certain water resource developments; grazing of livestock where previously established; and hunting and fishing. Restrictions have been placed on use of motorized vehicles and equipment, roads, logging, commercial enterprises, and structures. Management of established primitive areas is identical to wilderness until studies are completed and decisions are made by Congress to reclassify these lands as wilderness or to declassify them.

The National forests contain many areas of significant size that are roadless and undeveloped and are not specifically mentioned in the 1964 Wilderness Act. Some of these areas represent potential high-quality additions to the National Wilderness Preservation System. It is essential that they be given special consideration in planning because of the irreversible nature of some actions that could damage or destroy the wilderness resource. It is generally accepted that the wilderness characteristics and values that now exist in some roadless areas are lost after certain kinds of development occur. Areas on which roads are constructed, timber is harvested, land is cultivated, or permanent structures are constructed are essentially lost for future wilderness consideration.

Two other Federal programs include large tracts that are designated and managed to protect natural values. These are the Research Natural Area program administered by the Secretaries of Interior and Agriculture and the Natural Landmark designation program administered by the National Park Service. Under both programs, agencies making a designation may change it without Congressional action.

Table II-14 lists the acreages in each Western State that have been set aside as part of the National Wilderness Preservation System. Also listed are the acreages currently under study, the acres included in research natural areas, and acreages listed in the National Registry of Natural Landmarks.

Estuarine and Wetland Areas

These ecosystems include tidal wetlands, estuaries, and contiguous ocean waters to the depth of light penetration in the euphotic zone. These fragile systems are of special significance, because they provide basic life history requirements and food supplies for much of the Pacific coast fishery resources. Coastal areas further serve as important nesting, resting, and/or feeding habitat for a variety of animal life forms including migratory birds, fur bearers, and sea mammals as well as many threatened and endangered species. They contain significant marketable deposits of oil, gas, minerals, sand, gravel, and shell, and serve as vast sediment traps. In an undeveloped state they are the largest, least costly, and most efficient waste treatment systems known to man. Federal and State coastal zoning laws have been passed and several agencies have been charged with the preservation of coastal areas, including estuarine and wetland areas near the coasts. Uses made of the Nation's coastal ecosystems include: (1) Sites for urban and industrial development; (2) navigation channels and ports; (3) highways and airports; (4) waste receptacles; and (5) oil, gas, and mineral development. Historically, many of these uses have unilaterally precluded multiple use of developed areas.

About 2,530,000 acres of land and water along the Pacific coast are included as estuarine habitat. This includes such outstanding areas as Puget Sound and San Francisco Bay.

Wetlands are one of the most important habitat types for wildlife in the Westwide area. They are also among the most vulnerable to developmental pressures in arid regions where the water consumed by such wetlands is being considered as a source of additional water for other purposes and in coastal areas where the wetlands are desirable building sites.

Waterfowl, shore birds, marsh birds and fur bearers by the millions use wetlands to raise their young, as critical resting and feeding areas during migration, and as year-round habitat. The wetlands fringes are also important nursery areas for many species of fish. Hunting, fishing, wildlife photography, nature study, and many of man's other pursuits are intimately linked with the wetlands and their resources.

The following tabulation indicates the relative amounts of wetlands in the Western States as of 1956. Although no comprehensive survey has been completed recently, most samplings have indicated a decline in wetland areas since the survey was made in 1956.

Extent of Important Wetland Areas

State	Acreage
Arizona	28,400
California	559,300
Colorado	404,400
Idaho	108,900
Montana	187,000
Nevada	192,000
New Mexico	48,000
Oregon	472,600
Utah	637,800
Washington	233,200
Wyoming	30,300
Total	2,901,900

Source: "Wetlands of the United States," USDI Fish and Wildlife Circular 39, 1956.

Cultural Resources

Beginning with the Antiquities Act of 1906, the Congress has established protective status for historical and archeological places and artifacts as well as properties considered to have cultural value. Historical, archeological, and other cultural sites interface with water conservation and development projects where project features impact such sites. As more and more attention is being given to protection of cultural resources, these aspects have become important considerations in planning. Table II-15 indicates the number of historic sites on national and State registers in the Western States.

Biological Resources

The wide variety of native vegetation in the West serves important environmental functions while contributing to the wealth of the Nation. One of the important environmental functions includes the provision of suitable habitat for important species of fish and wildlife. No comprehensive survey or analysis of native vegetation was made during the Westwide Study. However, an analysis of the surface cover is shown in the land resource portion of this chapter.

In arid and semiarid areas the riparian vegetation provides a significant amount of the wildlife habitat. With food and shelter available in close proximity to a supply of water, the river courses attain a carrying capacity for wildlife several times greater than that of adjacent arid lands. Such areas support significant amounts of hunting for big game and upland game animals.

In some areas vegetation associated with stream channels is considered a threat to water supplies. This vegetation includes a broad grouping of grasses, shrubs, and trees all having one characteristic in common; a strong affinity for water. The highest water consumer of the group in the Southwest is saltcedar. This plant was introduced during the 19th century and has spread widely. Dense growths of saltcedars cause accumulation of sediment, block river channels, increase flood hazards, make access to water by fishermen and livestock difficult, and restrict some recreational activities. Conversely, saltcedars provide habitat for wildlife; pollen for the bee industry; recreational opportunities (birdwatching, hunting, etc.); and create greenbelts. In the Western United States the total area of saltcedar growth has increased from an estimated 10,000 acres in 1920 to more than 900,000 acres in 1961 and possibly as much as 1-1/3 million by 1970. The consumptive use of water by the plant was estimated as 40 to 50 thousand acre-feet in 1920, 3.5 million acre-feet in 1961, and possibly as much as 5.0 million acre-feet in 1970. Not only is the growth increasing in areal extent but also in density.

The population of native and introduced animals in the West provides economic and environmental quality values through such public use as fishing, hunting, sightseeing, birdwatching, photography, and other forms of recreation. Harvest and management of some species also provide commercial benefits, for example, commercial fishing. No comprehensive surveys or analyses of animal populations were made as a part of the Westwide Study. Emphasis was given to certain

Table II-14.—*Number of areas and acreage of wilderness, primitive, potential wilderness, research natural areas, and natural landmarks by State (acres rounded to the nearest 1,000 acres)*

(acres rounded to the nearest 1,000 acres)

State	Area type											
	Natural wilderness preservation system[1]		Primitive areas[2]		Potential wilderness areas[3]		Research natural areas[4]		Natural landmarks[5]		State totals[6]	
	No.	Acres (1,000)	No.	Acres (1,000)	No.	Acres (1,000)	No.	Acres (1,000)	No.	Acres (1,000)	No.	Acres (1,000)
Arizona	9	554	2	24	26	2,789	29	54	5	6	71	3,427
California	19	1,704	–	–	34	5,501	52	161	15	185	120	7,551
Colorado	6	280	–	–	65	2,672	22	88	5	22	98	3,062
Idaho	3	1,233	–	–	35	3,069	19	57	1	1	58	4,360
Montana	6	1,722	1	7	42	3,011	29	75	3	35	81	4,850
Nevada	1	65	–	–	9	4,024	48	182	6	316	64	4,587
New Mexico	5	679	1	8	29	840	16	20	1	[7]	52	1,547
Oregon	12	838	2	90	17	458	29	65	3	3	63	1,454
Utah	–	–	3	112	19	1,641	23	130	2	1	47	1,884
Washington	4	1,085	–	–	29	2,835	23	13	6	42	62	3,975
Wyoming	4	1,989	–	–	34	2,165	7	175	4	188	49	4,517
Westwide	69	10,149	9	241	339	29,005	297	1,020	51	799	765	41,214

Source: Western United States Water Plan Working Document—Wilderness Areas—November 1973.

[1] Areas established by Public Law 88-577 and subsequent legislation.

[2] Areas established by the Bureau of Land Management on Public Domain Lands.

[3] Areas identified for study under Public Law 88-577 on Federal Lands.

[4] Areas established by the Secretaries of Interior and Agriculture on Federal Lands.

[5] Areas identified by the National Park Service as part of the National Registry of Natural Landmarks on both public and private lands.

[6] Total acreage figures may include duplicate amounts where designated areas overlap.

[7] Acreage figure not available.

groups of animals thought to affect water resource planning.

Big game winter range has been degraded and significantly reduced in extent by farm, industrial, recreational, and other developments. One major source of those critical habitat losses is water conservation and development projects. Improved pumping and other water-handling technology have resulted in increased irrigation of lands formerly uneconomical for development. Many of those areas represent limited critical winter range for deer and other big game.

One of the unfortunate consequences of growth and development in the United States has been the extermination of some native species of fish and wildlife. Serious losses in other species of native wild animals with educational, historical, recreational, and scientific value have occurred and are occurring. The United States has pledged itself, pursuant to migratory bird treaties with Canada and Mexico and the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, to conserve and protect, where

Table II-15.—*Number of protected historic sites by State*

State	National register[1]	State list[2]
Arizona	62	10
California	276	36
Colorado	78	10
Idaho	43	6
Montana	40	9
Nevada	18	3
New Mexico	81	18
Oregon	34	4
Utah	68	9
Washington	86	10
Wyoming	74	25

Source:

[1] National Register of Historic Places, Federal Register, February 19, 1974.

[2] Information provided by the National Park Service, December 1972.

practicable, the various species of native fish and wildlife, including game and nongame migratory birds, that are threatened with extinction.

There appear to be three major threatened species problem areas at this time in the Westwide area. Manmade changes which have already taken place in the main stem Colorado River and its major tributaries have placed in danger of extinction several endemic fish species with special adaptation to historic flow conditions. Further changes could cause the loss of the remaining habitat which allows these remnant populations to survive. Particularly vulnerable habitat areas occur in the Yampa, Green, and Colorado Rivers. Also in the Colorado Basin, riparian wetlands, which provide essential habitat for Yuma clapper rail and Mexican duck, are being eyed as potential locations for water salvage or channel modification operations.

In the Great Basin a series of relict fish species depend on very limited habitat in springs, seeps, etc., which are supplied by ground water. Mining such ground water could eliminate the habitat for these threatened species.

Water Quality

The West has long been noted for the beauty and high quality of its rivers and lakes. Overall, the quality of this water is still high, but in many instances it is threatened with serious degradation. Energy development, urbanization, industrial expansion, farm and grazing practices, forestry, natural resource development, and human activities of many kinds have or potentially can act to lessen the quality of water in the West. Protection of high-quality water and restoration of now inferior quality waters to a higher quality are major concerns for the Westwide area.

Water quality varies throughout the West. This variation is due to the nature, extent, and magnitude of pollutants which are discharged into surface and ground waters from a wide range of both point and nonpoint sources. State and Federal agencies have developed, or are developing data on the extent and the nature of these pollutants. Ground-water quality and pollution, however, are much less known and understood than are surface-water quality and pollution.

The magnitude and severity of point source pollution other than natural salt springs generally are related to concentrations of human activity; i.e., urban areas, mining areas, industrial areas, irrigated areas, concentrated feedlot areas, energy producing areas, etc. Under the Federal Water Pollution Control Act Amendments – 1972, the various States, in conjunction with the Federal Government, are making comprehensive efforts to solve the water pollution problems caused by these sources. The magnitude of energy development and associated urbanization, mining, water use, and overall economic activity, the projections of increasing use and development of all the other Westwide resources, and ever-increasing population will make this a large and difficult task. This is a major Westwide problem which must be addressed.

A very critical parameter of water quality for aquatic life is temperature. In both stream and estuarine areas, natural high summer temperatures are only a few degrees below lethal limits for many fishes and aquatic invertebrates. In industrial and energy producing areas, the use of water for cooling purposes has to be carefully planned to avoid thermal pollution of adjacent waters.

Nonpoint source pollution, i.e., pollution of diffuse sources emanating from and accelerated by such man-caused factors as construction, logging, grazing, agriculture, roadbuilding, mining activities, etc., is much less known and its causes and extent less understood than are point sources. Given the overall nature of the Westwide area, however, and of man's activities in relation to it, nonpoint pollution problems are and will be a most important aspect of water pollution and associated efforts to control them.

Many of the upstream reaches of surface waters in the Westwide area are generally of good or excellent quality. Exceptions, of course, do exist. The downstream reaches of major streams, terminal lakes, estuaries, and coastal waters are subject to quality degradation from many sources and are the scene of most severe pollution problems. Cleanup efforts directed at pollution problems, both upstream and downstream, and nondegradation of existing water quality are issues of major importance. The quality of ground water varies throughout the West and in some areas is unsuitable for certain uses.

Sediment washed from croplands, unprotected forest lands, overgrazed pastures, strip mines, roads and construction areas, is a serious problem in many areas throughout the Western States. Sediment is also a carrier of other pollutants of water such as plant nutrients, insecticides, herbicides, and heavy metals. The problem occurs on both irrigated and nonirrigated lands. About 48 percent of the total land area of the 11 Western States is under the control of Federal agencies. Sediment originating from these Federal lands constitutes a significant portion of the total problem. The quality of many western streams, lakes, and estuaries has been seriously degraded by excessive amounts of sediment. Areas of high sediment yield in the West and erosion and sediment control measures are discussed in more detail elsewhere in this report.

Pesticides embrace a wide variety of chemical compounds for controlling undesirable forms of life which threaten man, his possessions, and portions of the natural environment that he values. Their use in the West has increased correspondingly to that of the Nation as a whole. In extensive agricultural areas, such as in California's Central Valley, Arizona's irrigated areas, and other western crop producing areas, the use of chemical totals very large quantities. Pesticides can reach humans directly through drinking water, but the concentrations in most cases are far below toxic levels. There is no evidence at present that long-term human consumption of such water is harmful. The effects of this chemical use on water quality and its effects on animal life could be a significant problem, one that now requires better understanding and more accurate knowledge.

Nitrogen and Phosphorous, as nutrient elements, are important factors in the enrichment of western streams and often eutrophication of western lakes. Both nutrients, associated with fertilizer, feedlots, municipal sewage, etc., may be important factors in the water quality of the Westwide area.

In the Columbia-North Pacific Region irrigation return flows are believed to be a significant source of nutrients, especially phosphates. This is true specifically in the Yakima and Snake Basins and in some areas of the Columbia Basin Irrigation project. Irrigation return flows in the San Joaquin Valley of California are known to contain high levels of nitrogen.

In addition, irrigated agriculture has a major impact on the mineral quality of surface waters. Mineral pollution, commonly known as salinity, is a problem that is becoming increasingly important in surface waters and ground waters throughout the arid portions of the West. The impact of irrigated agriculture on salinity is a complex problem which has economic, political, legal, and philosophical implications, as well as physical and technological aspects.

A clear distinction exists between the two basic causes of salinity increases in streams of arid and semiarid regions throughout the West. These may be referred to as the salt loading and salt concentrating effects. The former is associated with the discharge of additional mineral salts into the stream system by municipal and industrial wastes, by water from natural sources, and by irrigation return flows. In contrast, the salt concentrating effect occurs as a result of the consumptive use of water. No additional mineral salts are discharged, and the salt load in the stream remains constant, but the salt concentration increases as a consequence of loss of water from the stream system. Irrigated agriculture often contributes to both of these types of salinity increases. Many streams in the arid and semiarid regions of the West display a progressive increase in salinity between their headwaters and mouths, especially where a large part of the total water supply is consumptively used by irrigated agriculture.

In addition to these causes of salinity increases, there are other causes that may be important from a basinwide viewpoint. These include evaporation losses from reservoirs and other water bodies, consumptive losses associated with municipal and industrial water uses, evapotranspiration losses from native vegetation on noncropped land, out-of-basin diversions of water, and natural sources associated with runoff and with mineral springs.

From a Westwide viewpoint, the areas most adversely affected by salinity increases from irrigation return flows are located in the lower reaches of the river systems of the Southwest. These include the Colorado River, which serves seven States and Mexico, the Rio Grande and Pecos Rivers in New Mexico and Texas, the San Joaquin River in California, the Sevier River in Utah, the South Platte and Arkansas in Colorado, and other smaller streams. In most instances, the water quality is excellent in the headwater tributaries of these stream systems. All of these stream systems display a progressive increase in salinity levels as the water flows to the lower reaches of the drainage basins.

Although there are numerous existing reservoirs throughout the West, relatively few of them have storage specifically allocated to water quality control. In some situations, the regulation of streamflow for other purposes is of benefit to water quality control. Such benefits are often confined to limited stream reaches since significant diversions for beneficial uses may occur a short distance below the storage reservoirs.

Air Quality

Air quality in the West, although only indirectly related to water, is a factor directly related to the overall quality of life in this area. It is also a factor directly related to man's activities. The air sheds of the West, with notable exceptions, are presently of high quality. The exceptions include Denver, Los Angeles, Salt Lake City, other large urban centers to a varying degree, and certain mountain valleys or desert areas subject to a resource processing air pollution source. These exceptions are of such magnitude as to be important subjects for State-Federal abatement efforts under appropriate laws.

Areas of existing air quality problems and areas not presently subject to such problems are threatened by air quality deterioration. Increased use of coal for energy production, increased resource processing of many kinds, and increasing urban concentrations make the West's existing and potential air quality problems very important issues to be dealt with now and in the future.

Air pollution, particularly that associated with heavy metals released in energy production, may have a detrimental effect on western water quality. Some researchers believe these metals and pollutants may end up in waters and in the biotic food chain.

Land Quality

Arid and semiarid lands consisting of vast acreages in the Great Basin and in southwestern deserts, are great storehouses of environmental, recreational, and cultural values. Arid and semiarid areas of the West are lands of appealing variety, rich in history, geology, flora, fauna, and exciting scenery. Here are found the lowest elevations on the Nation's surface, some of the most colorful flowers, and some of the most unusual animals. More important, these lands that are close to population centers offer opportunities for expansive recreational experiences.

The list of recreational opportunities accommodated by these lands is almost endless and some of these are available nowhere else in the United States. People come not only for the common activities such as camping and picnicking but also for such activities as sailplaning, sand chariot sailing, rocket launching, target shooting, and longrange archery.

Because of their vastness, the Nation's arid and semiarid regions are frequently considered to be unlimited and indestructible; yet in reality, they are very fragile. Recreational use of the desert areas has outpaced the capacity of land managers to plan for and accommodate that use. As a consequence, valuable historic sites, plant communities, and other natural areas have been adversely affected.

The West has been inflicted with a growing number of land use problems, aggravated by a sharply increased demand for and sale of mountain and stream valley property. Urban areas have seen an increasing proliferation of agglomerated residential, commercial, industrial, transportation, and utility developments. Many of these developments have encroached on flood plains or water influence zones. In many areas of the West, property is being sold and developed – often without adequate provisions for water supply, sewage disposal, aesthetics, open space, accesss, soil stabilization, fire safety, or overall affect on the environment.

LAND RESOURCE BASE

The Westwide Study area is comprised of all or parts of 9 hydrologic regions lying within the 11 States. These States comprise 40 percent of the contiguous United States land and water areas as presented in table II-16. The water areas in the West represent 20 percent of the total water area in the contiguous United States. The widely diverse climate, geology, physiography, and soils in the Western States have influenced the nature of land resources, their use, development, management and ownership.

Table II-16.—*Land and water area by State (1,000 acres)*

States and Nation	Westwide		
	Land	Water[1]	Total area
Arizona	72,675	227	72,902
California	100,207	1,357	101,564
Colorado	66,390	328	66,718
Idaho	52,877	600	53,477
Montana	93,258	1,124	94,382
Nevada	70,314	432	70,746
New Mexico	77,713	153	77,866
Oregon	61,355	749	62,104
Utah	52,693	1,659	54,352
Washington	42,542	818	43,361
Wyoming	62,101	561	62,662
Westwide	752,125	8,008	760,133
Contiguous United States	1,894,755	39,637	1,934,392
Total United States	2,264,245	49,490	2,313,735

[1] Includes bodies of water under 40 acres in size.
Source: Conservation Needs Inventory (USDA), 1967; Type I Framework Study Reports; Statistical Abstract of the United States.

Land Ownership

Privately owned and federally owned land areas are nearly the same; slightly more than 46 and 47 percent, respectively. Municipal, county, and State governments own 6 percent of Westwide area lands. Figure II-6 and table II-17 present these data in some detail.

Private Lands. – The 350,751,000 acres of private land are scattered throughout the Westwide area, generally in the plains and fertile valleys where water exists. The 66,205,000 acres or 70 percent of Montana in private ownership contrast with the 9,564,000 acres or 14 percent of Nevada as privately owned land.

The United States Government holds 50 million acres in the contiguous United States in trust for the Indians. The 19.4 million acres in Arizona, 7.5 in New Mexico, 5.2 in Montana, and 10.5 million acres in the other eight Western States comprise 12 percent of Westwide privately owned sectors. The 42.4 million acres in 180 western reservations, colonies, rancherias, or pueblos are managed to provide income and to maintain the Indians' culture.

The management of 308.1 million acres of privately owned and controlled land is vested with thousands of individuals, corporations, and legal entities. Except for some general restrictions such as taxes and zoning laws, these individual owners and managers traditionally have had the right to use the land much as they saw fit. The use and management of

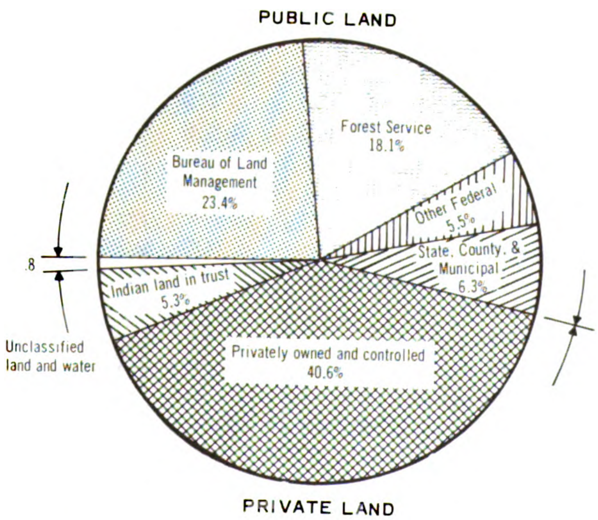


*Figure II-6. **Land ownership – Westwide Study area.***

private land is basically for monetary gain. Thus, the broad patterns of livestock raising, cropping, timber, industry, mining, and urbanization in the private sector generally represent use of the land for economic purposes.

Public Lands. – Municipal, county, and State governments manage nearly 7 million acres to provide public services and amenities for those people within their jurisdictional boundaries.

The 355,654,000 acres of federally owned land are predominant in the mountainous and arid basins. Federal lands range from 29 percent in Montana and in Washington to 86 percent in Nevada and averages 47 percent in the Westwide Study area.

The Bureau of Land Management and the Forest Service are the largest Federal land management agencies in the West. Together, they manage nearly 315.5 million acres. As directed by Congress, these lands are managed for the wise use of outdoor recreation, range, timber, watershed, and fish and wildlife habitat. Legislation recognizes the multiple-purpose values of such lands and currently they are managed to achieve maximum multiple use. Certain areas of remaining wilderness and areas possessing unique features have been designated as "wilderness" or "primitive" areas. The National Park Service administers 13.7 million acres of public land in the area. These lands are managed to preserve natural, scenic, historic, or recreational values. The Fish and Wildlife Service manages 4.2 million acres of land to perpetuate and produce fish and wildlife for enjoyment and use. The 16 million acres managed by the Department of Defense, 3.6 million by the Bureau of Reclamation, and 2.6 million by other Federal agencies are principally functional lands acquired for specific public purposes.

Surface Cover

Land covers 752.1 million acres and water covers 8.0 million acres of the surface areas. Percentages of these covers are shown in figure II-7. The land area is categorized as Cropland, Range and Grassland, Forest, Alpine, Other and Urban.

The landscape is composed of the visual manifestation of man superimposed upon the dominant and enduring landform. Man appears to alter the landscape in two basic ways: (1) through the manipulation of the natural resources in such activities as farming, mineral extraction, and forest management, and (2) through the introduction of structures as buildings, roads, etc.

Table II-17.—*Westwide land and water ownership by region and State*

Region and State	(1,000 acre-feet)														
	Public lands												Private lands		
	USDA		USDI					Dept. of Defense	Other Federal lands	Total Federal	State	County and municipal*	Indian land in trust	Privately owned land	Unclassified land and water
	FS	Other Agriculture	BLM	F&WL	NPS	BR	Other Interior								
Columbia-North Pacific															
Washington	9,016	1	275	110	1,903	393	7	504	381	12,590	3,316	390	2,508	23,872	685
Oregon	13,867	15	15,313	433	64	161	3	149	3	30,008	1,710	421	690	24,732	394
Idaho	19,790	33	11,839	20	85	582	–	94	575	33,018	2,746	145	831	14,045	521
Montana	8,737	–	152	20	656	–	–	–	1	9,566	646	10	619	5,081	175
Wyoming	2,226	–	13	25	686	–	–	–	–	2,950	9	–	–	288	–
Nevada	676	–	1,870	–	–	–	–	–	–	2,546	–	–	144	605	4
Utah	47	–	52	–	–	–	–	–	–	99	26	–	–	116	–
Subtotal	54,359	49	29,514	608	3,394	1,136	10	747	960	90,777	8,453	966	4,792	68,739	1,779
California															
California	19,880	1	16,816	51	4,113	218	–	3,035	25	44,139	1,953	1,939	543	51,633	1,357
Oregon	1,641	–	278	30	97	5	–	7	–	2,058	10	–	142	1,802	137
Subtotal	21,521	1	17,094	81	4,210	223	–	3,042	25	46,197	1,963	1,939	685	53,435	1,494
Missouri															
Montana (incl. Hudson Bay)	7,872	56	7,999	117	444	269	122	616	609	17,495	71	–	4,584	55,921	214
Wyoming	5,150	–	9,360	12	1,584	600	2	19	–	16,727	3,733	–	1,887	22,627	–
Colorado	2,509	15	298	–	166	18	–	82	–	3,088	1,061	194	–	14,706	–
Subtotal	15,531	71	17,657	129	2,194	887	124	717	609	37,310	4,865	194	6,471	93,254	214
Great Basin															
Idaho	490	–	399	–	–	–	–	–	–	889	57	–	–	1,182	43
Wyoming	173	–	410	–	–	–	–	–	–	583	84	–	–	302	–
Nevada	4,286	–	40,920	1,619	117	386	–	3,444	2	50,774	43	26	888	7,512	280
Utah	3,980	–	10,637	88	17	32	–	1,847	–	16,602	1,538	–	62	8,398	1,420
Subtotal	8,929	–	52,366	1,707	134	418	–	5,291	2	68,848	1,722	26	950	17,394	1,743
Upper Colorado															
Wyoming	1,140	–	7,929	12	–	45	–	–	–	9,126	958	–	–	3,388	–
Utah	3,616	–	12,656	10	410	83	–	59	–	16,834	1,864	2,890	2,060	–	203
Arizona	6	–	261	–	84	–	–	–	–	351	22	12	4,036	–	13
Colorado	8,410	–	6,840	1	340	26	1	55	26	15,699	465	77	755	7,589	82
New Mexico	142	–	1,524	–	22	4	–	–	9	1,701	283	21	3,706	523	–
Subtotal	13,314	–	29,210	23	856	158	1	114	35	43,711	3,592	3,000	10,557	11,500	298
Lower Colorado															
Nevada	147	–	5,586	753	300	213	–	314	1	7,314	57	5	5	410	133
Utah	289	–	1,115	–	–	–	–	–	–	1,404	137	–	–	554	145
Arizona	11,525	–	11,943	772	2,344	364	–	3,544	86	30,578	9,308	25	15,320	13,036	101
New Mexico	2,837	–	1,370	–	1	–	–	22	12	4,242	874	39	1,118	2,274	–
Subtotal	14,798	–	20,014	1,525	2,645	577	–	3,880	99	43,538	10,376	69	16,443	16,274	479
Rio Grande															
Colorado	1,800	–	516	–	37	–	24	–	–	2,377	205	21	–	2,211	3
New Mexico	5,944	–	10,597	144	217	176	–	2,758	233	20,069	6,173	526	2,525	18,938	–
Subtotal	7,744	–	11,113	144	254	176	24	2,758	233	22,446	6,378	547	2,525	21,149	3
Arkansas-White Red															
Colorado	1,402	–	643	–	–	–	–	97	344	2,486	1,361	–	–	14,305	33
New Mexico	195	–	72	2	1	8	–	–	8	286	1,443	78	–	9,535	–
Subtotal	1,597	–	715	2	1	8	–	97	352	2,772	2,804	78	–	23,840	33
Texas Gulf															
New Mexico	–	–	51	–	–	–	–	3	1	55	640	75	–	2,742	–
Westwide Total	137,793	121	177,734	4,219	13,688	3,583	159	16,649	2,316	355,654	40,793	6,894	42,423	308,327	6,043
Arizona	11,531	–	12,204	772	2,428	364	–	3,544	86	30,929	9,330	37	19,356	13,036	214
California	19,880	1	16,816	51	4,113	218	–	3,035	25	44,139	1,953	1,939	543	51,633	1,357
Colorado	14,121	15	8,297	1	543	44	25	234	370	23,650	3,092	292	755	38,811	118
Idaho	20,280	33	12,238	20	85	582	–	94	575	33,907	2,803	145	831	15,227	564
Montana	16,609	56	8,151	137	1,100	269	122	616	610	27,061	717	10	5,203	61,002	389
Nevada	5,109	–	48,376	2,372	417	599	–	3,758	3	60,634	100	31	1,037	8,527	417
New Mexico	9,118	–	13,614	146	241	188	–	2,783	263	26,353	9,413	739	7,349	34,012	–
Oregon	15,508	15	15,591	463	161	166	3	156	3	32,066	1,720	421	832	26,534	531
Utah	7,932	–	24,460	98	427	115	–	1,906	–	34,939	3,565	2,890	2,122	9,068	1,768
Washington	9,016	1	275	110	1,903	393	7	504	381	12,590	3,316	390	2,508	23,872	685
Wyoming	8,689	–	17,712	49	2,270	645	2	19	–	29,386	4,784	–	1,887	26,605	–

*County and municipal ownership is not available in some states; these acreages are included with private lands.
Base Year 1965

Source: Western United States Water Plan Working Document – Land Resources Base, June 1973.

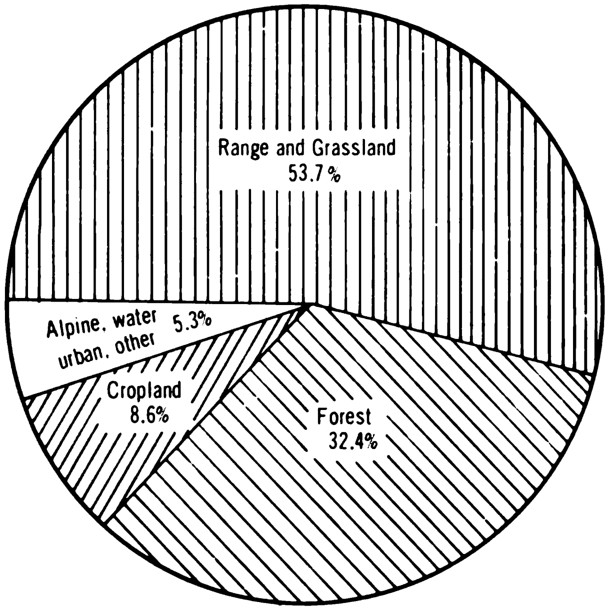


Figure II-7. ***Surface cover – Westwide Study area.***

Patterns are created as a result of the kind and extent of man's manipulation.

The acreages of the water and land categories are shown by regions and by States in table II-18. The percent of the surface cover categories within each of the 11 Western States is shown in table II-19.

Cropland. – Land area in cropland varies from less than 3 percent in the arid Lower Colorado and Great Basin Regions to more than 15 percent in the higher rainfall areas.

The 65,129,000 acres of cropland include land tilled for field crops, rotational hay and pasture, cover and soil improvement crops, summer fallow, and land in fruit and nut orchards, in bush foods, berries and similar fruit crops. They also include formerly tilled land that has not purposely been converted to another use.

Almost two-thirds of the cropland in the West is used to produce livestock or livestock products. There are large acreages of hay and feed grain in all regions. Irrigated pasture occupies large acreages in every region except the Lower Colorado.

Vegetables are grown on about 6 percent of the cropland. The remainder of the cropland is divided about equally among food crops (wheat, rice, sugar beets, and potatoes are the most important); fruit and nuts, and oil, fiber and seed (mostly cotton, safflower and alfalfa seed).

Range and Grassland. – Range and grassland cover over half of the Westwide area. It is the dominant vegetative cover in 8 of the 11 Western States. The 407,824,000 acres of range and grassland are lands permanently used for forage, including wild hay, mountain meadows and native pastures. Both pastureland and hay land comprise grassland. Grass and forbs, northern desert shrub, southern desert shrub, and salt desert shrub are the types of range. Plant cover consists principally of native grasses, forbs, and shrubs, all valuable for forage.

Forest. – Forests cover nearly one-third of the area. They cover half the States of Washington and Oregon and share with range and grassland as dominant vegetative cover in California and Idaho.

The 245,890,000 acres of forest are lands at least 10 percent stocked by forest trees of a size capable of producing timber or other wood products or capable of influencing the water regime. Many genera of trees are found including cottonwood, maple, oak, pine, spruce, fir, juniper and redwood.

Alpine. – With the exception of Mt. Washington in New Hampshire, all alpine areas in the continental United States are in the Rocky and Cascade Mountains and the Sierra Nevada. Even in the West,

Table II-18.—*Westwide surface cover by region and State, 1965* *(1,000 acres)*

Region and State	Land type: Cropland	Range and grassland	Forest	Alpine	Other	Urban	Total land area	Water area: Under 40	Over 40	Total land and water area
Columbia-North Pacific										
Washington	8,304	8,522	22,970	850	950	946	42,542	133	686	43,361
Oregon	5,348	22,522	27,480	170	1,107	731	57,358	203	394	57,955
Idaho	5,989	21,999	20,901	375	1,303	182	50,749	37	520	51,306
Montana	252	1,961	12,708	294	457	118	15,790	52	255	16,097
Wyoming	88	1,138	1,653	260	25	11	3,175	15	57	3,247
Nevada	7	3,167	106	-	12	1	3,293	2	4	3,299
Utah	8	204	26	-	3	-	241	-	-	241
Subtotal	19,996	59,513	85,844	1,949	3,857	1,989	173,148	442	1,916	175,506
California										
California	11,910	39,552	43,580	-	2,835	2,330	100,207	201	1,156	101,564
Oregon	352	741	2,815	-	69	20	3,997	13	139	4,149
Subtotal	12,262	40,293	46,395	-	2,904	2,350	104,204	214	1,295	105,713
Missouri										
Montana (including Hudson Bay)	12,377	52,000	9,773	580	1,126	1,612	77,468	146	671	78,285
Wyoming	2,092	34,191	6,839	1,400		68	44,590	74	310	44,974
Colorado	6,385	7,857	3,397	200	633	451	18,923	21	105	19,049
Subtotal	20,854	94,048	20,009	2,180	1,759	2,131	140,981	241	1,086	142,308
Great Basin										
Idaho	627	1,123	340	-	29	9	2,128	3	40	2,171
Wyoming	49	769	142		-	4	964	2	3	969
Nevada	275	48,462	8,484	100	1,741	169	59,231	12	280	59,523
Utah	1,696	12,728	8,712	164	3,298	2	26,600	4	1,416	28,020
Subtotal	2,647	63,082	17,678	264	5,068	184	88,923	21	1,739	90,683
Upper Colorado										
Wyoming	183	11,578	1,143	196	187	85	13,372	18	82	13,472
Utah	555	11,646	9,668	85	1,584	80	23,618	30	203	23,851
Arizona	11	3,131	845		412	19	4,418	3	13	4,434
Colorado	931	7,730	13,954	1,048	717	164	24,544	37	86	24,667
New Mexico	37	4,688	1,437		35	21	6,218	-	16	6,234
Subtotal	1,717	38,773	27,047	1,329	2,935	369	72,170	88	400	72,658
Lower Colorado										
Nevada	18	5,559	2,014		99	100	7,790	1	133	7,924
Utah	24	923	1,257		26	4	2,234	4	2	2,240
Arizona	1,643	44,676	21,491	10	34	403	68,257	10	201	68,468
New Mexico	72	4,334	4,054	1	32	39	8,532	-	15	8,547
Subtotal	1,757	55,492	28,816	11	191	546	86,813	15	351	87,179
Rio Grande										
Colorado	194	1,656	2,221	100	583	48	4,802	3	12	4,817
New Mexico	763	34,397	12,156	30	268	525	48,139	1	91	48,231
Subtotal	957	36,053	14,377	130	851	573	52,941	4	103	53,048
Arkansas-White-Red										
Colorado	3,359	9,893	3,424	80	1,112	253	18,121	11	53	18,185
New Mexico	654	8,205	2,300	8	71	78	11,316	1	25	11,342
Subtotal	4,013	18,098	5,724	88	1,183	331	29,437	12	78	29,527
Texas Gulf										
New Mexico	926	2,472		-	34	76	3,508	-	4	3,512
Westwide Total	65,129	407,824	245,890	5,951	18,782	8,549	752,125	1,037	6,972	760,134
Arizona	1,654	47,807	22,336	10	446	422	72,675	13	214	72,902
California	11,910	39,552	43,580	-	2,835	2,330	100,207	201	1,156	101,564
Colorado	10,869	27,136	22,996	1,428	3,045	916	66,390	72	256	66,718
Idaho	6,616	23,122	21,241	375	1,332	191	52,877	40	560	53,477
Montana	12,629	53,961	22,481	874	1,583	1,730	93,258	198	926	94,382
Nevada	300	57,188	10,604	100	1,852	270	70,314	15	417	70,746
New Mexico	2,452	54,096	19,947	39	440	739	77,713	2	151	77,866
Oregon	5,700	23,263	30,295	170	1,176	751	61,355	216	533	62,104
Utah	2,283	25,501	19,663	249	4,911	86	52,693	38	1,621	54,352
Washington	8,304	8,522	22,970	850	950	946	42,542	133	686	43,361
Wyoming	2,412	47,676	9,777	1,856	212	168	62,101	109	452	62,662

Base Year 1965
Source: Western United States Water Plan Working Document– Land Resource Base- June 1973.

Table II-19.—*Percent of surface cover within States, 1973*

State	Surface type							
	Crop-land	Range and grassland	Forest	Alpine	Other	Urban	Water	Total
Arizona	2.3	65.6	30.6	.01	.6	.6	.3	100.0
California	11.7	39.0	42.9	—	2.8	2.3	1.3	100.0
Colorado	16.3	40.7	34.5	2.1	4.6	1.4	.4	100.0
Idaho	12.4	43.2	39.7	.7	2.5	.4	1.1	100.0
Montana	13.4	57.2	23.8	.9	1.7	1.8	1.2	100.0
Nevada	.4	80.8	15.0	.1	2.6	.4	.7	100.0
New Mexico	3.1	69.5	25.6	—	.6	1.0	.2	100.0
Oregon	9.2	37.5	48.8	.2	1.9	1.2	1.2	100.0
Utah	4.2	46.9	36.2	.5	9.0	.2	3.0	100.0
Washington	19.1	19.7	53.0	2.0	2.2	2.1	1.9	100.0
Wyoming	3.9	76.0	15.6	3.0	.3	.3	.9	100.0
Westwide	8.6	53.7	32.4	.8	2.5	1.1	.9	100.0
Contiguous United States	22.6	33.1	33.5	.3	5.3	3.2	2.0	100.0

Source: Western U.S. Water Plan Working Document — Land Resource Base, June 1973.

they comprise less than 1 percent of the land area. Only in the States of Wyoming, Colorado and Washington do they comprise over 2 percent of the States' surface.

The 5,951,000 acres of alpine occur on elevated slopes and in glaciated basins above timberline elevations. The severe climatic conditions at the high elevations (from about 5,000 in the North to 12,000 feet in the South) limit vegetal growth. Fragile plant communities are extremely slow to recuperate following disturbance. More commonly found alpine plant species include sedges, bluegrass, gentian, willows, and bluebells. Shale, rockslides, snowfields and glaciers are found in the alpine barren areas.

Other. – The 18,782,000 acres of other lands are lands not classified as cropland, range or grassland, forest, alpine, or urban and built-up areas. This category consists of other farmlands including farmsteads, farm roads, feedlots, fence and hedgerows, rural residences, nonvegetal cover on military installations, landfills, wetlands, barren lands such as salt flats, rock exposures, dunes and beaches, and miscellaneous lands. Utah substantially exceeds the 2.5 percent of State surface area categorized as other because of that State's salt flats.

Urban. – There are 8,549,000 acres in this category of surface cover. They consist of urban and built-up areas of more than 10 acres; institutional, industrial, and commercial sites; roads; railroads; airports; cemeteries; golf courses; and parks within urban boundaries.

Water. – Water accounts for about 1 percent of the surface area. The 8,009,000 acres comprise permanent inland water surface areas such as lakes, reservoirs, ponds and streams, sloughs, estuaries, canals, indented embayments and sounds, and other coastal waters behind or sheltered by headland or islands separated by less than 1 nautical mile of water. They exclude 220,000 acres of Pacific West Coast waters.

Water areas are divided into two categories according to size of bodies of water. An area of 1,037,000 acres consists of ponds and lakes of not more than 40 acres and rivers and streams that are less than one-eighth mile wide. The remaining 6,972,000 acres are made up of lakes, ponds, and reservoirs at normal pool elevation having over 40 acres and rivers over one-eighth mile wide.

Selected Land Uses

Man makes use of the land to conduct his activities. He lives, works, plays, and pursues human interests on, under, or over the land. Data on his activities are base factors in planning for wise land use and management.

Among the problems involved in collecting data on man's activities are classification of type and intensity, uses not obvious to the observer, and several uses concurrently being made on the same parcel of land. For example, an area covered with trees may provide surroundings for a camper, hiker, birdwatcher or hunter; any of these recreationists may use the area at varying intensities. The rangelands' value for greenbelt or open space is not as obvious to many observers as its value for cattle grazing. A cropland area may provide upland game habitat as well as food production.

Land is used for the production of food, fiber and wood products, mineral extraction, recreation, hunting and fishing, water production, for utilities, transportation systems, and places to manufacture, trade, and reside, and for areas on which to pursue human interests. The construction of a super highway or expansion of a town into prime agricultural or timber producing lands eliminates use of these lands for food and fiber production. Thus, less productive lands must be used to produce needed food and fiber. This same action may drastically affect fish and wildlife habitat or create flooding problems which, in turn, will affect additional uses of the land.

Land Use for the Production of Food, Fiber, and Wood Products

By far the largest amount of land is used in the production of food, fiber, and wood products. About two-thirds of the total land area is used for these purposes.

Irrigated Land. – As shown on table II-20, water is applied by artificial means on 23,740,000 acres of cropland and 7,145,000 acres of grassland. The means vary from intensively managed irrigation system on specialty crops to water spreading on native grassland. Irrigated grassland may yield several times per acre the forage on nonirrigated grassland. It often complements the feed crops and range and dry pastureland and hay land in supporting stable livestock enterprises.

Dry Cropland and Grassland. – An estimated 18,810,000 acres or about half of the nonirrigated cropland were harvested. The unharvested dry cropland includes cropland used solely for pasture or grazing, summer fallow, soil building crops, planted acreages not harvested, and formerly cropped land that has not yet changed use. (See table II-21.) Range and dry grassland are most extensively used for meat production. The use of these acres is perhaps the largest single factor contributing to the Western cultural image.

Value of Crop Production. – Crops grown on the 37.5 million acres of harvested cropland are shown in table II-22. Value of this crop production in 1964 and valued at 1967 prices was $3,370 million. Value of the United States crop production in the same year and prices was $17,170 million.

Table II-20.–*Irrigated agricultural land by State, 1969*
(1,000 acres)

State	1964 crops harvested			Acreage harvested		Irrigated base	
	Feed	Food	Other	1964 All farms	1969 Class 1-5 farms	Crop-land	Total Agr. land
Arizona	520	171	397	1,006	1,029	1,640	1,672
California	2,605	3,056	937	6,437	6,195	8,788	10,339
Colorado	1,621	411	13	2,044	2,175	1,704	3,356
Idaho	1,219	856	63	2,239	2,219	3,468	3,772
Montana	1,192	180	12	1,380	1,371	693	2,216
Nevada	466	25	13	503	495	300	917
New Mexico	406	82	200	688	622	1,029	1,254
Oregon	793	228	49	1,086	1,071	2,002	2,251
Utah	644	109	38	796	679	1,364	1,663
Washington	407	440	66	909	993	1,452	1,708
Wyoming	979	121	5	1,103	1,093	1,300	1,737
Westwide	10,852	5,679	1,793	18,164	17,942	23,740	30,885

Source: 1972 OBERS Projections, Vol. 5, Table 6: 1969 Census of Agriculture Land Resource Base, Western U.S. Water Plan Working Document – June 1973.

Table II-21.—*Nonirrigated Agricultural Land by State, 1972*
(1,000 acres)

State	1964 crops harvested				Nonirrigated agricultural base	
	Feed crops	Food crops	Other crops	Cropland harvested	Dry cropland	Grass & rangeland
Arizona	16	2	3	20	14	47,775
California	988	328	241	1,409	1,571	38,001
Colorado	968	1,584	144	2,682	8,819	25,484
Idaho	734	861	101	1,696	3,148	22,818
Montana	2,682	3,672	123	6,433	11,936	52,438
Nevada	4	25	0	4	0	56,571
New Mexico	102	92	34	218	1,422	53,871
Oregon	812	879	270	1,965	3,698	23,014
Utah	96	171	9	270	919	25,202
Washington	1,164	2,291	91	3,514	6,852	8,266
Wyoming	380	218	7	599	1,112	47,239
Westwide	7,946	10,123	1,023	18,810	39,837	400,679

Source: 1972 OBERS Projections, Vol. 5, Table 6. Land Resource Base, Western U.S. Water Plan Working Document – June 1973.

Grazing. – Domestic livestock and wildlife graze 740,741,000 acres. Herbivorous animals can graze as they roam rotational and permanent pastures, meadows, rangeland, and noncommercial forest.

Balanced use is an essential element in the production of meat products and also contributes toward maintenance of wildlife. Grazing is largely confined to pastures and grasslands; however, some grazing is also carried on in forest and alpine areas. The use of alpine areas for grazing is decreasing because of the critical soil-vegetation stabilization factors and, to a certain extent, conflict with other uses such as wilderness and recreation. These changes in use are being compensated for by more intensive management of other grazing areas. See table II-23.

Livestock pasture in 9.5 million acres of cropland. They also grazed improved and native grassland, rangeland, and some forest land. Value of western livestock in 1964 (in 1967 prices) was $2,762.6 million.

Timber Production. – Timber as considered here is limited to the commercial forest land which is that forest land capable of producing wood fiber in economic quantities on a sustained yield basis without undue soil disturbance or impairment of other land uses. Because of the critical soil-water-vegetative relationships, these commercial forest lands are irreplaceable in this study area. See table II-24.

Production of timber products for the 11 Western States is shown in table II-25 in comparison with the national production. It is interesting to note that approximately 75 percent of softwood saw logs and veneer come from western forests.

Mineral Resources

The Westwide States produced 20 percent of the Nation's total mineral value in 1972. In addition to being the location of an important portion of the Nation's mineral fuel reserve, the Westwide area is the major domestic source of important metals such as copper, molybdenum, nickel, silver and gold and nonmetals such as trona and potash. The largest mineral producing State in the area is California, whose mineral output was nearly one-third of the area total. The petroleum producing States characteristically are the high-value producers in the mining industry. In the Westwide area these are California, New Mexico and Wyoming. Arizona and Utah rank high in the value of minerals produced in the Western United States as a result of their copper production. See figure II-8.

Table II-22.—*Acres of crops harvested by State, 1967 (1,000 acres*)*

State	Food crops								
	Wheat	Rye	Rice	Citrus	Non-citrus**	Vege-tables	Sugar beets	Pota-toes	Peas & beans
Arizona	50.0	—	—	30.0	26.6	74.1	11.6	10.9	—
California	349.8	—	360.0	189.6	1,375.0	706.5	201.2	110.4	1.9
Colorado	1,940.2	12.0	—	—	19.4	28.4	127.6	46.4	179.0
Idaho	1,299.1	8.0	—	—	19.6	40.0	147.1	304.3	191.0
Montana	4,727.6	5.0	—	—	2.4	1.5	57.2	8.4	8.0
Nevada	18.0	—	—	—	.2	—	—	.7	—
New Mexico	141.0	—	—	—	18.8	13.2	—	3.1	4.0
Oregon	1,046.0	16.0	—	—	130.0	142.6	19.5	49.1	9.0
Utah	279.0	—	—	—	15.8	9.9	25.3	7.7	9.0
Washington	2,925.0	16.0	—	—	153.6	185.1	47.6	64.0	125.0
Wyoming	310.3	14.0	—	—	.02	1.8	51.1	3.4	38.0
Westwide	13,086.0	71.0	360.0	219.6	1,761.4	1,203.1	688.2	608.4	564.9

State	Feed crops						Other crops		
	Corn	Silage	Sorghum	Oats	Barley	Hay	Flax	Peanuts	Cotton
Arizona	22.0	15.0	246.0	—	160.0	232.8	—	—	255.9
California	224.0	126.1	424.0	85.0	1,450.0	1,894.8	1.0		613.9
Colorado	271.0	455.6	345.0	60.0	237.0	1,483.3	—	—	—
Idaho	24.0	57.0	—	62.0	529.0	1,321.7	—	—	—
Montana	19.0	50.0	—	140.0	1,255.0	2,370.6	5.0	—	—
Nevada	—	6.0	—	1.0	17.0	410.6	—	—	2.3
New Mexico	17.0	124.0	314.0	—	16.0	269.7		8.0	126.8
Oregon	12.0	22.0	—	94.0	266.0	1,139.7	—	—	—
Utah	—	43.0	—	21.0	125.0	582.2	—	—	—
Washington	20.0	34.0	—	37.0	226.0	875.0	—	—	—
Wyoming	24.0	32.0	—	92.0	96.0	1,223.9	—	—	—
Westwide	633.0	964.7	1,329.0	592.0	4,377.0	11,804.3	6.0	8.0	998.9

*Acreages less than 500 acres are indicated with (—) dash.
**Acres of noncitrus are totals rather than acres harvested from 1967 CHI data.
Source: Unpublished OBERS Agricultural Base Data — December 1, 1971. Land Resource Base, Western U.S. Water Plan Working Document — June 1973.

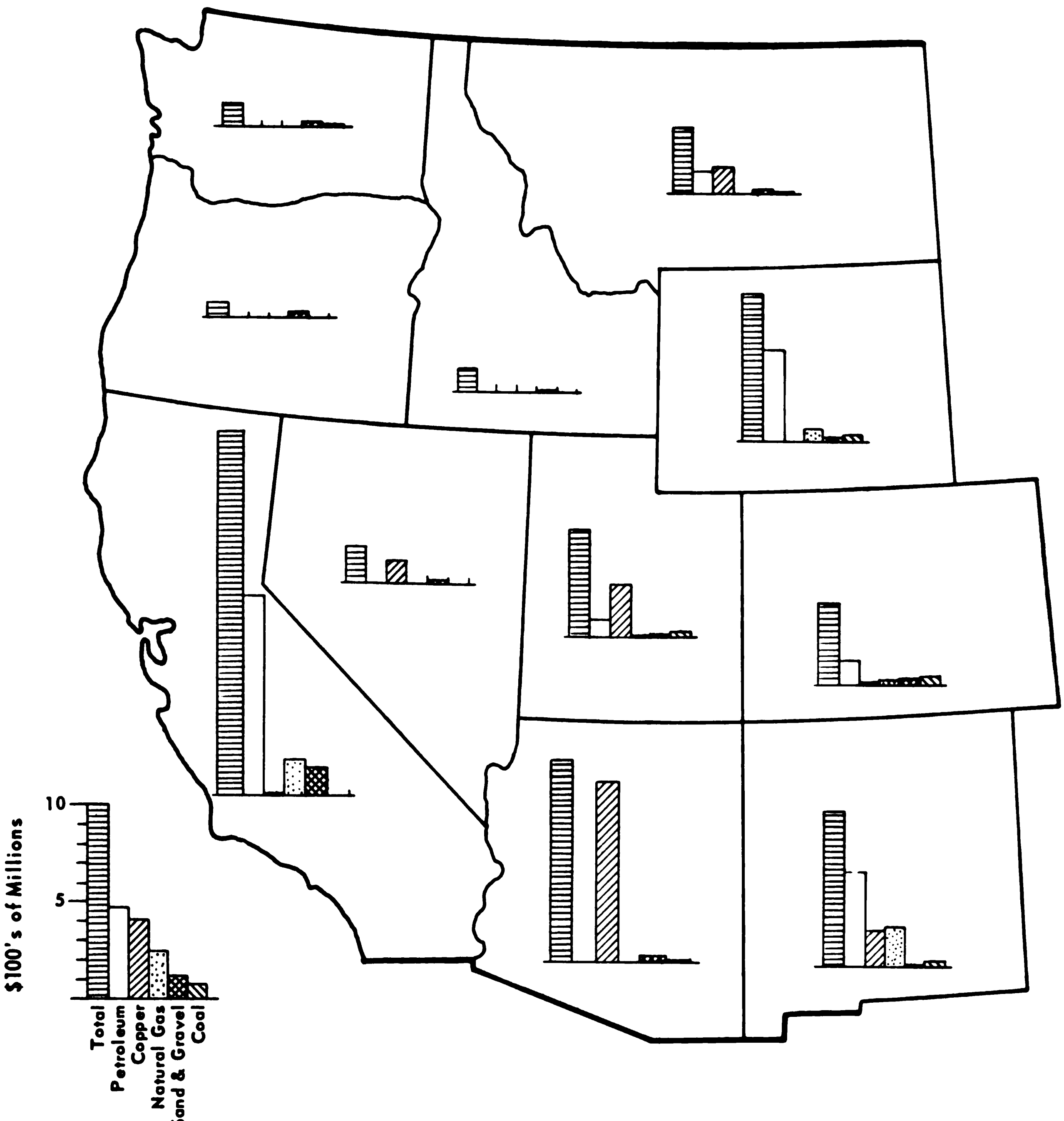


Figure II-8. Value of mineral production, 1972.

Table II-23.—*Grazing acreage by State*

State	Grazing use (1,000 acres)
Arizona	56,392
California	44,249
Colorado	24,419
Idaho	32,218
Montana	60,279
Neveda	53,921
New Mexico	63,729
Oregon	33,653
Utah	37,323
Washington	13,458
Wyoming	51,100
Westwide total	470,741

Table II-24.—*Commercial forest land by State*

State	Ownership	
	Public	Private
	(1,000 acres)	
Arizona	2,666	1,311
California	8,370	7,130
Colorado	13,914	4,923
Idaho	12,736	3,122
Montana	12,460	4,918
Nevada	76	73
New Mexico	3,838	2,430
Oregon	16,622	10,022
Utah	2,806	818
Washington	10,105	9,255
Wyoming	2,100	250
Westwide	85,693	44,252

Table II-26 indicates the size of the mineral industries in the Westwide area, the relative positions of the 11 States, and the area's relationship to the national mineral industries. Figure II-9 portrays the percentages of the total industrial production for petroleum, copper, natural gas, sand and gravel, coal, and other for the United States and for the Westwide area.

While mineral products are mined by and benefit private industry almost entirely, some control of mining is maintained by local, State, or Federal agencies through the leasing of Federal lands, various permits and licenses, and pollution and reclamation laws.

Not only is mineral production highly concentrated in a small number of States, but a few commodities account for most of the value of minerals produced. Table II-27 presents the 1972 value of selected mineral commodities produced in the 11 State Westwide area and the proportion each is of the total value of mineral production in the area.

The value of cement produced was somewhat greater than the value of coal, and that of stone and uranium only slightly smaller. The values of other individual mineral commodities produced including gold, silver, lead, zinc, molybdenum, potash, phosphate, nickel, etc., were considerably smaller.

Table II-25.—*Output of timber products for the United States and Western Region*[1]*, 1970, by source of material and softwoods and hardwoods (1,000 cubic feet)*

Products	Species group	Total output						
		United States	Western Region	Douglas-fir	Ponderosa pine	California	No. Rocky Mountain	So. Rocky Mountain
Saw logs	Softwoods	4,957,481	3,371,900	1,438,985	471,562	751,789	549,699	159,865
	Hardwoods	1,355,458	43,193	35,040	1,620	5,520	50	963
Veneer logs and bolts	Softwoods	1,000,587	741,562	531,138	69,452	67,862	67,682	5,428
	Hardwoods	125,644	1,702	1,546	0	138	18	0
Pulpwood	Softwoods	4,285,407	1,319,319	982,880	30,698	124,962	136,900	33,879
	Hardwoods	1,325,740	33,449	29,474	0	3,975	0	0

[1] Includes Hawaii and Black Hills area of South Dakota. Volumes not available at this printing, but not felt significant for purposes of this report.
Source: Data extracted from "Forest Statistics for the United States by State and Region, 1970," published by USDA, Forest Service, 1972.

Table II-26.—*Mineral production in Westwide States, total value and selected minerals, 1972*

State	Total value of mineral production (thousands of dollars)	Total value: Percent of Westwide	Total value: Rank in Westwide	Petroleum (including natural gas liquids): 42-gal bbl (thousands)	Petroleum: Percent of Westwide	Petroleum: Rank in Westwide	Petroleum: (thousands of dollars)	Copper: (thousands of short tons)	Copper: Percent of Westwide	Copper: Rank in Westwide	Copper: (thousands of dollars)
Arizona	1,050,881	16	3	1,020	<1	7	3,233	892,450	57	1	913,869
California	1,891,953	29	1	362,300	48	1	989,672	475	–	8	486
Colorado	421,698	6	6	35,100	5	4	116,056	4,400	< 1	6	4,506
Idaho	112,629	2	9	–	–	–	–	2,680	< 1	7	2,744
Montana	323,823	5	7	33,900	4	5	102,378	121,685	8	4	124,605
Nevada	181,702	3	8	100	<1	–	w	101,119	6	5	103,545
New Mexico	1,066,139	16	2	148,750	20	3	455,876	167,070	11	3	171,080
Oregon	76,516	1	11	–	–	–	–	w	–	–	w
Utah	536,795	8	5	28,460	4	6	84,358	267,870	17	2	274,299
Washington	107,624	2	10	–	–	–	–	w	–	–	w
Wyoming	746,743	11	4	150,717	20	2	456,558	–	–	–	–
Westwide	6,516,503	20		760,347	19		2,208,131	1,557,749	95		1,595,134
United States	32,000,000			4,093,580				1,642,764			

State	Natural gas: Million cubic feet	Natural gas: Percent of Westwide	Natural gas: Rank in Westwide	Natural gas: (thousands of dollars)	Sand and gravel: (thousands of short tons)	Sand and gravel: Percent of Westwide	Sand and gravel: Rank in Westwide	Sand and gravel: (thousands of dollars)	Coal: (thousands of short tons)	Coal: Percent of Westwide	Coal: Rank in Westwide	Coal: (thousands of dollars)
Arizona	640	<1	7	119	18,550	7	5	25,174	2,900	7	6	10,150 (est)
California	580,100	24	2	194,334	115,700	41	1	163,789	w	–	–	w
Colorado	117,000	5	4	19,539	28,460	10	2	31,951	5,500	13	4	36,500
Idaho	–	–	–	–	12,068	4	7	12,237	–	–	–	–
Montana	40,000	2	5	5,600	16,570	6	6	26,467	8,000	19	3	16,000
Nevada	-	–	–	–	10,081	4	9	12,636	–	–	–	–
New Mexico	1,213,000	51	1	194,080	9,587	3	10	8,613	8,200	19	2	28,200
Oregon	–	–	–	–	24,489	9	3	34,981	–	–	–	–
Utah	39,000	2	6	7,020	11,240	4	8	11,005	4,300	10	5	32,800
Washington	–	–	–	–	23,383	8	4	27,990	2,635	6	7	17,786 (est)
Wyoming	375,059	16	3	60,760	9,098	3	11	14,916	10,928	26	1	40,898
Westwide	2,364,799	10		481,452	279,226	30		369,759	42,463	7		182,334
United States	24,000,000 (est)				935,000				585,000			

w = Data withheld to avoid disclosing company confidential information.
Source: Bureau of Mines field data.

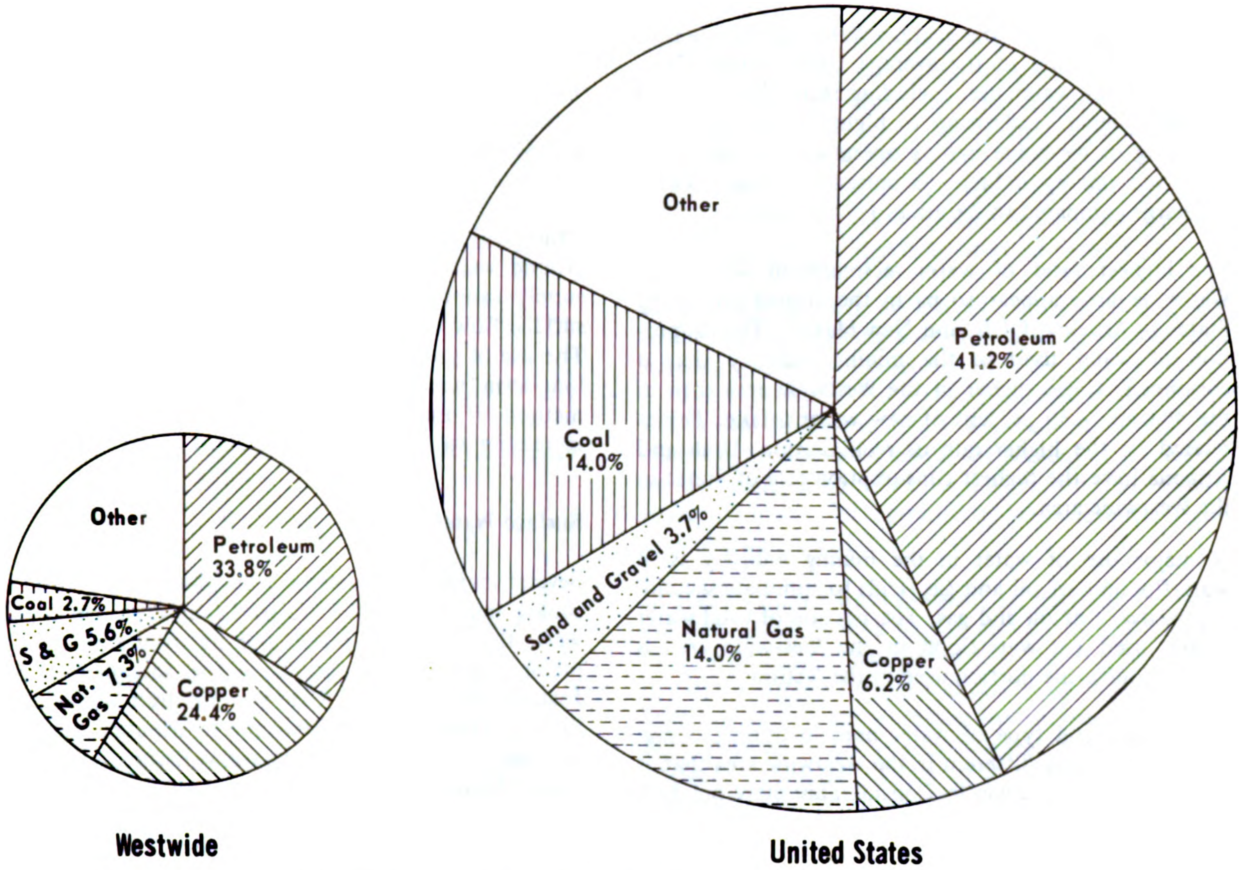


*Figure II-9. **Mineral production, United States and Westwide Study area – 1972.***

Table II-27.—*Value of selected commodities in Westwide area, 1972*

Commodity	Value	Percent
Petroleum (including natural gas liquids)	$2,208,131,000	34
Copper	1,595,134,000	24
Natural gas	481,452,000	7
Sand and gravel	369,759,000	6
Coal	182,463,000	3
		74

As indicated by the 1967 Census of the Mineral Industries, the total quantity of water used in the mineral industries in the United States in 1968 was 11.3 million acre-feet. This includes water recycled and reused. The amount of new water used was estimated at 4.3 million acre-feet. Total water discharged was about 3.7 million acre-feet which indicates an average consumption rate of 14 percent of the new water used.

Within the mineral industries of the United States, metal mining was the largest user of new water with 35 percent of the total. Nonmetallic minerals, except fuels, were nearly equal in their new water demand with 34 percent, while oil and gas extraction account for 28 percent. If total water use including recirculation is considered, the oil and gas extraction is the greatest user with 40 percent of the total. About 60 percent of new intake water is used for process water, the balance being used for oil and gas field flooding, cooling, steam-electric power generation, sanitary services, etc.

The approximately 0.6 million acre-feet of new water diverted by the mineral industries in the Westwide area in 1968 was about 14 percent of the new water intake by the mineral industries of the entire country. The State of California accounted for one-third of this amount; Utah, nearly 20 percent; Arizona, 15 percent; and Wyoming and New Mexico, 10 percent each.

The pattern of water use in the mineral industries of the 11 Western States area varies considerably from that of the Nation as a whole.

The water intake by the average Westwide mining firm is lower than that of the average United States firm, but the gross water use, including recirculation, is 50 percent higher, indicating a higher level of water recycling in Westwide mining operations. Water in the Westwide mining industry is reused 3.8 times before discharge compared to 2.6 times for the Nation.

The highest rates of water recirculation within the Westwide area appear to be in the copper-producing States – Arizona, Utah, and New Mexico. The proportion of water used in the mining industry that is consumed is also higher in the Westwide area than in the Nation – 36 percent of new water intake. This is related to the higher rate of recirculation. Utah and Arizona have the highest consumption rate of States in the Westwide area.

A major use of water in the mining industry is in waterflooding of oil and gas fields to stimulate secondary recovery of oil and gas. The portion of total water intake used for waterflood in the Westwide area is nearly double the portion used in the Nation.

The source and type of water used in mining operations is also quite different in the Westwide area than it is in the Nation as a whole. Considerably more brackish water is used; for example, with nearly one-half of the total water intake brackish. Thirty percent of new intake water is treated before use in the Westwide area with only 20 percent treated nationally. Corrosion control is the major treatment given.

Mining companies traditionally develop their own water sources. Only about 6 percent is obtained from public water systems in the West. Nationally, about one-half of the water used in mining comes from surface sources, a little less than one-quarter from ground-water sources, and about the same amount from water encountered during the process of mining itself. In the Westwide States, a considerably higher portion of total water intake (44 percent) is from ground-water sources, while only one-quarter is from surface-water sources and another quarter is mine water.

The pattern of water discharge after use by the mining industry in the 11 Western States also varies considerably from the national pattern. In the Nation, two-thirds of the water discharged after use is returned to a surface-water body while in the Westwide area only about 40 percent of used water goes back into a surface-water body.

WATER RESOURCES

The water supply of the West is the sum of the surface-water runoff and the ground-water outflow. As a close relationship exists between surface and ground water of a region, they cannot be treated as independent sources of water. A change in the regimen of either will generally affect the other. Vast supplies of ground water are present in most subregions, but this supply cannot be used without causing a decrease in surface flow or a depletion in ground water in storage. The use of ground water generally does not add to the long-term water supply, but it can be an effective method of improving overall water management and increasing water supplies in the short term.

Surface Water

Several major river systems drain the nearly 1,180,000 square miles in the 11 Western States. In the Northwest, the Columbia River and its tributaries are the major drainages. In California, the Sacramento, San Joaquin, and Klamath River systems drain nearly all of the area. The Colorado River and its tributaries and the interior draining rivers of the Great Basin are the other major drainage systems lying west of the Continental Divide. East of the Divide, the Missouri, Arkansas, and Rio Grande River Systems drain the Westwide study area. Nine water resource regions have been designated by the Water Resources Council to coincide with the major river systems. Figure I-1 (in Chapter I) shows the major rivers and water resource regions.

Precipitation over the West varies tremendously with the average annual amounts of more than 200 inches in the Olympic Mountains in the northwest corner of Washington to less than 2 inches in Death Valley, California. Only one of the 11 Westwide States, Washington, receives more average annual precipitation than the national average of 30 inches. Figure II-10 shows the annual average precipitation for each State. Distributions within each State vary substantially as shown in figure II-11.

Water supplies are unevenly distributed over the 11 Western States and within each State itself. Furthermore, water supplies vary considerably between years and between seasons of the year. Because of these wide variations in distribution and runoff patterns, in many areas of the West, economic development has been dependent upon construction of storage and conveyance facilities to provide adequate water supplies.

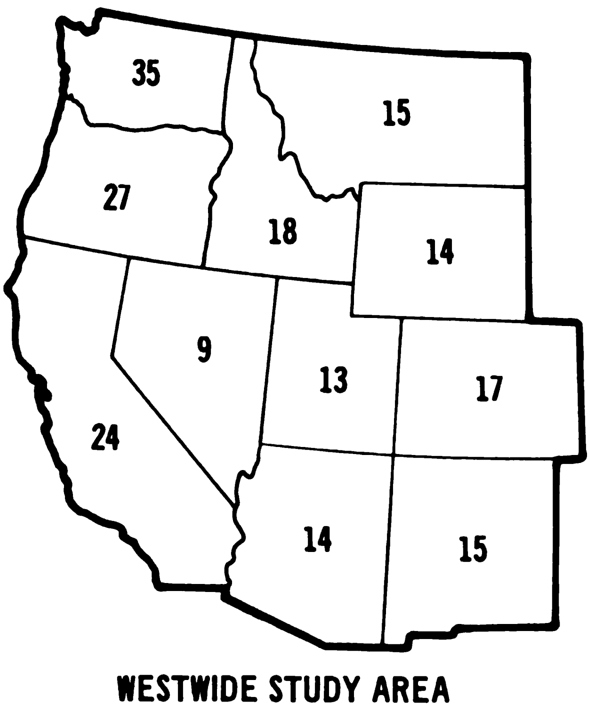


Figure II-10. Average annual precipitation in inches.

Of the 428 million acre-feet of undepleted water supply, which is the natural flow in the streams prior to works of man, 50 million acre-feet is inflow from Canada and 378 million acre-feet originates in the 11 Western States. About 70 percent of the supply originating in the Western United States is found in the States of Washington, Oregon, and California. A summary of undepleted surface water yield by State and water resource region is shown in table II-28.

To regulate runoff in the 11 Western States, 679 reservoirs, each having a storage capacity of over 5,000 acre-feet, have been constructed. These reservoirs have a total capacity of more than 216 million acre-feet of which 184 million acre-feet are available for use. The usable capacity equals about 44 percent of the average annual undepleted water supply for the 11 Western States. Summary of reservoirs by water resource region is shown on table II-29.

In recent years withdrawals for all purposes in the 11 Western States have averaged about 137 million acre-feet. Withdrawals are defined as the water that is diverted from the supply source for useful purposes. It does not include instream uses for hydropower, navigation, recreation, fish and wildlife, and other such instream purposes. Table II-30 shows withdrawals summarized by State and by region.

Table II-28. — *Water supply summary, State and region (1,000 acre feet)*

State	Average annual undepleted water yield within State	Region	Average annual undepleted water yield within region
Arizona	1,960	Missouri	23,880
California	72,890	Arkansas-White-Red	1,440
Colorado	15,350	Texas-Gulf	10
Idaho	44,380	Rio Grande	2,670
Montana	32,190	Upper Colorado	15,130
Nevada	3,250	Lower Colorado	2,650
New Mexico	2,190	Great Basin	8,350
Oregon	83,550	Columbia-North Pacific	248,350
Utah	7,720	California	75,890
Washington	99,480		
Wyoming	15,410		
Subtotal — States	378,370	Subtotal — Region	378,370
Net inflow from Canada	50,060	Net inflow from Canada	50,060
Westwide	428,430		428,430

Source: Westwide State Reports (unpublished)

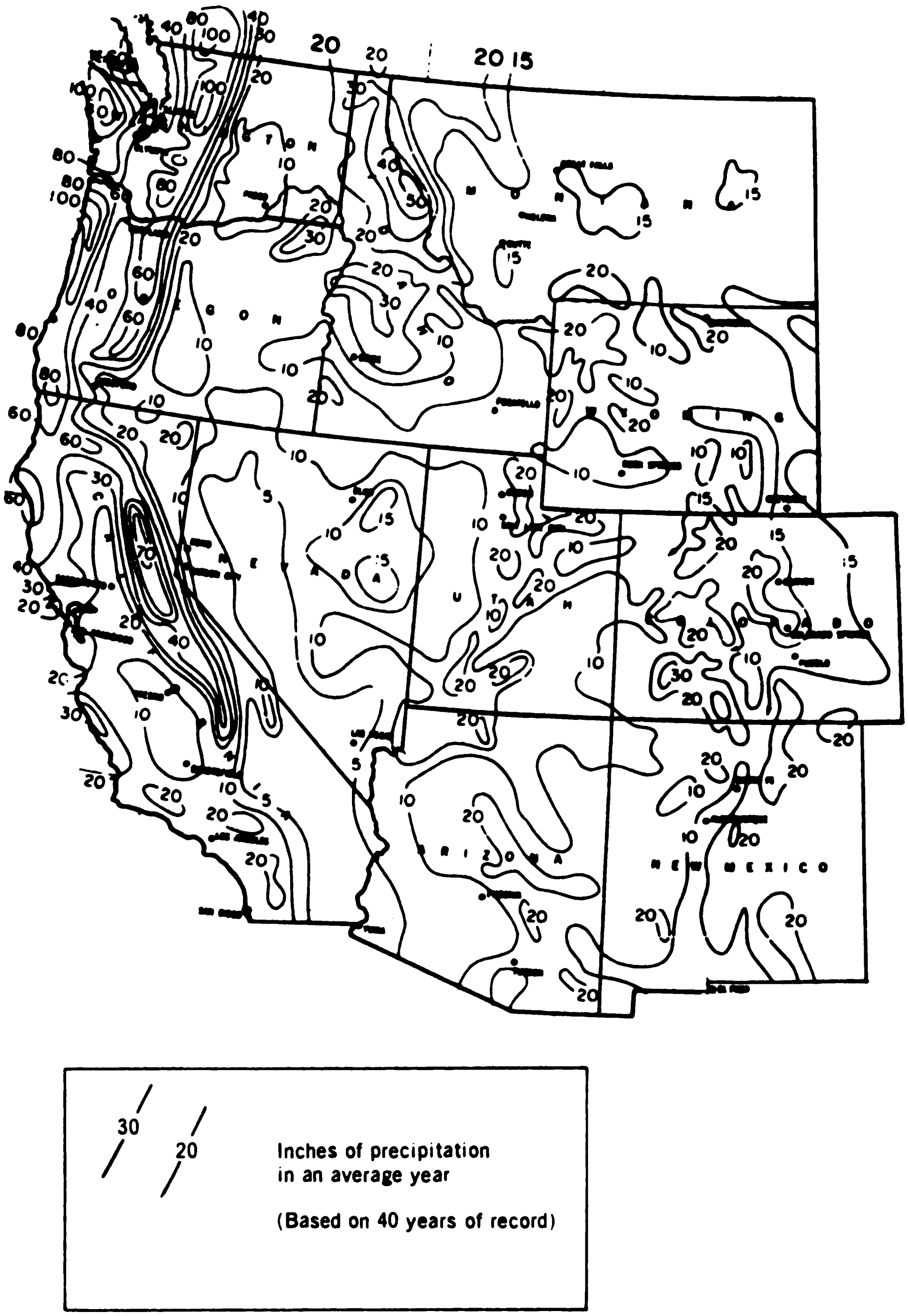


Figure II-11. Average annual precipitation – distribution over the Westwide Study Area.

Table II-29.—*Existing reservoirs – nine regions (Westwide portion)*

Subregion	No. of reser-voirs	Storage capacity Total (1,000 acre-feet)	Usable
Rio Grande	23	3,974	3,958
Arkansas-White-Red	14	1,730	1,321
Missouri	105	32,785	26,005
Upper Colorado River	40	36,186	33,083
Lower Colorado River	27	39,383	35,883
Great Basin	48	4,319	4,237
California-South Pacific	221	38,425	36,931
Columbia-North Pacific	201	59,630	42,734
Texas-Gulf	0	0	0
Westwide	679	216,432	184,152

[1] 5,000 acre-feet or larger.
Source: Westwide State Reports (unpublished).

Depletions were approximately 78 million acre-feet in 1970 and are estimated to be 83.6 million acre-feet in 1975, as shown in table II-31. Depletions are defined as that part of withdrawals which does not return to the stream and includes plant transpiration, evaporation, losses in conveyance to deep percolation, domestic and industrial consumption, etc. Of the total depletions about 59 million acre-feet are expected to be used for irrigation; 6.4 million acre-feet for municipal, industrial, mineral, and thermal electric cooling purposes; and 3.2 million acre-feet for recreation, fish and wildlife, and other purposes (exclusive of instream needs).

The ratio of depletions to withdrawals for large geographic areas can vary significantly due to a number of factors such as the number of times the withdrawn water returns to the river downstream for subsequent withdrawal, the efficiency with which each withdrawal is used, and the amount and character of reservoir storage in the basin. Comparison by States and water resource region of the percent of depletion to withdrawal is shown in table II-32.

Table II-33 shows the estimated 1975 future water supply by States. The modified supply represents the total annual water supply available to each State from inflow, imports, and within-State water yield less estimated 1975 exports and within-State depletions. The net water supply represents supply available after estimated compact, legal, and instream 1975 commitments for downstream flows. With respect to the State totals, after these commitments, remaining supplies can be considered available for either future instream uses such as for fish, wildlife, recreation, water quality, power, and navigation, or for consumptive use within economic, environmental, and physical constraints which could preclude full development.

More detailed information about the estimated 1975 water supply situation, the localized areas of shortage, and the areas of ground-water overdraft is provided for each State by subregion in chapter VI.

Transregion Diversions

Of the 9 water resource regions in the 11 Western States, only waters of the Upper and Lower Colorado Regions are used to supply substantial needs outside the region of origin. For example, in Colorado and Utah there are 43 transregion diversions to supply municipal, industrial, and agricultural needs in adjacent regions. All of the seven Colorado River Basin States benefit both within and outside the Colorado River region from the flows of the Colorado River. Estimated 1975 exports from the Colorado River total about 5.3 million acre-feet. Estimated future diversions are dependent upon legal and institutional constraints, seasonal variation of supply and long-term supply management practices. However, based on such constraints, existing or planned diversion facilities have an estimated maximum transregional diversion capability of 7.5 million acre-feet. Historic and estimated future transregion diversions from or to the Colorado River are shown on figure II-12. The export capacity of existing and soon to be constructed facilities are sufficient to divert substantial additional water from the Colorado River system.

Interregional transfers of water to areas of water deficiency are being made in all but 2 of the 11 Western States; however, most of the transfers occur in California, Colorado, Utah, and New Mexico. The importance of water transfers is made evident by the fact that one out of every five persons in the Western States is served by a water supply system that imports from a source 100 miles or more away. Of the total quantity of water diverted, approximately half is for municipalities and industries and the other half for irrigation. In the Colorado River regions, water exported annually represents about one-third of all water withdrawn within the regions. The only transfer across a state boundary is from the Upper Colorado Region in Colorado into the Rio Grande Region in New Mexico.

Table II-30. — *Recent withdrawals by State and region*[1]

State or Region	Withdrawal year	Irrigation	M&I including rural	Minerals	Thermal electric	Recreation fish and wildlife	Other	Reservoir evaporation	Consumptive conveyance losses	Total withdrawals
	(1,000 acre-feet)									
State										
Arizona	1965	7,096	349	102	7	169	78	141	–	7,942
California	1965	29,020	4,131	118	[2]8,220	652	–	828	4,148	38,897
Colorado	1970	7,826	473	65	19	29	111	904	367	9,794
Idaho	1966	17,668	739	27	–	245	49	1,677	5,100	25,505
Montana	1970	6,292	361	14	67	–	206	1,112	–	8,052
Nevada	1969	3,301	245	–	63	–	10	1,099	–	4,718
New Mexico	1970	3,206	205	84	66	45	52	261	–	3,919
Oregon	1975	7,624	1,581	–	23	36	17	1,597	–	10,878
Utah	1965	4,803	415	95	7	616	951	461	–	7,348
Washington	1975	6,523	1,934	–	–	–	29	1,400	–	9,886
Wyoming	1968	7,358	134	85	13	–	–	387	–	7,977
Colorado River Main Stem Evaporation		–	–	–	–	–	–	1,862	–	1,862
State summary		100,717	10,567	590	265	1,792	1,503	11,729	9,615	136,778
Region										
Missouri		12,414	529	83	82	4	252	1,108	57	14,529
Arkansas-White-Red		1,534	151	–	6	24	55	113	48	1,931
Texas-Gulf		594	19	22	7	–	3	12	–	657
Rio Grande		3,219	173	47	33	37	28	816	53	4,406
Upper Colorado		5,224	110	108	38	21	139	766	209	6,615
Lower Colorado		7,421	492	111	13	169	84	1,369	–	9,659
Great Basin		7,635	525	74	63	614	850	1,645	204	11,610
Columbia North Pacific		32,896	4,425	27	23	271	93	4,577	4,896	47,208
California		29,780	4,142	118	[1]8,220	652	–	1,323	4,148	40,163
Region summary		100,717	10,567	590	265	1,792	1,503	11,729	9,615	136,778

[1] Includes both surface and ground-water withdrawals.
[2] Sea water withdrawals.
Source: Westwide State Reports (unpublished).

Table II-31. – *Estimated 1975 total depletions by State and region*

State or region (Type 1)	Irrigation	M&I including rural	Minerals	Thermal electric	Recreation fish and wildlife	Other	Reservoir evaporation	Consumptive conveyance losses	Total depletion
State									
Arizona	4,242	210	69	32	89	686	140	–	5,468
California	24,200	3,903	123	–	635		1,050	1,834	31,745
Colorado	3,630	282	17	30	55	91	[1]1,144	372	5,621
Idaho	8,193	118	1	–	–	43	1,677	–	10,032
Montana	3,265	262	10	1	–	207	1,112	–	4,857
Nevada	1,619	137	2	34	37	6	1,099	–	2,934
New Mexico	1,789	113	52	39	56	56	[1]336	–	2,441
Oregon	3,670	207	—	23	–	18	1,597	–	5,515
Utah	2,608	138	24	13	490	911	[1]576	–	4,780
Washington	3,569	381	–	–	–	37	1,400	–	5,387
Wyoming	2,372	62	88	16	–	–	[1]458	–	3,012
Lower Main Stem system losses and reservoir evaporation	–	–	–	–	–	–	1,760	–	1,760
State summary	59,157	5,813	386	188	1,378	2,055	12,369	2,206	83,552
Region									
Missouri	5,632	348	78	24	4	250	1,111	57	7,504
Arkansas-White-Red	831	66	1	6	23	37	123	53	1,140
Texas-Gulf	390	11	4	5	0	3	12	–	425
Rio Grande	1,590	94	35	8	45	31	792	53	2,648
Upper Colorado	1,931	39	49	75	62	145	671	209	3,181
Lower Colorado	4,494	291	79	38	147	691	167	–	5,907
Great Basin	3,832	202	16	9	462	798	1,612	–	6,931
Columbia-North Pacific	16,102	857	1	23	–	100	4,577	–	21,660
California	24,355	3,905	123	–	635		1,544	1,835	32,396
Lower Main Stem system losses and reservoir evaporation	–	–	–	–	–	–	1,760		1,760
Region summary	59,157	5,813	386	188	1,378	2,055	12,369	2,206	83,552

[1] Adjusted for proportionate share of Colorado River Main Stem evaporation.
Source: Westwide State Reports (unpublished)

Table II-32.—*Relationship of depletions to withdrawals by State and Region*

State	Depletion as a percent of withdrawal[1]	Region	Depletion as a percent of withdrawal
Arizona	63	Missouri	51
California	75	Arkansas-White-Red	55
Colorado	54	Texas-Gulf	57
Idaho	34	Rio Grande	60
Montana	60	Upper Coloredo	47
Nevada	46	Lower Coloredo	63
New Mexico	59	Great Basin	56
Oregon	51	Columbia-North Pacific	43
Utah	59	California	74
Washington	54		
Wyoming	36		
Eleven state summary	56	Nine region summary	56

[1] Depletions and withdrawals adjusted to approximate 1970 conditions.
Source: Westwide State Reports (unpublished).

Table II-33.—*Estimated net future water supply by State, 1975 (1,000 acre-feet)*

State	Modified 1975 supply	Net water supply
Arizona[1]	2,097	397
California[1]	50,650	26,510
Colorado	9,852	1,097
Idaho	69,288	53,458
Montana	42,984	37,344
Nevada[1]	1,963	1,741
New Mexico	2,693	236
Oregon	78,030	66,029
Utah	12,386	1,668
Washington	256,282	245,782
Wyoming	14,141	3,853

[1] Colorado River lower main stem system losses and reservoir evaporation of about 1,760,000 acre-feet are not included in determining modified and net water supply.
Source: Westwide Study State Reports (unpublished).

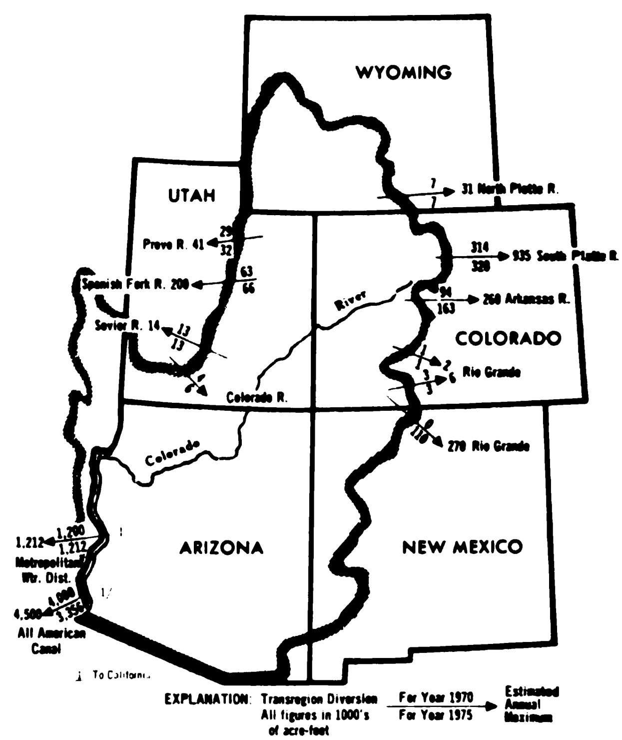


Figure II-12. Existing transregion diversions – Colorado River system.

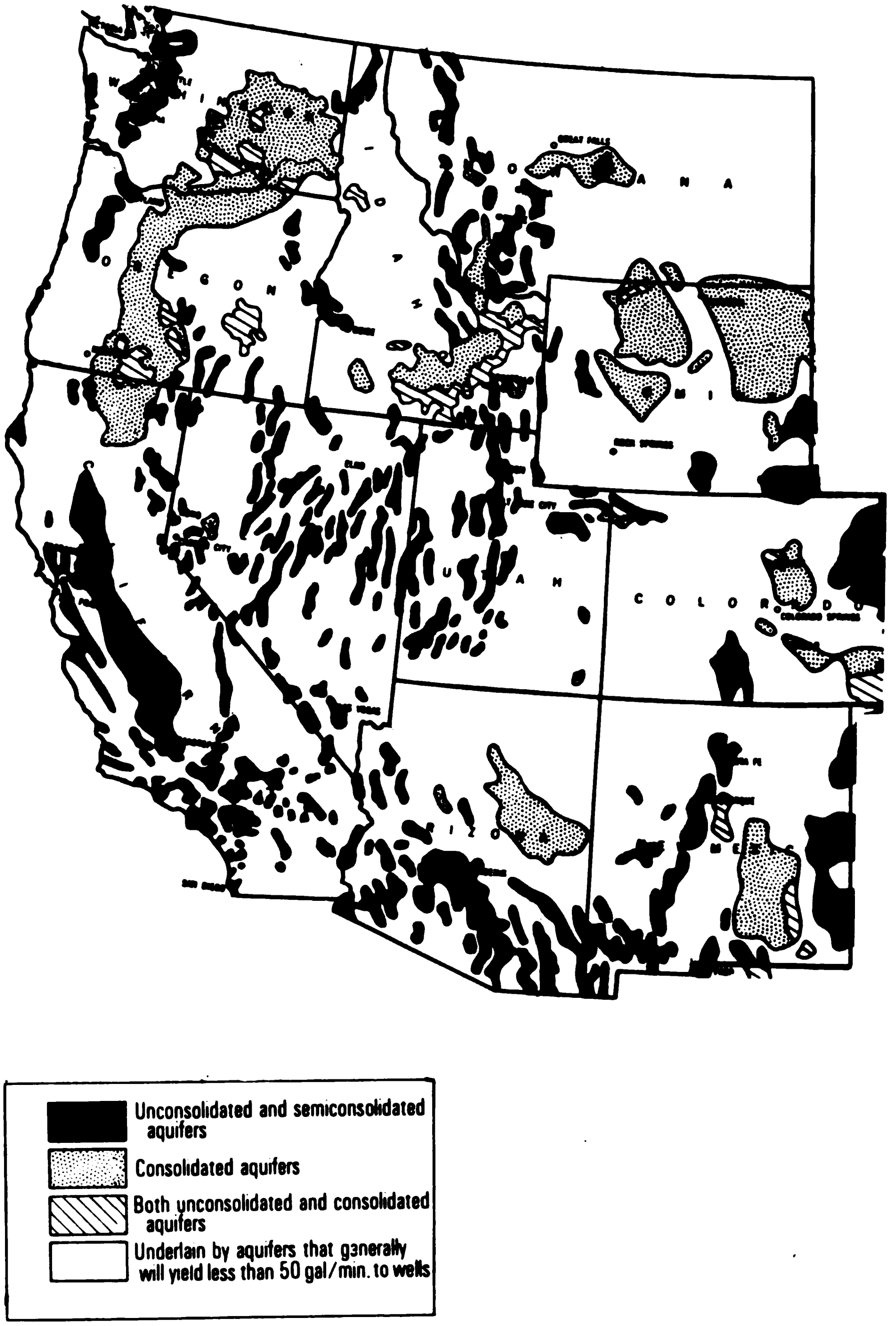


Figure II-13. Ground-water aquifers – Westwide Study area.

Ground Water

Ground water is an important source of water supply in the 11 Western States. It is estimated there is approximately 6.2 billion acre-feet of water in storage at depths in the range from 50 to 200 feet. However, the amount recoverable is not known because of unanswered questions concerning location of supplies with respect to users, physical data in depth and nature of aquifer, pumping costs, ground-water quality, and social policies toward mining ground water. Figure II-13 shows the principal aquifers in the area and figure II-14 shows ground-water use as percent by total by States. Table II-34 shows the ground-water use in 1970 by subregions. Also shown in this table is the ground-water storage at depths generally in the range from 50 to 200 feet. These data support the proposals to make more extensive use of ground water and ground-water aquifers to meet future water supply needs.

The principal aquifers in most subregions of the West are unconsolidated sediments, commonly in or adjacent to stream valleys, and volcanic rocks, or both. In parts of some subregions, consolidated sedimentary rocks are productive aquifers.

The storage capacity of the natural underground reservoirs is many times the storage capacity of all the surface reservoirs that have been constructed or that likely will be constructed. Ground-water reservoirs can be used for input and output of water the same as for surface reservoirs by artificial recharge and withdrawal by pumping. In areas where ground-water reservoirs are large but recharge is small, water demands are met for many years by "mining" the ground water.

"Mining" if ground water can add significantly to the economy of many areas for a finite period of time, which depends on the rate of mining and the initial quantity of ground water in storage, as is true of any mineral resource. Some States permit the mining of ground water; others try to regulate its use within a theoretical "safe yield."

The unconsolidated sediments which are extensive throughout the West generally have specific yields ranging from 10 to 20 percent but a wide range of permeabilities due to wide ranges in the size and distribution of interstices between the grains. Beds of sand and gravel commonly yield a few hundred to a few thousand gallons per minute of water to wells. Volcanic rocks, primarily basalt, occurring mainly in the Northwest generally have low specific yields, ranging from less than 1 to about 3 percent depending on the width and distribution of fractures. Yields of a few hundred gallons per minute of water from wells

Figure II-14. Ground-water as percent of total use.

sedimentary rocks, especially limestone, dolomite, and completed in these rocks are widespread. Consolidated sandstone, contain excellent aquifers in parts of the Great Basin, the western Missouri River, and the Rio Grande Regions. Yields of wells completed in limestone commonly range from a few hundred to a few thousand gallons per minute. The yields of wells completed in sandstone generally range from a few tens to a few hundred gallons per minute (gal/min). The yield of wells completed in shale generally is less than 10 gal/min. Crystalline rocks are widespread in the Rocky Mountains. They generally yield less than 10 gal/min to wells, but they do provide adequate water for domestic supplies at many mountain homesites.

Much work has been done toward evaluating the ground-water resources in parts of the study area, but much more remains before systematic planning of ground water is achieved. The conjunctive development and use of surface- and ground-water supplies require careful study of the interrelationship. The quantity of recoverable ground water in storage to different depths should be determined, as it represents the reserves available for extraction and the volume of the underground reservoir that can be managed readily for storage of water. The physical properties of aquifers control the quantity of water that can be stored or yielded, the rate at which water can be added to or withdrawn from the underground reservoirs, and the change in water levels that will result from withdrawal

Table II-34.—*Estimated use of ground water and ground water in storage in 1970*

Region and subregion	Ground water withdrawn (1,000 acre-feet per year) Public supplies	Rural	Irrigation	Self-supplied industrial	Thermo-electric power generated	Total	Ground water consumed[1] (1,000 acre-feet per year)	Available data on storage at varying depths (1,000 acre-feet)
Missouri								
Upper Missouri River tributaries	10	15	44	7	0	76	38	8,700
Yellowstone River	9	13	60	19	0	101	50	14,800
Western Dakota tributaries	0.1	0.4	0	0	0	0.5	0.2	400
North Platte-Niobrara Rivers	16	1	38	29	1	85	42	70,000
South Platte-Arikaree	69	0.4	836	46	0	951	476	115,000
Subtotal	104	30	978	101	1	1,210	606	209,000
Arkansas-White-Red								
Arkansas Valley	10	9	220	12	0	251	143	22,000
Canadian-Cimarron	3	4	75	0.6	0.1	83	47	72,700
Subtotal	13	13	295	13	0.1	334	190	94,700
Rio Grande								
Rio Grande-Colorado	4	2	669	4	0	679	360	2,000,000
Rio Grande-New Mexico	89	11	296	85	10	491	260	2,250,000
Pecos River	21	8	445	8	0.7	483	256	24,000
Closed basins	5	2	182	9	0	198	105	236,000
Subtotal	119	23	1,592	106	11	1,851	981	4,510,000
Upper Colorado								
Green River	13	3	33	9	4	62	31	–
Upper Main Stem	7	3	10	5	0	25	13	–
San Juan-Colorado	11	8	23	4	0	46	23	-
Subtotal	31	14	66	18	4	133	67	88,000
Lower Colorado								
Lower Main Stem	77	10	420	24	4	535	371	109,000
Little Colorado	6	6	21	16	4	53	37	250,000
Gila	200	32	3,980	147	41	4,400	3,060	114,000
Subtotal	283	48	4,420	187	49	4,990	3,470	473,000
Great Basin								
Bear River	35	3	89	7	0	134	64	12,000
Great Salt Lake	105	46	102	57	0	310	148	49,900
Sevier	13	12	311	2	0	338	161	21,700
Humbolt	7	1	157	4	0	169	81	43,600
Central Lahontan	12	5	26	14	4	61	29	16,100
Tonapah	5	0.8	168	19	0	193	92	50,600
Subtotal	177	68	853	103	4	1,205	575	195,000
Columbia-North Pacific								
Clark Fork, Kootenai, Spokane	137	10	101	51	0	299	109	69,000
Upper Columbia	34	8	161	27	0	230	84	35,000
Yakima	40	8	81	10	0	139	51	13,000
Upper Snake	56	16	1,960	322	0	2,360	866	67,000
Central Snake	34	16	526	22	0	598	219	100,000
Lower Snake	27	8	49	35	0	119	44	31,000
Mid Columbia	16	13	132	67	0	228	84	47,000
Lower Columbia	39	85	36	105	0	265	97	8,000
Willamette	35	50	126	6	0	217	80	27,000
Coastal	4	30	61	23	0	118	43	27,000
Puget Sound	96	24	37	14	0	171	63	40,000
Oregon closed basin	1	1	60	6	0	68	25	56,000
Subtotal	519	269	3,335	688	0	4,811	1,765	520,000
California								
North Coastal	14	8	151	7	0	180	102	700
San Francisco Bay	128	20	320	131	0	599	338	1,200
Central Coastal	67	16	1,090	36	0	1,210	682	7,600
South Coastal	867	29	1,230	248	336	2,710	1,530	10,600
Sacramento Basin	175	25	4,000	60	0	4,260	2,400	22,000
Delta-Central Sierra	82	9	1,490	66	0	1,650	930	–
San Joaquin Basin	100	19	2,780	60	0	2,960	1,670	80,000
Tulare Basin	239	28	5,820	32	0	6,120	3,450	–
North Lahontan	0.7	0.9	6	2	0	10	6	700
South Lahontan	54	8	570	15	0	647	365	–
Colorado Desert	26	10	300	6	0	342	193	3,600
Subtotal	1,753	173	17,800	663	336	20,700	11,700	126,000
Westwide	2,999	570	29,339	1,879	405	35,234	19,354	6,215,700

[1] Based on the ratio of water consumed to water withdrawn from all sources for the region.

Source: United States Geological Survey Circular 676 (1972).

of a given volume of water. The mineral content of aquifer materials largely controls the chemical quality of the ground water. The depth to water, pumping lifts, and well spacing must be known in order to estimate pumping costs.

There is presently a lack of information on the benefits and costs, both economic and environmental, needed for evaluation of alternative plans for water management including the value of benefits foregone if the water is not used.

CHAPTER III
ASPECTS OF THE FUTURE

INTRODUCTION

This chapter deals with trends and concepts which affect the future of the West in terms of requirements for water and related lands, concerns for the environment and quality of life. The central focus is on the complex role that water will play in meeting varying demands through the year 2000. In a world characterized by change as rapid as has been experienced during the twentieth century, it is impossible to forecast the future with any level of precision. About the only certainty is that future conditions will be different from present conditions. The world of 20 years hence will be significantly different from the world of today.

Water resource planning has in the past coped with the problem of future forecasting by projecting historical trends into the future. This approach has demonstrated utility for many purposes. It had the virtue of being objective and systematic in its use of present and historical data as the basis for deriving trend lines for the future. However, these projections have proven inadequate in many instances and current information suggests that still other changes, not indicated by historical trends, may be occurring in the 11 Western States. These changes, if they occur, would result in a future much different from that indicated by historical trends.

Planning for the use of the nation's water resources must be responsive to values and preferences which predominate in the society. This task is particularly difficult during a time when the Nation's values are undergoing rapid changes.

One of the key values which has historically supported water resources development has been that associated with the growth ethic. There has been, in recent years, a national debate concerning growth. Manifestations of that debate are found in a variety of sources. Under Federal sponsorship, recent years have seen the publication of: *Goals for Americans*, 1960, the report of the President's Commission on National Goals; *Toward a Social Report*, 1969, sponsored by the Department of Health, Education, and Welfare; *Toward Balanced Growth: Quantity with Quality*, 1970, the report of the White House National Goals Research Staff; and *Population and the American Future*, 1972, the report of the Commission on Population Growth and the American Future. Additionally, a variety of other publications dealing with problems of growth have added to the debate, a noteworthy example being the Club of Rome's *Limits to Growth*, 1972. Thus, values for growth are under challenge; consequently, water planners must cope with ambiguity until national goals are more clearly defined.

The lack of consensus governing what is meant by the phrase, "the wise use of the nation's water resources," is reflected in multifaceted national water policy which is unclear and confusing to many. The June 1973 report of the National Water Commission, *Water Policies for the Future*, includes a large number of specific recommendations. However, these recommendations have not yet resulted in a clear, unified sense of policy and direction. Many of the recommendations are proving valuable and will be implemented. Others are more controversial and may never become fully acceptable.

Many values and situations affect and complicate water resource planning in the West. Water planning is complicated because of the population growth which will occur; because of the rich energy and mineral resources which can be developed to meet national and worldwide energy demands; and because the West hosts major areas of public land, parks, wilderness areas, wild and scenic river reaches, and other environmental resources of value to the nation. It is complicated because the role of federally subsidized irrigation projects that has helped build the West is changing; even though there are still opportunities to apply water to land to meet new national and international demands for food and fiber. It is complicated because of the existing problems of salinity in major river reaches, erosion of the land resources, depletion of large zones of ground water, and continuing flood damages. It is complicated because legal and institutional arrangements for water do not foster efficient and effective use of water supplies.

Changes in national policy, coupled with changes in values and preferences affecting economic growth, environmental quality and social well-being, means that the task of water resource planning for the future of the West is growing more complex and difficult. However, regardless of preferences or values, growth in population and associated growth and demands in allied areas are going to continue in the West, and there will be increasing demands on limited water supplies.

It is an inescapable fact that water has played an important role in the past in the economic growth of the West. Water is sure to have a continuing important role in the future. This role and all of the related problems must be considered in assembling a reasonable picture of the future of the West and in determining how water resources planning fits as a component of that picture.

KEY FACTORS IN THE FUTURE OF THE WEST

Key factors which are pivotal in shaping major directions of the future of the West include the role of water and its increasing interrelation with the political, economic, social, and physical factors which are significant in making decisions that shape and determine much of the quality of life in the West's future. These key factors are discussed in the following sections: population growth, economic development of energy and other resources, environmental quality, land use, water supply and management, Indian water requirements and changing trends in planning.

Population Growth

The human race was increasing by about 20 million per year before World War II; now it is increasing annually by more than 70 million. The United States contributes about 2 million people annually to the world's population increase, yet even here, many people are concerned about the rate of growth. About one-third of the current annual United States population growth is reflected in the growth of the 11 Western States.

United States Population Growth. – Nationally, the population had grown to 203,735,000 by the time of the 1970 census and is currently in excess of 210 million. Given these increases, it might seem reasonable to expect similar rates of increase in the future. However, predicting future population growth has proved difficult even when armed with the best information and techniques. For example, not more than 10 years ago the Bureau of Census Series A projections showed a United States population of more than 480 million in the year 2020 was considered acceptable by many. However, in 1973, the new Series F population projections (current fertility levels) indicate a figure of 270 million in year 2020. The difference between these two projections alone is approximately equal to the present population of the Nation. See Table III-1.

The Bureau of Census used to publish three different levels of projections of population growth, based primarily upon different birth rate or "fertility" assumptions. However, partly in response to the propensity of many planners to accept the middle level as "realistic," the Bureau now publishes four levels of population growth projects – Series C, D, E, and F. Series A and B have been dropped fairly recently as being unrealistic in view of rapidly changing trends. Figure III-1 shows the difference between these four levels of projected population.

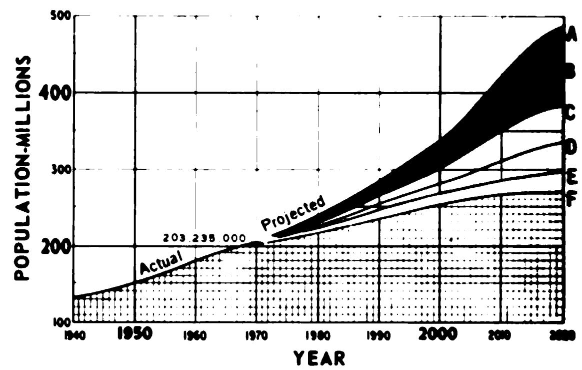


Figure III-1. ***Demographic trends.***

Table III-1.–*United States and Westwide comparative growth*

Area	Population 1970 (1,000's)	Series E Projections: 1980 Population (1,000's)	1980 Percent increase over 1970	1990 Population (1,000's)	1990 Percent increase over 1970	2000 Population (1,000's)	2000 Percent increase over 1970
United States total	203,235	224,733	10.6	246,949	21.5	265,504	30.6
Westwide only	33,735	41,034	21,6	47,374	46.4	57,205	69.6

Source: The Commission on Population Growth and the American Future, 1972, Vol. 5, *Population, Distribution, and Policy.*

To the extent tht such projections are used to establish society levels of needs or requirements, it is obvious that very different problems exist for the planner, depending on which level of projections is selected. It is also true, however, that the more substantial differences in numbers of people emerge largely after the year 2000. Thus, in certain respects the near-term problems are not that different as a function of population growth between now and the year 2000. A certain amount of population growth is "built in," and will occur regardless of other changes.

One of the most striking changes in demographic trends is the rapid decline in birth rates beginning in the 1960's and extending into the 1970's to the present. The latter period is most significant because it came during a time when most demographers had expected a rise in birth rates. During this time frame the children of the "baby boom" era after World War II entered the prime childbearing years. However, December 4, 1972, saw the fertility rate at the level of 2.11 children per woman – the zero population growth (ZPG) rate figure, which is the fertility level used in the Series E projections. That level has continued to decline to the present, where it is about 1.8 and still dropping. Where it may stop this unanticipated decline is unknown, but some are beginning to think in the terms of a declining population as a possible eventuality, a novel idea in American society.

Population Growth in the West. – Population growth in the 11 Western States is closely intertwined with the growth and distribution of the Nation's population as a whole. One important feature of the Nation's population is its mobility and the resulting migration trends.

A westward movement of the Nation's population has been underway since the days of the Founding Fathers. This migration toward the West is shown in the movement of the population center of the Nation. (Fig. III-2.) This shift in the Nation's population to the West is brought about by two major factors – increases in the net fertility of the West's population (the number of births exceeding the number of deaths) and increases due to net migration (the number of people moving to the West in excess of those moving out of the West) which have occurred.

No matter how stated or projected, it is evident that areas of the West are filling up and doing so rapidly. Even with a decline in rate of national population growth there is every indication that the westward trend will continue. Using the Bureau of Census Series E (ZPG) projections, the population of the West will increase at a rate more than twice that of the rest of the Nation (table III-1).

What this rate of growth means for the West can be illustrated by using 1970 population levels as a point of comparison. It means, for example, that every year between now and year 2000 the West will add a population increase equal to the 1970 population of Idaho or Montana. Stated another way, it means the addition of one new city of 65,000 people every month in the West between the present and the year 2000. These are examples of the growth in the West through the year 2000 even with ZPG national projections.

Table III-2 shows projected growth of population in each of the 11 Western States for the years 1980, 1990, and 2000. Series E (ZPG) projections are shown along with Series B, both arrayed into metropolitan and nonmetropolitan categories. Within the last decade framework studies completed in the Westwide Study area included Series B among their projections of population growth. Thus, table III-2 shows the Series B figures to illustrate the impacts of the rapidly changing demographic processes and projections. It also demonstrates the problems of reliability in using "nationally consistent" sets of projections such as this or OBERS based on historical trends when planning at the State levels, because of the difficulties of keeping them updated. For example, the relatively small increases in year 2000 (or decreases in some instances) for the 11 Western States with relatively small population bases such as Wyoming, Montana, and Idaho obviously do not recognize current economic growth related to resource development, including mineral fuels.

In addition to growth in numbers of people, other demographic features of the West will change. While the West is thought by many to be predominantly rural in character, the converse is closer to the truth in terms of where people live. Eighty percent of the people of the West now live in urban areas compared to only 69 percent of the rest of the Nation. By year 2000, it is projected that 90 percent of the West's population will reside in metropolitan areas – areas where a contiguous population exceeding 100,000 exist – as compared to 83 percent for the rest of the Nation. Given that the 40 percent of the land mass of the 48 adjacent States is contained within the 11 Western States, the result of continuing urbanization will be that the West of the future will consist of vast reaches of sparsely populated

Table III-2.—*Projected population for 11 Westwide States*

Population size group	Census 1970	1980	Series B[1] 1990	2000	1980	Series E 1990	2000
Arizona	1,772	2,460	3,280	4,238	2,343	2,929	3,516
Metropolitan	1,320	1,900	2,814	3,687	1,809	2,416	3,059
Balance of area	452	560	466	551	534	514	457
Percent metropolitan	74.48	77.23	85.78	87.00	77.23	82.47	87.00
California	19,953	26,087	34,168	43,200	24,840	30,515	35,842
Metropolitan	18,639	24,669	32,909	41,806	23,490	29,391	34,686
Balance of area	1,314	1,418	1,259	1,394	1,350	1,124	1,157
Percent metropolitan	93.41	94.57	96.32	96.77	94.56	96.32	96 77
Colorado	2,207	2,807	3,486	4,300	2,673	3,113	3,567
Metropolitan	1,671	2,373	3,056	3,872	2,259	2,730	3,213
Balance of area	536	434	429	428	414	384	354
Percent metropolitan	75.71	84.53	87.68	90 06	84 53	87 68	90 06
Idaho	713	776	850	912	739	759	756
Metropolitan	148	241	279	313	230	249	260
Balance of area	565	535	571	598	510	510	496
Percent metropolitan	20.69	31.06	32.82	34.37	31 06	32.82	34 47
Montana	694	744	803	850	709	717	706
Metropolitan	0	102	232	260	0	107	216
Balance of area	694	642	571	590	709	610	490
Percent metropolitan	0	13.74	28.87	30.60	0	14 97	30 60
Nevada	489	778	1,159	1,682	740	1,035	1,395
Metropolitan	416	697	1,075	1,593	664	960	1,322
Balance of area	73	81	84	89	77	75	74
Percent metropolitan	85.14	89.60	92.75	94.73	89.60	92.75	94.73
New Mexico	1,016	1;197	1,458	1,704	1,140	1,302	1,414
Metropolitan	316	448	807	1,001	426	631	732
Balance of area	700	750	650	702	714	671	681
Percent metropolitan	31.08	37.39	55.38	58.78	37.39	48.48	51 81
Oregon	2,091	2,478	3,042	3,635	2,359	2,716	3,016
Metropolitan	1,281	1,684	2,407	2,946	1,603	2,149	2,445
Balance of area	811	794	635	689	756	567	571
Percent metropolitan	61.24	67.96	79.13	81.05	67.97	79.13	81.06
Utah	1,059	1,290	1,571	1,877	1,228	1,403	1,558
Metropolitan	822	1,104	1,386	1,693	1,052	1,237	1,404
Balance of area	238	185	185	185	176	165	153
Percent metropolitan	77.57	85.62	88.21	90.16	85 63	88.21	90.16
Washington	3,409	4,107	5,092	6,157	3,910	4,548	5,108
Metropolitan	2,394	3,330	4,240	5,345	3,170	3,787	4,345
Balance of area	1,015	777	852	812	740	761	763
Percent metropolitan	70.22	81.08	83.27	86.82	81.07	83.27	85.06
Wyoming	332	350	377	394	333	337	327
Metropolitan	0	0	0	0	0	0	0
Balance of area	332	350	377	394	333	337	327
Percent metropolitan	0.00	0.00	0.00	0 00	0.00	0.00	0.00
Westwide	33,735	43,074	55,286	68,949	41,014	49,374	57,205
Metropolitan	27,007	36,548	49,205	62,516	34,703	43,657	51,682
Balance of area	6,730	6,526	6,079	6,432	6,313	5,718	5,523
Percent metropolitan	80.06	84.85	89.00	90.67	84.61	88.42	90.35
United States total	203,235	236,020	276,509	320,003	224,733	246,949	265,504
Metropolitan	144,313	182,530	229,675	273,387	173,218	203,883	225,275
Balance of area	53,923	53,490	46,834	46,616	51,515	43,066	40,229
Percent metropolitan	71.01	77.34	83.06	85.43	77.08	82.56	84 85

[1] Used in framework studies but no longer published by the Bureau of Census. Included for comparison purposes.

Source: The Commission on Population Growth and the American Future, 1972, Vol. 5, *Population, Distribution and Policy*, pp. 162-167.

Year	North Latitude ° ′ ″	West Longitude ° ′ ″	Approximate Location
1790	39 16 30	76 11 12	23 miles east of Baltimore, Md.
1850	38 59 0	81 19 0	23 miles southeast of Perkersburg, W. Va.
1900	39 9 36	85 48 54	6 miles southeast of Columbus, Ind.
1950	38 50 21	88 9 33	8 miles north-northwest of Olney, Richland County, Ill.
1960	38 35 58	89 12 35	In Clinton County about 6½ miles northwest of Centralis, Ill.
1970	38 27 47	89 42 22	5.3 miles east southeast of the Mascoutah City Hall in St. Clair County, Ill.

★ Center of Population

("Center of population" is that point which may be considered as center of population gravity of the United States or the point upon which the United States would balance if it were a rigid plane without weight and the population distributed thereon with each individual being assumed to have equal weight and to exert an influence on a central point proportional to his distance from that point)

Source: U.S. Bureau of the Census, *U.S. Census of Population: 1970, vol. I.*

Figure III-2. Geographic centers of population.

land interrupted occasionally by large metropolitan areas (see fig. III-3).

The metropolitan areas identified on figure III-3 each attract the bulk of new economic and population inflow from out-of-State. They also attract enterprises and populations from the rural areas from within each state. This trend represents a process which tends to feed upon itself and become self-generating. Newcomers are attracted to the opportunities in the urban complex and industry is attracted to the labor pool and services. Finance is attracted to the concentration of industry and people. The rural population is attracted to job opportunities. Developers are attracted to the opportunities for land value appreciation and new governmental jurisdictions come into being alongside existing ones. New schools, roads, and services involving land and water are required to provide for the needs of the increased population and industry base. Once started, the process tends to become irreversible. Contrasted with this rapidly urbanizing phenomena, most rural areas are not growing and, in fact, the population is declining creating a dichotomy: rapid urbanization in the metropolitan area as compared with lack of growth in neighboring rural regions.

This increasing urbanization has important implications for those segments of the population traditionally associated with the rural areas – the American farmer. In 1920, 1 of every 3 Americans lived on a farm; in 1960 the figure had dropped to 1 in 12 and in 1971, 1 in 22. The average age of farm proprietors was 48.7 in 1945; by 1969 it had risen to 51. In 1960 18 percent of the farm population was over 55, whereas in 1970 over 25 percent exceeded 55. Not only was the average farmer

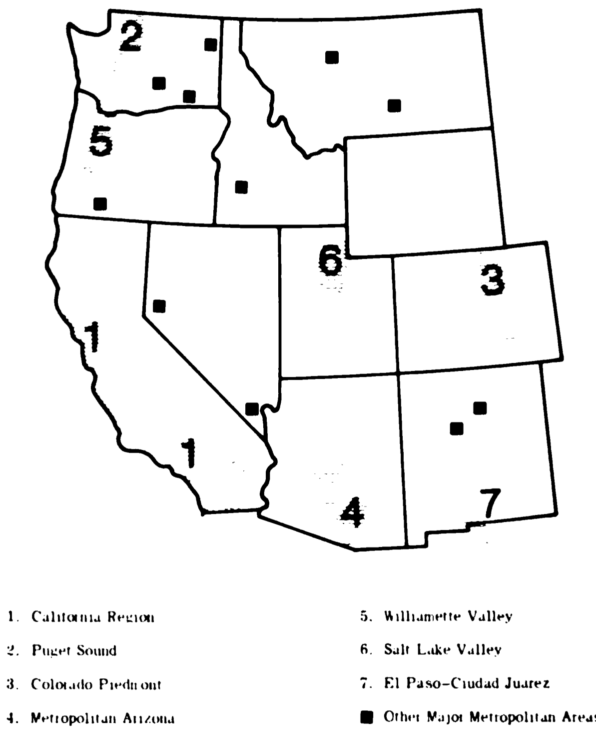


Figure III-3. ***Urban regions – year 2000 – Westwide Study area.***

getting older, there was such an exodus of young adults of childbearing age from farms between 1960 and 1970 that the number of farm children under 14 dropped 50 percent.

Whether or not the enormous productivity of farms can be further expanded or even sustained will be one of the more significant problems of the next 30 years. Many assumptions regarding increased productivity and increased efficiency of water use also presume the presence of enough farmers with adaptability to make the required technological changes. Concern has been expressed in the decline of family farms and the increase in large scale corporate farming and ownership of agricultural lands.

Another important feature of the demography of the West is that about one-half of all American Indians live in the West. Despite relatively low life expectancy and high infant mortality rates, current projections show the Western Indian population increasing anywhere from about 100 percent to 250 percent between 1970 and 2000. This is a much faster rate of growth than the West itself – possibly doubling the percentage of the Indian's share of Western population by the year 2000. This increase in Indian population will be due to a high birth rate coupled with a narrowing of the gap between Indians and the rest of the Nation in infant mortality rates, health services, and economic conditions. It is anticipated that improving the length and quality of life for the Indian peoples of the West will receive higher national priority between now and the year 2000.

Another aspect of population growth in the future West is the location of communities in currently unpopulated or sparsely populated areas because of the development of new resources such as shale, oil, coal, or other important minerals. Such growth is largely unpredictable from normal demographic analyses because it occurs in response to changes in national priorities and needs. Although, the population change is essentially insignificant from a national perspective, its local impacts will be profound. For example, the sudden location of one of two cities of 40,000 in the Piceance Basin in Western Colorado for oil shale development would severely strain the existing social and economic infrastructures of such communities as Rifle (population 2,150), Meeker (population 1,597), and Rangely (population 1,591). Similar growth could occur in the coal deposit regions of Montana and Wyoming.

The population and demographic trends in the West suggest continued population growth at rates faster than the Nation and that there will be increasing urbanization of that population. Increasing demands for domestic, municipal, and industrial water will occur and will force more closely integrated land and water use planning in urban growth areas. Problems will arise in changing land use from agriculture to urban, transport of supplies to the new urban areas, and flood protection in such areas.

Economic Development of Energy and Other Resources

The economy of the West can be expected to become more diversified in the future. The increasingly metropolitan population will provide labor for industry of more kinds in the future and increasing demands for manufactured goods, services, and food. The level of economic activity is closely related to population growth especially in urbanized areas where availability of labor, markets, transportation, and social services provide investment opportunities. On the other hand, in less populated areas, it is the economic development of local resources that becomes the causal factor for population growth.

Table III-3 shows projected earnings for each State and the Westwide area for 1980 and 2000. These projections are modified OBERS to be consistent with the Level E (ZPG) population projections. The total economic activity is expected to increase by 220 percent by year 2000. The most significant rate of increase is expected in Nevada (320 percent) followed by Arizona (248 percent).

For the United States as a whole, the expected increase in earnings will amount to almost 200 percent by year 2000, somewhat below what is expected in the West. Yet these relative higher levels of income will not be evenly distributed over the geography of the West. Areas of depressed and declining economies in rural settings, in and near Indian reservations, and where natural resources are being depleted will require national attention in the future. For example, the average per capita Indian income in the West was only one-half of the Westwide average in 1970.

Using the 1972 Series E OBERS projections published in April of 1974, Table III-4 presents a State by State estimate of expected earnings by nine economic

Table III-3.—*Projected earnings by State (millions of 1967 dollars)*

State	1969	Year 1980	2000
Arizona	$ 4,309	$ 7,627	$ 18,051
California	61,782	91,906	182,034
Colorado	5,661	9,610	19,450
Idaho	1,632	2,309	4,240
Montana	1,579	2,144	3,649
Nevada	1,626	2,769	6,185
New Mexico	2,184	3,224	6,209
Oregon	5,387	8,179	15,938
Utah	2,367	3,759	7,832
Washington	9,832	13,300	25,188
Wyoming	823	1,152	1,972
Westwide total	$ 97,182	$145,979	$ 289,748
Percent change		50	198
United States total	$554,912	$828,666	$1,655,420
Percent change		50	198

Source: 1972 OBERS Projections – Series E – April 1974, Volume 4, Water Resources Council.

groupings – agriculture, forestry, and fisheries; mining; construction; manufacturing; transportation, communications, and public utilities; wholesale and retail trade; finance, insurance, and real estate; services; and Government. The growing concentration of activity in the manufacturing and services groupings generally follow the National trends. Inasmuch as historical trends form the basis for OBERS and do not reflect currently expected growth in minerals, especially those related to energy development, some important shifts in the distribution of earnings could occur.

Mineral Development for Energy and Other Uses. – Meeting any reasonable projection of energy requirements for the Westwide Study area and demands for export to other power markets in adjoining States will play an increasing role in the economy of the West. Implications for water quantity and quality in the future are many, varied, and complex. Water problems which must be faced to meet increasing energy requirements in the next decade or two involve mining, processing, cooling, and siting of energy plants. Additionally, satellite towns and industries that must provide needed services will require water supplies. Hydroelectric power is expected to play a relatively smaller role in meeting future energy requirements.

Among the most significant possible impacts on future water supply planning will be the economic, environmental, and social impacts associated with the potential large-scale development of oil shale and coal resources. Development of oil shale deposits in Colorado, Utah, and Wyoming – the richest in the world – if it occurs, will require the founding of new communities on the western slopes of the Rocky Mountains. Water for this new energy development and the communities which would likely develop around it would place new demands on an already tight supply. Pollution problems, especially salinity, may be aggravated as a result. Treatment of mined ore and reclamation of spoil areas will be a major environmental problem.

Coal development in Wyoming and Montana has the potential to add diversification to the economies of those two States. Coal development, if it occurs, like oil shale will require new communities along with their support services, placing significant new demands on the water supplies. Reclamation of strip-mined areas may impose additional demands on water where it is needed for restoration or enhancement.

The great number of sites needed throughout the Westwide area for the siting of nuclear and fossil

Table III-4.—*Future distributions of earnings among economic groupings*

11 Western States—by States and totals

State	Agriculture, forestry, and fishery	Mining	Construction	Manufacturing	Transportation, communication, and utilities	Wholesale and retail trade	Finance, insurance, and real estate	Services	Government	State total
Arizona										
1969	259	185	337	746	251	707	231	675	917	4,309
1980	263	281	621	1,239	460	1,225	520	1,410	1,680	7,627
2000	327	430	1,260	2,634	1,053	2,500	1,340	3,757	3,750	17,051
California										
1969	1,939	313	3,460	15,141	4,332	10,340	3,387	10,378	12,491	61,782
1980	2,146	333	5,200	19,932	6,717	14,956	5,583	18,238	18,800	91,906
2000	2,636	376	9,907	35,106	13,350	26,969	12,469	42,209	39,013	182,034
Colorado										
1969	275	124	380	918	437	1,016	314	852	1,344	5,661
1980	350	165	692	1,589	713	1,752	569	1,694	2,087	9,610
2000	461	230	1,287	2,812	1,433	3,348	1,337	4,124	4,419	19,450
Idaho										
1969	265	30	109	270	111	275	60	213	278	1,632
1980	280	29	151	396	152	390	99	386	427	2,309
2000	350	33	259	708	262	655	208	906	858	4,240
Montana										
1969	253	54	100	177	143	262	60	205	325	1,579
1980	254	56	141	239	178	355	92	338	492	2,144
2000	299	68	225	391	267	579	179	702	940	3,649
Nevada										
1969	35	34	131	69	114	233	68	632	310	1,626
1980	42	40	207	119	201	384	134	1,113	530	2,769
2000	54	58	425	257	455	808	336	2,526	1,265	6,185
New Mexico										
1969	149	140	146	131	153	315	86	400	663	2,184
1980	172	158	221	213	231	466	151	677	934	3,224
2000	210	193	407	421	437	829	336	1,515	1,860	6,209
Oregon										
1969	230	12	344	1,424	436	1,035	261	759	885	5,387
1980	216	16	491	2,033	631	1,474	451	1,421	1,443	8,179
2000	249	23	911	3,631	1,154	2,593	1,009	3,354	3,014	15,938
Utah										
1969	73	108	131	391	191	406	98	323	647	2,367
1980	82	127	227	579	291	607	175	634	1,038	3,759
2000	101	169	435	1,074	564	1,153	415	1,613	2,307	7,832
Washington										
1969	440	14	619	2,574	649	1,652	499	1,300	2,084	9,832
1980	410	22	866	2,808	924	2,240	781	2,261	2,989	13,300
2000	485	30	1,537	4,723	1,715	3,913	1,678	5,177	5,929	25,188
Wyoming										
1969	72	102	66	55	86	122	28	103	189	823
1980	88	117	97	78	112	165	43	169	282	1,152
2000	103	158	168	137	174	266	85	354	526	1,972
Westwide										
1969	3,990	1,116	5,823	20,996	6,903	16,363	5,092	15,840	20,133	97,182
1980	4,303	1,344	8,914	29,225	10,610	24,014	8,598	28,341	30,702	145,979
2000	5,275	1,768	16,821	51,894	20,864	43,613	19,392	66,237	63,971	289,748
Index										
1969	100	100	100	100	100	100	100	100	100	100
1980	108	120	153	139	154	147	169	179	152	150
2000	132	158	289	247	302	267	381	418	318	298

Source: 1972 OBERS Projections—Series E—April 1974, Volume 4, Water Resources Council fueled thermal electric and coal gasification plants will necessitate judicious planning in the near time frame. Utilization of surface and ground-water supplies and wastewater and return flows from irrigation have good potential for cooling water. Though perhaps farther in the future, the use of cooling water discharge from nuclear complexes for irrigation, recreation, and fish and wildlife show promise in areas of abundant water and large arid land areas in central Washington and Oregon. Making fresh water in joint production with power in Southwest areas of water shortage out of geothermal brine may prove economical in the future.

There will be increased demand for petroleum, natural gas, and uranium as sources of energy although these do not involve water to a great extent. Other important minerals found in the West such as copper, phosphate, trona and molybdenum will add to the economic growth in various areas and will have some effect on municipal and industrial water supplies.

Yet, to make it all fit together – economically, environmentally, and socially – the need for institutional rearrangement will become even more pressing in the near future. The national objective of attaining national self-sufficiency in energy production inside of 10 years, will require coordinated regional planning, more efficiently structured procedures for site approvals, and more long-range planning at all levels of Government and industry. The energy crisis may be more of an institutional lag than a technological one. The ability of the American people to advance and compress both institutional and technological change in a short decade is well demonstrated by the successful space program including manned trips to the moon.

Irrigation Development. – Federally sponsored irrigation has played an important role in the economic development of the West. Western economics have industrialized to the point where further irrigation development is questioned as being a major factor for growth. No doubt western irrigated agriculture will continue to make a substantial contribution to the production of food and fiber even though its relative position in national production may diminish. There remains in the West, however, significant areas of abundant water and contiguous land resources where additional production can be secured through new irrigation or providing supplemental water supplies. Although private investment will continue to support the growth of irrigation it is likely that Federal assistance programs will be required in the future if there is to be large-scale multipurpose and multiobjective development of water and land resources. Because of the large proportions of western water devoted to irrigation, future emphasis is anticipated on programs to improve water management systems on currently irrigated areas to reduce associated water losses and improve water quality.

Available projections of future food and fiber needs present a cloudy picture at best. The assumptions made in OBERS projections and those of the National Water Commission analysis which suggest that further allocation of water for irrigated agriculture is not warranted in the near future seems to be in conflict with recent national and international food shortages. The beneficial effects on United States trade balances and the need for National and international food reserves raises again the questions of what indeed is the appropriate role of the Federal Government in extending financial assistance to new irrigation projects.

New interest, though not yet well defined, is seen growing in the future in programs to arrest rural decline and to improve economic conditions in chronically depressed, agricultural oriented, small trading centers. Recent legislation in the form of the Rural Development Act of 1972 attests to this concern. As farm populations continue to decrease and farm transactions shift to larger trading centers, rural counties and small towns will stagnate and wither. New economic opportunities must be found to supplement the agricultural base in these rural areas. The migration of displaced agricultural workers places additional demands on metropolitan centers.

Establishing policy on Federal support of the improvement and development of irrigation will require much more reliable information on comparative farm production advantages, future national and international needs, and relationships to desirable social and economic conditions in rural and sparsely populated areas.

Outdoor Recreation. – With projected shorter workweeks and increased affluence the role of the West as one of the Nation's playgrounds will continue to be important. There will be increasing demands for water-related recreation near urban areas. Tourists in increasing numbers will enjoy the wilderness and primitive areas, the wild and scenic river reaches, and in so doing, will have important impacts on the economy of the West. The problems of overuse of the National parks and recreation areas will be an increasing concern. Waiting lines at campgrounds and the current necessity to have advance reservations at such scenic areas as Yellowstone National Park draw mute testimony to the problem.

Other Related Economic Factors. – Overall, it can be expected that the future Western economy will become stronger and more vigorous as new opportunities are created from the demands of a dynamic society, a changing economic structure, and a search for improvement in the quality of life. The major economic questions impacting on new water supplies concern the development of energy and other mineral resources, meeting the growing leisure needs while maintaining the high-quality environmental settings of rivers and lakes, providing for industrial needs, and the potential use of available water and land resources for irrigated agriculture. Concentrated urban growth will bring many new problems concerning flood-plain management and use including parks and open space, water quality protection, and competition for outdoor recreation outlets. Major water-supply systems will require expansion to meet municipal growth. There will be some scattered problem areas in securing supplies, but the primary needs will be related to small rural communities. Cutting across all these problem areas are the technical means and the new institutional arrangements needed to make better and more efficient use of existing supplies.

Environmental Quality

In response to the concern over protection of environmental values, much Federal and State legislation has been passed that set goals and made commitments in an effort to protect and improve environmental values. The National Environmental Policy Act (P.L. 91-190) and other national legislation prescribes goals and objectives such as: preservation of wilderness areas on public lands, establishment and preservation of wild, scenic, and recreational rivers; protection and management of fish and wildlife resources; protection of endangered animal species; prevention, control, and abatement of water pollution; protection and enhancement of the quality of air resources; and protection and preservation of historic properties. Even though serious attention is being given to accomplishment of these goals, the degree that the goals can or should be reached is still being debated. The public has and is still demonstrating a willingness to sacrifice some developmental opportunities and indicated economic betterment for action programs which are designed to protect and enhance certain aspects of environmental quality. Even though the ground rules are being formulated, the tough realities of implementation and how they impact on water use and development are yet to be faced. They raise a great number of issues which are so interrelated that a discussion of one includes many of the others. The subsequent discussion is focused on how certain environmental efforts will meet important water conservation and water quaity concerns of people today and how they may influence the future of water-related plans and management programs.

Park and Recreation Areas. – Acreages set aside as National and State park and recreation areas have increased in the last decade and laws relating to protection of such areas have been strengthened. The number and size of municipal parks, greenbelts, and trails have increased as more county and municipal governments have organized park and recreation authority and obtained funding. The recently published National Plan "Outdoor Recreation – A Legacy for America" calls for completion of a program for "* * * Acquisition of those superlative areas needed to round out the Federal Recreation Estate * * *" and continued use of the land and water conservation fund "* * * to acquire needed Federal lands and assist the States in acquiring and developing recreation lands and facilities and to improve the management and administration of recreation resources * * * "

Wild, Scenic, and Recreational Rivers and Other Stream Values. – In the West, the first studies of the 1,126 stream miles authorized for study under Section 5(a) of the Wild and Scenic Rivers Act are nearing completion. These studies provide the basis for Congressional decisions as to the miles to be added to the 508 miles already placed in the National system. Until such decisions are made, the river reaches included are reserved from development.

The 2,398 miles of stream reaches now listed under Section 5(c) of the Act are protected to the extent that studies of wild river aspects must be done when alternative development proposals are being considered for those reaches. These studies may result in certain reaches of rivers being added by Congressional action. Also important are additions that may be made to the 1,326 miles of streams protected under State wild and scenic river laws in Oregon and California. Other States may establish wild and scenic river systems also.

Several States have recognized instream flows for fish and recreation, and water quality as a beneficial use of water and other States are giving this active consideration. Studies to identify amounts of flow required to sustain fish populations in streams have been initiated in some areas. Information from these studies will provide a basis for specifying instream water requirements for reaches which have important fishery values. Some water control and management programs will require adjustment to accommodate this purpose. Stream fisheries may benefit from the streamflow regulation provided by water management programs.

Although the supply of water available for future use is not threatened by protection programs, storage and diversion sites will have to be located and planned with streamflow requirements in mind. In several instances, opportunities for development of hydroelectric power may be preempted. At a minimum, planners will find increased difficulty in presenting acceptable development plans where streams with identified free-flowing vaues may be affected. The development of a range of alternative plans for these streams in accordance with the Water Resources Council's Principles and Standards will greatly improve the planning and decisionmaking process.

Wilderness, Primitive, and Natural Areas. – Under the Wilderness Act (Public Law 88-557) and related programs administered by Federal agencies, the acreage of land and water legally or administratively protected from further development or uses not compatible with wilderness, primitive, or natural areas is expected to increase. A portion of the 30 million acres of Federal land now classified for study under the Wilderness Act will most likely be added to the 10 million acres already included in the National Wilderness preservation System. Increases are also expected in the 241,000 acres identified as primitive areas on lands administered by the Bureau of Land Management, the 1 million acres identified as Research Natural areas by the Departments of Interior and Agriculture, and the 800,000 areas identified as natural landmarks under a program administered by the National Park Service.

Biological Resources. – The variety and number of living natural resources in the West fluctuates in response to natural biological cycles and environmental changes wrought by man. The majority of species remain in useful abundance and with adequate management is expected to continue. Some species, however, have been eliminated from their former range and have declined almost to the point of extinction.

The protection afforded rare and endangered species of plants and animals has increased greatly during the past decade and this trend may continue for some time. The recently strengthened Endangered Species Act provides national emphasis to protective measures. As more is learned about the habitat requirements of such species, more effort and more land and water may be dedicated to preservation programs.

Endangered species of fish and other organisms depending on riverine habitat are affected by water resource development. In addition, construction programs disrupt or impair habitat for some species that are less water dependent. Water development and management programs can be used to develop, maintain, and protect necessary habitat. However, in the future water planners will need to develop alternatives which minimize interference with endangered species habitat.

The use of land and water resources for hunting and fishing has been increasing. Fishing has increased at a rate faster than the rate of population growth. Fish and wildlife management programs are expected to continue or even accelerate to meet current and projected demands. This will require more intensive management and protection of existing habitat as well as new refuge and intensive use areas. Protection of existing high-quality habitat from competing uses is especially important but complementary uses should be encouraged.

Consideration of fish and wildlife and other biological resources will continue to play a major role in water programs and conflicts over alternative use proposals will likely intensify. However, implementation of the current Principles and Standards for water planning will make important contributions to resolving these issues.

Water Quality. – With passage of the Federal Water Pollution Control Act Amendments of 1972, major water quality goals were established. These include elimination of the discharge of pollutants into navigable waters by 1985 and provision of water suitable for the propagation of fish, shellfish, and wildlife and suitable for recreating in and on by July 1, 1983.

Attainment of the goal will require an unprecedented commitment of funds and manpower as well as some major changes in water management programs. Water quality improvements will change the emphasis given to water programs.

Elimination of water pollution would render large quantities of water usable for a variety of purposes. However, multipurpose and comprehensive water plans and programs will have to be reshaped to recognize this emphasis. Managing water to maintain high quality may be more costly than the water development program of the past. With more attention to new technology for water quality control it may be that fewer water transfer schemes will be necessary. However, maintenance of high-quality water standards may restrict the short-term use which might otherwise be made of water.

Water Supply and Management

Most studies agree that using any reasonable projections of growth, the Southwest area will remain the West's hardcore area of water shortage. Three regions of the Southwest; the Rio Grande, Lower Colorado, and the southern portion of the California Region are already experiencing a tight water-supply demand situation. Regional surface water supplies are being augmented by a drawdown of ground water and importation from other regions to meet current demands.

Southern California imports water from northern California and from the Colorado Region to meet its water needs. The Lower Colorado Region has met requirements by overdraft of the ground-water supplies such as is occurring in the central Arizona area. The upper portion of the Rio Grande Region will also experience severe deficits in the near future and without new sources of water supply will have to resort to the conversion from irrigation to higher priority uses.

Available studies indicate that projected economic growth to the year 2000, will result in a deficit in water supply in the Great Basin Region, the Upper Arkansas-White-Red basins, and the Upper Platte River basins without major reallocations of agricultural waters to higher priority uses.

Recent successes in research and development of weather modification techniques suggest that greater reliance will be placed in the future on this developing technology for augmentation of existing water supplies. Specific problems involving environmental and institutional aspects will require greater attention before implementation is achieved.

Improvements in water management will receive increasing if not predominant attention in planning to meet future demands. The environmental ethic and new thrusts on conservation and shortage of suitable reservoir sites will make solutions to water problems more difficult. Many of the major river basins and subbasins in the West are already highly controlled by works of man. New demands will increasingly have to be met with reallocation of supplies, total water management concepts including conservation and improved efficiencies, and by salvage and reclaiming poor quality supplies. These approaches will introduce new complexities which will require modern systems analyses and computerized operational techniques to identify alternatives and find the best solutions.

Making better use of existing resources will require more than physical solutions which often cannot be implemented because of institutional constraints concerning water rights, pricing structures, and organizational structures of water planning entities at local, State, Regional, and National levels. Competition and conflicts in use in highly controlled river basins may bring strong pressure for change. The establishment of water rights for hitherto unrecognized beneficial uses such as for fisheries, recreation, and aesthetics will challenge man's abilities to make the most productive use of limited water supplies and the physical works already in place.

Indian Water Rights and Requirements

Past investments in water resource developments which involve rivers and streams running through or bordering Indian reservations, have in most cases not been for the benefit of Indians. The western Indians are currently seeking to redress this balance with water related programs and projects which are necessary to support economic development and other relevant needs on their reservations. The reallocations of scarce water supplies, presently in non-Indian use, could potentially temper patterns of economic activity in many areas of the West.

The Federal Courts have during the past 70 years exhibited their concern for the protection of Indian land and water resources through rulings favorable to the Indians. Although it is difficult to predict the specific rulings in the many facets of Indian water rights court proceedings, it seems likely that through some means water to meet legitimate water requirements for Indian reservations will become available. It is anticipated that more and more development programs will be implemented to utilize surface waters available to the reservations.

In some states where industries and firms have utilized water supplies which are in conflict with Indian water claims, water reallocations to Indians could occur.

Where there are reallocations, either an alternative source of supply will have to be developed, or be given consideration to use of existing supplies through water conservation, management, and water pricing to encourage more efficient use of scarce water over time. Ultimately, arrangements for Federal or State compensation to existing users may be involved in some instances.

Although it is uncertain as to how the courts will rule on the extent of Indian water rights, the water needs and requirements to support the purposes of the Indian reservations will undoubtedly be an important element in the legal proceedings.

Land Use

Congress is considering legislation on land use policy which would provide Federal assistance to the states for the purpose of land use planning. A number of states have already passed or are actively considering state land use bills. The issue of appropriate land use has emerged as a significant element of the overall resource planning problem as a response to a number of pressing concerns. The kinds of concerns requiring a more comprehensive land use planning effort include: urban blight; suburban expansion into mile after mile of tract housing developments each producing its own version of aesthetically unattractive results; revenue problems for core cities; decentralization of employment within metropolitan areas, transportation problems; location of homes and businesses in flood plains; increasing demands for domestic, municipal, and industrial water systems; encroachment of urban areas on prime agricultural lands; loss of important historic or cultural sites; and random development of second homes in mountain and desert areas.

Recent surveys in a number of states have shown that a majority of people would prefer to live in small communities where the "small town" atmosphere and sense of community identification can be obtained. However, most of those responding to such surveys also indicate a preference for the small community to be located close to a large metropolitan area. Thus, the general desire is to have both the small town and easy access to the amenities of the large city. Such desires are quite consistent with the proliferation of housing and industrial park developments outside core cities.

The focus of the concerns is thus upon (1) urban land use, (2) the location of key facilities – airports, highways, major housing subdivisions, ets., – which will significantly alter land use patterns, (3) the designation of areas of critical environmental concern, and (4) the preservation of valuable resource areas for agriculture, forestry, and mineral production.

In the West, the effect of concentrating on these concerns will be the increased attention to land and land use planning issues, thus bringing land and water planning into better balance. Water programs in the future of the West will necessarily be oriented to meeting the needs of land use plans. Because of the high concentration of federally owned lands in the West, there will be a special need to carefully define the character of the Federal role in water and land planning for the 11 Western States.

Changing Trends in Water Resources Planning

Any listing of factors significant in the future of the West would be incomplete if the changes in water resource planning were left out. In the last thirty years changes in social attitudes, values, preferences, and practices have occurred at a pace perhaps unparalleled in man's history. Johnson[1] has vividly described some of the major impacts of these changes upon water resources planning. As shown graphically in figure III-4, five major historical eras in water resource planning have been classified as to the central concern of the era, i.e., building, controlling, allocating, protecting, and social. With each new era the overall complexity of the tasks facing the planning community has increased. Even more important, however, is the fact that the time period associated with each of these eras has shortened. Thus, the water planning community is confronted with the paradoxical situation of having to treat increasingly complex demands in ever shorter periods of time.

Multidisciplinary and Multiinterest Planning. – As planning problems have become more complex, the specialized knowledge associated with different disciplines has come more into play. Interdisciplinary teams devoted to planning activities are now the norm rather than the exception and, in the future, the trend toward including more disciplines in the process will likely continue. The implementation of new legislation and administrative policy impacting water planning along with the emphasis upon increasing involvement of state, local, and private entities in the planning process mean an increasing emphasis upon intergovernmental participation.

---

[1] Johnson, G. P., "Applied futures research for water resources planning." Unpublished manuscript. Center for Advanced Planning, Institute for Water Resources, Corps of Engineers, Alexandria, Virginia, 1972.

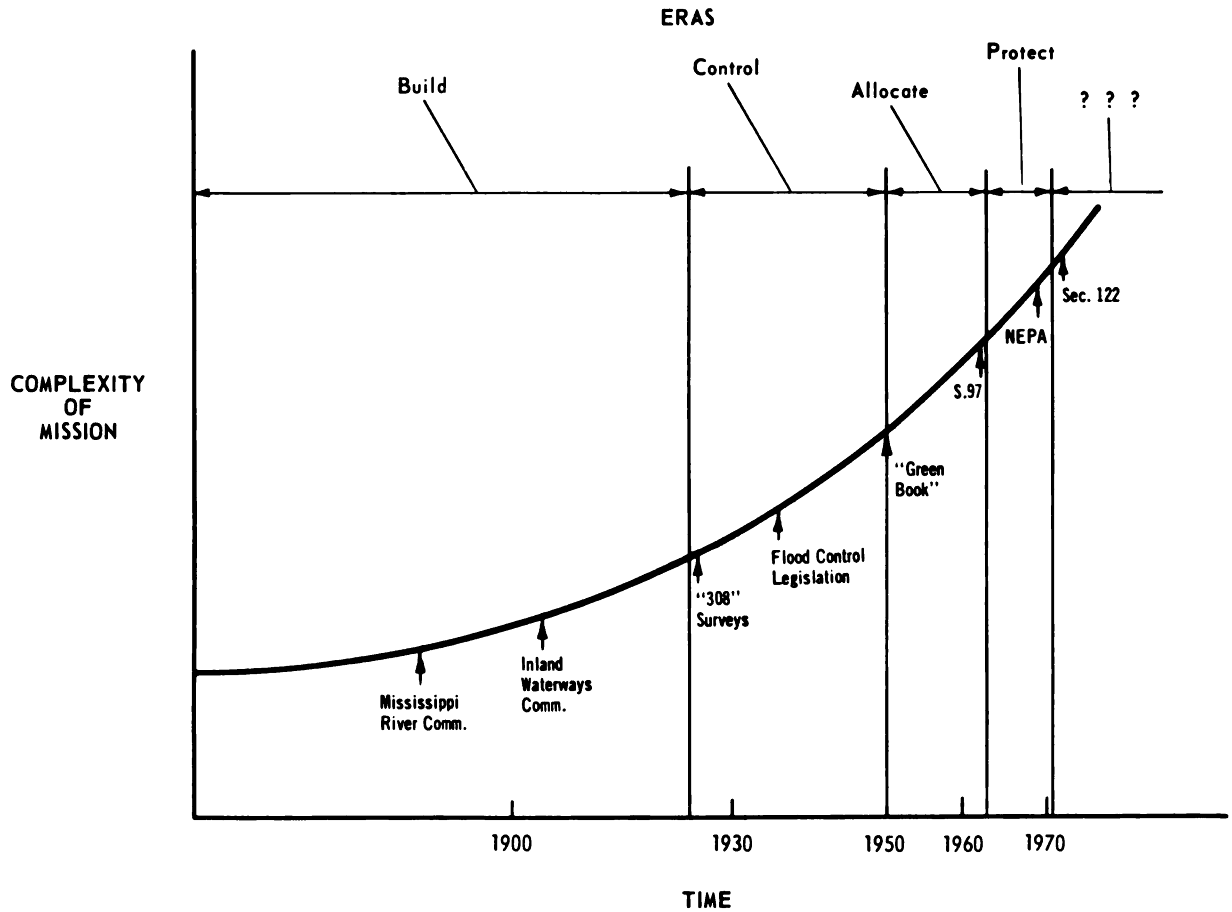


Figure III-4. Major historical eras in water resource planning.

Another trend is increased public involvement and participation in the planning process implemented via a substantial variety of value systems and interests in planning: for example, the National Environmental Policy Act of 1969 and the Council on Environmental Quality Guidelines for preparation of environmental impact statements, the Federal Water Pollution Control Act Amendments of 1972, and the Water Resources Council's Principles and Standards. The character of future water resources planning will more and more directly involve the public than ever before as a consequence of these and other Federal laws.

Changing Techniques. – New techniques in planning are emerging. Among these are more sophisticated and complex forms of modeling, using computers to simulate physical, economic, social and environmental conditions and to evaluated impacts of alternative decisions and policies. Tradeoffs, both quantitative and qualitative, will be examined more carefully than ever before with such techniques. The methodologies for generating alternative future scenarios will advance with the aid of computers and, as methodologies for generating and using alternative futures become more accepted, the role of this promising concept in water resources planning will enlarge. Judgmental values will be used to establish priorities among issues and alternatives. Accurate technological forecasting will be very important in the planning process.

Analyses of attitudinal, belief, value, and behavior system differences will be more carefully and systematically addressed in the planning process. Social and institutional concerns which provide the context for so much of planning will be considered as objectively as the physical parameters are today. Linkage between natural resource planning and human resource concerns will become more evident.

Finally, the very character of planning is changing in a way which more completely recognizes the dynamics of the interdependent social, economic, and physical system interactions which occur in society. Planning is being conceived more as an ongoing process with greater flexibility to meet changes in priorities, needs, and requirements of society as such changes occur at an accelerated pace. Recognition of the process character of planning will facilitate development of the anticipatory capability necessary to good long-range planning.

Implications of Changing Directions in Federal Water Planning Policies. – Even though no clear, integrated national water policy has been articulated, it is possible to see changes in the direction of national policy emerging which will affect future water programs. The first years of the 1970's have been host to dramatic changes in response to emerging new public values and viewpoints on environmental, economic, and social aspects of water programs. The advanced degree of water project development, the growing scarcity of water, and the greater emphasis on quality as opposed to quantity are combining to force new directions in water policy. Recent evidence of Federal activities began with the Task Force Report of the Water Resources Council of July 1970 modified by Proposed Principles and Standards published in the Federal Register on December 21, 1971, and culminated with the approved Principles and Standards. The practical problems of putting them into effect lies in the immediate future.

As previously mentioned the National Water Commission's prolific recommendations covered a wide spectrum of water and related land problems including legal facets as well as organization of water planning establishments; economic parameters; environmental aspects; and cost sharing. The recommended changes for non-Federal cost sharing are probably one of the most sensitive issues facing future decisionmakers. The Commission's recommendations for greatly reduced Federal subsidies for many purposes have generated a great deal of interest and controversy; and, if implemented, could have major impacts on water plans.

The enactment of proposed legislation for reorganization of the Federal water planning establishment into a single entity at the Departmental level would result in important changes in agency responsibilities in water and land resources. Such broad institutional changes may influence the policies and direction of certain mission-oriented agencies which have evolved over a long period of time. Proposals for consolidation and integration of Federal activities in water and land resources have been made many times in the past by special commissions, councils, and other study groups. Such an approach may result in a more cohesive and efficient water planning, development, and operating structure which is more responsive to the changing needs of local, state, and national interests. The final decision awaits future action by Congress.

Future Programmatic Impacts of New Planning Criteria. – The newly established Principles and Standards provide for the formulation of plans to explicitly recognize two objectives of national economic development and environmental quality. A four-account system for evaluation of beneficial and adverse effects is to be used to display impacts on these two objectives plus two accounts relating to regional development and social well-being. One plan is to be formulated to make optimum contributions to the national economic objective. Another plan is to be formulated to emphasize contributions to the environmental quality objective. A recommended plan must have sufficient national economic benefits accruing in monetary terms to direct users to offset all project costs, unless the environmental objective is served. Some provision is made for exceptions where significant physical, technological, legal, or public policy constraints are involved.

The explicit planning for the two stated national objectives of national economic development and environmental quality and the application of an interest rate substantially higher than has been used in the past[1] will no doubt have important implications for the types and numbers of proposed water plans in the future. Many plans on the books may need to be reformulated or discarded. The final interpretation as to which authorized but unfunded projects will be subject to the approved Principles and Standards has important ramifications because of the large backlog of authorized water projects. Because this backlog has accumulated over a long period of time, restudy cannot be conducted simultaneously for all projects and programs and careful screening as to the relative criticality of need will be necessary.

Although a considerable amount of reanalysis and appraisal will be necessary before definite conclusions and recommendations can be drawn on the application to presently formulated plans, some

[1] It should be noted, however, that the interest rate is subject to Congressional action which may result in a reduced rate.

preliminary judgments can be drawn. The primary effects of the increasing discount rate are that future benefits are discounted to a greater extent than formerly, and annual capital costs are increased. Future analyses will bring into question the more marginal projects and will give considerably less weight to long-term project impacts.

Perhaps the greatest effect will be on Bureau of Reclamation plans in the 11 Western States which include irrigation of new lands as a major purpose. It is possible that more than one-half of those plans will not meet the criteria for justification under the economic efficiency criteria. Those remaining would likely cover smaller service areas encompassing only the most productive lands. The character of new and reformulated projects would shift more to those providing supplemental water and those involving low initial investment. The relatively high initial cost of reservoir storage and interdependency of the various purposes served, could mean that a substantial number of multiple-purpose storage projects will have difficulty in meeting the new criteria.

Also it is expected that more alternative plans will be formulated to serve the environmental quality objective and be forwarded for approval and implementation. Greater consideration will be given to meeting needs with less reliance on major structural measures with justification relying on a careful analysis of an attention to the nonmonetary; social and environmental values. Future water resource planning investigations should anticipate and make allowances for a transitory period which normally follows major changes in policies and standards.

Potential New Cost-sharing Rules and Future Plans. – Just what new cost-sharing ground rules will finally result from current activities in this field is highly speculative. There appears to be widespread agreement with the National Water Commission's broad recommendations that there be greater uniformity and consistency in policies applicable to various Federal water resource agencies serving comparable purposes, and among alternatives achieving the same purpose. However, consideration is still being given to the National Water Commission's recommendations which generally call for much higher levels of non-Federal repayment by direct beneficiaries. A high non-Federal cost-sharing policy would encompass difficult problem areas such as identification of beneficiaries and inadequate pricing and taxing mechanisms; impacts on the fulfillment of future water needs involving long-range investments; in local areas, beyond the financial capability of present residents of the area; difficult coordination arrangements for repayment of projects benefiting more than one group of beneficiaries; and ramifications of a major shift in financial responsibilities from historic Federal participation to non-Federal interests.

The adoption of cost-sharing policy for non-Federal interests requiring substantially greater payback than now required could have a greater impact than that discussed above for implementation of the new Principles and Standards. There are, however, some prospects for increased cost sharing by non-Federal interests. There is a trend toward the greater use of conservancy districts as a means for assessing project beneficiaries. Legislation exists in 8 of the 11 States in the west – excluding Washington, Oregon, and Idaho – which permits the establishment of water resource districts. Some States have established funds which are available for financial assistance to local entities for development of water resources.

Because critical water problems do exist and because of the long lead time required in carrying out many of the solutions, water planning should proceed while awaiting Congressional establishment of cost-sharing criteria. However, care must be taken to make recommendations for ongoing and future water planning studies flexible enough to recognize these changing directions of national water policy.

Comprehensive Planning. – During the period fiscal year 1965 through fiscal year 1971, approximately $250 million of State-Federal planning monies were spent in the 11 Western States for water and related land resource studies including the development of comprehensive framework plans. Except for a portion of New Mexico and Colorado, the total area of the 11 States was covered by such studies. Table III-5 lists the study areas, the type or level of study, and the date plans were published.

Table III-5.–*Comprehensive inter-agency studies conducted in the 11 Western states (Water Resources Council coordination)*

Study area	Level of study	Publication date
Columbia North-Pacific	Type I	June 1972
California	Type I	June 1971
Great Basin	Type I	June 1971
Upper Colorado	Type I	June 1971
Lower Colorado	Type I	June 1971
Missouri	Type I	December 1971
Puget Sound	Type II	1971
Willamette	Type II	1969

Generally the approach used in the Type I Framework Studies was to translate OBERS projections of national and regional requirements for water and water-related goods and services and then compare these future requirements with water supplies and existing facilities. The result was labeled "water needs" for the purpose of formulation of alternative plans. Broad-gaged and rather ambitious plans were formulated to meet these "needs" identified by the projections of historic trends modified by the judgment of those formulating the plans. In most cases, the resulting plan was displayed in tabular form that indicated the acre-feet of storage or other actions required for various purposes. Additional detailed studies were recommended to meet the near-term requirements.

For the most part, the framework studies were effective in pulling together inventory on the current situation and in determining potential water development opportunities. However, most of the studies were not able to respond to emerging changes in water policy and national goals occurring at that time such as the National Environmental Policy Act. Features for environmental quality enhancement were included only where their establishment would complement or enhance traditional water control features. Generally, environmental quality needs were to be accomplished by further studies or by other programs. Exceptions to these statements occurred with the more recently published studies such as the Columbia North-Pacific.

While future work on water control features was suggested, implementation of the comprehensive plan was left to individual Federal, State, and local agencies. Because the plans were general in nature, priorities, funding, project costs and benefits, cost sharing, and responsibilities for action were not presented in detail. Their usefulness to future planning in the west will be primarily through their contribution to baseline hydrologic and similar data systems.

The Use of OBERS Projections in Perspective. – Among the tools developed for use in comprehensive framework studies were the OBERS projections of economic activity. They represented the only nationally consistent projections available for planning purposes and have, therefore, received a great deal of attention. Unfortunately, misunderstanding of the character and use of projections has occurred, and some of the limitations of projections are now becoming clear. For example, the reliability of projections, one of their most important features affecting their utility, is high at high levels of aggregation such as at the national level; at succeedingly lower levels of aggregation the reliability diminishes. The same pattern holds for increasing periods of time into the future; the further out in time, the lower the reliability. The difficulty facing water planners is that much planning must proceed from the lowest levels of aggregations up toward higher levels.

Another kind of misuse of projections has been to establish goals for planning. It is now generally realized that projections cannot be used to establish goals and that a range of alternative futures must be recognized. Complex economic, political, social, and environmental conditions must be analyzed for planning areas using planning goals as well as projections.

State Water Planning Activities. – More recently, with encouragement of the Water Resources Planning Act of 1965, efforts were initiated to assure that each State in the West had the opportunity to complete a State water plan. Early in the Westwide Study an attempt was made to coordinate the Study with the completion of State plans in each of the 11 Western States. It was anticipated that State plans would be completed prior to completion of the Westwide Report. Although this was not accomplished for most States, the ongoing work on State water planning, coupled with State reports prepared by Westwide State study teams, was a significant source for the identification of critical problems and problem areas considered in the Westwide Study. Through revenue sharing and other measures, current policy attempts to place responsibility for water resource decisions and plan implementation to State and local governments. If this trend increases as expected, State and local governmental plans for resource use in the West will become more important. As State and local governmental entities bear more of the responsibility for financing future water and related land development, the plans proposed will influence comprehensive planning to a greater degree. The most effective planning may occur under State led planning teams with Federal agency representatives participating rather than leading.

Future Level B Studies. – The previously conducted comprehensive framework studies were not, in all cases able to consider the impacts of the water quality control legislation. Section 209 of the 1972 Amendments to the Federal Water Pollution Control Act authorizes Level B studies to be prepared by the Water Resources Council by 1980, with priority for planning given to areas designated by

State and/or local governments in need of areawide waste treatment management plans.

The character of comprehensive planning is likely to change under the Federal Water Pollution Control Act Amendments of 1972. Future plans were expected to emphasize measures to control pollution and improve water quality with other water uses included to the extent they complement areawide wastewater treament plans. Study areas may be drawn on the basis of wastewater problems rather than by major drainage basins. Also, such study areas are likely to be geographically smaller than those previously considered.

With aggressive management of the 209 Program, the studies may focus on the measures and facilities necessary to complete useful water plans using inventories of existing resources and problems from completed studies. Under that assumption, the measures and structures necessary to problem solution will be identified, and detailed planning and implementation of water programs can proceed in an orderly and timely manner.

National Assessment. – Another planning effort scheduled for completion in the near-term future is the Second National Assessment of the Nation's water and related land resources. This assessment will identify, describe, and set a priority for the Nation's severe existing and emerging water needs and problems from both the state, regional, and national viewpoint.

These needs and problems will be identified and described at national, regional, state, and subregional levels for a range of future conditions regarding water policies, population growth, economic growth, environmental quality and implementation of improved water use technologies. The assessment will compare the identified needs and problems with estimates of available (1975) water supplies to determine the adequacy of the Nation's water and related land resources to meet the needs and goals of the people. Although this effort will indicate where water resource planning and development might alleviate future problems, alternative methods for solving identified problems will not be presented. The usefulness of this effort will be in understanding where to direct future study efforts.

It should be noted that while some responsibilities were shared by Westwide and the National Assessment and some similarities in objectives of the two studies existed, care was taken to coordinate study activities where possible and to avoid duplication between the two study efforts.

SUMMARY COMMENT

The basic objective of this chapter was not to be a comprehensive treatise on all of the problems of the West. Rather it was intended to examine certain salient aspects of the 2-1/2 decades remaining in this century and identify, to the extent possible, where problems relating to the use of the water and related land resources in the 11 Western States are emerging.

The focus was upon the people, the economy, changing demands and priorities for energy, environmental quality, water and land management and use, the role of the American Indian, and changes in planning, as each of these relate to the critical problems detailed in subsequent sections of this report. This overview of the factors which will influence the future of the West suggests that critical problems either now exist or can be anticipated in the near-term future. It poses the challenge for the establishment of clear priorities, creative planning, and careful implementation in order to achieve solutions to these problems in the best interest of both the West and the Nation. It is not a question of planning versus no planning, but whether growth will be channeled into directions which will optimize the quality of the life of people now in the West and those who will join their ranks in the future.

CHAPTER IV
WESTWIDE PROBLEMS

INTRODUCTION

The critical water-related problems in the West today are complex and interrelated with other problems to the extent that they cannot be neatly arranged by the traditional water functions, or by geographical areas. The problems are multifaceted and vary from broad general problems which exist throughout most of the Western States, through those encompassing major geographic regions, down to those in specific localized areas. This chapter focuses on those that are common to most of the Westwide area; chapter V on those regional problems applicable to a major river basin or two or more States; and chapter VI on those problems that are more State specific, including discussions on the local relationships to Westwide and regional problems.

The grouping and classification of the problems, which cover a wide spectrum of technical as well as institutional factors, rely on the combined judgments of the evaluators as to the extent of importance of an individual problem, or collection of interrelated problems which could be viewed as a set. Alternative problem resolutions are discussed where appropriate, and conclusions and recommendations are drawn for each of the critical problems identified.

The critical problems presented were selected primarily through three separate procedures: (1) The development of issue papers was for the purpose of evaluating critical problems. The State and Federal Study Team members experience, knowledge, and judgment were called upon in developing the issue papers that addressed critical Westwide water and land problems; (2) Selection and analysis of major water problem areas by the multidisciplinary, multiagency members of the Westwide Management Group, based on their knowledge and understanding of national and regional water priorities; and (3) Development and use of an analytical evaluation system whereby judgments were systematically weighed for such factors as (a) the number of people impacted, (b) severity of impact, (c) urgency of problem in relation to time, (d) environmental impacts, (e) economic effects, and (f) social effects. None of the procedures within themselves fully defined the degree of criticality; however, cumulatively, they were considered to provide a reasonable basis for selection of critical water problems.

The major problems considered in the Westwide Study are of sufficient priority to warrant recommending new or additional studies in the next 5 years. The particular order of priority or the degree of criticality will vary depending on what future actually develops in the West; however, every listed problem is now or is projected to become critical within the next 10-15 years.

Preservation and enhancement of environmental quality was considered as a major objective to be planned for in any resource development. Studies necessary to make decisions on environmental conservation matters such as wild, scenic, and recreation rivers were identified. Those environmental studies needed to accomplish multiobjective planning as set forth in the National Environmental Policy Act and the approved Principles and Standards, were outlined and considered to be necessary parts of future planning programs.

Even though adequate studies have been performed, certain critical problems persist in the West today because action programs designed to resolve them have never been implemented. It is assumed that congressionally authorized but unfunded projects will be implemented unless base conditions have changed to the degree that the plan is no longer responsive to the problems or by solving that problem, would create other problems. In that case, the authorized agency responsible for the program should take the necessary action for revision to satisfy changed requirements. The problems with authorized solutions are only briefly mentioned to support their criticality; however, they do not require recommendations for additional studies.

This report concentrates on two categories of problems. The first category contains those problems for which studies are authorized or underway but for which there should be additional State and Federal involvement or additional funding provided. These problems are covered to the extent necessary to dimension of the additional involvement or funding required. The second category, which encompasses the majority of the problems presented, involves those critical problems for which new study authorities are needed and where substantial new funding will be required.

Some of the Westwide problems are of a general enough nature that complete conclusions and recommendations are included in the problem writeup. Other Westwide problems have different applications or impacts in each State and require supplemental State or regional problem writeups to complete the presentation.

It is important to recognize that only the more important unresolved water and water-related problems are being presented. There are many other problems in the West that are being addressed by ongoing action programs. State and Federal responsibilities in these areas continue to require funding. Also there are some major water-related study needs such as navigation and flood control which have not been addressed where they do not directly impact water supplies. As such the program set forth in this document does not purport to be a complete treatise of all water and related land resource needs in the West.

At the end of chapter VI, there is a summary tabulation of all the studies recommended for initiation in the FY 1976-FY 1980 time frame. This tabulation dimensions these studies to the extent of participation, length of study, whether additional funding is needed, and the type or level of study proposed.

WESTWIDE NO. 1 – WATER REQUIREMENTS FOR ENERGY

SUMMARY

The role of Western water in meeting future high-priority energy needs is tied primarily to the development of large reserves of coal and oil shale, waste heat disposal from thermal electric and fuel conversion plants, supplying municipal growth directly associated with fuel production, and providing hydroelectric peaking power capacity. Although the current rate of growth of energy use is likely to be reduced nationwide through conservation measures, it is expected in the foreseeable future that increasingly large demands will be placed on Western resources. The great number of new and enlarged sites required for mining, processing, and energy conversion located in the Southwest, Rocky Mountain Region, and the Northern Great Plains will have important ramifications on both quantity and quality of water supplies. As much of the mineral energy wealth is located near or in areas involving national assets of high environmental values, the need for judicious and timely water and related land planning will pose many pressing issues. Because the Westwide area embraces the most highly developed systems of hydroelectric power in the Nation, potentials for new hydropower especially at existing structures will be considered in search of additional sources of energy.

DISCUSSION

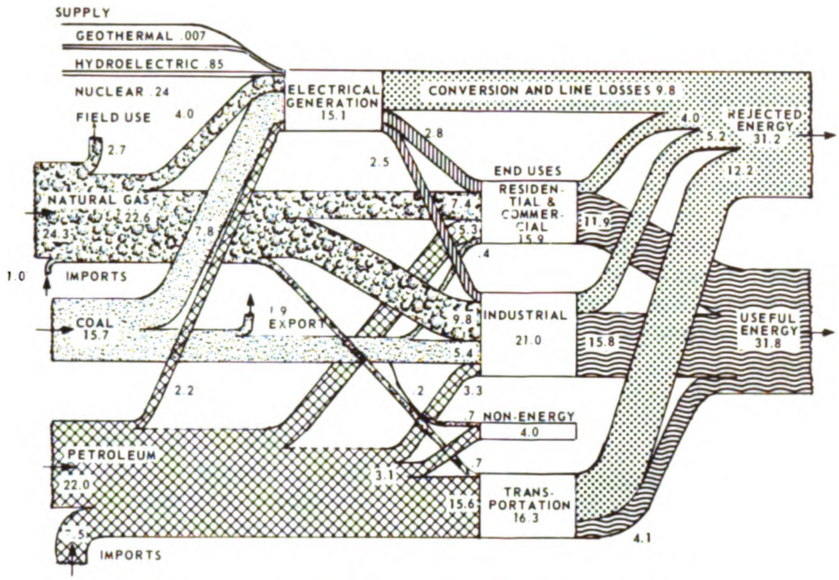
This discussion is a brief overview of the future energy development problems of the West to examine recent trends and projections, and overall implications on water supply. Since many of the associated problems are site specific, more details are presented in Chapter V, Regional Problems, and Chapter VI, State Problems.

The facts of today's United States energy picture speak for themselves. More energy has been consumed since 1940 than in all previous history. In the United States, current trends in increasing energy demand show a close correlation with the increasing Gross National Product. There is also close correlation between growth in per capita income and per capita energy use; the latter now at about 680,000 Btu per capita day. This rate compares with a world average of about 135,000 Btu per capita and stands in sharp contrast to a rate of 27,000 Btu per capita day in India. The American high-energy life style and industrialization of undeveloped countries is expected to increase the world per capita use rate and put new demands on all energy resources. In the United States, overall energy use is generally expected to triple by the year 2000. Even if a much more conservative growth pattern is assumed, the enormity of the related problems to be faced in the foreseeable future does not change significantly. They simply move forward slightly on the overall time scale in the latter part of this century.

A revealing picture of the energy flow patterns in the United States by major sectors for 1970 is shown in figure IV-1. For comparison, one approximation of the near-term United States energy trial balance of energy flow in the year 1985 is shown also in that figure. An increase in coal use, the increasing use of nuclear power, the growth of all consumptive sectors, the larger percentage of rejected energy from new sources, and the nominal decrease in natural gas use all suggest significant changes in the energy system. Of particular note is the projected increase in the electrical generation sector which is expected to emerge as the largest primary energy producer and consumer of fuel. Energy conservation, increased heat conversion efficiencies and changing technology away from conventional fuel burning could obviously influence this picture.

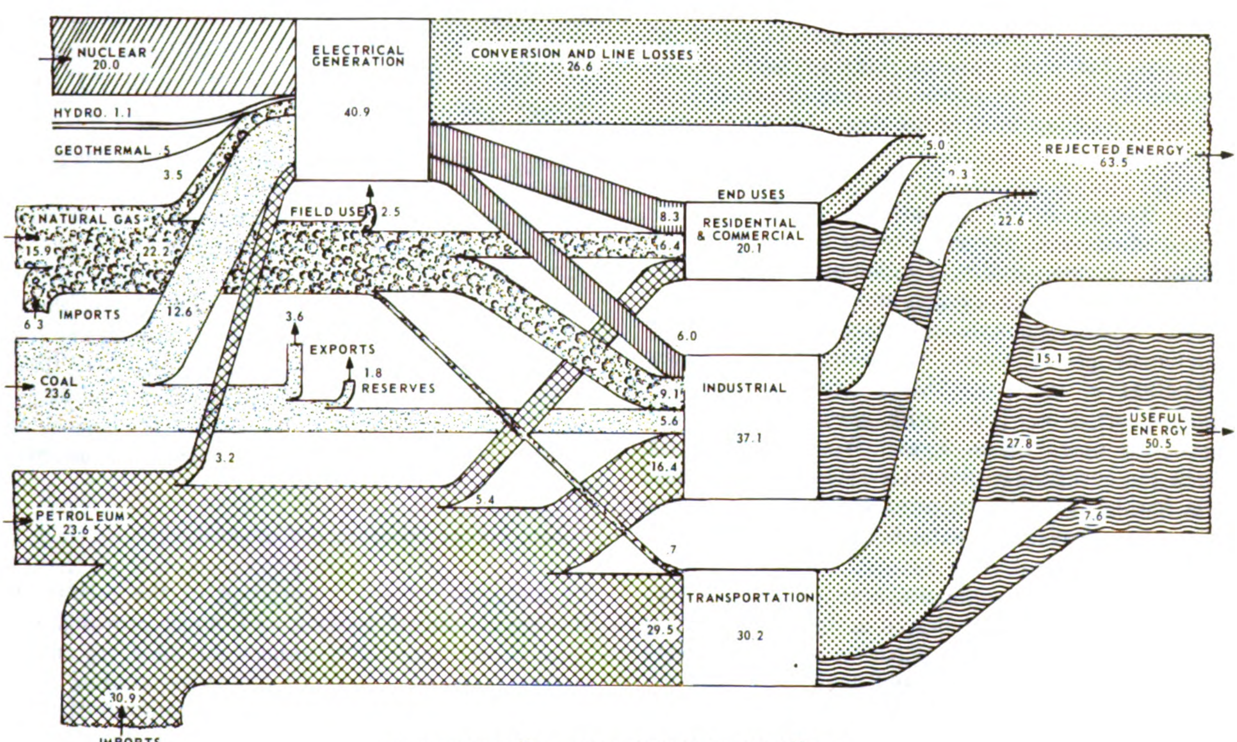
The impact of energy development on water merits close examination in the relatively arid West where energy and water share a unique and critical interdependence. Open space, air sheds, and water resources are expected to be under intensive pressure in order to develop new energy resources in the West. In perspective, the interdependence of energy and water resources covers all aspects of development from

1970



(NOTE: ALL VALUES ARE x 10^{15} Btu. TOTAL CONSUMPTION = 71.6 x 10^{15} Btu.)

1985



(ALL VALUES IN 10^{15} Btu. TOTAL CONSUMPTION = 122x10^{15} Btu.)

Figure IV-1. Energy flow patterns – 1970, 1985.

mining, milling, processing and conversion to power generation, hydroelectric power production, and water quality control.

The Nation's commitment to reduce reliance on foreign energy sources may impact water requirements along the West Coast in several ways. Increased offshore oil production on the continental shelf may require increased water for refining, but will, to some extent, replace crude oil presently being imported and refined along the coast. Alaska crude oil is expected to be refined in the Pacific Northwest where water supplies for industrial use are adequate.

Energy Resources in the West

The Western States contain much of the United States' undeveloped energy resources including strippable coal, oil shale, and uranium reserves. Over 70 percent of the country's strippable coal reserves are found west of the Mississippi. Most of the low-sulfur subbituminous coal and lignite resources and one-half of the bituminous coal containing less than 1.5 percent sulfur are concentrated in this area. Estimates of oil shale in Colorado, Utah, and Wyoming suggest that there are at least 600 billion barrels of potentially recoverable oil.

A large portion of the energy requirements in the West will continue to be met by liquid or gaseous petroleum products. One such gaseous diffusion plant would consume 2,000 MW of power, have an estimated total cost of $1.5 billion, and require about 30,000 acre-feet of water per year.

Many Western States are already involved in the nuclear fuel and power production cycle which includes mining, milling, enrichment, fabrication, power gereration, reprocessing, and waste disposal. The Atomic Energy Commission estimates that six new enrichment plants would be needed in the period 1983-2000 to meet the United States demand for enriched uranium. Thus, with nuclear powerplants already in operation in several Western States, the search for enrichment plantsites could focus on those areas having adequate coal-fired or nuclear-fired electric power and adequate water resources.

Hydroelectric power production is an important energy source in the West. As indicated in figure II-4, almost one-half of the generating capacity in the Westwide area was provided by falling water in 1972. In the three major power producing regions, the Northwest (Oregon, Washington, Idaho, Montana) had about 90 percent of its electric energy provided by hydro; the Southwest (California, Arizona, Nevada, New Mexico) about 25 percent; and the Rocky Mountain Region (Colorado, Utah, Wyoming) about 20 percent. Although there are many physical sites, the most viable hydroelectric damsites have been developed. There are, however, many undeveloped sites of major potential which are in controversy because of conflicting uses. An outstanding example is the hydroelectric dams proposed for a reach of the Middle Snake River. A license is now before the Federal Power Commission for issuance, but legislation in Congress would either effect a moratorium on development or exclude construction by declaring that that stretch of river and its surrounding area be reserved as a National Recreational Area. The greatest potentials for increasing generating capacity apparently lie in placing additional units in existing structures and the development of pumped storage to improve overall system operations. Total water management studies may disclose potentials for increased power production through improved operations in combination with additional units at existing powerplants such as on the Columbia River. The rapidly increasing costs of thermal-fired powerplants, which are used as a measure of hydroelectric value, indicate that relatively smaller hydroelectric plants should now receive increased consideration as part of multipurpose plans.

The western setting for future power development is characterized by relatively low population densities, vast open spaces, some limitation on amounts of cooling water, adequate rail transportation systems, and relatively high-voltage, interconnected power transmission systems.

Recent trends toward more complex generating power systems and larger units favor regional planning and development. Much of the seasonal load diversity between various parts of the Westwide area is already in use. Construction of future transmission lines between various load and generating centers should allow use of most of the existing and future load diversity. Changes in load patterns can have major effects on the amount of diversity available, tending to make major expenditures for specifically and solely taking advantage of load diversity doubtful economically.

Future Energy Development Impacts

As indicative of one assumption of the future, the Western Systems Coordinating Council provided electrical power generation projections on a region and load-resource area basis to dimension cooling water requirements. The Council is an organization of representatives of privately owned utilities, publicly owned non-Federal utilities and Federal power operating agencies producing, transmitting, and marketing electricity in the West. The total projected demand for

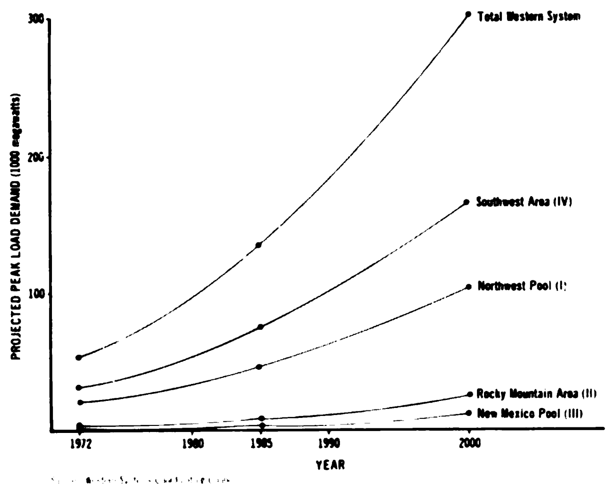


*Figure IV-2. **Projected demand for electric power – Westwide Study area.***

electric power in the West to year 2000 is shown by load-resource area in figure IV-2.

Figure IV-3 shows the cooling water requirements projected for these loads. Nearly 2.5 million acre-feet annually of fresh and waste water are needed to meet cooling requirements by the year 2000.

Relative demands and changes in sources of cooling water as projected by the Western Systems Coordinating Council are shown in figure IV-4. As the chart shows, nearly one-half of the total amount of fresh and

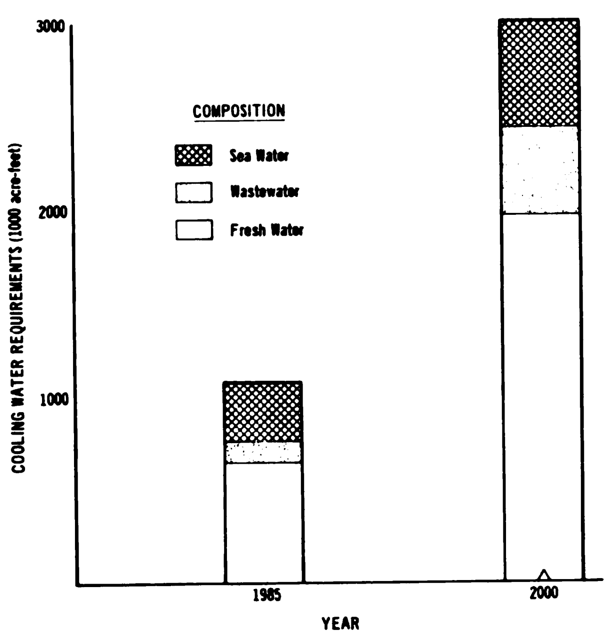


*Figure IV-3. **Thermal electric cooling water requirements – Westwide Study area.***

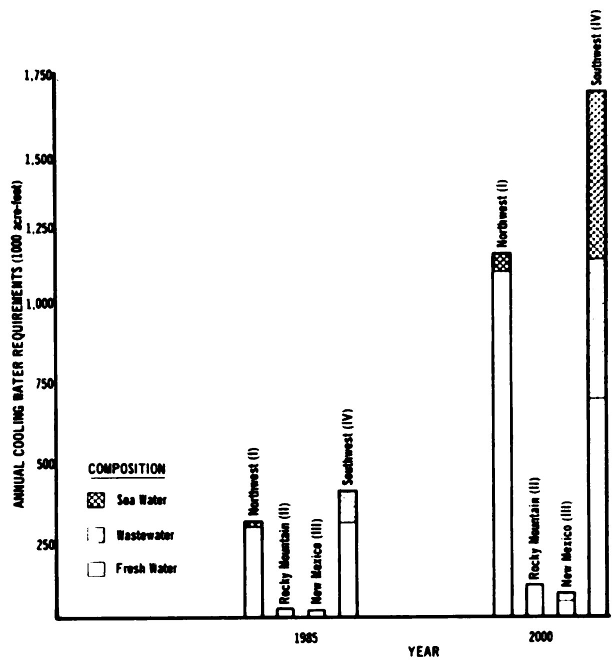


*Figure IV-4. **Thermal electric cooling water requirements for WSCC areas.***

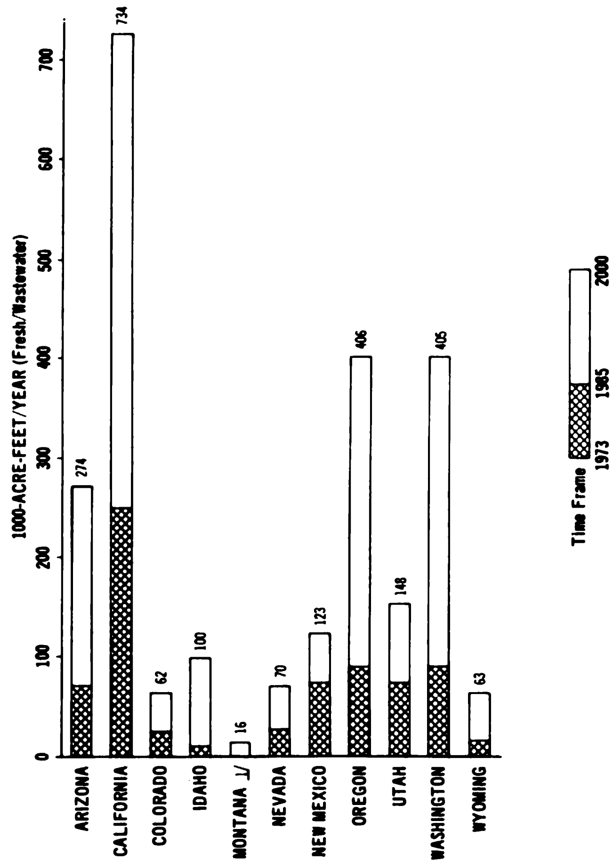
wastewater cooling is projected for the southwest area (1.15 million acre-feet).

A State-by-State breakdown of the Council's cooling water requirements for 1985 and 2000 is shown on figure IV-5.

A compliation of possible future powerplant capacities reflecting a variety of levels and degrees in the 11 Western States is summarized in table IV-1. This summary gathered from known sources of published information shows: (1) present powerplant capacity data and (2) planned future powerplant capacity (year 2000).

Powerplant siting and planning is a continuous process intended to assure adequate power to meet loads. Several factors affect siting: economics of a particular plant can change; a particular site can be in conflict with environmental uses or with new or revised requirements; or detailed investigations can surface previously unforeseen difficulties.

Much additional planning is required to actually meet projected load demand. As such, much of the potential capacity is not now committed and will certainly be supplemented. A cursory analysis of the tabulation reveals a lack or shortage of area potential powerplant capacity to meet demands in the Southwest. In the Northwest and Rocky Mountain regions, however, it



1/ Requirements for eastern Montana mine-mouth powerplants not included

Figure IV-5. ***Thermal electric cooling water requirements by States – 1985, 2000.***

appears that capacity may be available for export to other portions of the Westwide Study area. Brief profiles of anticipated future energy growth in the three major power areas should provide added perspective on relationships to water.

Pacific Southwest. – The pattern of fossil-fired thermal plants and coal development is expected to continue particularly in the coal-rich areas, 20 to 30 percent of which would occur in thr Colorado River basin. In an area of diverse mountain, desert, and unique canyon scenery, the environmental impacts of air pollution, proliferation of transmission lines, and strip mining have recently attracted public attention to the trade-off decisions involved. Nuclear plants, on the other hand, are generally expected to be located outside of the Colorado basin in remote desert locations and inland valleys, but still away from the major load centers. With a required lead time of 10 years, the impact of nuclear power in this area will not be strongly felt until after 1985. As a result of recent State legislation, a major shift

Table IV-1.—*Powerplant capacity – present and future by State (megawatts)*

State	1972 powerplant capacity	2000 planned powerplant capacity
Arizona	4,029	14,863
California	30,521	68,027
Colorado	2,905	25,027
Idaho	2,222	5,777
Montana	1,874	6,654
Nevada	3,651	18,692
New Mexico	3,756	6,948
Oregon	5,771	15,247
Utah	1,013	37,737
Washington	15,720	20,008
Wyoming	1,540	17,287
Westwide	73,002	236,267

Source: Field data, Western U.S. Water Plan

in siting thermal plants from the South Pacific coast to inland locations is expected, accompanied by accelerated demand for freshwater supplies. The overall impact on water resources in the area could put serious limitations on other competing water uses besides energy development. The use of waste water or ground water for cooling or processing and the use of offshore powerplant sites could ease the projected need of fresh surface water by the year 2000. Several sites with important pumped-storage potentials, such as Hoover Dam, when combined with efficient thermal baseload plants could improve overall system fuel effficiencies in the future.

Pacific Northwest. – The major expansion of power facilities in the Pacific Northwest is expected to be in baseload thermal powerplants, with increasing reliance on nuclear installations. Increased imports of energy from fossil fuel sources in the form of fuel or electricity from adjoining States, primarily Wyoming and Montana are also expected. As existing hydroelectric capacity is shifted from baseload to peaking service, the addition of units at existing dams is a logical step which should generally meet peaking requirements for the next 15 years or so. With its adequate water resources, the major problems will most likely involve environmental concerns. The combination of multiple-purpose water uses with thermal-power complexes located along the central reaches of the Columbia River are being considered. Once existing hydropeaking potentials are developed and thermal baseloading provided, utilization of abundant pumped-storage sites should receive increasing attention.

Rocky Mountain and Northern Great Plains. – The key energy resources of strippable coal, uranium, and oil shale with accompanying low energy area demands might make this region a major energy export center. The transportation of electric energy or coal and oil shale products out of the region is one of several alternative futures. Available water supplies are not always located in the immediate vicinity of energy resource areas: hence, interbasin water transfer, exchanges, ground-water use, or conversion of established water use may be required. The impacts of moving water resources to energy conversion areas are compounded by land reclamation problems resulting from strip mining, oil shale development, and accompanying transportation facilities. Actual water availability to support a regional energy export center is dependent on varying State water quality criteria, State policy toward development of energy resources for export, water rights, advanced energy conversion technology, and potential improvements in cooling techniques. The competitive uses of coal for producing fuels, chemicals, as well as thermal power must be considered in any long-range plan for water supply. There are some potentials for hydroelectric power production, but most sites involve conflicting uses. The competitive uses of water in the area such as instream requirements, irrigation, wild and scenic rivers, and wilderness areas emphasize the need for comprehensive, long-range multipurpose planning and could preclude full development of energy sources.

One generalized configuration of the locations of future major load centers and potential generating centers to meet those demands is presented in figure IV-6. The concentration of loads along the Pacific Coast due to large population centers is apparent. The matching generation sources present a more widely geographically dispersed picture of generating sites.

The Colorado River basin supplies affect energy development in over one-half the Western States. Potential water impacts are shown for projected growth in the basin for fuel conversion and electric power production from fossil fuel sources. Figure IV–7 presents the water requirements for oil shale and coal conversion, two abundant resources in this basin. These requirements may reach over 700,000 acre-feet by 1985. It is also important to note the wide range of water requirements per energy unit, depending on the process selected, as shown on

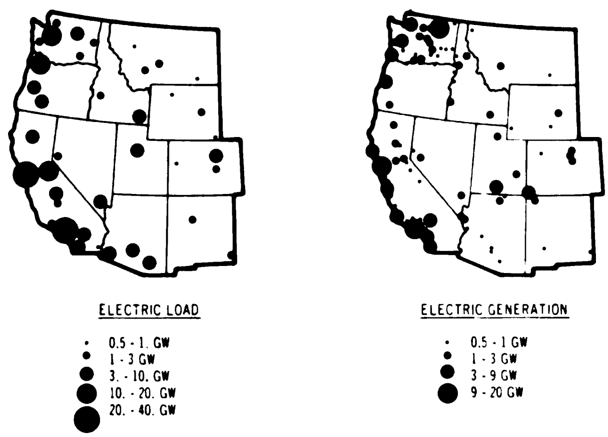


Figure IV-6. ***Generalized electrical load and generating centers – 1990***

table IV-2. Any or all of these processes could occur within the Colorado River basin. The energy forms shown are not necessarily substitutes for one another; in fact, they could be additive: i.e., coal mining and fossil fuel powerplants.

A general view of the mix of electric power generation to the year 2000 is shown for all three major energy resource areas in figure IV-8. By 2000, the growth of nuclear power generation is projected to be about 40 percent of the total in the Southwest

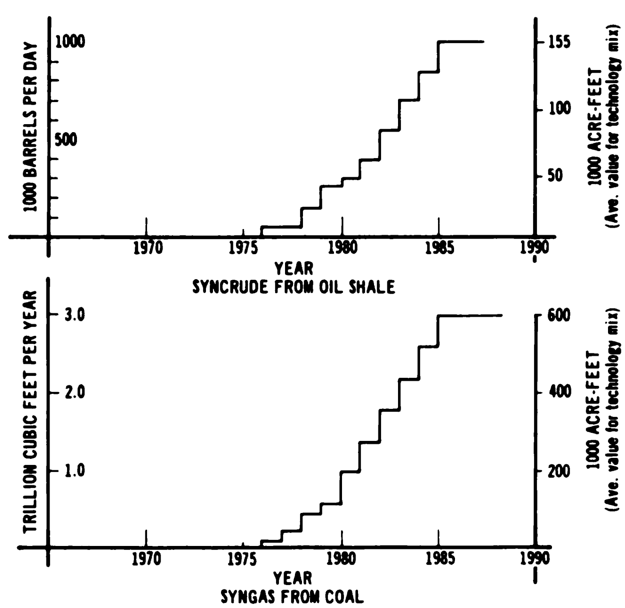


Figure IV-7. ***Water requirements for oil shale and coal conversion – Colorado River basin.***

region and about 50 percent in the Northwest. In the Rocky Mountain region, major reliance will be placed on fossil fired thermal plants which show a near-term, relatively stable growth, with less proportionate reliance on nuclear power.

Other Energy Forms

Other potential forms of energy conversion and electric power generation should be recognized for possible impacts on Western water resources. Potential energy forms for the future include solar energy, breeder reactor, nuclear fusion, geothermal, magnetohydrodynamic (MHD), fuel cells, thermionic, or thermoelectric conversion, and wind energy. In the pre-2000 time frame, the energy sources holding the best promise in the West for favorable impacts on water resources are geothermal, MHD, and the breeded reactor. The combined cycle, coal-fired MHD process, if successfully developed, could extend coal resources and significantly reduce cooling water requirements after 1985. The breeder reactor is also reported to have reduced water requirements and has the capability for greatly extending uranium resources. Geothermal development in the Southwest could actually add water to dwindling water supplies. Geothermal power development can proceed with either "dry" or "wet" geothermal fluids. The Geysers area in California is typical of "dry" field and supports a present power generation capacity of about 412 MW. Future expansion of the Geysers area and other areas in California is expected to add a total of 7,200 MW of geothermal power by 1990. Assuming that a portion of future power development will depend on "wet" systems, combined development of both power and desalted water appears as the best use of this unique Western resource. There are economic advantages to joint production as power development alone unavoidably rejects much of the available heat energy.

New energy conversion forms now under study include synthetic gas, oil, and fuels from oil shale, liquid hydrogen, tar sands, biological conversion of wastes and agricultural grains, and use of city waste products. Coal gasification now under pilot plant evaluation is considered one of the more promising concepts and would be of tremendous value in view of the predicted critical shortfall of natural gas supply by 1985. Again, process water would be needed in large quantities to supply full-scale coal gasification development in the West. With a predicted shortfall of natural gas, additional emphasis is expected for pipeline gas derived from Western strip-mined coal. In the Westwide Study area, coal gasification activity is expected to be concentrated in Montana, Wyoming, and New Mexico.

In general, fuel conversion technology is not efficient in terms of water consumption or energy conversion. Converting coal to gas wastes about 30 percent of the primary available energy. Secondary conversion of gas to heat energy wastes another 30 to 40 percent of the original energy content of the resource. For each conversion step, processing or cooling water is usually required. According to recent Bureau of Mines estimates, second generation gasification technology might be able to reduce water requirements to one-third of present water use.

Waste Heat Problems

A large portion of the cooling water used in the West today is saltwater. Estimated freshwater withdrawals for thermoelectric condenser cooling for the Westwide area in 1975 are not relatively great and only a small part of the water withdrawn was consumed. However, projected electric load increases point to large increases in actual freshwater consumption for cooling processes.

Table IV-2.—*Water/energy equivalent*

Fossil fuel alternatives	Production units	Water requirements (acre-feet)	Equivalent energy (billion Btu's)
Shale oil	1 million barrels	430	5,800
Coal	290,000 short tons	Negligible	5,800
Synthetic gas from coal	6.4 billion cubic feet	550	5,800
Fossil fuel powerplants	1.7 billion kilowatthours	35,000	5,800

Note: Some interesting energy relationships — 1 ton of bituminous coal yields 15,000 to 26,000 $\times 10^3$ Btu; 1 barrel of oil yields 5,800 $\times 10^3$ Btu; 1 kilowatthour of electrical output yields 3,412 Btu; 1 cubic foot of natural gas yields 1,032 Btu; 1 cubic foot of synthetic gas yields 900 Btu.
Source: Bureau of Mines field data.

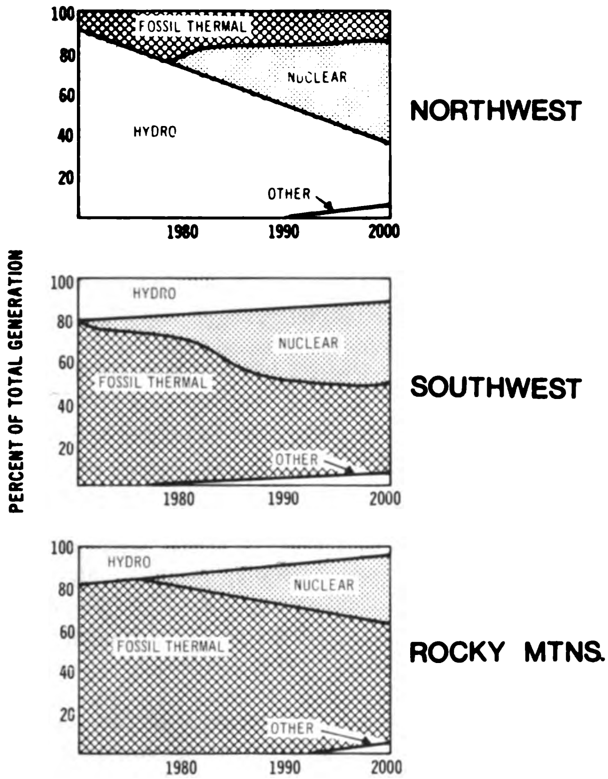


*Figure IV-8. **Generalized view of mix of electric power generation by area.***

In a typical thermal-electric power-generation facility, the amount of heat wasted represents 45 percent of the heating value of fuel used in fossil fuel plants, and up to 55 percent for nuclear plants. Where heat is wasted to water, temperature affects aquatic life. A drop in temperature following plant shutdown can also cause problems due to thermal shock. Improved cooling technology will be needed to protect waterways from adverse temperature changes.

For electric power generation, alternative cooling methods include: (1) Once-through, (2) cooling ponds, (3) canals, (4) wet-tower, and (5) dry-tower cooling. Table IV-3 shows typical water consumption under present-day technology. Once-through cooling, the cheapest and most efficient method available, can best be developed in the Westwide area along the Pacific Ocean, but this is seriously constrained because of seismicity, environmental, and public concerns. No fresh water is consumed using this source. Cooling ponds or reservoirs are also a form of once-through cooling. These water bodies, having an area of 1 to 2 surface acres per MW of power, are also large enough for recreational use. Water would be consumed through heat dissipation and natural evaporation. Cooling canals, though effective, now have limited use in the West.

Wet cooling towers may be either natural or forced draft. In arid climates, the natural draft towers are relatively ineffective. Selection of type depends on climatic conditions, operating costs, and other financial aspects. Water requirements are greater than for the other methods, and power is required for fans in a forced draft tower and for pumping the water to be cooled in all wet cooling towers.

Dry cooling towers for major powerplants use very little water. They are, however, much more expensive than wet towers. Only one has been built in the United States, for a small 30-MW plant, although two more larger units in the 300-MW range using dry cooling are under construction. Air-cooling towers reduce the thermal electric conversion efficiency of the plant during certain weather conditions. They also require

Table IV-3.—*Typical water use for power and energy conversion processes*

Power (1,000-MW unit at 85 percent load factor)	Water consumption (acre-feet/year)		
	Dry-tower cooling	Wet-tower cooling	Cooling pond
Fossil-fired plant	500-5,000	15,000	9,000
Nuclear plant (PWR, BWR)[1]	–	25,000	–
Nuclear plant (HTGR)[1]	–	15,000	–
		Total water requirement (acre-feet/year)	
Oil shale conversion 1 million barrels per day	–	155,000	
Coal gasification 250 million cubic feet per day[2]	6,000	10,000	
Coal liquefaction 100,000 bbl/day	10,000	25,000	

[1] PWR – Pressurized Water Reactor; BWR – Boiler Water Reactor; and HTGR – High Temperature Gas Reactor.
[2] Includes water for a source of hydrogen and for process steam.
Source: Field data, Western U.S. Water Plan

large quantities of materials such as copper which could be in short supply. A combination of dry and wet towers might be effective and efficient; however, it would be costly.

Federal water quality criteria regarding thermal pollution permit an 18° rise in cooling water discharge from potential steamplants as long as the temperature of receiving water is not raised more than 5°. Most States, however, have more stringent standards. Thus, potential mineral, chemical, and thermal pollution considerations will result in higher consumptive use rates for water withdrawals, since cooling tower blowdown returns with their higher salt contents will not be permitted to enter the streams.

Future development of offshore powerplants that use ocean water as a heat sink, waste-water cooling, extensive water recycling, and beneficial use of waste heat are expected to alleviate some of the pressure on freshwater resources. Use of hot water effluent for aquaculture, deicing, sewage treatment, space heating, and warm water irrigation remain as concepts to be evaluated for technical and environmental feasibility.

The Water Quality Problem

In addition to thermal pollution just discussed, primary energy development and fuel conversion plants may also affect water quality and land use. Coal mining, coal conversion, and oil shale development for energy production are viewed as the most serious threats to water quality in the West. Strip mining may seriously disturb patterns of drainage and surface runoff unless there is adequate advanced planning and implementation of effective controls. Also, damage can occur to surface and ground water from disposal of poor quality ground water encountered in mining and possible additions to pollution from processing.

Another less obvious yet important effect on water quality results from consumptive use of water through cooling. Although consumptive use in cooling systems without return flows effectively removes everything including salts from a river system, the net effect is usually increased salinity concentrations downstream.

In some Western coalfields, ground-water aquifers interface with coalbeds lying close to the surface. Removal of coal by surface mining could change flow patterns in these aquifers and dewater surface wells in the area. Moreover, unless strip-mined Western coalfields are properly graded and revegetated, excessive erosion rates could result. Water can play an important part in vegetative management and alternative reclamation plans.

Institutional Aspects

The following nonquantified items could have strong influences on the rate of growth of energy consumption and accompanying water resource uses. They must be considered in any long-range plan.

1. New social values emerging in environmental conservation and preservation issues are expected to increase public participation in decisionmaking for powerplant and energy development siting.

2. Public attitude changes towards mass transit and revised city planning could significantly affect transportation patterns and required liquid energy sources in the long term.

3. Future Federal policy regarding foreign oil imports, liquid natural gas imports, price adjustments, Alaskan oil, offshore development, and promotion of efficient energy use will have significant effects on the rate of energy and accompanying water resource development in the West.

4. Policies of individual states regarding the development and use of mineral resources within or outside the state could greatly influence water resource development.

Energy conservation including the increased efficiency in the use of energy sources will play an increasing role in the future. Current demands for electric power and other energy use have not fully evaluated this potential. Some recent studies examined this potential and concluded that the year 2000 electric power use might be reduced substantially with a well-planned energy conservation program. Certainly such a possible alternative to conserve the Nation's energy resources should be aggressively pursued. Some of the conservation methods which are being promoted or further developed for use include: improvement in and increased use of building insulation, more extensive use of rejected heat for public building insulation, design of powerplants and industrial processes to increase output per unit of energy input even at some increased unit cost, reduction in manufacturing and use of high-energy consuming products where reasonable alternatives exist, and use of taxing and pricing structures to discourage excessive and indiscriminate use of energy.

Organizational structures to facilitate coordination of powerplant and energy facilities planning are urgently needed on a regional level to overcome growing political, administrative, and technical complications. The compelling reasons and need for regional comprehensive energy site planning encompass: (1) present cost per Btu or per kilowatt variances between States, (2) wide differences in State siting laws, (3) lack of an information data base concerning environmental impacts, (4) need for preservation of environmental values by effective use of air, land, and water resources, and (5) need to develop an adequate energy supply at reasonable cost.

There are many Federal and State regulations that overlap, conflict, or delay present-day siting review and approval. One agency issues licenses for nuclear reactors, another licenses for hydroelectric projects, and a Federal permit from a different agency is needed for coal, oil or gasfired generators. One agency regulates gas pipelines for rates and services, another regulates oil pipelines. Still another agency approves use of Federal land for coal conversion plants, refineries, nuclear enrichment plants, etc. Public notices, hearings, environmental impact statements, and various judicial actions all frame part of the tortuous part for energy and corresponding water development. Although streamlined arrangements for coordinated review could speed up energy site location and development, care must be taken not to circumvent laws that provide for protection of social and environmental values. The natural environment is a complicated system that can be adversely affected by premature decisionmaking. Precautions would still be needed. In terms of water resources development, the present system of powerplant site planning will not solve the critical water resource problems involved. A Westwide Study compilation of planned and published utility powerplant sites shows that most specific site planning does not extend past 1979-80. Moreover, long-range plans of electric utilities which describe proposed sites and transmission corridors are generally not available. The estimate of 2.5 million acre-feet of water needed to meet cooling requirements is apparently based on generalized information rather than on specific site requirements after 1981-82. Utility planning is a continuous process intended to insure that electrical powerloads are met, that plants are available when needed, and that plants are not built in excess of need. Proposals are made and accepted or rejected dependiing on the progress of investigations, economic and environmental concerns, and load growth. Long-range planning is of necessity general rather than specific and must be adjusted to load and other conditions as they develop.

CONCLUSIONS

1. The development of large low-sulfur coal reserves and rich oil shale deposits will have major impacts on water and related land resources. Water requirements will not only result from mining and processing, but also from associated growth of adjacent towns and cities. Because of interrelationships with surface and ground water, serious water quality problems could occur. Reclamation of strip mines will have important environmental effects; however, information on related water requirements is meager.

2. Disposal of waste heat from thermal electric plants and from energy conversion plants will place increasing demands on water supplies in the near term. Increasing use of low quality return flows and of ground-water supplies in remote areas may help conserve better quality surface supplies. New technologies for cooling could also reduce future water cooling needs.

3. Expected energy development from fossil fuel, particularly in the Colorado River basin and Rocky Mountain area, will impose increased burdens on limited supplies and may seriously affect water quality. The consumptive use of water for power generation, coal conversion, and oil shale development may be 1.0 milion acre-feet from the Colorado River basin alone by 1985.

4. Additional regional planning in terms of greater leadtime and investment will be required to give proper attention to the complex land and water interactions of energy development. The present system of energy resource site planning is unwieldy and inhibits resolution of the water resource conflicts and land use problems involved. New approaches must be found to assist public and private utilities and energy agencies in planning for environmentally suitable energy development.

5. Major energy resources involve extensive areas of publicly owned lands and a great number of critical environmental, social, and economic problems will occur involving local, State and national interests. The environmental and quality of life aspects of Western energy exploration and development are of high concern but lack much meaningful data on environmental and social factors.

6. Multiple purpose combinations of power and water production such as from geothermal brines, use of cooling water effluents, desalting of seawater, and brackish supplies could provide advantages to both power and water.

7. The primary hydroelectric potentials are installation of additional hydro units at existing powerplants which will likely involve changes in operation of existing storage systems. There are a few remaining major sites for new hydropower developments. Other potential

hydro developments involve conflicting use. Opportunities remain in some areas for smaller units as parts of multiple purpose developments. In the Southwest where there is a preponderance of baseload thermal power, the addition of pumped-storage units at existing dams and reservoirs could add system efficiency. In the Northwest, although many pump-storage opportunities are available, the need up to about 1985 is the addition of baseload thermal power to supplement its predominantly hydro system, and additional hydro units at existing structures. Where future reservoirs are planned to meet high priority water requirements, consideration should be open to the inclusion of hydropower to the extent practical.

RECOMMENDATIONS

1. Various Level C studies, as presented in more detail in subsequent chapters, should be accelerated and expanded in those areas involving coal and oil shale resources being considered for near-term development. Related environmental and social impact studies should be initiated immediately because of past neglect in these areas of important concern.

2. Various Level B or special studies as presented in more detail in subsequent chapters should be continued, supplemented, and initiated in those areas where energy development is anticipated after 1985 in order to provide necessary leadtime to determine alternative courses of action. In addition to fossil fuel related studies, these would include use of return flows for cooling; potentials of dual purpose power and water supplies such as geothermal brines and seawater distillation; and thermal effluents for multipurpose use.

3. Initiation of a Westwide assessment of hydroelectric power potentials with the emphasis on increasing capacity at existing structures and surveying the role of pumped storage in integrated power systems should be considered.

4. A joint general siting study should be conducted with public, industry, State, and Federal participation on water and related land requirements for electric thermal powerplants and energy conversion plants.

5. Studies of ground-water resources in remote areas as possible future sources for thermal cooling as presented in the California and Nevada portions of chapter VI should be considered.

6. Policies should be formulated to encourage coordinated regional planning to give proper attention to complex environmental and social interactions and the interdependencies of water and land-use planning. Establishment of new organizational arrangements should be pursued to facilitate advance approval of energy sites and improved long-range planning of energy facility requirements.

7. Priority should be given to developing an overall energy policy for the Nation which will assure that long-term energy needs are met through a combination of energy conservation; research and development into new sources such as solar, geothermal, nuclear fusion, and wind; and exploration and development of known energy sources such as oil, coal and oil shale.

WESTWIDE NO. 2 – MUNICIPAL AND INDUSTRIAL WATER SUPPLIES FOR SMALL COMMUNITIES IN THE WEST

SUMMARY

Many small Western communities are faced with a lack of sufficient quantity and/or quality water supply to maintain or improve the viability of the community. Although an adequate water supply is not in itself the complete answer to rural community problems, it is essential to the public welfare under any stage of development.

At least one-quarter of the 6,500 nonmetropolitan communities has water in short supply, water of poor quality, or both. Without additional sources of good quality water, increasing community needs cannot be met. Without some outside financial and technical assistance, many of these communities, which are already experiencing declining economic activity and are burdened with providing other public utility services, cannot be expected to maintain a reasonable level of living.

To protect health, the State and Federal Governments have set water quality standards. The problem is the level of assistance necessary to provide an adequate supply of potable water that meets standards. There are several Federal programs that provide assistance. However, because of low funding levels, uncoordinated programs, and lack of local resources, many community water supply problems continue to persist. National policy enunciated in the Rural Development Act states that adequate water supplies should be provided for economic distressed communities to help with efficient and orderly growth and development.

DISCUSSION

Domestic water problems include lack of adequate supplies, mineralized supplies, inadequate storage and treatment facilities, and deteriorating distribution systems. Some of the causes of these physical problems are limited financial base, out-migration, and cost of water.

Additional municipal and industrial water supplies are needed in 848 subbasins. Water-short communities exist throughout the West but are prevalent in areas shown in figure IV-9. Water shortages in communities vary from infrequent water-use restrictions and limitations on new hookups to suppressed use of hauled supplies.

More than 340,000 people in the Westwide States are supplied with water in excess of 1,000 p/m (total dissolved solids) which is well over the maximum level set by the Public Health Service of 500 p/m (fig. IV-10). Although these statistics are not viewed as a large percentage of the total population, they do represent a growing concern over water supply that

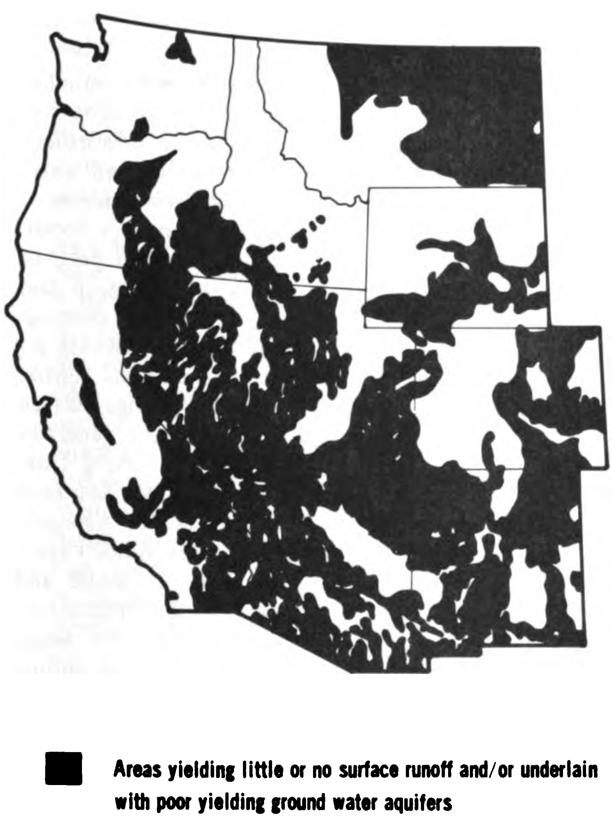


Figure IV-9. Areas with limited water supplies for small communities.

affects rural America. A majority of the people who drink highly mineralized water must pay hidden economic and health penalties for the content of their water supply. Water supply and treatment systems will receive renewed interest by many Western communities when safe drinking water standards presently before Congress become law and enforcement proceeds.

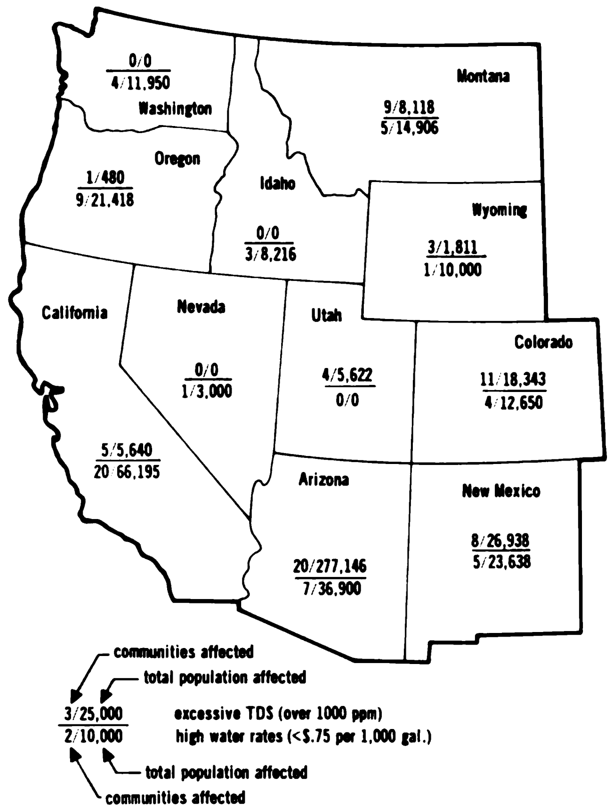


Figure IV-10. Areas of poor water quality and areas of high water costs.

Transporting water supplies over long distances and treatment to remove excess amounts of minerals result in high water costs. In the Westwide States, communities having a total affected population of 200,000 people (also shown on fig. IV-10), currently have water costs to the customer in excess of 75 cents per 1,000 gallons.

Several unincorporated communities have not been able to develop water supply or treatment plants. In some cases, equipment is so expensive that small communities do not have a sufficient financial base to afford the treatment. Many lack the administrative or technical skills needed to develop water supplies. Even though there may be a desire to maintain or improve the area's economic activity and there is a recognition of the important role of water, the communities may not be able to perform the planning, and secure the financing and legal and administrative guidance required.

The types of problems and potential solutions often extend far beyond a single community's boundary. For example, upstream waste discharges have caused water quality problems to downstream communities. Lowered aquifer water levels caused by deep well pumping have caused neighboring shallow wells to dry up. Transporting water over a distance may become practical when several small communities together can achieve economy of scale.

In several Western States, with limited water supplies, small communities may be forced to use more saline ground water. A common pattern is found among these communities. Over the years, community water supply was obtained from a mixture of poor and good quality well water. As the population grew, more poor water had to be used. Then, the total well capacity became insufficient to meet new demands. New, more expensive wells yielded even more mineralized water as a result of declining water tables in the area. Many communities are presently caught in this deteriorating situation.

The following paragraphs provide a general overview of community water problems for each of the States.

States

Arizona. – There are about 15 small communities in Arizona with a total population of 51,000 with critical water problems. Limited and costly ground-water supplies are a major problem in several northern Arizona communities such as Flagstaff, Williams, Ash Fork, Seligman, and Kingman.

There are no good aquifers in an extensive area north of the Mogollon Rim extending to the Grand Canyon. In this area some deep wells with static water levels more than 1,000 feet from the surface do provide some localized and very costly water. Ground-water supplies are generally of poor quality. Quality varies so greatly that many communities can use their better wells to mix with poor wells. Notable example of quality problems are: total salt content – Gila Bend, Allenville, and Buckeye; fluorides – Wilcox; lead – Silver Bell; and nitrate – Marana. In the few areas where the quality of surface water is bad, ground water is generally satisfactory. There are areas, however, where surface supplies cannot be developed. A few communities entirely dependent upon surface supplies have an acute quantity problem during periods of drought.

California. – There are 54 communities in California with a total population of 89,600 which have applied for water supply assistance. Only a small part of the water diverted for municipal and industrial goes to satisfy rural domestic and small community needs. Ground-water overdraft, land subsidence, and inadequate distribution systems are the most prevalent problems in rural areas.

Colorado. – Rural communities in Colorado can generally obtain sufficient domestic water although water quality can be a problem, particularly in the Pierre shale outcropping areas of the southeastern portion of the State. Quality problems seriously affect 14 communities in the Arkansas River basin, 23 communities in the South Platte River basin, and 4 communities in the upper Colorado region. Population affected by water quality problems is about 162,000. Three communities with a population of 6,000 are in short supply in the Yampa and Mancos Rivers of the upper Colorado region. The State has recently established a construction fund for loan assistance to small communities for water systems.

Idaho. – Quantities of rural domestic water supplies in Idaho are generally adequate. Water quality will continue to be a problem. Some areas in northern and central Idaho have shortages of ground water within a reasonable depth. The Moscow portion of the lower Snake subbasin has experienced a declining water aquifer over the years. In other parts of this area, depths to ground water are deep and quantities are limited. New supplies require development of surface water from small tributaries by storage and treatment in most of north and central Idaho. However, in the Clearwater basin, surface water supplies from small tributaries are generally inadequate; storage facilities and treatment from large tributary streams are necessary. Southern Idaho is generally considered to have an adequate supply of good quality ground water. Some exceptions exist such as "hard" water in Boise and biologically impure water in several communities. There are studies of water sources for select communities to indicate problem areas and outline alternative courses of action; however, shortages have not reached a point requiring local action in expanded development.

Montana. – This state has one of the most critical small community water supply problems in the Westwide area. It has listed 110 towns and cities with a total population of 104,800 that need additional water supplies and facilities. Forty-one of these communities have water quantity problems. The problems are most severe in the upper Missouri basin and in the Yellowstone basin where persons maintain cisterns or transport water for domestic use. Some communities have an adequate source of water but inadequate facilities. In total, 35 communities need facilities or treatment and distribution systems. Many of the communities have a source for providing adequate volume but water quality is poor. Fifty-three of the communities have water quality problems. Many of the solutions will cost a great deal or money to provide adequate water supplies.

Nevada. – The most acute water problems in Nevada are in the closed basin areas in the central part of the State. Generally domestic supplies for household use are adequate for farms and ranches. The most pressing problems are those for small communities. In 28 communities with a total population of 24,000 the problems include short supplies, warm water, waste contamination, or mineralized supplies which are high in fluoride, sulfates and iron content. Several systems developed during the mining period of the late 1800's and early 1900's should be completely replaced. Some communities could bring their systems up to standard if water were treated to reduce iron, fluoride, and other minerals. However, in many instances it is cheaper to haul drinking water from other sources.

New Mexico. – There are about 180 communities in New Mexico each having populations less than 2,500 that do not have public water facilities. Of the total population in the State, approximately 28 percent are not served by public water facilities. Based on the 1969 Preliminary Economic Development Plan for the State of New Mexico, there are 36 cities and communities proposed for water supply and sewage works at an estimated cost of over $6 million. In the southern part of the Pecos River basin, notably in the Rosewell area, the encroachment of saline water in the aquifer is threatening municipal supplies. Large scale pumping in the Southern High Plains had resulted in water level declines up to 50 percent during the 1932-1960 period. In the upper Rio Grande basin as of 1966, there were 42 communities with populations of 100 or more that had no water system or a system that would be inadequate for the projected 1985 populations. In the upper Rio Grande basin, 32 communities had minerals in their water supply that were in excess of standards set by the New Mexico Department of Health and Social Services.

Oregon. – Several studies are underway in Oregon to secure additional data on 183 communities with a total population of 313,000 people that have water quantity problems. The major problems concerning domestic water are generally inadequate storage and distribution systems and often insufficient water supply at the source. A large number of the small coastal communities are in need of regional-type water systems with upstream storage. For some more widely dispersed eastern Oregon communities, additional ground water will need to be developed; for others, lack of storage is the problem.

Utah. – There are about 100 domestic water systems which cannot meet health standards in Utah. Many small communities with populations of 100 to 4,000 have little opportunity to meet these standards. Small widely scattered communities in Tooele Valley of western Utah and in the area of southern Utah must use poor quality spring and well water. St. George and Cedar City have already developed the ground-water supply. The Navajo Indian Reservation requires additional supplies for their orderly growth and development. Small communities in the Sevier basin have short supplies. Price in the Green River basin and another 10 communities of 50 to 100 suffer both from inadequate quantity and quality of water supply; some domestic water is directly withdrawn from an irrigation canal. Water-short supplies exist in the energy mineral-rich Uinta Basin.

Washington. – There are 685 cities and communities listed in Washington with water quantity or water quality or distribution system problems. The Pacific beach areas have limited local water supplies. Local wells are subject to salt intrusion if pumped too hard. Water supplies for these areas are available inland; however, the cost of individual systems may be more than most of the communities can afford. Areas adjacent to Puget Sound have community water problems varying from slight to severe. Supplies are short for many of the islands and will likely need to be transported from the mainland, probably from Olympic mountain streams. Most of the smaller communities on the eastern side of Puget Sound will be forced to join together to seek an adequate supply in the Cascades. Domestic water for Roberts Point, a small peninsula, is now being hauled by truck through Canada from Blaine, Washington. Bickleton, the only town in water-short, south-central Washington, may have to complete with water used for irrigation. Quantities should be available, however, from either the Ukemia or the Columbia Rivers. The people on farms and many small towns ranging from 50 to 3,500 population in the eastern central Washington are experiencing domestic water problems due principally to an overdraft of water use from a limited aquifer. The recharge rate appears to be slow and the water table is receding rapidly. Importation of water seems to be the ultimate solution. State assistance is available to small communities through the State of Washington's Department of Ecology.

Wyoming. This state has 25 communities having a total population of 26,000 people with critical water supply problems. Nearly 28 percent of the people in Wyoming are now facing or will face some type of water quality or quantity problem. Most of the towns facing these problems depend upon the ground water for their sources. Some ground-water supplies are of poor quality and many are of limited quantity. Areas that are facing an immediate problem are those near the developing coal resource areas. Areas in northeast Wyoming are limited in surface supplies and the ground water is of limited quantity and quality.

PROBLEM RESOLUTION

Assistance to resolve water supply problems for small communities is available from various State and Federal programs. A few States provide for rather detailed planning as well as some financial aid, while others provide only a minimum of technical assistance. Other than the Federal water development agencies, the Economic Development Administration, Department of Housing and Urban Development, and the Farmers Home Administration provide technical assistance and funding through authorized programs. Each of these agencies provides aid under widely varying criteria concerning population, unemployment and income levels, and other factors. The recently enacted Rural Development Act of 1972, though not yet fully implemented, also provides for assistance to rural communities having water supply problems. Water development plans of the Soil Conservation Service, Corps of Engineers, and the Bureau of Reclamation include service to small communities when related to multipurpose projects. Thus a dimension of the problem is institutional, due to the complex organizational framework, occasionally overlapping and sometimes untimely programs. Perhaps the major difficulty being experienced in problem resolution is that of inadequate funding of both State and Federal programs.

CONCLUSIONS

1. Water shortages and poor quality water plague many communities throughout the West. Stability and well-being of communities and rural areas can be adversely influenced by inadequate water supplies. Evaluating national objectives concerning population dispersal may require increasing Federal assistance in rural communities.

2. Even though assistance programs are available, many small communities are not only handicapped financially but lack available administrative and technical skills. Consistent and effective cost-sharing arrangements in the form of grants or loans to local communities are needed to provide for future water requirements.

3. State and Federal planning assistance is needed to aid small communities in determining requirements, locating supplies, and treating and distributing water. There is a need to coordinate the various Federal programs available and to provide adequate funding.

4. The individual States are the logical entities to appraise the needs of communities for assistance and to arrange for that assistance.

RECOMMENDATIONS

1. A review of current programs should be undertaken by a State-Federal group to ascertain their effectiveness toward meeting water supply needs for small communities and to determine the adequacy of funding levels, effectiveness of qualifying criteria, ease of obtaining aid, and responsiveness to community needs.

2. In regard to communities in which water appears to be a limiting factor cooperative State-Federal inventory should be made with an evaluation of the potential impacts on those communities if water is not made a limiting factor. Study results can serve as the basis in establishing priorities and scheduling assistance to other programs.

3. A special study of communities selected by the States should be initiated by a State-Federal group to provide planning and technical assistance for municipal water services. After a review of available data at the State and Federal level, two or three "target" or "impact" communities per State should be selected on a test case basis for detailed assessment of community enhancement resulting from an improved water supply

system. This could include communities which have received assistance. The study would survey available programs, technology, legal issues, and estimate costs and physical facilities involved. The study should yield State-Federal recommendations for cost sharing and implementation of community programs for expanded community services.

4. Implementation of a trial program funded on new criteria determined above would be aimed at communities selected by the State and Federal interests as demonstrating critical water requirements on a priority basis. A future detailed study would develop plans and evaluate the impacts of water development, pollution control, and other effects on rural communities to determine the course of future action.

5. The State should take the lead in channeling assistance to the communities from Federal assistance programs.

WESTWIDE NO. 3 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

Development of the full range of opportunities for the Americans who live on the 172 Indian reservations in the West will be subject to the adequacies or the inadequacies of dependable supplies of good water. Existing demands, however, continue to compete for water supplies which would otherwise be used to promote Indian developments. Federal commitments to the Indians require that the Government maintain its special efforts to ensure that, to the full extent of Indian entitlements, the necessary water remains available for such use as may be determined beneficial and equitable for the Western Tribes. Identification of the quantity and quality of water is not only needed by Indian entities to plan and realize full development of their reservation potentials, it is also necessary to clearly establish the extent of their rights to use of water in the Western States. Specific problems concerning the determination of Indian water requirements are discussed in more detail for each State in chapter VI.

DISCUSSION

Problems at Indian reservations can be characterized as lack of access to the same level of economic and social opportunity afforded other Americans. Former President Johnson in his unprecedented message to Congress on American Indians stated, "With rare exception, Indian communities are so underdeveloped that there is little, if any, opportunity for significant social or economic progress * * * " " * * * our goal must be: A standard of living for the Indian equal to that of the country as a whole." President Nixon in his message of July 8, 1970, to Congress stated, "The first American – the Indian – is the most deprived and most isolated minority group in our Nation." " * * * our Government has made specific commitments to the Indian people. For their part, the Indians have often surrendered claims to vast tracts of land and have accepted life on Government reservations. In exchange, the Government has agreed to provide community services – services which would presumably allow Indian communities to enjoy a standard of living comparable to that of other Americans. This goal, of course, has never been achieved."

The magnitude of the Indian problem can best be described by comparing selected economic factors for Indians with similar data for the non-Indian residents of the Western States. Figures for 1970 show median family Indian incomes are about one-half of those reported for other families. Most Indian families live on incomes which are substandard by the federally defined income level of poverty. In terms of jobs, the record of employment is among the worst in the country. In 1970, the average rate of Indian unemployment was nearly seven times as great as the level indicated for the States. Progress has been made in the field of education, but current Indian education levels will continue to lag behind the other Western groups. While many factors contribute to the overall problem, this statement addresses only those aspects of the problem related to the development and use of adequate water supplies.

At virtually all of the established Indian reservations in the 11 Western States, the quantity and quality of water readily available determine the degree to which natural resources can be developed and utilized. For example, where dryland farming is not adequate, the production of food and fiber may be limited by the amount of water that can be diverted for irrigation of crops; mineral development and energy production cannot occur where there is inadequate water for mining, processing, and production plan operation; and fishery resources and outdoor recreation cannot be maintained where water supplies are being depleted for off-reservation uses.

In some areas there are adequate water supplies to accommodate both Indian and non-Indian development needs and State water plans can be adjusted to reflect Indian requirements without difficulty. However, in other water-short areas, obtaining adequate supplies of water to provide for tribal needs will, at best, be a difficult achievement. This is particularly true for those tribes located in States where competing uses have already or are fast approaching the point of oversubscribing existing supplies of water. The ultimate quantity of water and the pace at which it is made available for Indian development in these critical short areas will depend primarily on the speed in which Indian water entitlements can be legally established in the courts. Since the issue is complex, it may take years before the courts make a definitive judgment. During the ensuing period, many of the Tribes will continue to have difficulty in obtaining the water necessary to alleviate current economic problems and to stimulate further growth on their reservations.

The controversies over Indian water rights and entitlements in the West are not a recent phenomena. The issue was addressed by the Federal Courts as early as 1908 in the case of Winters v. U.S. Government involving the Ft. Belknap Reservation in Montana. The water rights issue in Winters was argued on constitutional grounds – relationship between the Federal Government and Indian Tribes – and secondarily, on economic considerations for the affected tribe. In brief, the court pointed out that American Indian Tribes granted to the Federal Government certain rights to vast landholdings, holdings which were capable of supporting their historical ways of life. In return for giving up their rights – accepting the dominant society's way of life – by agreeing to move to the reservations, the Federal Government assumed specific Treaty obligations (explicit or otherwise) to the tribes – obligations which could not be abridged by State actions. The courts further realized that goals of having Indians move into the mainstream of America would not be possible if the tribes were not provided the resources and economic means to do so.

In the West, the means for reaching these goals rested primarily on the availability of dependable supplies of water. The Winters' court realized that the reservation was too small for the migrating ways of the Indian and was valueless without water to support the way of life as envisioned by the tribe and the Federal Government. The Indians were expected to settle on the reservations and become industrious citizens. This would not be possible if the tribe were denied necessary water to support its endeavors in creating viable economy on tribal lands. On these grounds, the court ruled that the Ft. Belknap Tribe had a legal right to utilize waters originating on, flowing through and/or adjacent to its reservation. The Winters decree was later upheld by the Supreme Court and is used today as the benchmark case in establishing Indian water rights throughout the country.

Notwithstanding conflicts on water supplies, national and worldwide priorities for goods and services have created a general demand for a reevaluation and development of Indian resource potentials. This is not unrealistic when viewed in terms of today's problems; for example, increasing world shortages of food and fiber products, the increasing national dependence of agricultural exports to mitigate international balance of payments deficits, and the worldwide energy crisis. The Indian resources (vast reserves of oil, gas, and coal plus millions of acres of potentially productive farmland) show promise for helping correct the imbalance between existing supplies and demands for these products. The success of bringing these resources into production will depend not only on large capital expenditures – public and private – but also on the availability of large and dependable sources of water to support the necessary energy processes as well as to enhance productivity, through development of Indian lands. The beneficial effects, however, will not be one sided. Increases in purchases of consumer products and factor inputs as related to the development will be reflected by increased incomes and profits by firms and businesses which are in the main located off the reservation.

Some examples of specific areas where conflicting water demands have created major resource problems for tribes, include localities in the Southwest along the lower Colorado River where water for municipal and industrial and irrigation uses complete with already overappropriated water supplies; in the Great Basin where water diversions are reducing the levels of terminal lakes on or adjacent to Indian reservations; in the Northern Great Plains where pending coal development is expected to affect water availability for other Indian developments; and in the Northwest where there are conflicts affecting irrigation potentials on Indian lands and in some instances valuable fish and wildlife resources. These problems are discusses in more detail in chapter VI.

PROBLEM RESOLUTION

Responsibility for the administration of Indian lands and waters on the 172 Indian reservations in the West rests with the Bureau of Indian Affairs; however, the rights to the lands and waters actually are vested with the Indians or tribes. Such rights are read from the treaties and agreements between the Indian Tribes and the United States which have been approved by acts of Congress or formalized by Executive Orders. Because the purpose of the Indian reservation is to provide an economic base for the Indian people residing thereon, it has been argued that the Indian water right is a right to use the available reservation waters for any beneficial use including irrigation, livestock, domestic, power, recreation, industrial, and municipal purposes. The Federal courts require that present and future water requirements be identified to legally dimension Indian water rights.

The Bureau of Indian Affairs has initiated investigations recently for purposes of quantifying water supplies and requirements on Indian reservations in the West. While this represents a significant breakthrough in the quantification of resources and needs, the total effort to date has been limited to scoping and analyzing the problem situation for only 20 of the 172 reservations located in the Westwide planning area.

CONCLUSIONS

1. The overriding but interrelated issues of Indian water rights, reservation resource problems, and the resolution of economic needs on the reservations have made it imperative that a determination of present and future water requirements for all tribes be determined as soon as possible. The revised planning schedule of Westwide only allowed for the identification of major resource problems by time frame for approximately 70 percent of the Indian reservations. The results of the survey are shown in table IV-4. To solve these problems, including related issues, could take at least 25 years to properly address all Western resource problems at the present rate of funding, which is roughly $1.5 million per year. In order to ensure that answers are expeditiously forthcoming and that effective remedies can be instituted within a reasonable period, the present program of investigation must be expanded beyond its current levels.

2. Studies needed for each reservation range in scope from single-purpose investigations – seeking new sources of domestic water – to comprehensive planning involving multiple problems and uses of land and water. Studies and costs should be tailored to reflect the complexities of the problems. In order to ensure that answers are expeditiously forthcoming and that effective remedies can be instituted within a reasonable period, the present programs of investigation must be expanded beyond their current levels.

3. Indian water-related resource studies along with estimated costs required to cover the entire investigative spectrum – problem identification, analysis, and concluding recommendations for improvements – were estimated during the Westwide Study. The proposed funding level as shown on table IV-5 is based on present Bureau of Indian Affairs experiences in the West in conducting similar studies, time required in completing all study phases by reservation, and on Western tribal objectives of having all resource issues resolved and their solutions identified through specific resource programs by 1990.

RECOMMENDATIONS

1. The Federal Government, when requested by the respective tribes, should conduct special studies through the Bureau of Indian Affairs to provide appropriate background parameters for Indian water right cases and/or in support of justification of Indian water and related land-resource programs. Technical assistance from Federal agencies also should be made available as required.

2. The documentation of present and future Indian water requirements and related problems should be followed by recommendations for improvement fully supported by the Government and specific Congressional appropriations to ensure that Indian programs and projects are implemented and constructed in a timely manner.

WESTWIDE NO. 4 – MANAGING FLOOD PLAINS

SUMMARY

Throughout the Westwide area, as with the rest of the Nation, cities and communities usually developed along the banks of rivers or in close proximity to sources of water. As the cities grew, use and development of the flood plains expanded. Periodic floods caused ever increasing dollar damages as the flood plains became obstructed and developed. Numerous flood protection works were requested, authorized, and constructed over the years to hold back the flood waters. The absence of flood plain regulations and/or the illusion of immunity from further flooding created by minor or inadequate flood control projects and from relatively long periods between major floods, often resulted in still further development of the flood plain and in turn the need for further flood protection. The futility of attempting to develop and then protect the development of the flood plain is evidenced by the simple fact that in spite of the billions of dollars that have been spent on flood protection, annual flood damages grow

Table IV-4.—*Indian reservation water and related problems in the Westwide planning area by time frame*

Reservation problem area	Resolution of issue required by		
	1973 to 1985	1985 to 2000	After 2000
	Number of reservations involved where resource problems were identified		
I. Inventories needed to identify and quantify surface water supplies on the reservations	68	5	3
I. Land use inventory needed to identify and quantify:			
a. Potential irrigable acres	26	2	2
b. Mineral resources	68	6	5
c. Forest resources	39	2	–
d. Historical, religious, and archeological areas	89	1	–
e. Fish and wildlife habitats, estuaries, etc.	90	6	2
f. Conservation needs—erosion control, sedimentation, and salinity; drainage and flood damages, etc.	85	8	6
I. Water resources studies needed to identify and quantify requirements for:			
a. Irrigation and other agricultural needs	92	5	3
b. Power	39	–	–
c. Recreation	109	3	3
d. Municipal and industrial uses	75	4	3
e. Rural domestic uses	114	4	4
f. Low flow augmentation for fish and wildlife, estuaries, etc.	42	3	–
g. Mineral development	58	7	6
h. Maintenance of water supplies	61	3	1
V. Resource studies needed to identify and quantify ground-water potentials	87	4	6
V. Studies needed to identify and dimension the resource potentials for improving economic and social conditions on the reservations	98	2	2
I. Studies needed to measure present and potential environmental problems (water and water quality, population, congestion, shift in land use, etc.) associated with development programs on the reservation	92	6	6

Source: Bureau of Indian Affairs Areawide Field Survey, Western United States Water Plan.

Table IV-5.—*Estimated expenditures needed to complete and/or initiate new studies on Indian reservations in the Westwide planning area*

Area offices reporting	Tentative study costs identified ($1,000)				
	Phase I[1]	Phase II[2]	Phase III[3]	Phase IV[4]	Total
1. Albuquerque (includes New Mexico, parts of Colorado and Utah)	3,900	1,500	3,300	1,300	10,000
2. Billings (includes Montana and Wyoming)	300	200	400	200	1,100
3. Phoenix (includes Arizona [except Navajo Reservation], Nevada, and parts of Utah)	2,500	3,600	800	200	7,100
4. Portland (includes Idaho, Oregon and Washington	1,600	800	700	300	3,400
5. Sacramento (California)	700	1,400	300	300	2,700
6. Window Rock (Navajo Reservation)	6,000	2,200	1,500	800	10,500
Projected costs identified	15,000	9,700	7,000	3,100	34,800

[1] Phase I Studies: The general objective of these studies is to provide Tribal planners with information and data on the present status of ground and surface water supplies, water quality, land resources, and other resources on their reservations.
[2] Phase II Studies: The purpose of these studies is to determine the present and future land and water requirements on the reservations.
[3] Phase III Studies: Emphasizes plan formulation, investigations of site locations for dams and reservoirs, and benefit-cost analysis.
[4] Phase IV Studies: Are designed to provide information on environmental impacts of selected development proposals.
Source: A Bureau of Indian Affairs areawide survey of research requirements by type of study.

larger each year. The growth in annual flood damages is due primarily to development but also to increases in the value of contents in properties already in flood plain areas. The way to halt these ever increasing costs is flood plain management, which achieves optimum and wisest use of the flood plain resource through a whole mix of traditional structural measures and nonstructural measures. Some of these measures are detention or retention reservoirs, dikes, levees, channels and diversions, and others are watershed protection, land use adjustments, flood warning systems, evacuation, flood proofing, flood insurance of specific properties, zoning and acquisition. Inconsistencies in Federal cost-sharing policy for alternative measures for achieving similar objectives of flood plain management have resulted in primary reliance on structural measures.

DISCUSSION

Flood plain management is a concept that is meeting greater acceptance. Potential solutions for a specific problem site will vary with the economics of each flood plain and its relationship to the alternative plans of land use for the entire community or region. Possible solutions range from the traditional flood modifying means to such measures as greenbelts and parks. Flood plain management does not mean simply to clear away all existing development on the flood plain and create parks and greenbelts. However, there are often opportunities in flood plain areas to make excellent natural parks and greenbelts which provide both recreational activities and restoration of urban beauty. Whether traditional or nontraditional adjustments are employed, the objectives of flood plain management cannot be achieved without recognizing the opportunities of enhancing or protecting natural resource values or the costly consequences of failure to do so.

Section 206 of the Flood Control Act of 1960 authorized the Corps of Engineers to provide the states and local governments with the flood hazard information they need to regulate the use of the flood plain. This Flood Plain Information Service has been favorably received by States and local entities. Section 6 of the Watershed Protection and Flood Prevention Act (P.L. 566-83) authorizes the Soil Conservation Service to conduct flood hazard studies in smaller communities and rural flood plain areas. To date, this information has been mainly about floods and flooding because with limited funds this appeared to be of highest priority. However, current planning for the best use of the flood plain also requires information on the human uses and values of an undeveloped flood plain dedicated to floodwater storage, recreation, fish and wildlife habitat, and other natural resource values.

Requests for services have exceeded the funding and trained capability of the agencies to respond. A lack of sufficient Federal funds and manpower ceilings are limiting the services that can be provided. This often delays the State and local governments' ability to implement the alternative solutions available.

By the end of September 1973, 234 places in the 11 Western States had adopted some form of flood plain regulations. Montana and Arizona have recently adopted a statewide flood plain management program. The States of Washington and California have programs which encourage the adoption of flood plain regulations; and Oregon and Colorado are working in that direction. A few of the larger cities in the remaining states have flood plain ordinances or are considering them. Flood plain regulations are no more the sole answer to flood-related problems than is any other group of tools, but they are likely to be part of the solution in all flood prone areas, in the broad context of flood plain management.

Special flood hazard studies and flood plain information reports are prepared when requested by the States and local agencies. Flood insurance studies are prepared at the request of HUD, in connection with its Flood Insurance Program. All are completed as rapidly as funds and manpower will allow.

The various types of flood hazard identification studies provided by Federal agencies are of great value to state and local governments in determining alternative plans for use of their flood plains; however, a large backlog of needed reports and studies exists as shown in table IV-6.

PROBLEM RESOLUTION

The time frame for solution of this problem is from the present to the distant future. The solutions in all cases will involve local or state land-use decisions assisted by the flood hazard information provided by the involved Federal agencies. This will at best be an evolutionary process that may require years to execute once the local decisions have been made. The heaviest burden of the costs involved, under current laws, falls upon the local or State governments. They are often unable to meet these costs except over long periods of time. This fact has in the past contributed to the greater reliance upon flood modifying solutions where Federal funds were often more available and local costs were less. The basis for these decisions, however, should be a calculation and comparison of the total costs to the Nation.

Section 73 of the 1974 Water Resources Development Act provides a precedent in policy that should greatly increase the viability of flood plain management. Section 73 makes it mandatory for all Federal agencies to consider non-structural alternatives in all flood protection projects in the survey, planning, or design phases; and, where a nonstructural alternative is recommended, non-Federal participation shall be comparable to the value of lands, easements, and rights-of-way which would have been required under Section 3 of P.L. 74-738 for structural measures but in no event shall exceed 20 percent of the project costs. The implications of this provision will have a profound impact upon Federal flood protection planning and enhance possibilities for successful flood plain management programs at local, regional, and State levels.

Adoption of enabling legislation by States and developing consistent programs are important not only for the general flood plain management approach but also for setting the stage for community eligibility under the National Flood Insurance Program. States should examine the suggested legislative tools developed as a part of the work on the "Regulation of Flood Hazard Areas to Reduce Flood Losses," issued by the Water Resources Council and the legislation already adopted by other States. Each State should also set out the requirement for State agencies to recognize the flood hazard in land development or sales decisions as has been done at the Federal level by Executive Order 11296. This order requires the executive agencies and their heads to (1) provide leadership in avoiding uneconomic development on the Nation's flood plains; (2) evaluate the flood hazard potential prior to

Table IV-6.—*Comparison of urban places with flood problems and preparation of flood plain information reports and flood insurance studies by State*

State	Number of "urban places" with a flood problem		Number of studies or reports completed as of June 30, 1973		
	All places (1973 SCS survey)	Places with a tion of 2,500 or more (1967)	Flood plain information reports (CE)	Flood insurance studies (for HUD by corps SCS, and USGS)	Flood hazard studies (SCS)
Arizona	265	43	8	3	
California	1,700	369	70	79	
Colorado	251	51	22	13	1
Idaho	178	32	9	1	
Montana	115	30	5	0	1
Nevada	37	12	3	1	
New Mexico	298	34	4	1	
Oregon	659	60	16	7	3
Utah	240	39	10	1	
Washington	453	84	18	3	
Wyoming	63	19	4	0	
Westwide	4,259	800	169	109	5

Source: Field data, Western U.S. Water Plan.

committing Federal funds for construction, loans, or grants; (3) evaluate flood potential on Federal lands to be disposed of and restrict future development on vulnerable lands as a condition of disposal; and (4) evaluate flood hazards as a part of all Federal land use planning.

CONCLUSIONS

1. There is a need for expansion of the Federal Flood Plain Information Program and Flood Hazard Studies. The relatively small Federal expenditures involved in providing flood plain information and followup services may obviate great expenditures for damages, disaster relief, subsidized insurance, and flood control in the future.

2. On the part of State and local governments, a priority need exists for flood plain regulations, a vital part of any flood plain management program (and required by HUD as a condition for eligibility for flood insurance). Flood plain regulations are needed throughout much of the Westwide area.

3. In addition to flood hazard information, additional environmental data on flood plains are needed for a multiple-objective planning approach.

RECOMMENDATIONS

1. A substantial increase in the funding of the Flood Plain Information and Flood Hazard Studies spread over the next 2-3 years is needed. This increase in funding will enable the involved Federal agencies to respond to the increasing numbers of requests for their services.

2. There should be enabling lesiglation in those States in which there is some doubt about the legality of (a) community or county adoptions of flood plain regulations, or (b) the extraterritorial jurisdiction of larger communities for subdivision regulations. Provisions should also be made for establishing a regulatory base for flood plain management such as the programs adopted by Montana, Arizona, and several Midwestern and Eastern States.

3. Studies on the collection of basic environmental planning data covered under Westwide No. 5 should be coordinated with flood plain information studies as required for flood plain management programs.

WESTWIDE NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING

SUMMARY

Federal legislation, including the Fish and Wildlife Coordination Act and the National Environmental Policy Act, and the Principles and Standards for Planning Water and Related Land Resources promulgated by the Water Resources Council require that adequate consideration be given to man's interest in the natural environment. To accomplish this, adequate information on environmental resources and their potential to meet man's various needs in recreational, cultural, and scientific areas must be available.

In the Westwide area, there are immediate needs for basic biological data to be used in connection with planning for development and use of water and related lands. Anticipated developments for energy production, municipal and industrial growth, and food and fiber production compete with measures necessary for conservation and development of recreation fish and wildlife and other environmental resources. These and other impending multiple-purpose water development planning efforts require basic environmental data for development of viable alternative plans. Most critically needed are basic data on: (1) Minimum and maximum streamflows and optimum reservoir levels needed for recreation activities and maintenance of fishing habitats; (2) riparian habitat necessary for desired wildlife populations; (3) wetland areas necessary for waterfowl and other fish and wildlife species; (4) habitat requirements of threatened and endangered plant and animal species; (5) critical factors necessary to maintain coastal ecosystems; (6) habitat required to support big game species during winter conditions; (7) the management, protection and recreation-carrying capacities of fragile recreation resources and ecosystems such as high mountain lakes and streams and terminal lakes; (8) the impacts on recreation and recreation water resources resulting from urbanization; (9) benefits and losses that result from recreational vs. other uses of flood plains; (10) direct and indirect impacts on water-related recreation resources likely to result from the extensive development of various energy resources; and (11) potential nationally signficant natural areas and high-quality natural lakes. These data are especially important in areas with high potential for use in meeting energy needs. Additional manpower and funding should be focused on the collection and analysis of data in each of these critical areas so that information will be available in a timely manner.

This discussion covers needs for broad information required to assess overall planning problems. Requirements for information needed for resolution of other specific environmental problems are included as parts of regional or State specific problem discussions in chapters V and VI.

DISCUSSION

Basic environmenal planning data comparable in details to the data available for other water planning disciplines such as hydrology, engineering, and economics are not on hand. Planning for the environmentally related needs of people is difficult to accomplish without the same level of planning information as that available on crop production, product pricing, business economics, flood damage, etc.

The tourism-recreation industry is the second, third, or fourth most important industry in each Westwide State. A significant supporting element of this industry is the outdoor resources of these States which provide areas of high-quality fishing, hunting, riding, photography, and other related uses of the natural attributes of the West. Plans for the perpetuation and growth of this major industry, which is critical to the economy of many rural areas should involve the provision of water for conservation and development of streams, wetlands, riparian, and other areas which the tourist comes to use and enjoy in various ways.

To accomplish multipurpose water resource planning, agencies must have accurate determinations of the flows needed to maintain or improve rivers for sport and commercial fisheries, wildlife, recreation, aesthetics, and other environmental purposes. Proper provisions for maintenance of critical wetland habitat, for the special water needs of threatened and endangered species, and for freshwater inflows needed to maintain desirable estuarine conditions all require detailed studies. Instream flow requirements, wetlands inventory and evaluation, and endangered species habitat requirements are all vital aspects of determing water requirements, particularly where water for energy development may compete for available water. These data are also critical in determining water availability for use on public lands and Indian lands in the West. Under the Principles and Standards, environmental quality planning must include environmentally oriented plans as well as adequate consideration of environmental factors in formulating alternative plans with economic development emphasis.

Environmental Data Gap

Other environmental data deficiencies related to outdoor recreation cross a broad spectrum of natural resource and social concerns. The kind and quality of recreation opportunities provided are intermingled with many other uses made of the natural resource base. For example, there is a need to better determine the effects thar various kinds of development have or will have on the recreation opportunities provided by streams. This includes the need to know what minimum flows are necessary to provide the visual qualities and floating experiences expected in Wild, Scenic, and Recreational rivers. However, these determinations must also take into account the legal problems associated with whether or not such flows can be provided under the present interpretation of water rights and beneficial uses. Data are generally lacking on the quality and quantity of recreation opportunities that are associated with various flows and the possible conflicts that recreation flows may have with other uses. This kind of analysis, where applicable, also needs to consider means of maintaining higher reservoir levels during the principal recreation season.

In order to meet recreation demands, recreation access and facilities have been expanded nationwide. In many areas, recreationists have been expanding their own frontiers without the benefit of new developments through the increasingly popular activity of backpacking and the use of cycles, four-wheel drives and other recreational vehicles. Careful planning is needed to avoid deterioration of the recreation resource base as a result of such expansions. For example, fragile ecosystems, such as those associated with high mountain lakes and streams, can suffer from recreation vehicle use and other intensified recreation impacts simply through the provision of minimal access where there was none before. As the demand to open such areas to greater use continues to increase, the need to develop and implement the carrying capacity concept and other more intensified management techniques for various recreation activities and areas increases. At present, very little information is available on carrying capacities and management of various recreation resource types.

Terminal lakes are an important but diminishing recreation resource in some parts of the West. Special measures will probably be needed to protect the wildlife and fishery habitats associated with them. Most notable are Pyramid Lake, Walker Lake, the Great Salt Lake, and the Salton Sea, which has the characteristics of a terminal lake.

It is recognized that a considerable amount of open space and recreation resources are being lost to urbanization. It is probably most significant along the coast and in mountainous areas. More needs to be known about the magnitude of the environmental impacts associated with such developments. The impacts range from increased waste discharge into rivers and coastal waters with resulting effects on aquatic habitat, loss of open space, increased air pollution, to the urban-like effects that concentrations of summer or winter recreation homes have on high-quality resources. The resulting encroachment on forest and rangelands may affect the ecological balance and productive capabilities of the land, water, vegetation, and wildlife.

Flood plains have considerable influence on the recreation environment. More needs to be known about the long-range impacts that result when changes are made within the natural flood plain. Where effective, zoning, acquisition of land and easements, and the pricing of flood insurance for these areas should encourage the location of damageable developments elsewhere to favor parks, open space, and low-damage installations where flooding is likely to occur. However, there is little existing data to prove that these uses are the wisest and most economical in the long run.

Projections indicate extensive development of coal, oil shale and other energy resources in Western States. Little is known about the long-range impacts on recreation resources that may result from the water supply and water use aspects of this development. An intensive research and planning program is needed to determine where adverse impacts are likely to occur and to provide a basis for helping decisionmakers guide this important development in a least-environmentally destructive manner.

There is a need for the Federal Government and States to complete a program of identification and selection of nationally significant natural areas in connection with the National Natural Landmarks Program and comparable State programs. There is also a need for States to initiate comprehensive inventories and analyses of natural lakes to identify more definitively those with high recreation, natural, and fish and wildlife values. Supplemental programs incidentally, are needed to protect the values of these natural areas and lakes.

Instream Flow Requirements

Free-flowing streams provide for unique cultural, scientific, and recreational activities that are in short supply in many areas. Streams provide habitat for fish and stream-related wildlife, create opportunities for recreation and increase environmental quality in several ways. Because aquatic organisms vary in their needs seasonally and much of stream-related recreational activity is also seasonal, instream water needs are variable. Seasonal requirements must be integrated into a suitable overall regimen if an acceptable ecosystems it to be maintained.

Water development projects often modify stream conditions and alter their capacity for fish production, recreation, and maintaining desirable natural conditions. However, many of the basic economic and social goals of water development can be achieved in ways that complement environmental needs.

Many existing water diversions degrade aquatic environments and resource managers are increasingly concerned over threats to the remaining natural stream values in the West. The problem involves both biological and legal questions and the solution must include legislative action as well as technical and field studies. Existing water laws are not conducive to preservation of instream flows thus aggravating the problem in those cases where such flows can be an objective of a water resource project. Even when releases are provided for in preproject operation studies and in authorizing legislation, it is difficult to assure that once operations are undertaken, such water will remain in the stream for appropriate distances. This situation occurs even where fish and wildlife and environmental preservation benefits based on analysis of anticipated downstream flow conditions are included in the project justification. Thus, management of stream systems for environmental values is very difficult.

For the most part water laws in the Western States are based generally on the law of appropriation and provisions to guarantee minimum sustained streamflows are weak or lacking. Some states do recognize minimum flows for maintenance of fish and wildlife as a beneficial use. Legislation is needed in other Westwide States to protect suitable base flows in perennial streams. Legal recognition is needed in all states for the recreational and asethetic benefits of instream flow maintenance. Future water development proposals requiring Congressional action should specifically identify base flow needs for affected streams and recommend maintenance of suitable flows as a condition to the commitment of public funds.

Field determinations of specific instream flow needs in the past have often been accomplished under the pressure of short study deadlines. In the absence of detailed study, an amount approaching the historic average annual minimum flow has sometimes been considered as a suitable minimum flow for fishery and related purposes even though this resulted in a loss of fishery and other values. Moreover, since naturally occurring low flows often are of short duration and usually reach this level gradually, any suddenly imposed or extended periods of low flow due to a project are quite detrimental in most cases.

Field surveys and studies must be designed to adequately describe the minimum flow regimen needed to sustain a given stream ecosystem without material degradation. Many parameters – biological, chemical, and physical in nature – should be covered at a level geared to meet specific study requirements and a suitable methodology must be developed to encompass these parameters.

Determination of instream water needs for all streams in the West with environmental values is a long-term task. Studies should be focused initially on streams in areas where near-term and mid-term solutions are being sought for other water problems such as in the areas with coal and oil shale development potential. However, it is important that studies be completed on all significant streams at an early date.

Specific attention also must be given to those streams which furnish spawning and nursery areas for anadromous fish. Valuable sport and commercial fisheries for salmon as an example are dependent on the maintenance of adequate flows during several critical periods of the year. These critical periods include upstream migration, incubation of the eggs buried in the stream gravel, growth of the young fish and migration of smolts to the ocean.

Instream flow determinations should be made for most of the significant and vulnerable streams in the West over the next 5 years. Acceptable results will require close cooperation among State and Federal planning and management agencies. The studies would identify instream flow levels which would optimize fishery and other environmental values and clarify the nature of the trade offs involved in planning decisions.

Riparian Wildlife Habitat

Assessments are needed to identify the critical areas that are important to assure adequate stocks of those species of fish and wildlife supported by habitat along stream channels. Where these areas occur, improved methods of stream alteration may be found that provide the necessary control but maintain the habitat required for biological populations.

Flood plain ecosystems generally are the most productive inland habitat in North America, with species diversity and abundance reaching high levels. Stream channel stabilization and control may diminish productivity and profoundly affect seasonally flooded areas and the recharge of swamps, marshes, and small lakes.

A necessary step is assessment and measurement of the degree that stream alterations are affecting aquatic ecosystems. Relationships within natural and disturbed aquatic systems must be currently determined. The rate at which important habitats are affected should be analyzed. Stream ecosystem values for improving water quality, preventing downstream floods, and recharging aquifers should be recognized.

Stream system alterations will likely continue to be used to meet demands for flood control and water yield improvement. Biological experts must provide factually based alternatives that minimize or avoid adverse effects on stream ecosystems. With several Federal agencies planning and implementing stream channelization and other stream alteration procedures, there is a special responsibility on the Federal government for the development of procedures to protect stream ecosystems.

While studies are planned by the Fish and Wildlife Service beginning in fiscal year 1975, most are in the East. Appropriate studies in the West need to be undertaken to cover very specific conditions in stream types occurring only in the West.

Wetlands Areas

Wetlands are among the most important types of habitat for wildlife in the West. They are also among the areas most vulnerable to change. In arid regions the water consumed by wetlands is sometimes viewed as a source of water for other purposes. In coastal areas, wetlands have been filled for industrial, residential, and recreational sites.

While earlier inventories, most in the early 1950's, showed extensive past losses of wetlands, no recent surveys have been undertaken to determine the current status of such areas. It is important to know which areas have remained unchanged as well as what has been gained or lost, what has significantly deteriorated, what is most vulnerable to early damage, and what areas could be restored by provision of adequate water supplies.

Diversion of water supplies, the inundation of flood plains and other riparian areas, drainage, and channelization, all may affect wetlands. An understanding of the local and regionwide status and relative value of the wetlands is required for an adequate assessment of the environmental consequences of various alternative water plans. Comprehensive land use plans, fish and wildlife plans, and general recreational plans, all prepared at the State level, require an up-to-date inventory and evaluation of wetlands.

Waterfowl, shore birds, marsh birds, fur bearers by the millions use wetlands to raise their young, as critical resting and feeding areas during migration, and as year-round habitat. Management of waterfowl populations, including provision of adequate habitat, is a Federal responsibility. Wetlands fringes are also important nursery areas for many species of fish.

Hunting, fishing, wildlife photography, nature study, and many other of man's pursuits are intimately linked with the wetlands and their resources. Unless provision is made in water development planning for the preservation of critical wetland areas, particularly as to the allocation of necessary water supplies, these interests and activities of man may not be protected adequately.

Threatened and Endangered Species

One of the unfortunate consequences of growth and development in the West has been the extermination of some native species of fish and wildlife. Reductions in the populations of other species of native wild animals with educational, historical, recreation, and scientific value have occurred and are occurring. In addition to those many species now threatened with extinction in the Westwide area, there are a number of rare species in the Westwide area which, if not given consideration in water development planning, could end up on the endangered list.

The United States has pledged itself, pursuant to migratory bird treaties with Canada and Mexico and the Convention of Nature Protection and Wildlife Preservation in the Western Hemisphere, to conserve and protect, where practicable, the various species of native fish and wildlife, including game and nongame migratory birds, that are threatened with extinction. In the Endangered Species Conservation Act, Congress charged the Secretary of the Interior, the Secretary of Agriculture, and the Secretary of Defense, together with the heads of bureaus, agencies, and services within their departments, with the protection of species of native fish and wildlife, including migratory birds, that are threatened with extinction and insofar as is practicable and consistent with the primary purposes of such bureaus, agencies, and services with the preservation of the habitats of such threatened species on lands under their jurisdiction.

Habitat conditions in the Colorado River and its major tributaries have placed several endemic fish species with special adaptations to historic flow conditions in danger of extinction. Possible further changes would cause the loss of the remaining habitat which allows these remnant populations to still survive. Particularly vulnerable habitat areas occur in the Yampa, Green, and Colorado Rivers. Fish species of immediate concern include the humpback chub, the Colorado River squawfish, and the woundfin. Some of the unknowns are the size of the remaining populations, the specific factors in river development which may have contributed to their decline, and life history details, including specific habitat requirements.

Also in the Colorado River basin, riparian wetlands which provide essential habitat for the Yuma clapper rail, California black rail, and the Mexican duck may be affected by channel modifications. Little is known about the habitat requirement for these species.

In the Great Basin, a series of relict fish species depend on a very limited habitat in springs, seeps, etc. which have a vital connection with ground-water resources. Such species as the Devils Hole pupfish and the Pahrump killifish are particularly vulnerable to ground-water withdrawals; and further studies should be made not only of their ecology but also of means to insure that the springs, holes, or sloughs in which they occur are not drained by ground-water mining.

Several threatened trouts – the Apache trout now limited to Ord Creek and East Fork of the White River and two small lakes on the Fort Apache Reservation, the Gila trout surviving only in the headwaters of the Gila River, the Paiute trout in Alpine and Inyo County, California, and the greenback cutthroat trout limited now to Blackhollow Creek in the Cache La Poudre drainage – require additional studies on how their survival can be assured as part of the general water development planning picture.

Another threatened trout, the Lahontan cutthroat is a significant consideration in future planning for Pyramid Lake and the Lower Truckee River and further studies on the reestablishment of natural spawning runs of pure strains of this species are needed.

For all the above endangered species and for a very much larger number of threatened species, the specific habitat requirements in such areas as waterflow regimens, temperatures, water quality, substrate conditions, etc. are not known in nearly enough detail so that adequate provisions can be made for their survival in water development planning activities. The present tempo of research activities on these species will not provide the necessary information soon enough so that critical water planning decisions can be made in a timely manner.

There is a critical need for a greatly stepped-up research program so that these species are not "guessed" into extinction as water control facilities are installed. Unless timely studies are made on the habitat requirements of threatened and endangered species, specific provisions cannot be included in water development plans to ensure their survival. The situation is more critical where proposed coal and oil shale developments overlap critical habitat.

Estuarine Habitat

Coastal ecosystems include tidal wetlands and estuaries. These fragile systems are of special significance in the Westwide area because they provide basic life support for much of the Pacific Coast fishery resources. Coastal areas further serve as important nesting, resting, and/or feeding habitat for a variety of animals including birds, fur bearers, and sea mammals as well as many threatened and endangered species. The estuarine mudflats and waters and marsh vegetation are vital wintering, feeding, and resting areas for many migratory ducks, geese, swans and shore birds. They contain significant marketable deposits of oil, gas, minerals, sands, gravel, and shell, and serve as vast sediment traps. In an undeveloped state they are the largest, least costly, and most efficient waste treatment systems known to man.

Coastal areas have been altered by man at an alarming rate through dredging, filling, channelization, pollution, and diversion of freshwater inflows. Natural functions of many ecosystems will be significantly degraded or essentially lost in the near future without proper planning and management. In view of their values and pending losses, strong initiatives must be taken to assure that coastal ecosystems are given full consideration in water and related land use planning.

Uses made of the Nation's coastal ecosystems include: (1) Sites for urban and industrial development; (2) navigation channels and ports; (3) highways and airports; (4) waste receptacles; and (5) oil, gas, and mineral development. Historically, many of these uses have unilaterally precluded multiple use of developed areas. A variety of uncontrolled and improperly planned and constructed alterations and developments have occurred.

While there is a need to protect, preserve, and control vital estuarine habitats, the whole spectrum of man's social and economic pursuits must be considered. This requires a plan for each estuary which takes into account various levels of development and the specific resources which must be protected. The coastal States are moving to establish the institutional mechanisms required. The California Coastal Conservation Act, enacted in November 1972, requires that a plan including all areas from 3 miles seaward to 1,000 yards landward of mean high tide be presented to the State legislature by December 1, 1975. The Oregon Coastal Zone Management Act (Act 608-1971) created the Oregon Coastal Conservation and Development Commission, charged with submission of a natural resource management plan and method of implementation to the 1975 session of the legislature. The Washington Shoreline Management Act of 1972 (Chapter 90.58 PCW, ratified by electorate as Initiative 43B) has similar provisions.

The primary emphasis of the Westwide Study was limited to the freshwater inflow aspects of the estuaries. The most critical problem in preparing multiple-purpose water-supply plans is the lack of basic biological information. The various planning efforts under way or under consideration by local, State, and Federal agencies must have this input at the earliest date possible.

Biological studies of the freshwater supply aspects of the estuaries would involve the determination of the critical fish and wildlife habitat areas in both intertidal and open water locations and the interrelationship of these areas to water quality, flushing patterns and rates, sedimentation patterns, and freshwater inflows. The amount and regimen of freshwater inflows necessary to maintain desirable estuarine salinity level gradients, nutrient levels for fish and wildlife, and general maintenance of critical ecosystems are vital input to any multiple-purpose water development planning in upstream areas. Storage and diversion of freshwater in coastal basins could have significant effects on the estuarine ecosystems.

An understanding of estuarine ecosystems requires extended studies to determine the roles of freshwater inflows and the other critical elements. Basin biological studies should be initiated immediately, concentrating on estuaries where developmental pressures are most evident or where relatively pristine areas appear most vulnerable. Specific estuarine problem areas are included in Regional Problems No. 6 and in discussions of water-related problems in Washington, Oregon, and California.

Critical Big Game Winter Range

Big game winter range has been degraded and severely reduced in extent by farm, industrial, recreational, and other developments. A major contributor to critical habitat losses has been water use and control projects. Improved pumping and other water handling technology has resulted in increased irrigation of lands formerly uneconomical for development. Many of those areas include limited critical winter range for deer and other big game.

Compensation for winter range losses include revegetation and control of livestock grazing on remaining winter range after the new croplands are fenced. The extent of compensation with these measures is meager compared with the possibilities in irrigation of native and exotic woody plants that provide big game browse. Limited data indicate browse production can be many fold with increased water supply. A long-term research program is needed to ascertain potentials in irrigated browse management. Severe reduction in big game herds during recent years requires a major effort to maximize winter range productivity. From a water supply standpoint, the need for such research would be heightened by the probable use of weather modification to increase the snowpack in many areas of the West which will concentrate big game on lower altitude winter range making the problem even more critical.

Resources Affected by Energy Developments

Development of extensive oil shale deposits underlying Federal lands in Colorado, Wyoming, and Utah appears imminent. A final environmental statement on some lease tracts has been prepared and test tracts have already been leased. A mature industry producing 1 million barrels of oil per day would require additional leasing of Federal lands, and additional environmental statements. The largest low-sulphur coal deposits in the world are about to be developed in Wyoming, Montana, and the Dakotas. Additional coal resources are likely to be developed in Colorado, Utah, and New Mexico.

Development of these resources will probably have substantial environmental impacts. A number of threatened species of fish and wildlife and important recreational and scenic resources will be affected.

Ancillary development will include powerlines, pipelines, roads, urban development, and water impoundment and diversion projects. Major, but ill-defined, disruptions of both on and off site ecosystems pose an imminent threat. Proper environmental baseline inventories of habitat and fish and wildlife populations in the areas to be affected are lacking. The art of revegetating reclaimed arid mines with suitable wildlife food and cover species in semiarid areas is still in the developmental stage. Scarcity of high-quality water will require the ultimate in technology for conservation and treatment, plus long-range planning priorities for use that include revegetation and maintenance of fish and wildlife. Studies have already been programed to accurately assess the impact of proposed developments on the environment to permit the formulation of recommendations for alternative project designs that will lessen the impact of development on the ecosystem; and to make recommendations for restoration of the disrupted areas. However, again there is a critical need for basic environmental data as the basis for such assessments and planning.

PROBLEM RESOLUTION

One approach to developing needed environmental information for both environmental and development plan alternatives in water planning is the traditional one of relying on whatever basic environmental data happen to be available for the project area and to extrapolate by judgment where data are missing. This process would be started at the same time intensive planning for other functions was initiated using the much more definitive data generally available for other functional areas and would thus not give equal consideration to the environmental aspects of the immediate project area nor would it allow adequate consideration as to how the natural resources of this area contribute to the needs of a much larger surrounding region.

A more acceptable approach would entail making the necessary effort to assure that adequate reliable information is available in the natural environmental area prior to intensive water and related land use planning. Background studies on how man's needs in recreational, scientific, and cultural areas can be met by the various components of the natural environment such as streams, wetlands, estuaries, etc. would allow for a much more comprehensive planning approach to meeting all of man's water-related needs. Coordinated Federal and State effort is required so that timely information is available in those areas where early development is most likely to be under consideration and so that any duplication of effort is avoided.

CONCLUSIONS

New and strengthened laws related to environmental matters and forceful National and State policy guidelines require that acceptable information about environmental resources be collected, presented for public inspection, and fully considered when water and related land use choices are made.

1. Generally, environmental information necessary to assure reasoned decisions on many water and related land use problems is lacking, incomplete, or inconclusive. It is difficult to assure the same degree of reliability to hastily developed survey data when compared to carefully prepared and analyzed geologic and hydrologic information.

2. Since the absence of reliable information reduces the acceptability of decisions on resource use, a unified effort is needed to assure that the environmental data necessary for reasonable choices are collected, analyzed, and used properly. Most critically needed are basic data on: flows required to maintain stream fishery habitat, scenic qualities, and water-dependent recreation activities; riparian habitat adjacent to stream channels needed to support desirable wildlife; wetland habitat requirements of threatened and endangered species; critical factors necessary to maintain coastal, outstanding natural, and terminal lake ecosystems; and habitat required to support big game populations during winter conditions.

3. The highest priority for future study is in areas that would be affected by facilities and programs related to energy production.

4. Measures to provide the instream flow needs for environmental purposes, including the water needs for riparian and estuarine habitats and water needs for endangered species cannot be fully implemented until the States have effective laws that provide for such flows as a beneficial use of water and allocate an adequate amount of their water resources to these public purposes.

RECOMMENDATIONS

A joint State-Federal effort is necessary to assure that the necessary information on environmental matters is collected, presented, analyzed, and used in decision-making. This effort should focus on the following areas of most critical need.

1. The effort to determine and document instream flow requirements for critical areas should be continued and expanded. This will require approximately 10 years of concentrated effort in the West.

2. Study of the effects of alternative approaches to stream alteration should be continued and expanded to cover specific conditions on stream types occurring in the West.

3. An updated wetlands inventory for the Westwide area should be carried out over the next 5 years in cooperation with State and Federal agencies. This study should lead to an analysis of the water requirements of critical wetlands and of restoration of those wetlands which should be restored. A followup program on restoration and an inventory should continue for an additional 5 years. Concurrent studies of riparian habitat necessary to support desired levels and variety of fish and wildlife population should be carried out.

4. Funding over and above present levels should be provided for accelerated studies of threatened and endangered species in the path of probable water and related land development. An immediate 10-year study program should concentrate on threatened species most vulnerable to habitat loss or change through water development in the West.

5. Basic environmental data related to estuarine can meet their various responsibilities in areas of anadromous fisheries, migratory waterfowl, planning for energy production, water use planning and operation, etc. Studies of water supply would complement other biological and physical oceanographic studies necessary to identify habitat requirements for estuarine dependent species. Details of study requirements for the three Pacific Coast States are presented in regional or State specific problem presentations.

6. Research and pilot studies to develop techniques for enhancement of critical big game winter ranges in the West should be initiated soon so that such techniques will be available at the time decisions are being made on any land use changes on present winter range, on related water developments, and on weather modification programs. A long-range study program in cooperation with the States is required to develop the tools to handle this problem. Studies would take place where it is determined that lands, water supplies, research facilities and State cooperative efforts would best lend themselves to a productive pilot program.

7. The first priority for implementing studies is in areas of Colorado, Wyoming, Utah, Montana, and New Mexico so that any delays in developing adequate energy sources for the Nation may be forestalled. The major areas of water-related environmental data are needed for planning purposes in these energy-related areas are: (1) instream flow needs for fish and wildlife, general environmental, and recreational uses; (2) specific range and habitat requirements of threatened and endangered animal and plant species and; (3) inventory data on critical wetlands and riparian habitat.

8. Those states who have not as yet, should actively consider the establishment of a legal basis for allocating water resources to maintain instream flows and estuarine freshwater inflows to support the many uses the public makes of stream and estuarine environments.

WESTWIDE NO. 6 – NEED FOR ADDITIONAL FLAT-WATER RECREATION OPPORTUNITIES

SUMMARY

The increase in outdoor recreation activity over the past 15 years is well documented. Water-dependent activities (boating, swimming, fishing, ice skating, water skiing) account for one-fourth of present outdoor recreation use. Heavy recreation use in areas accessible to large population centers has imposed considerable pressures on available flat-water resources. Inadequate recognition of recreation as a beneficial use of water in the past has prevented full realization of the recreation potential of manmade lakes. Built originally for varieties of economic purposes, some have become predominately recreational in use. Potential for higher utilization for outdoor recreation at existing reservoirs includes improvement or enhancement through operation and management, provision of additional facilities, and changes in water use which may require legal and institutional changes. Reevaluation is needed to determine additional opportunities available to meet needs for flat-water recreation in high-density use areas.

DISCUSSION

The following statement on natural lakes and reservoirs is quoted from the President's message to the Congress of December 19, 1973.[1]

> "There is a need to identify and protect for public use and enjoyment those lakes which have significant values and which should be managed for outdoor recreation, wildlife conservation, and scenic beauty. Supplemental to this is the need to develop research programs to examine the many aspects of natural phenomena in natural lakes and lake areas.
>
> "There is a responsibility for States to initiate comprehensive inventories and analyses of lakes to identify more definitively those with high recreation, natural, and fish and wildlife values. Supplemental programs to protect these values also should be established.
>
> "Although less than one-half of the States have natural lakes with surface areas of 10 or more square miles, more than three-quarters of the States have manmade reservoirs with 10 square miles or more of surface area.
>
> "Only recently has recreation been included as a specific project purpose for reservoir construction. Many early reservoirs were constructed as a single purpose project, often by private power companies concerned only with acquiring sufficient land on which to store the water required for power generation; little if any land was purchased or available for recreation. Reservoirs today play an important role in providing outdoor recreation opportunities, frequently within short driving time of urban areas."

A Geological Survey summary published in 1966 lists a total of 1,562 reservoirs and controlled natural lakes of 5,000 or more acre-feet capacity on which construction was either completed or begun prior to 1963. These reservoirs provide over 14,830,000 surface acres of water. The summary indicates that recreation is considered to be a legitimate use on only one-third of the reservoirs, with a total of about 9,654,200 water surface areas. Some of these reservoirs, built originally for a specific purpose which they no longer serve, are now used only for recreation. There are 679 major reservoirs in the 11 Western States many of which are playing an important role in meeting water-related needs.

[1] "Outdoor Recreation – A Legacy for America" The First Nationwide Outdoor Recreation Plan, 1973.

In each of the type I framework studies, a systematic inventory and analysis of outdoor recreation demand, supply, and needs were made. Needs were determined by location, time frame and magnitude in terms of capacity of use, acres of developed land, and acres of water surface. Every State is required to have a Statewide Comprehensive Outdoor Recreation Plan (SCORP), endorsed by the Governor and found adequate by the Secretary of the Interior, as a prerequisite for cost sharing in the Land and Water Conservation Fund. In developing these SCORP's, each of the Western States has also made a systematic determination and evaluation of its outdoor recreation needs by location, time frame, and magnitude. One of the initial jobs of the Westwide Study was the analysis of the water-based outdoor recreation needs data from the comprehensive studies and State recreation plans.

This information indicated a range of needs for additional recreation surface water from less than 100 acres near a small town in Montana to over 100,000 acres for a major metropolitan area in California. For the purpose of determining critical needs under the rescoped Westwide Study, only those areas were identified which demonstrated a need for at least 10,000 acres of additional effective recreation surface water either now or by 1985. Areas of critical needs were identified, figure IV-11, which included the populous South Pacific Coast area from about San Francisco to San Diego; the Front Range of the Rocky Mountains north and south of Denver; the Phoenix-Tucson area; and the Rio Grande Valley in the general vicinity of Albuquerque.

PROBLEM RESOLUTION

Although plans include recreation potential in new reservoir projects, the prospect for new reservoir projects becoming useful recreation resources for these critical areas before 1985 is extremely limited. A major exception might be the Central Arizona project as discussed subsequently.

The apparent alternative for meeting these critical needs and/or enhancing water-based recreation opportunities is dependent upon increasing the effectiveness of the existing resource base, i.e., the streams, lakes, and reservoirs presently in place. The protection and enhancement of the water-based recreation opportunities and other values associated with free-flowing streams are treated elsewhere in this report as a separate issue.

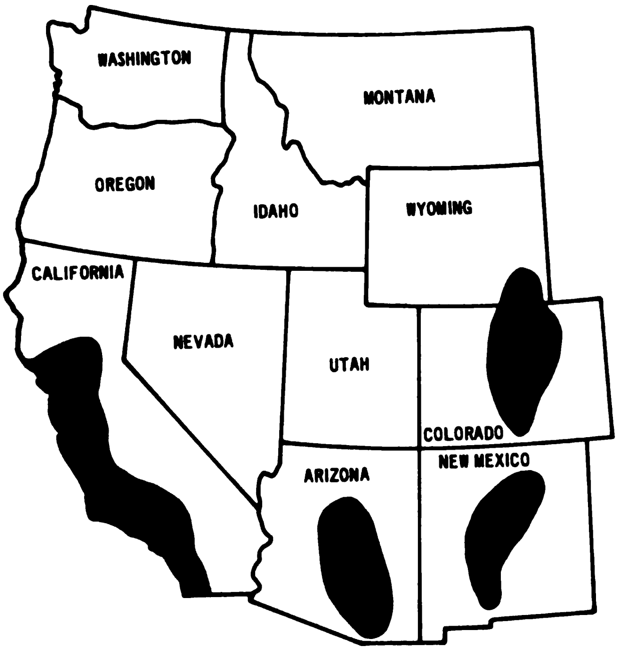


Figure IV-11. Areas needing additional flat water for recreation.

Virtually every one of the Westwide State Study Teams identified Federal reservoirs which, with some modification in operation and management, could provide additional public recreation opportunities. Figure IV-12 identifies these reservoirs. There is a large Federal investment in these projects. There is a corresponding Federal responsibility to insure that operation and mangement are aimed at securing maximum public benefits.

Most of the Federal reservoir projects which exist today were authorized, planned, and constructed a number of years ago, prior to the time when outdoor recreation was recognized as a bona fide project purpose. Built originally for such purposes as irrigation, power, and flood control, some of them have become increasingly valuable for recreation. The present system imposes a number of constraints on recreation use and development of western reservoirs. For example, the Bureau of Reclamation is limited to a maximum expenditure of $100,000 for recreation development on any existing project. Also, a recent (1974) Amendment to the Federal Water Project Recreation Act provides for 75 percent Federal cost sharing of fish and wildlife development at Federal reservoir projects, but only 50 percent of the general recreation costs can be assumed by the Federal Government.

Any decision to change the purpose and/or operation of these existing Federal projects must be supported by a body of data and an analysis which clearly demonstrate that the public interest will be served by changing the present system. However, decisionmakers cannot come to grips with this matter until a study is made and the information analyzed to determine what alternative courses of action are viable.

Any studies aimed at modifying existing Federal reservoir operations, management, and development policies to enhance outdoor recreation opportunities and use must involve:

a. The Federal agency having responsibility for the project (usually the Bureau of Reclamation or Corps of Engineers);

b. The State in which the project is located;

c. The agency (State, Federal, or local) responsible for administering and managing the outdoor recreation function of the project;

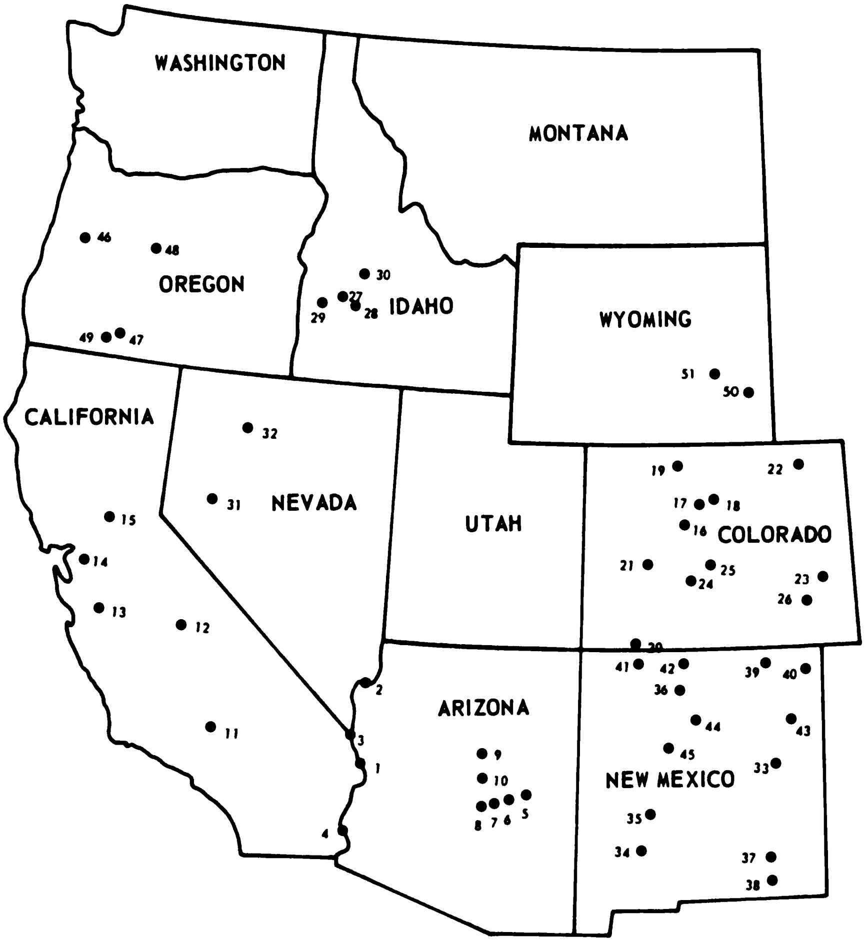
d. The State and Federal fish and wildlife agencies;

e. The Federal agency responsible for coordinating outdoor recreation; and

f. Other involved governmental or private entities, such as M&I water agencies and irrigation districts.

Based on the information developed by the Westwide State Study Teams, there are well over 100 reservoirs which have high potential for meeting recreation needs, figure IV-12. Not all of these studies can or should be done at once. If figure IV-11 is superimposed on figure IV-12, those reservoirs which fall within the most critical areas of need emerge. Table IV-7 lists reservoirs which should be given high-priority, early study for additional flat-water recreation potential.

An additional water source that could meet priority recreation needs is the water that will be supplied by the authorized, but yet to be constructed, Central Arizona Project (Bureau of Reclamation). This project is a large water-supply system consisting of several reservoirs and about 370 miles of aqueduct much of which are located reasonably close to Phoenix and Tucson. Since resources are so few near these cities, the potential of the Central Arizona Project in meeting urban recreation needs is great. The recreation potentials have not been fully evaluated in light of today's demands. Additional recreation studies are needed to review the potentials and ensure priority consideration



RESERVOIRS

State	Map No.	Name	State	Map No.	Name
Arizona	1	Havasu	Idaho	27	Lucky Peak
	2	Mead		28	Arrowrock
	3	Mohave		29	Lake Lowell
	4	Imperial		30	Deadwood
	5	Roosevelt			
	6	Apache	Nevada	31	Lahontan
	7	Canyon		32	Rye Patch
	8	Saguaro			
	9	Horseshoe	New Mexico	33	Alamogordo
	10	Bartlett		34	Caballo
				35	Elephant Butte
California	11	Woolomes		36	El Vado
	12	Millerton		37	McMillan
	13	San Luis		38	Avalon
	14	Contra Loma		39	Stubblefield
	15	Folsom		40	Maxwell No. 13
				41	Navajo
Colorado	16	Green Mountain		42	Heron
	17	Willow Creek		43	Conchas
	18	Granby		44	Abiquiu
	19	Lake John*		45	Jemez Canyon
	20	Navajo			
	21	Paonia	Oregon	46	Fern Ridge
	22	Sterling*		47	Howard Prairie
	23	Nee So Pah* (group)*		48	Prineville
	24	Taylor Park		49	Emigrant
	25	Twin Lakes			
	26	John Martin	Wyoming	50	Glendo
				51	Guernsey

*Non-Federal

Figure IV-12. Reservoirs with recreation potential – Westwide Study area.

Table IV-7.—*Reservoirs suggested for early study for additional flat-water recreational potential*

State	Map No.	Reservoir	Construction agency	Agencies administering recreation
California[1]	13	San Luis	USBR	California State Park
	12	Millerton	USBR	California State Park
	15	Folsom	USCE	California State Park
	11	Woollomes	USBR	Kern County Park
	14	Contra Loma	USBR	E. Bay Regional Park
Colorado	16	Green Mountain	USBR	Colorado Division of Parks
	17	Willow Creek	USBR	National Park Service
	18	Granby	USBR	National Park Service
	24	Taylor Park	USBR	U.S. Forest Service
	25	Twin Lakes	USBR	U.S. Forest Service
Arizona[2]	5	Roosevelt	USBR	U.S. Forest Service
	6	Apache	USBR	U.S. Forest Service
	7	Canyon	USBR	U.S. Forest Service
	8	Saguaro	USBR	U.S. Forest Service
	9	Horseshoe	USBR	U.S. Forest Service
	10	Bartlett	USBR	U.S. Forest Service
New Mexico	33	Alamogordo	USBR	State Park and Recreation Commission
	35	Elephant Butte	USBR	State Park and Recreation Commission
	36	El Vado	USBR	State Park and Recreation Commission
	44	Abiquiu	USCE	Corps of Engineers
	45	Jemez Canyon	USCE	Corps of Engineers
Wyoming[3]	50	Glendo	USBR	Wyoming Recreation Commission
	51	Guernsey	USBR	Wyoming Recreation Commission

[1] These studies should be funded and undertaken as part of the ongoing USBR Central Valley Total Water Management Study.
[2] Should be undertaken as part of the ongoing USFS Land Use Planning Study.
[3] Should be undertaken as part of the ongoing Bureau of Reclamation North Platte Water Management Study.

to innovative ways of satisfying urban recreation and environmental needs.

A special situation exists with respect to the main stem impoundments of the Lower Colorado River. Although these projects are not located close to urban areas, they are heavily used for recreation. The lack of alternatives makes them more valuable than the distances from population centers suggest. Total recreation use in 1968 along the Colorado River, from Lake Powell to the Mexican border, was about 11 million visitor-days. About 80 percent of the use south of Davis Dam originates in California. Inadequate recognition of recreation as a beneficial use of water in the past has prevented full realiziation of the recreation potential of these Lower Colorado River projects. Built originally for a variety of economic purposes, the substantial increases in recreation use warrants reevaluation to determine how the benefits by purpose matched with original estimates and whether specific action programs are needed to accommodate changed uses.

As discussed in Regional No. 4, Managing Water and Related Land of the Lower Colorado Main Stem, Federal action to improve the existing recreation resources is especially appropriate and needed. The lower river is almost entirely under Federal control or administration which is divided among many agencies, each with its own management objectives. In view of the river's acknowledged recreation and environmental values, the level of Federal control and responsibility and the many resource management problems, an intensive review of its entire operation – land and water – is warranted.

Each study would include the following:

a. Analysis of recreation market areas;

b. Comparison of preauthorization studies and projections with actual recreation use today;

c. Identification of factors limiting general recreation use;

d. Identification of factors limiting fish and wildlife production and utilization;

e. Development and evaluation of alternative schemes of reservoir (water) operations to optimize recreation benefits;

f. Evaluation of impacts (tradeoffs) on other water uses and functions (includes development of a mechanism to provide just compensation for benefits [values] lost);

g. Evaluation of downstream flow effects on recreation, fish and other values; and

h. Formulation of a recommended plan in concert with a non-Federal public body.

CONCLUSIONS

1. Multiobjective multiagency studies of existing and authorized reservoirs identified above should be conducted to determine if greater economic and social benefits could be realized by reallocation of stored waters and/or modification of operations.

2. Recreation development and use of existing and authorized Federal reservoirs are constrained by seemingly outmoded Federal and State laws, policies, and institutional arrangements. Any studies aimed at modifying present conditions must demonstrate the feasibility of relaxing legal aid and institutional constraint.

RECOMMENDATIONS

1. State and local governments and private interests should take actions to coordinate the planning and management effort of park and recreation (including fish and game) agencies with municipal water supply, and managing entities to take full advantage of the public recreation potentials to be derived from multiple use of these water and related land resources.

2. Studies should be initiated at level C scope on the 23 existing and authorized Federal reservoirs identified as high priority above, including those in the Central Arizona Project and those in the Lower Colorado River covered in a subsequent regional problem writeup. The study should extend over 8 years starting in FY 1977 with 6 to 12 months devoted to each reservoir. The program should then be reappraised and the remaining reservoirs shown in figure IV-12 considered for study.

WESTWIDE NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS

SUMMARY

About 30,000 miles of the Nation's rivers and streams have been utilized for reservoir storage. In addition, an unknown number of miles have been modified and utilized for various types of economic development. The expanding ability to harness nature has not been balanced by the ability to predict and control the adverse consequences of man's action on the environment. Concern over the continued modification and pollution of the Nation's rivers, lakes, and streams was in part expressed through passage of the National Wild and Scenic Rivers Act. Much progress has been made toward preserving free-flowing streams since establishment of a Rivers System in 1968. Much remains to be done.

DISCUSSION

The Wild and Scenic Rivers Act of October 2, 1968 (P.L. 90-542), declares it to be the policy of the United States that:

> "* * * certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments

shall be protected for the benefit and enjoyment of present and future generations. The Congress declares that the established national policy of dams and other construction of appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes.

"The purpose of this Act is to implement this policy by instituting a national wild and scenic rivers system, by designating the initial components of that system, and by prescribing the methods by which, and standards according to which additional components may be added to the system from time to time."

Figure IV-13 shows the location of existing and study rivers under the provisions of P.L. 90-542. Section 3(a) of the Act established a National Wild and Scenic System by designating eight rivers as immediate components of that system. Additional rivers can be added to the system by Federal law or State legislation with approval of the Secretary of the Interior. Section 5(a) designated 27 other rivers for detailed (Level C) study as potential additions to the National System and set forth a mechanism whereby the Secretaries of Interior and Agriculture may recommend that Congress add new rivers to the 27 already under study.

Also, under the National Environmental Policy Act and the Federal Power Act, Federal agencies must consider alternative uses of a river. Further, the approved Principals and Standards require not only that conventional water development projects be formulated and evaluated in terms of both economic and environmental objectives, but also that wild and scenic river studies be done in like manner.

A number of bills have been introduced to the 93rd Congress which would amend Section 3(a) of the Wild and Scenic Rivers Act, P.L. 90-452, so as to make additinal rivers immediate components of the National System, or to amend Section 5(a) which would require study of specific rivers as potential additions to the System. However, a Federal Interdepartmental Study Group on Wild and Scenic Rivers (composed of representatives form 10 different agencies representing the Secretaries of Interior and Agriculture) has been analyzing outstanding rivers nationwide. As a result of this analysis, the Secretary of the Interior recently recommended to Congress that one comprehensive

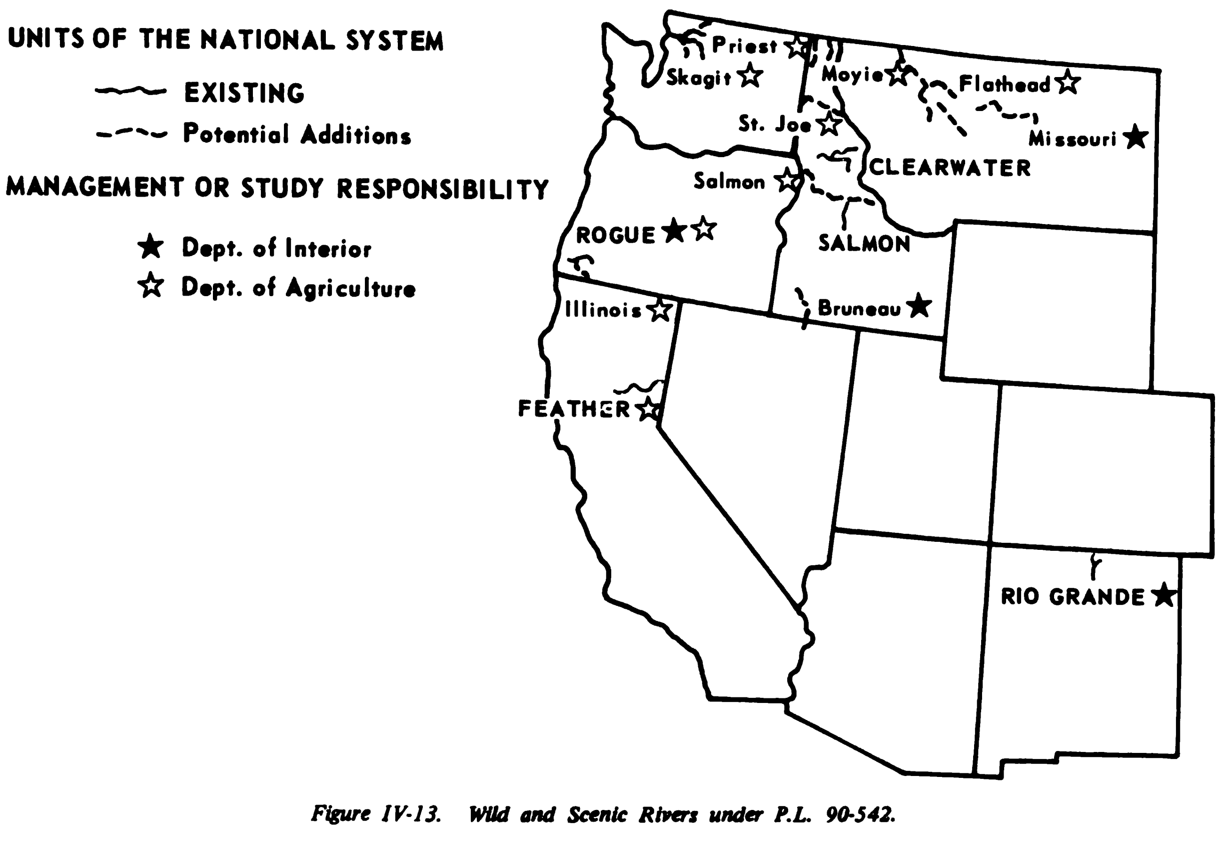


Figure IV-13. Wild and Scenic Rivers under P.L. 90-542.

substitute bill, calling for study of 32 rivers for potential addition to the National Wild and Scenic Rivers Systems, be enacted. Sixteen of these rivers are within the Westwide States. (See below.) These rivers do not comprise the total list that should be studied; rather, it was the interagency committee's judgment that these should be studied first.

A primary recommendation of the *Nationwide Outdoor Recreation Plan* is that the Department of the Interior will complete a program of identification and selection and a plan for acquisition of those superlative areas needed for the Federal recreation estate. To this end, committees of concerned Federal representatives have been formed at both the Washington and Regional levels to review and develop criteria which rivers must meet to qualify for inclusion within the National Wild and Scenic Rivers System with administration by a Federal agency and criteria for rivers to be included in the National System, with administration by a non-Federal agency.

At present, 2 of the 11 Westwide States (Oregon and California) have enacted substantive State Wild and Scenic River Programs. Nationwide, 21 States have established such programs.

Both the Oregon and California laws encompass basic objectives similar to the Federal law. Detailed information regarding the specific rivers covered by these State programs is found in chapter VI on State problems.

From approximately 500 rivers considered, the Westwide State Study Teams identified 77 priority rivers including 23 associated tributary streams as warranting study as potential additions to the Wild and Scenic River System. These 77 rivers include a number of streams identified by the Secretaries of Interior and Agriculture in 1970 as potential additions to the National System which must be "evaluated (for their Wild and Scenic River potential) as part of *any* Federal planning involving the use of water and related land resources in the river areas."[1] Figure IV-14 summarizes this information.

PROBLEM RESOLUTION

From the foregoing, it is obvious that not all listed rivers can or should qualify as critical problems for immediate study. However, compliance with the previously cited Federal laws and policies, as well as orderly planning and decisionmaking, requires that:

[1] Section 5(c) of the Wild and scenic Rivers Act, P.L. 90-542, as amended.

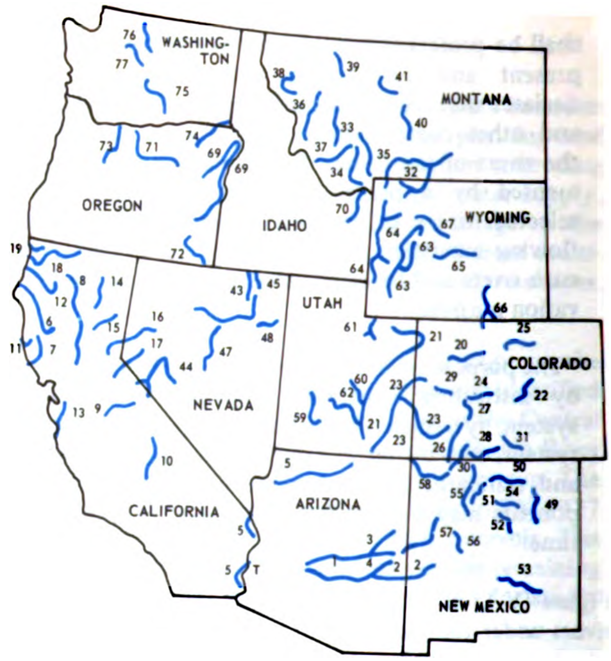


*Figure IV-14. **High-priority potential additions to the Wild and Scenic River System – Westwide Study area.***

a. Priority consideration be given to those additional rivers identified by the Secretaries of Interior and Agriculture and recommended to Congress by the Secretary of the Interior for addition to the list of study rivers in Section 5(a) of the Wild and Scenic Rivers Act.

b. Because of their direct and often conflicting relationship with other critical Westwide issues identified elsewhere in this report, studies of the free-flowing values of other priority rivers identified in this study should be undertaken as soon as possible. If studies of these rivers are not made very soon irreversible actions may forever remove these streams from the list of high quality potential additions to the National System.

c. As indicated in "a." and "b." above, the following rivers and associated tributaries be studied as called for in Section 5 of the Wild and Scenic Rivers Act for potential addition to the National System, and that the first three rivers – because of the likelihood of their being developed for energy purposes – be given the highest priority for study. This is required by Section 5(c) of the Wild and Scenic Rivers Act, as recently amended, and is reinforced by the Administration's goal of achieving energy self-sufficiency.

Table IV-8.—*Rivers given high priority to be studied for inclusion in National Wild and Scenic Rivers System*

River	State(s)	Reach and tributaries involved
Highest priority study rivers		
1. Sweetwater	Wyoming	The main stem from its source to the confluence with Chimney Creek.
2. White	Colorado	The entire river, including the North and South Forks.
3.. Yellowstone	Montana and Wyoming	The main stem from Yellowstone Lake to Pompey's Pillar and its tributary, the Clark's Fork.
Other high priority study rivers recommended to Congress by Secretary of the Interior		
4. Gila	New Mexico Uta	The segment upstream from the Arizona-New Mexico boundary line to the river's source including its principal tributaries but exclusive of the authorized Hooker Reservoir site.
5. Green	Colorado and Utah	The entire river below Flaming Gorge Reservoir, except for the reach from the town of Jensen, Utah, to the boundary of the Dinosaur National Monument.
6. Kern (North Fork)	California	The North Fork main stem from its source to Isabella Reservoir.
7. American (North Fork)	California	The North Fork from Mountain Meadow Lake to the Auburn Reservoir and the lower 7.5 miles of the North Fork of the North Fork.
8. Columbia	Washington	The main stem from Priest Rapids Dam to McNary Reservoir.
9. John Day	Oregon	The main stem downstream from North Fork and the North Fork downstream from Baldy Creek and Granite Creek downstream from Clear Creek.
10. Blackfoot	Montana	The main stem from Landers Fork to Milltown Dam.
11. Colorado	Colorado and Utah	The main stem from the confluence of the Gunnison River to the confluence of the Dolores River including the Dolores River below the proposed McPhee Dam but excluding the segment from 1 mile above Highway No. 90 to the confluence of the San Miguel River.
12. Madison	Montana	The main stem from Earthquake Lake to Ennis Lake.
13. Owyhee	Oregon	The main stem from the Idaho State line downstream to the Owyhee Reservoir. *Provided, however,* that the authority of the Chief of Engineers to undertake emergency flood control work along the Owyhee River under the authority of Section 5 of the Flood Control Act of 1941 (55 Stat. 650), as amended (33 U.S.C. 701n), shall not be affected by study of this river.

Table IV-8.—*Rivers given high priority to be studied for inclusion in National Wild and Scenic Rivers System* (cont.)

Other high priority study rivers recommended to Congress by Secretary of the Interior		
River	State(s)	Reach and tributaries involved
14. Salt	Arizona	The main stem from its source to Stewart Mountain Dam.
15. Snake (Upper)	Wyoming	The main stem from its source to Palisades Reservoir, excluding Jackson Lake. *Provided, however,* that study of this river shall not affect the authority of the Chief of Engineers to undertake the maintenance work for the flood protection project along the Snake River authorized by the Flood Control Act of 1950 (64 Stat. 180), nor shall it affect the authority of the Chief of Engineers to undertake emergency flood control work along the Snake River under the authority of Section 5 of the Flood Control Act of 1941 (55 Stat. 650), as amended (33 U.S.C. 701n).
16. Wenatchee	Washington	Entire river, including Lake Wenatchee, and its tributaries, the Chiwawa and White Rivers
17. Tongue	Wyoming and Montana	Source in Wyoming to Ashland, MT, excluding Tongue River Reservoir.
18. Wind	Wyoming	Source to Boysen River.
19. Escalante	Utah	Source to Lake Powell.
20. Sacramento	California	Sources to Shasta Lake and Keswick Dam to Chico Landing.
21. Russian	California	Ukiah to mouth (Pacific Ocean).
22. Methow	Washington	Confluence of Lost River and West Fork of Methow to head of Wells Dam pool.

Ideally, all free-flowing river studies should result from additions by Congress to section 5(a) of P.L. 90-542. This would assure orderly scheduling, funding, and study by the Federal agencies. However, there has been a tendency in the past to avoid nominating highly controversial rivers for study under the provisions of the Wild and Scenic Rivers Act. Furthermore, it is unlikely that all the studies necessary to resolve critical issues would be authorized by means of the above Act.

P.L. 90-542 is not the only method of preserving free-flowing river values nor is it the only vehicle for conducting the necessary studies. Both the National Environmental Policy Act and the approved Principles and Standards provide a vehicle for conducting such studies. However, in order for these multiobjective studies to be carried out properly, a wider range of expertise and additional funds must be made available beyond the historic levels.

There is a growing interest in many States to establish State Wild, Scenic, and/or Recreational River Systems. In many cases, this may be the most viable alternative for determining how certain rivers should be developed and managed.

As an alternative to fee acquisition, States should, where appropriate, use zoning or less-than-fee acquisition methods in acieving scenic river preservation. States and local governments, working in concert and utilizing available powers and authorities such as zoning, could limit or prohibit the placement of structures; designate location of structures in relation to a river's edge, property or subdivision line, and floodflows; limit the subdivision of lands and control the location and design of highways, roads, and public utility transmission and distribution lines; and prohibit or limit the cutting of trees or other vegetation within specified distances from the river's edge. These measures would add further to the protection of valuable river resources.

With respect to specific rivers identified above, study of the free-flowing alternative must precede or at least coincide with the study of the structural alternatives. Therefore, the relative priorities for study are dependent upon the criticality of other issues, such as energy, M&I, etc., which require structural alteration or diversion of the rivers identified.

Studies conducted under the authority of the Wild and Scenic Rivers Act and studies of free-flowing alternatives, in conjunction with structural development proposals, both require a multiobjective and multidisciplinary approach. As a minimum, these studies must involve:

a. The Federal agency with responsibility for Wild and Scenic River Studies (usually Bureau of Outdoor Recreation or Forest Service, or both);

b. The Federal agency with major fish and wildlife responsibilities and expertise;

c. The Federal agency with major responsibilities and expertise in the structural water development project or potential; usually Corps of Engineers, Bureau of Reclamation, or Soil Conservation Service;

d. The Federal land management agency, if Federal lands are involved;

e. Appropriate State agencies responsible for the above functions at the State and local levels; and

f. The public.

In accordance with the Water Resources Council's Principles and Standards it is essential that every study team have available the expertise to develop and evaluate both structural and nonstructural alternatives and that any plan recommendations be accompanied by a complete display of trade offs.

The overriding objective of plan formulation and evaluation of all levels is to reflect and measure society's preferences for alternatives. With respect to the rivers identified by the Congress and/or the appropriate Departmental executives, a plan to preserve the free-flowing values of the river is a reasonable alternative during the multiobjective planning process. This situation is also true of the specific river reaches identified above as being critical Westwide problems.

Based on the widespread interest in free-flowing rivers and the potential for litigation when the wild river alternative is not considered, it may be advisable to formulate and evaluate a nonstructural alternative plan whenever structural development of a western river is planned.

CONCLUSIONS

1. The Departments of Interior and Agriculture, working with other involved Federal agencies, States, localities, and private interests, are required to complete and submit to the Congress reports on the study category rivers named in Public Law 90-542 by October 2, 1978. In addition, the two Departments should be prepared to study the additional 16 rivers recently recommended to Congress by the Secretary of the Interior (and other rivers Congress may add to the bill), subsequently recommend other high priority rivers to Congress for study and periodically review and update the section 5(c) list of rivers.

2. Development of wild and scenic river programs by States which have not already initiated such systems would aid substantially in identifying those rivers and streams which should be protected. Those States which have already established wild and scenic river systems should expand them as appropriate.

3. In some Western States, the problems of protecting important riverine recreation and fishery resources are compounded because they are not recognized as beneficial uses. There is an opportunity for these States to increase the potential value of rivers and streams by enacting legislation to permit such uses to be considered as beneficial water uses. Without such measures, total water availability may be committed to other uses to the total exclusion of recreation and fishery benefits.

4. Studies restricted only to those river segments which do not confict with structural water development proposals constitute a serious deficiency in providing necessary planning data and information to decisionmakers.

RECOMMENDATIONS

1. Most of the 27 specific river studies required by section 5(a) of P.L. 90-542 either have been completed or will be completed in the near future. Based on the actions of Congress, and the practicality of making additional recommendations by the Secretaries of Interior and Agriculture, the list of 5(a) study rivers should be expanded and studies begun as soon as practicable.

2. Implementation of not only P.L. 90-542, but also the National Environmental Policy Act and the approved Principles and Standards for Water and Related Land Planning, provide a needed planning basis for addressing and resolving conflicts between development and preservation. Priority should be given to studying outstanding or unique river segments involving critical issues and conflicts. These studies should be initiated in FY 1976 and would require 1 to 2 years per river segment.

WESTWIDE NO. 8 – IMPACT OF WILDERNESS AREAS ON WATER PLANNING

SUMMARY

The Wilderness Act of 1964 (P.L. 88-577) established a National Wilderness Preservation System for which about 11 million acres has been designated. Most of this area is in the Westwide area and not only is of special value to this region but also represents the major nationwide wilderness resource base. Many potential additions to the system are being considered. The establishment of Wilderness Areas will have an impact and may have a major impact on the location and development of facilities to meet future water demands. There also may be an effect on the conduct of future weather modification programs.

DISCUSSION

Wilderness Areas necessarily restrict incompatible developmentally oriented uses and activities. Permitted activities include ingress and egress to state and private property, application of the existing mining laws with certain restrictions until December 31, 1983; recreation in undeveloped surroundings; certain existing water resource developments; grazing of livestock where previously established; and hunting and fishing. Strict restrictions have been placed on use of motorized vehicles and equipment, roads, logging, commercial enterprises, and structures. Management of established Primitive Areas is identical to Wilderness until studies are completed and decisions are made by Congress to reclassify these lands as Wilderness or to declassify them. On July 1, 1973, there were within the Westwide area, 62 legislatively established wildernesses within the National Forests. These areas contained a total of about 10 million acres. Wilderness studies have been completed or are in progress on the remaining 4.1 million acres of "Primitive Areas" for which the Act required study.

Within the National Wildlife Refuge System, Congress has acted to designate 25 units of Wilderness, covering 103,435 acres. The studies are in various stages of completion on the remaining areas in the system, comprising nearly 28.5 million acres. There are 63 National Parks in 26 States, containing about 28 million acres that must be studied for suitability or nonsuitability as Wilderness. It is reasonable to expect that a substantial portion of these lands will be added to the National Wilderness Preservation System.

Lands administered by the Bureau of Land Management are not covered by the Wilderness Act, however, legislation is being considered to extend provisions of the Wilderness Act to these lands. The Bureau administers 175 million acres of land in the study area some of which are roadless and undeveloped. Seven areas (164,000 acres) have been classified as primitive and other areas are being proposed.

The National Forests contain many areas of significant size that are roadless and undeveloped and are not specifically mentioned in the 1964 Wilderness Act. Some of these areas represent high quality potential additions to the National Wilderness Preservation System. It is essential that they be given special consideration in planning because of the irreversible nature of some actions that could damage or destroy the wilderness resource. It is generally accepted that the wilderness characteristics and values that now exist in some roadless areas are lost after certain kinds of development occur.

With this in mind, a roadless area review was conducted and 265 areas totaling 9.7 million acres have been selected for additional study and for protection of their wilderness resource characteristics until a final determination can be made. When this acreage is combined with the formal wilderness area listed earlier, there is a total of 24.5 million acres of National Forest land in the 11 Western States being managed as Wilderness.

During the study of potential wilderness areas, evaluations are made to determine total present and future uses which may be made of the resources of the area. At this time full evaluation needs to be made as to the water supplies and facilities which may be needed for local or regional resource development. These values should be weighed along with others in the establishment of wilderness areas.

Long term weather modification programs, which produce a repeated or prolonged change in the weather during any part of successive years, may have significant imapcts in terms of ecological and physical effects. Pending legislation is expected to resolve concerns relating to the application of weather modification to wilderness areas.

CONCLUSIONS

1. The establishment of a wilderness area does not appreciably affect the water supply or yield from the area.

2. Establishment of wilderness areas is not necessarily an irreversible action as far as the resources of the area are concerned. Changing priorities and national needs could at a later date justify reevaluation of the wilderness designation.

3. Areas designated as potential wilderness study areas preclude the collection, storage, and conveyance of water supplies until the necessary studies and evaluations have been completed and a decision reached. It is therefore very desirable to coordinate studies of wilderness areas with water and land resource planning to prevent costly delays in the implementation of total programs for the area or region.

RECOMMENDATIONS

1. Future studies of either potential wilderness areas or resource development projects should include comprehensive evaluation of total land and water needs.

2. The Federal land management agencies should continue interdisciplinary studies of the amount, quality, and geographic location of wilderness needed on public lands. These studies and appropriate wilderness designations should be completed as soon as possible before major manmade intrusions have developed.

WESTWIDE NO. 9 – WATER QUALITY AND POLLUTION CONTROL

SUMMARY

Water pollution has long been recognized as a major type of environmental degradation. Principally, it has been associated with the discharge of municipal and industrial wastes into stream systems. To a great degree, this is true in the East. In the West, however, it is only in isolated spots that municipal and industrial wastes are the primary pollutants. The major contributors to water pollution in the West are sediment from erosion which constitutes the greatest volume of any pollutant, nutrients from fertilizers, pesticides from agricultural uses, irrigation return flows, and the effects of impoundment and stream regulation.

Mostly these sources of pollution are classified as nonpoint sources. There are a number of Federal-State programs and activities that can control or minimize pollution from these nonpoint sources.

DISCUSSION

Any substance found in surface or ground waters becomes a pollutant when its concentration reaches an objectionable level or in any other way interfers with man's use of water. The sources of water polltuion may be grouped into two broad categories: point sources and nonpoint sources. As defined in the 1972 Act, the term "point source" means any discernible, confined, and discrete conveyance, from which pollutants are or may be discharged. Thus, a chief characteristic of point sources is that pollutants from them are discharged into waters at identifiable and discrete points. Nonpoint sources of water pollution have two general characteristics. First, the pollutants from these sources may originate from numerous sites scattered throughout a given area and are transported to surface and ground waters through diffuse routes. Secondly, nonpoint sources are widespread throughout the United States and are especially significant in the West. A wide range of pollutants associated with natural conditions and man's activities contribute to the nonpoint source problem. These pollutants include sediments, natural salts, pesticides, chemical fertilizers, animal wastes, plant residues, salts, minerals, oil, acid, and numerous other substances. They find their way into water through diffuse overland runoff from rural and urban areas, seepage, natural drainage channels, manmade drainage systems, and various combinations of these routes.

Historically, water pollution abatement and control programs have been aimed at point sources, involving primarily waste discharges from municipalities and industries. Many cities were located on present sites to take advantage of the terrain to assure adequate drainage of precipitation into natural water courses. This nonpoint source of runoff carries heavy loads of urban wastes into the public water courses. Oil from city streets and parking lots; automobile tire particles; garbage and litter; empty food, household chemicals, and toilet containers; grass clippings; weeds; discarded vehicle tires; brush; and various pet, rodent, and other animal sewage and wastes are typical of these wastes. The impact upon fish and wildlife which depend upon the receiving waters, and upon recreational water uses, can be devastating. The costs to collect and treat urban runoff before entering public water courses are expected to be high. But plans must be made whereby this water quality problem can be addressed and solved.

Point source pollution control is being attacked in all Westwide areas under a joint State-Federal program as established by the 1972 Amendments. With sufficient funding, existing and emerging technology is expected to substantially solve current and as yet unknown future pollution problems from point sources. As greater control is achieved over point sources, it will become increasingly important to focus on the benefits and costs of controlling nonpoint sources of pollution. The relative cost effectiveness of initial efforts to control nonpoint source pollution will likely be greater than that for the final increments of control of point sources.

Overall, relatively little attention has been directed to the prevention and control of pollution from nonpoint sources. Throughout several of the Western States, where major municipal and industrial sources are far more widely dispersed than in some other parts of the country, existing water quality data indicate that nonpoint sources may be of much greater importance than previously realized. At present, knowledge of the sources, extent, and effects of nonpoint pollution is quite limited. Some research and investigations have been undertaken in recent years on a few specific nonpoint problems, but the overall category of nonpoint pollution has been largely neglected. Major efforts must therefore be made to: identify sources, determine the nature and extent of pollution originating from these sources, develop appropriate prevention and control technology, develop implementation procedures, assess and evaluate institutional mechanisms necessary for regulation and control, develop and adapt regulatory and enhancement procedures, and identify and promote appropriate legislative action.

Though the 1972 Act recognizes nonpoint pollution control as basically a State responsibility, the Federal Government will have a large role to play in its control. Technical assistance, supplementary monitoring, and planning help will all be appropriate Federal actions. The Federal land management agencies will, of course, have a direct role in the control and prevention of nonpoint pollution from their lands.

Water quality varies widely throughout the West. The upstream reaches of streams are generally of excellent quality. The downstream reaches of major streams, terminal lakes, estuaries, and coastal waters are subject to quality degradation caused by pollutants from municipal and industrial discharges, agricultural activities, natural resources development and utilization, and natural sources. The quality of ground water also varies greatly and in some areas is unsuitable for some uses. Today, these water quality problems in the West are receiving more and more attention.

Some of the critical Western water quality problems are directly related to: land use and management, sediment from erosion, nutrients from fertilizers, pesticides usage, irrigation return flows, and impoundments and streamflow regulation. The Nation's "energy crisis" has focused a great deal of attention on the possibilities for developing and utilizing the vast coal, oil shale, and geothermal resources of the West. Possible degradation of water quality which could result from extensive development and utilization of these resources is a matter of public concern.

The use, treatment, and management of land resources affect both the quantity and quality of runoff as well as the location and magnitude of water uses. Major reform efforts such as statewide zoning and other land use controls are receiving increased attention throughout the West. Since land and water resources are so closely related alternative plans for future development and utilization of these resources should give full consideration to the impacts on water quality.

Pollution of water supplies is an integral part of many of the Westwide problems which have been delineated elsewhere in this report. The various types of pollution are presented at this point to generally scope the problem in the Western States.

Sediment from erosion constitutes the greatest volume of any pollutant in the surface waters of the West. Other pollutants such as plant nutrients, natural salts, pesticides, and heavy metals are also carried by sediment. Erosion of croplands, drainage channels, unprotected forest lands, overgrazed lands, strip-mined areas, roads, and other construction areas contribute to the total sediment load. Sediment originating from these sources is a serious problem in many areas throughout the Western States. The erosion problems occur on both irrigated and nonirrigated lands. Sediment decreases the storage capacity of reservoirs, increases treatment costs for domestic and industrial water supplies, damages fish life, and reduces recreational and aesthetic values. Existing erosion control technology has not been universally accepted and used, primarily because of direct or indirect economic considerations.

Fertilizer usage has expanded rapidly in the West in recent years, not only in agriculture but in other uses such as forest lands and recreational areas as well. This rapid expansion of usage has raised many questions concerning nutrient pollution of surface and ground waters. The objective of maximizing crop production is not always compatible with the objective of reducing nutrient pollution of water. Proper use and management of fertilizers will need more study.

In recent years there has been a tremendous increase in pesticide usage. Pesticides are widely used on both irrigated and nonirrigated lands. Pesticides may enter water through spraying operations, runoff from treated areas, percolation through soil, accidental dumping, and waste discharge by producers. High levels of certain pesticides have been responsible for mortalities of fish and other aquatic life. Populations of many aquatic and predatory birds have been reduced as a result of feeding on affected aquatic life. Pesticides must be used wisely to avoid water pollution and other environmental problems that may affect human health and welfare. In spite of substantial progress being made in the control of pesticides, much remains to be done to solve existing and emerging problems. Concern for solving these problems can be noted in passage of the National Pesticides Act (92-516).

Streamflow changes are also important factors in western water quality. When a free-flowing stream is impounded, its physical, chemical, and biological characteristics are modified, thereby resulting in changes in the quality of water. The changes in quality that occur during storage can be beneficial or detrimental to water within the impoundment and in the downstream reach below the dam.

The nature and extent of streamflow regulation are important factors affecting the quality of water supplies. The occurrence and frequency of low flows are critical to water quality control and are often the result of the management regimen of the stream system. Irrigation diversions, municipal and industrial diversion, hydropeaking, and reservoir storage are major factors in streamflow changes. The effects of man-caused or mangified low flows on the natural biotic regime of a stream is often little understood. This is an area of concern needing much more study.

As the water resources of the West become more completely utilized, the ability of stream systems to assimilate the used waters and their wastes may be just as important as providing adequate amounts of water for various uses. Because of this there will probably be a continuing need for adequate flows to minimize the impact of nonpoint source pollution on the quality of streams.

Growing concern about all types of water pollution has raised many questions regarding the nature and extent of water quality problems associated with irrigated agriculture. These problems include sediment from erosion, nutrients from fertilizers, pesticides and salinity. The extent and magnitude of these problems for most individual irrigation projects or areas in the West have not been adequately documented. A great deal more extensive and intensive monitoring will be required to close this gap in existing knowledge.

Mineralization of ground water is a major problem encountered in many Westwide areas. All ground waters contain dissolved minerals. The natural leaching of soil by percolating waters in arid regions often causes natural accumulations of minerals which limit the usefulness of the ground water. The use of water by native vegetation increases the mineral content of the ground water. These and other natural processes are a major factor in the pollution of ground water in many parts of the Westwide area.

Until recently, however, little thought has been given to the effects of the subsurface water environment as a result of man's waste disposal practices and other activities. The effects of subsurface water pollution, and the fate of pollutants discharge in the substrata are not well understood. Adequate knowledge of the hydrology and geology of the ground-water regime is not presently available. What is known, however, is that once underground water is polluted it is nearly impossible, or at least nearly infeasible for man to correct the problem.

In a 1971 report written for the Environmental Protection Agency on ground-water pollution in Utah, California, Arizona, and Nevada (Fuhriman, Burton, and Associates), the following ground-water pollutants, in approximate order of importance, were listed: (1) natural causes; (2) irrigation return flow; (3) seawater intrusion; (4) solid wastes; (5) oil field brine disposal; (6) animal wastes; (7) accidental spills of hazardous materials; (8) water from fault zones and volcanic origin; (9) evapotranspiration of native vegetation; (10) injection wells for waste disposal; (11) fertilization of agricultural lands; (12) land disposal of wastes; (13) seepage of polluted surface water; (14) urban runoff; (15) connate water withdrawal; (16) mining activities; (17) aquifers interchange; (18) mineralization from soluble aquifers; (19) crop residues and dead animals; (20) pesticide residues; and (21) land subsidence effects. Though the factors in this list would vary in importance from place to place, it gives a good idea of the spectrum of activities that can degrade underground water.

The extent of the ground-water pollution problem and its seriousness, causes of the pollution, and practical control measures need to be known. The West's ground water is an invaluable resource that Federal, State, and local governments need to understand and to protect before it is degraded any further.

CONCLUSIONS

1. Today, water quality is being recognized as an essential and critical element of water resources planning, development and management. Water of suitable quality must be available in adequate quantity at the times and places needed for all intended beneficial uses which may include domestic, industrial, agricultural, recreational, fish and wildlife, and other requirements. A suitable water supply is one which satisfies water quality criteria for the intended uses. Quality, therefore, is inseparable from quantity and must be evaluated along with the purposes and uses for which water supplies are developed.

2. Various legal and institutional arrangements pertaining to the management and control of water in the West have a direct bearing on water quality control. Water rights law as it has evolved in the West over the past century is not compatible with many instream uses, including water quality control. Other conflicts arise because water rights do not guarantee quality of water. Increasing competition for the remaining .water supplies intensifies these conflicts.

3. In the West, it has been recognized that adequate planning for maximum use, preservation, and enchancement must take into consideration the complex interrelations of water quantity and quality, of supply, use and disposal. Existing legal and institutional arrangements must, therefore, be evaluated in terms of their effectiveness in assuring that water supplies of adequate quantity and quality are available for all beneficial uses.

RECOMMENDATIONS

1. In addition to continuing a major effort to control point sources of pollution, the State water pollution control agencies and the Federal resource agencies should increase their efforts to analyze, prevent, and control nonpoint sources of pollution.

2. In the development and implementation of prevention and control programs for nonpoint sources of pollution, the State water pollution control agencies should make maximum use of ongoing research and technical assistance programs of other State and Federal agencies.

3. The State's basin and areawide water-quality management plans and State water plans should be fully coordinated throughout all phases of development and implementation.

4. The Federal and State resource agencies should assume full responsibility for assuring that adequate consideration is given to the preservation and control of water quality associated with the future development, management and utilization of water and other natural resources. These agencies should devote immediate attention to those geographical areas which have critical existing or emerging water quality problems.

WESTWIDE NO. 10 – INCREASING SALINITY IN MAJOR RIVER SYSTEMS

SUMMARY

Mineral pollution, commonly known as salinity, is a problem that is becoming increasingly serious in surface waters throughout the Western United States. This problem results from both natural and man-related actions. As the water supplies in the West are more intensively used, salinity problems are expected to become more severe. Only the Columbia River system of the major drainage systems in the Westwide Study area is not faced with high levels of salinity in various reaches of its streams.

The two basic causes of rising salinity levels in streams in the West are salt-loading and salt-concentrating processes. Salt loading results from contributions of additional mineral salts into the streams such as municipal and industrial wastes, inflows from natural sources, and irrigation return flows. The salt load in the return flow to the stream is normally greater than the amount of the salt in the water, diverted, thereby increasing the salt burden in the stream. In contrast,

the salt-concentrating effect occurs as a result of the consumptive use of water where the salt tonnage remains but there is a lesser amount of water returning to the stream. Many streams in the arid and semiarid regions of the West display a progressive increase in salinity between their headwaters and mouths, especially where a large part of the total water supply is consumptively used by irrigated agriculture and there are intervening points of salts from natural sources.

DISCUSSION

Salinity of surface waters refers to their content of mineral salts which include mainly chlorides, sulfates, and bicarbonates of calcium, magnesium, and sodium. In arid and semiarid regions, the soils contain larger amounts of salts, and the surface waters generally have higher salt concentrations. Evaporation losses from reservoirs and other water bodies, consumptive losses associated with municipal and industrial water uses, evapotranspiration losses from native vegetation on noncropped land, irrigation uses and return flows, and out-of-basin diversions of water are other causes of increasing salinity.

The major water-quality problems resulting from irrigation are due to the basic fact that plants are large consumers of water. Growing plants extract water from the supply and leave salts behind, resulting in a concentration of the dissolved mineral salts already present.

In addition to having greater concentrations of salts in the return flow resulting from evapotranspiration, irrigation also adds salt to the soil profile. Irrigation return flows provide the vehicle for conveying the concentrated salts to a receiving stream or ground water reservoir. In some areas, return flows from irrigation drainage can pick up significant amounts of salts from encountering surface and subsurface mineral deposits. In the past 75 years, irrigation has grown from less than 4 million acres to over 30 million acres in the West.

Regarding the effects of salinity, two general categories of water use should be distinguished: consumptive and nonconsumptive. The former includes agricultural uses, such as irrigation and livestock watering, as well as municipal and industrial uses. The latter comprise such use as hydroelectric power generation, navigation, water-oriented recreation, fish and wildlife habitat and silt control. In most regions of the West, the detrimental effects of salinity are generally confined to the consumptive uses of water. The existing levels of salinity in most streams appear to have relatively little detrimental effect on nonconsumptive instream uses, but this aspect needs more research.

There have been questions about relation of the Federal Water Pollution Control Act to salinity. Although salinity is being considered as a pollutant by the Environmental Protection Agency, there are problems in setting standards and discharge goals. There are also problems in determining "the best available technology economically achievable," as stated in the Act, for the various sources and contributions to increasing salinity levels. The achievement of the national goal of elimination of salt discharges by 1985 in the absence of technology that can be practically implemented could have serious adverse effects on the entire irrigated agricultural industry in the West.

Within the Westwide study area, most reaches adversely affected by salinity increases from irrigation return flows are located in the lower reaches of the river systems of the Southwest. These include the Colorado River, which serves seven States and Mexico, the Rio Grande and Pecos Rivers in New Mexico, the San Joaquin River in California, the Sevier River in Utah, the South Platte and Arkansas Rivers in Colorado, and other smaller streams. In most instances, the water quality is excellent in the headwater tributaries of these stream systems. All of them display a progressive increase in salinity levels as the water flows to the lower reaches of the drainage basins. (See figure IV-15.) For example, there is approximately a 20-fold increase in the concentration of mineral salts in the Colorado River between its headwaters in Colorado and Imperial Dam in Arizona, the point of last major diversion in the United States.

The increasing salt concentrations in the Colorado River have been a problem of major concern to the Lower Basin States and Mexico for a number of years. As a consequence, the salinity problem in the Colorado River basin has been studied in more depth than in most of the other drainage basins of the West. During the past several years, detailed studies of the salinity problem in the Colorado River system have been made by the Environmental Protection Agency, the Geological Survey, and the Bureau of Reclamation. A regional paper in chapter V presents additional details on salinity in the Colorado River.

Ground water may also become polluted due to man's activities. The most common sources of pollution are certain manufacturing processes, fertilized fields, sewage effluent, and feedlots. Ground water is less susceptible to pollution than surface water, but once ground water is polluted the problem may persist for a long time. In certain areas of the West – most notably portions of California, New Mexico, and Montana – some ground water is now saline and others are becoming more saline. At several locations overlying

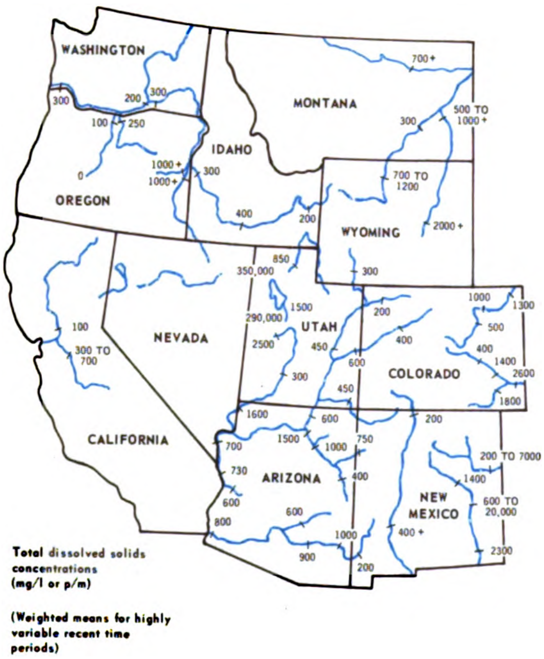


Figure IV-15. ***Salinity levels in stream systems – Westwide Study area.***

saline aquifers, poor quality ground water is being used for various purposes and problems resulting from this use are occurring. Overdrawing the freshwater aquifers has permitted intrusions of seawater in several areas of California.

Detrimental effects from excessive salinity in water supplies are primarily economic in nature and include such effect as reduced crop yields, loss of productive land base, increased quantities of water for leaching, higher management and operating costs, impalatable water supplies for domestic use, added treatment costs for municipal supplies, corrosion and scaling of pipes and equipment, accelerated fabric wear, greater water requirements for cooling, added treatment cost of industrial water, and other costs for industrial makeup and processed water. In addition, these losses in production or reduced economic activity will result in less employment and personal income in other activities such as marketing, processing, and transportation.

PROBLEM RESOLUTION

Based upon present knowledge, the technical possibilities for minimizing and controlling salinity may include (1) those possibilities for reducing salinity concentrations by augmenting the water supply and (2) prospects for lowering salinity concentrations by reducing salt input into the river system. Various factors, including economic feasibility, lack of research information, and legal and institutional constraints, may limit the number of potential solutions.

It appears that the most practical means of reducing salt loads include impoundment and evaporation of point source discharges, diversion of runoff and streams around areas of salt pickup, improvement of irrigation conveyance facilities, improvement in onfarm irrigation systems and water management, improved management and treatment of land contributing salts from natural diffuse sources, and desalination of saline discharges from natural and manmade sources. It may be possible for some of these measures to be implemented in a variety of locations and combinations to achieve basinwide management and control of salinity. The conjunctive use of ground water and surface water can be an effective method of improving and maintaining better water quality.

The Environmental Protection Agency has a continuing "Irrigation Return Flow Research and Development Program" aimed at finding practical and economically acceptable means to control the salinity and nutrient contributions of irrigated agriculture to surface and ground water resources. Other Federal agencies, including the Bureau of Reclamation, the Department of Agriculture, and the Geological Survey, also have ongoing research and other studies which will contribute to the development of control technology for pollutants associated with irrigated agriculture. Several of the Western States are increasing their efforts to develop more effective control measures and techniques for agricultural pollutants.

CONCLUSIONS

1. Natural sources of salinity, such as those associated with runoff and mineral springs, are in many cases not well understood or defined. Better land management potentials for desalting natural mineral springs offer good prospects for successfully reducing salinity levels. However, more analyses of the natural sources problem and potential control measures are needed, including economic evaluations.

2. Within the 11 Westwide States, the areas most adversely affected by salinity increases in surface waters are located in the lower reaches of the river systems of the Southwest. These include the Colorado River (see chapter V), the San Joaquin in California, the Sevier in Utah, the South Platte and Arkansas in Colorado, the Rio Grande, and several smaller streams.

3. There is a lack of information on irrigation return flow quality as affected by irrigation practices, soil-plant salinity relationships, leaching requirements, subsurface return flow, cultural practices, irrigation scheduling, and treatment of return flows. More information is also needed on economic impacts, the role of water pricing, cost-sharing arrangements and other institutional control methods.

4. Major ground-water salinity problems occur in California, New Mexico, and localized areas of Montana, Colorado, and Arizona. They are dimensioned in more detail along with other State salinity problems in chapter VI.

5. The salinity problem is so diverse and has so many aspects that Federal, State, and local governments and organizations must be involved. State water laws are intimately involved along with Federal lands, inter-State, and even international streams. Local governments and organizations have the responsibility of putting many of the control measures into practice.

RECOMMENDATIONS

1. Control of salinity levels should be an important part of all water resource planning studies. Ongoing program education and technical assistance programs should stress the importance of conservation measures in salinity control.

2. Specific recommendations in regard to additional studies are covered in chapters V and VI on regional and State issues. These are mostly tied to recommendations for total water management and level B studies under section 209 of the Federal Water Pollution Control Act. The agencies involved should coordinate and integrate the salinity control aspects of these studies.

3. Ongoing research aimed at finding practical and economical methods of controlling pesticides, fertilizer, and minerals from irrigation return flows should be pursued vigorously.

WESTWIDE NO. 11 – MANAGING WASTE WATER AND URBAN STORM WATER

SUMMARY

In addition to salinity problems that pervade the entire region, urban runoff also poses a significant water-quality problem. The volume of urban effluents discharged into rivers is expected to increase by 300 percent between now and year 2000. Most future water management plans for principal cities are based on utilizing the natural flow of rivers and ground water resources as major sources of water. Little attention is being given to the development of urban storm and wastewater, a source of future water supply. The reduction in pollutants discharged into rivers becomes very important if the desired quality is to be achieved and maintained for the intended use of the river water. Thus, because waste water must be extensively treated to meet pollution discharge requirements, further use of this water becomes more practical. Some specific benefits which can be obtained from development of waste water are (1) additional use through recycling; (2) environmental enhancement; (3) improved water quality; (4) possible economic benefits if the alternative source of water is expensive; and (5) many intangible benefits. Some of the factors which govern the use of reclaimed water are (1) quantity, (2) quality, including health standards, (3) legal rights, (4) economics, and (5) public acceptance of reclaimed water, (6) environmental consequences of discharging wastes, and (7) discharge standards.

DISCUSSION

Waste-water management plans are necessary for urban areas throughout the United States. These plans are intended to implement the goals of the Federal Water Pollution Control Act (P.L. 92-500), i.e.:

1. That the discharge of pollutants into the navigable waters be eliminated by 1985; and

2. That, where attainable, an interim goal of water quality which provides for the protection of fish, shellfish, and wildlife, and provides for recreation in and on the water be achieved by July 1, 1983.

Section 208 of P.L. 92-500 directs Governors of the States to identify areas which as a result of urban-industrial concentration or other factors have substantial water-quality control problems. The Governors must designate (a) boundaries of each such area, and (b) a single representative organization, including elected officials from local governments or their designees, capable of developing effective areawide waste treatment management plans for such areas.

In order to identify the magnitude of water quality degradation and to design systems to solve this problem, constituents and physical characteristics such as heat and water volume must be accounted for by source, such as (a) point sources of pollution, including municipal sewage and storm sewer outfalls; industrial outfalls, including thermal discharges; and sewage from vessels; (b) nonpoint sources including urban and rural runoff, acid and other mine drainage, construction runoff, and salt water intrusion; and (3) in-place or accumulated pollution sources including bottom loads, sludge banks, and harbor dredgings.

Unless the problems associated with constituents from these sources are understood, it is unlikely that the impacts generated by a waste-water system will be foreseen and properly assessed. Identifying the constitutent loads by source also will allow establishment of priorities for planning, and is necessary to assure that waste-water management systems designed for sources of immediate concern are compatible with future systems to handle other sources.

Water supply needs cannot be divorced from water quality. Water supply needs might be met by inbasin surface or ground water withdrawals, reuse, or interbasin transfers. The quality of each of these sources must be considered as a part of an overall system dealing with the interrelationships of the quality of both inflows and outflows, with the latter including treatment plant effluents and nonpoint sources of pollution from storm water runoff.

Recycled waste water has been put to many uses. Irrigation of crops, development of recreational areas, and cooling water are the more common uses. Since waste water is mostly available in areas where water-based recreation deficiencies are greatest, its potential for meeting recreation needs could be significant. There should be few restrictions on the use of recycled water other than quality considerations, except for direct human consumption. Because of the uncertainty of the ability of present treatment methods to eliminate pathogenic organisms from waste waters and the inability to identify and propagate them in the laboratory, there is a general feeling at this time that waste water should not be directly reused for drinking purposes. Further research is needed in this area to be sure that public health is not endangered. Current understanding of ecological processes indicates that the safest way to assure the high quality of watercourses is to reduce the levels of waste-water impurities such that they will have no significant adverse environmental affects or social-hygenic impact.

PROBLEM RESOLUTION

The responsibility for waste-water management rests with States and local interests. They may request inter-State and Federal agencies to assist them in meeting the goals of P.L. 92-500. For example, State and local interests can request the Corps of Engineers, where authority exists or can be obtained from Congress, to make studies and prepare plans under the aegis of the Urban Studies Program. The studies normally take about 3 years from time of funding. The Bureau of Reclamation also prepares waste-water plans especially where Reclamation project water supplies are involved and irrigation may be a potential use of the effluent.

All waste-water studies should be geared to the priorities established in the section 303(e) basin plans prepared by the States with the approval of the Environmental Protection Agency regional administrators. They should also be coordinated with any studies undertaken under section 209 of P.L. 92-500. The Corps of Engineers has 6 urban studies underway in the 11 Western States. Ongoing studies and scheduled completion dates are:

1. Seattle – Puget Sound, 1974
2. Spokane, 1975
3. Boise, 1976
4. Denver, 1976
5. San Francisco Bay and Sacramento-San Joaquin Delta, 1977
6. Salinas-Monterey, 1976

An urban water management study has been authorized for the Yakima, Washington area. Resolutions have been provided for studies at Portland-Vancouver and Phoenix, Arizona; and other resolutions have been requested. In addition to the above studies, the Bureau of Reclamation is participating in a study of Las Vegas Wash point sources, and a countywide study for Ventura County, California.

CONCLUSIONS

1. The State should be the lead agency for waste-water studies but could be led by a Federal agency acting as a consultant to the State.

2. The initial funding of waste-water studies should be geared to the priorities under the State section 303(e) basin plans. These studies should be coordinated with studies called for under section 209.

3. The waste-water aspects of an urban study are directed toward two compatible goals: minimizing water quality degradation from waterborne wastes; and maximum efficient waste-water reuse.

4. Although recycling waste water may not result in an appreciable increase in supplies in the immediate

future, it is anticipated future recycling could meet some of the future water needs. This will be especially true where waste waters are now being discharged to the ocean.

5. Reclamation of waste water will play an important part in water quality improvement. The Federal Water Pollution Control Act Amendments of 1972 will have a considerable effect on future waste water supplies and recycling. It could result in water users recycling more of their wastes for their own use rather than treating it sufficiently for return to streams. This would result in a reduction of waste-water discharges and less demand on available freshwater supplies.

RECOMMENDATIONS

1. Ongoing studies should be continued and proposals resulting therefrom should become an integrated part of regional water use and development plans.

2. Studies should be initiated when requested by the states or when waste water is of significant quantity to be studied as a solution for regional water needs. It is expected that urban requests for the period FY 1976-86 will involve Yakima, Washington; Portland, Oregon; Colorado Springs, Colorado; Carlsbad, New Mexico; and Phoenix, Arizona.

WESTWIDE NO. 12 – EROSION AND SEDIMENTATION

SUMMARY

Erosion and sedimentation both from natural and manmade sources are common problems throughout the West. Sedimentation and erosion problems occur in range, grassland, forest, cropland, and urban areas in some form in all of the Western States; but they are greatly accelerated where man's activity has modified the vegetative cover.

Sediment, the product of erosion, may cause damage during transport all along streams, rivers, lakes, and wherever it is deposited. Sediment can result in overwash, swamping, and increased flooding. It accumulates in reservoirs, increases treatment costs of municipal and industrial supplies, makes navigable streams impassable without dredging, clogs irrigation and drainage improvements, smothers growing plants and spoils harvestable crops, increases maintenance costs of utility and transportation facilities, decreases the recreational value of water, and adversely affects the fishery resource.

Erosion is a major contributor to salt loading in western streams. Soils high in salt content such as marine shales are high contributors and probably the largest diffused source. These salts are highly soluble and are concentrated in surface runoff through erosion.

DISCUSSION

Critical Sediment and Erosion Problem Areas

Erosion is affecting the public and private land resource base and the resulting sediment affects downstream water quality. Excessive soil losses on agricultural land result in loss of productivity, higher production costs, and social costs. Erosion may cause slides, channel degradation, flood plain scour, valley trenching, and land voiding. This may result in the undercutting of building and bridge foundations. Areas with sediment yield rates greater than 0.5 acre-foot per square mile per year are displayed in figure IV-16. Table IV-9 shows sediment yield rates by States and regions.

Range and Grass Land. – Much of the desert areas of Arizona, California, Nevada, and eastern Oregon is in the low-sediment yield classes because of limited runoff. Erosion is depressed in much of the

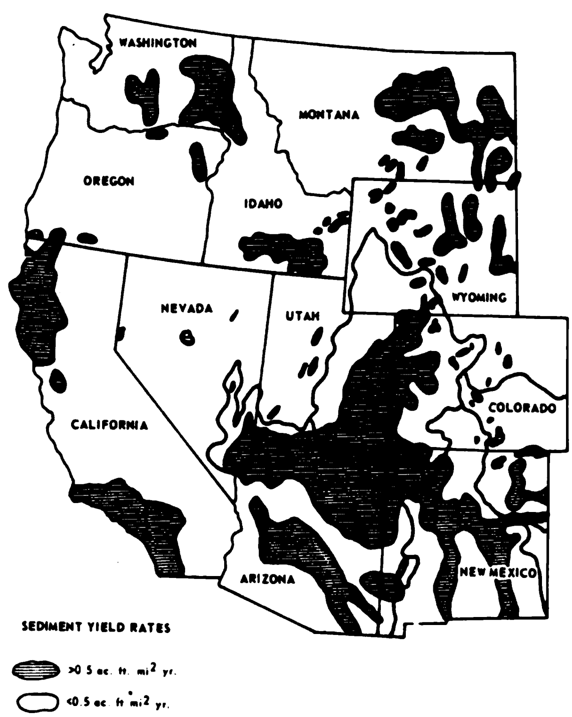


Figure IV-16. Areas of high sediment yield – Westwide Study area.

Table IV-9.—*Present annual sediment yield rates by region and State*

Region and State	Drainage area (square miles)	Area by annual sediment yield classes — Annual sediment yield in acre-feet per square mile: >3.0	1.0-3.0	0.5-1.0	0.2-0.5	0.1-0.2	<0.1	Annual sediment yield: Total (acre-feet)	Acre-feet per square mile
		(square miles)							
Columbia-North Pacific									
Idaho	80,165	82	1,271	5,015	4,718	7,138	61,941	11,620	0.14
Montana	25,152	–	–	–	125	2,201	22,826	1,200	.05
Nevada	5,155	–	–	–	14	4,393	748	690	.13
Oregon	90,553	–	–	1,386	10,708	36,420	42,039	12,370	.14
Utah	376	–	–	–	–	309	67	50	.13
Washington	67,303	425	2,015	2,043	3,591	32,259	26,970	14,700	.22
Wyoming	5,080	–	–	–	–	2,630	2,450	520	.10
Subtotal	273,784	507	3,286	8,444	19,156	85,350	157,041	41,150	0.15
California									
California	158,693	2,928	4,558	25,858	35,187	80,543	9,619	62,170	0.39
Oregon	6,484	–	–	27	–	1,673	4,784	520	.08
Subtotal	165,177	2,928	4,558	25,885	35,187	82,216	14,403	62,690	0.38
Missouri									
Colorado	29,414	–	–	289	11,221	12,849	5,055	6,320	0.21
Montana	122,319	–	3,402	13,457	45,755	30,033	29,672	33,690	.28
Wyoming	70,265	–	1,347	4,016	27,975	22,495	14,432	19,590	.28
Subtotal	221,998	–	4,749	17,762	84,951	65,377	49,159	59,600	0.27
Great Basin									
Idaho	3,392	0	79	494	672	349	1,798	840	0.25
Nevada	92,903	55	0	194	6,881	7,413	75,694	7,560	.08
Utah	41,563	95	454	307	7,457	22,868	10,382	8,080	.19
Wyoming	1,514	–	–	–	583	923	8	285	.19
Subtotal	139,372	150	533	995	15,593	31,553	87,882	16,765	0.12
Upper Colorado									
Arizona	6,927	–	48	2,174	2,501	2,204	–	2,820	0.40
Colorado	38,525	–	1,565	7,389	10,553	7,570	11,448	13,290	.34
New Mexico	9,937	–	1,547	1,867	5,932	591	–	6,660	.68
Utah	36,903	421	3,043	13,802	10,190	8,573	874	23,030	.62
Wyoming	21,049	–	–	1,235	8,713	9,415	1,686	5,470	.26
Subtotal	113,341	421	6,203	26,467	37,889	28,353	14,008	51,270	0.45
Lower Colorado									
Arizona	106,982	–	6,161	16,714	46,616	32,686	4,805	46,320	0.47
Nevada	12,382	3	0	1,123	4,152	817	6,287	2,770	22
New Mexico	13,478	–	587	1,758	8,201	2,637	295	5,770	.43
Utah	3,491	22	395	707	2,139	228	0	2,190	63
Subtotal	136,333	25	7,143	20,302	61,108	36,368	11,387	57,050	0.45
Rio Grande									
Colorado	7,526	–	-	9	141	3,653	3,723	790	0.10
New Mexico	74,751	376	8,923	11,981	40,497	8,523	4,457	44,010	.59
Subtotal	82,277	376	8,923	11,990	40,638	12,176	8,174	44,800	0.55
Arkansas-White-Red									
Colorado	28,411	–	–	688	8,922	16,307	2,494	6,210	0.22
New Mexico	17,793	–	330	2,092	13,904	1,150	317	7,280	.41
Subtotal	46,204	–	330	2,780	22,826	17,437	2,811	13,490	0.29
Texas-Gulf									
New Mexico	5,913	–	–	–	5,913	–	–	2,070	0.35
Westwide Total	1,184,399	4,407	35,725	114,625	323,261	358,850	344,865	348,885	0.29
Arizona	113,909	–	6,209	18,888	49,117	34,890	4,805	49,140	0.46
California	158,693	2,928	4,558	25,858	35,187	80,543	9,619	62,170	.39
Colorado	103,876	–	1,565	8,375	30,837	40,379	22,720	26,610	.26
Idaho	83,557	82	1,350	5,509	5,390	7,487	63,739	12,460	.15
Montana	147,471	–	3,402	13,457	45,880	32,234	52,498	34,880	.24
Nevada	110,440	58	–	1,317	11,047	12,623	82,729	11,020	.10
New Mexico	121,872	376	11,387	17,698	74,447	12,901	5,063	65,790	.54
Oregon	97,037	–	–	1,413	10,708	38,093	46,823	12,890	.13
Utah	82,333	538	3,892	14,816	19,786	31,978	11,323	33,350	.41
Washington	67,303	425	2,015	2,043	3,591	32,259	26,970	14,700	.22
Wyoming	97,908	–	1,347	5,251	37,271	35,463	18,576	25,870	.26

Source: Developed from Soil Conservation Service Field Office data. August 1974 arid area due to formation of desert pavement or surface armouring with rock which protects underlying soil.

Critical features of rangeland subject to severe erosion are the amount of cover and degree of abuse. Areas with limited cover, fine-textured easily dispersed soils, and sloping terrain are easily eroded. These areas commonly occur on soils derived from shale. Much of the Colorado River in the Four Corners area is in this category. Western Colorado near Grand Junction, eastern Utah, the Little Colorado in Arizona, and several areas in New Mexico have excessive erosion. Valley trenching has occurred on shaley fine-grained alluvial fill in portions of the Little Colorado in Arizona. In the Rio Puerco, about two-thirds of the sediment comes from gully and arroyo trenching; and slightly less than one-third from sheet and rill erosion. Although the Rio Puerco has less than 20 percent of the Upper Rio Grande basin drainage, it contributes almost half of the measured sediment but less than 9 percent of the water yield.

High-sediment yield areas in Montana are associated with geologic erosion of barren or nearly barren areas where Pierre and Bearpaw marine shales outcrop at the surface. These badland areas are mainly in the central and eastern part of the State. Sediment yield rates as high as 15 acre-feet per square mile per year have been measured in the shale badland areas. Gully erosion and downstream valley trenching, in addition to sheet and rill erosion, are also problems in these basins. Numerous small reservoirs have filled with sediment in a few years.

Forest Land. – Most of the forest areas have low-sediment yields because of stable soils and good vegetative cover. Most of the erosion problems are generally very localized and are related to construction, mining, logging, grazing, and recreation activities. Some exceptions in forested areas where critical erosion and sedimentation occur are:

1. Northwest California, which is a combination of forest and grassland. – Rains of medium duration and high volume and intensity saturate the unstable soils on steep slopes and produce large volumes of runoff with high peaks. Excessive grazing, disturbance of the soil by deer over extensive areas, careless logging, and improper road construction and maintenance are the main sources of accelerated erosion. The Eel River has the highest recorded average annual suspended sediment yield per square mile for a large watershed in the United States. About 25 percent of the erosion is from landslides, 65 percent from channel erosion, and 10 percent from sheet and rill erosion. The average annual suspended load, 1957 to 1967, was more than 31 million tons; however, the floods in December 1964 and January 1965 caused a suspended discharge of 160 million tons in a 30-day period.

2. The chaparral areas located in the San Gabriel, San Bernardino, and San Andreas Ranges of southern California are very susceptible to erosion where soils on sloping terrain are subject to long-duration and high-intensity rains. Destruction of plant cover and ground litter by frequent wildfires and by man's encroachment, including road and building construction on poorly chosen sites, has caused severe erosion problems including mass movement of soil.

3. The granitic batholith forms the soil or much of the forested area in central and southwest Idaho and is considered unstable when disturbed as the rock weathers into shallow sandy soils. The mantle depth is only a few inches on millions of acres in the Salmon River, Boise Range, and Sawtooth Mountains and the need for intensive forest and range management practices are obvious.

4. The Wasatch Mountains are a moderate sediment source between the extremes of the highly erodible California coastal area and stable Rocky Mountains. With the loss of cover, the Wasatch Front Range soils are highly erodible. The extremely high natural geologic erosion rates have formed the scenic beauty of several unique national parks and monuments in the Utah area.

Cropland. – Most noteworthy of upland erosion is the wheatland area of the Columbia Plateau in eastern Washington and Oregon and northwest Idaho. This includes the Palouse Area which is discussed in more detail in a Regional Problem 9 in chapter V. Most of the cropped area is covered with loose soil which is fine-grained, unstable windblown material on slopes up to 50 percent. In this winter wheat country, the soil profile frequently is saturated and freezes before a snow cover occurs. This results in a supersaturated layer of soil which erodes during the late winter or early spring runoff. Soil losses with these conditions can be 25 to 150 tons per acre. Sediment deposition results in overwash, increased flooding, accumulation in reservoirs, damage to irrigated lands, a decrease in the recreational value of water and adverse effects to the fishery resources of the Columbia River system. Some other areas of dry cropland in central Washington, southeastern Idaho, eastern Colorado, and eastern Montana have serious erosion but are not as extensive as the Columbia Plateau.

Urban. – Subdivision development accelerates rates of erosion and creates problems of downstream deposition in many of the rapidly developing urban areas of the West. Disturbed soils are susceptible to erosion and mass movement due to bare ground exposure.

Highway construction causes problems due to lack of early stabilization of cuts and fills in many areas. It is estimated that close to a quarter of a million acres are being converted to urban and built-up areas annually. This area is susceptible to accelerated erosion for a 3- to 5-year period.

Miles of moderate and serious channel erosion and associated soil losses are tabulated in table IV-10.

Critical Diffuse Salt Source Areas

Critical diffuse salt source areas occur in much of the semiarid to arid portions of the Western States and are generally associated with outcrop areas or soils derived from soft marine shales. Over one-half of the 10.7 million tons of salt estimated to flow in the Colorado River is from diffuse salt source areas. These areas include 30 percent of the Green River Basin in Wyoming; the semiarid areas of eastern Utah and western Colorado which have extensive areas underlain by shales of the Mancos and Wasatch Formations; and areas along the Little Colorado River, Vermillion Cliffs, San Pedro and San Carlos Rivers in Arizona, and the Virgin River in Nevada and Utah where there are outcrops in the Chinle and Moenkopi Shale Formations.

Also soft marine shales of the Pierre and Bearpaw Formations occur in semiarid areas of Montana, Wyoming, and Colorado. They extend over 40 percent of the Western Dakota tributaries, 25 percent of the Middle Yellowstone, 10 percent of the Lower Yellowstone, 30 percent of the Middle Missouri, 20 percent of the Musselshell, 30 percent of the lower Tongue, 25 percent of the Powder, 40 percent of the Marias, 50 percent of the Milk River; and outcrop or underlie portions of the Platte drainages.

The Great Basin has extensive areas of salts occurring in Lake Lahontan and Lake Bonneville sediments; however, much of this salt is located in the Great Salt Lake and various playa lakes associated with ancient Lake Lahontan and Lake Bonneville. Other critical salt-contributing areas include shale outcrops of members of the Arapien Formation in the Sevier River and many others scattered throughout portions of the Great Basin.

Other critical salt source areas which occur mainly in association with saline marine shales are the Upper Arkansas in Colorado and the Rio Grande and Pecos drainages in New Mexico.

Salts have also built up in soils over time in the Snake River Valley of Idaho, Yakima Valley in Washington, the Imperial, Sacramento and Tulare Basins in California, and the Closed Basin of the Rio Grande in Colorado because of inadequate leaching under arid climatic conditions. See table IV-11.

Relationship of Sediment and Salt Loading with Degradation of Water Quality

Water quality is directly related to suspended sediment and salt transported from surface areas except where point sources contribute substantial amounts. Saline shales occurring on sloping terrain are usually high contributors of both salt and sediment, particularly in arid and semiarid climatic zones with sparse vegetation.

A review of a few of the water quality records indicates that the variance in annual sediment or salt load can vary by a factor up to 10, depending on runoff. For example, the salt load (TDS) on the Rio Grande at the El Paso gage has varied from 84,000 to 1,200,000 tons per year for water years 1936 to 1959. The salt load (TDS) on the Pecos River at Red Bluff gage has varied from 328,000 to 3,380,000 tons per year or 17 to 173 tons per square mile for water years 1938 to 1959. Table IV-12 shows runoff, sediment load, and salt load at selected locations.

Very little data are available in most of the States to relate sediment and salt loading. Recent records show about 2 percent of the gaging stations measuring both sediment and salt load from such sources as return flow from irrigation, runoff from shale aquifers, saline springs, etc. Techniques for continuous and accurate monitoring of sediment and salt are expensive and generally beyond the reach of broad stream coverage. Many states are instituting a program to collect additional data on water quality and these data will be valuable to future studies.

Table IV-10.—*Existing streambank erosion in terms of bank miles and annual soil loss by region and State*

Region and State	Total channel length (stream miles)	Watersheds < 400 square miles: Moderate erosion: Length (bank miles)	Watersheds < 400 square miles: Moderate erosion: Soil loss (tons/mile)	Watersheds < 400 square miles: Serious erosion: Length (bank miles)	Watersheds < 400 square miles: Serious erosion: Soil loss (tons/mile)	Total channel length (stream miles)	Watersheds > 400 square miles: Moderate erosion: Length (bank miles)	Watersheds > 400 square miles: Moderate erosion: Soil loss (tons/mile)	Watersheds > 400 square miles: Serious erosion: Length (bank miles)	Watersheds > 400 square miles: Serious erosion: Soil loss (tons/mile)
Columbia-North Pacific										
Idaho	83,060	4,324	390	501	740	2,763	1,057	820	0	0
Montana	29,170	940	180	140	400	1,500	150	80	78	200
Nevada	5,900	224	300	12	1,700	205	47	450	5	2,600
Oregon	77,270	10,950	300	2,110	210	3,046	0	0	900	1,000
Utah	0	0	–	0	–	0	0	0	0	0
Washington	62,350	7,195	190	934	480	2,875	477	320	477	750
Wyoming	5,730	171	360	18	800	420	0	–	20	800
Subtotal	263,480	23,804	290	3,715	360	10,809	1,731	610	1,480	880
California										
California	118,000	43,600	600	7,234	1,200	12,200	6,210	600	990	1,200
Oregon	7,630	831	370	21	710	0	0	0	0	0
Subtotal	125,630	44,431	600	7,255	1,200	12,200	6,210	600	990	1,200
Missouri										
Colorado	20,980	890	570	890	1,690	470	80	510	20	1,700
Montana	157,640	2,270	270	741	640	7,946	794	220	412	580
Wyoming	69,050	7,278	340	3,092	1,620	4,320	425	350	90	1,720
Subtotal	247,670	10,438	340	4,723	1,480	12,736	1,299	280	522	820
Great Basin										
Idaho	7,440	596	370	66	770	0	0	0	0	0
Nevada	84,410	5,094	330	882	1,740	1,159	265	450	30	2,440
Utah	55,870	4,650	360	590	1,310	670	193	530	16	1,960
Wyoming	1,580	80	380	30	2,000	230	25	380	10	2,000
Subtotal	149,300	10,420	350	1,568	1,540	2,059	483	480	56	2,220
Upper Colorado										
Arizona	40,000	13,000	250	0	0	60	100	300	0	0
Colorado	55,760	2,950	750	3,200	1,910	920	220	750	320	1,940
New Mexico	6,760	2,580	360	857	1,520	147	60	360	40	1,520
Utah	44,540	19,558	380	2,408	1,430	1,270	625	570	104	2,150
Wyoming	22,480	2,914	200	1,184	970	980	100	200	20	970
Subtotal	169,540	41,002	350	7,649	1,570	3,377	1,105	540	484	1,910
Lower Colorado										
Arizona	142,000	13,700	220	2,700	630	4,169	605	300	426	850
Nevada	17,160	656	350	250	1,900	388	143	530	0	0
New Mexico	11,070	3,678	360	1,075	1,520	689	138	360	15	1,570
Utah	3,850	1,630	650	312	1,950	60	18	980	0	0
Subtotal	174,080	19,664	390	4,337	1,020	5,306	904	360	441	880
Rio Grande										
Colorado	7,540	20	300	10	1,500	170	0	0	0	0
New Mexico	67,660	18,044	360	8,083	1,520	2,240	300	360	144	1,520
Subtotal	75,200	18,064	360	8,093	1,520	2,410	300	360	144	1,520
Arkansas-White-Red										
Colorado	15,610	3,400	790	3,630	1,980	810	430	790	450	1,980
New Mexico	23,770	2,341	360	1,857	1,520	476	57	360	48	1,520
Subtotal	39,380	5,741	620	5,487	1,820	1,286	487	740	498	1,940
Texas-Gulf										
New Mexico	3,460	174	360	116	1,520	0	0	0	0	0
Westwide Total	1,247,740	173,738	420	42,943	1,360	50,183	12,519	540	4,615	1,200
Arizona	182,000	26,700	230	2,700	630	4,229	705	300	426	850
California	118,000	43,600	600	7,230	1,200	12,200	6,210	600	990	1 200
Colorado	99,890	7,260	750	7,730	1,910	2,370	730	750	790	1,960
Idaho	90,500	4,920	390	567	740	2,763	1,057	820	0	0
Montana	186,810	3,210	240	881	600	9,446	944	190	490	520
Nevada	107,470	5,974	330	1,144	1,770	1,752	455	470	35	2,460
New Mexico	112,720	26,817	360	11,988	1,520	3,552	555	360	247	1,520
Oregon	84,900	11,781	300	2,131	290	3,046	0	0	900	1,000
Utah	104,260	25,838	410	3,310	1,450	2,000	836	610	120	2 180
Washington	62,350	7,195	190	934	480	2,875	477	320	477	750
Wyoming	98,840	10,443	300	4,324	1,440	5,950	580	330	140	1,500

Source: Developed from Soil Conservation Service Field Office data.

August 1974

Table IV-11.—*Soil salinity classes by sediment yield groups by region and State*

Region and State	Total drainage area (square miles)	Saline subsoil Sediment yield acre-feet per square mile			Slightly saline profile Sediment yield acre-feet per square mile			Saline profile Sediment yield acre-feet per square mile			Soil salinity none (square miles)
		<0.2	0.2-1.0	>1.0	<0.2	0.2-1.0	>1.0	<0.2	0.2-1.0	>1.0	
Columbia-North Pacific											
Idaho	80,165	–	–	–	266	78	–	278	242	–	79,301
Montana	25,152	–	–	–	–	–	–	241	10	–	24,901
Nevada	5,155	97	–	–	–	–	–	–	–	–	5,058
Oregon	90,553	–	–	–	–	–	–	5,026	496	–	85,031
Utah	376	–	–	–	101	–	–	–	–	–	275
Washington	67,303	3,181	999	–	–	–	–	–	–	–	63,123
Wyoming	5,080	–	–	–	–	–	–	–	–	–	5,080
Subtotal	273,784	3,278	999	–	367	78	–	5,545	748	–	262,769
California											
California	158,693	13,497	6,800	–	5,990	800	–	6,900	140	–	124,566
Oregon	6,484	–	–	–	–	–	–	804	–	–	5,680
Subtotal	165,177	13,497	6,800	–	5,990	800	–	7,704	140	–	130,246
Missouri											
Colorado	29,414	260	160	–	51	–	–	–	–	–	28,943
Montana	122,319	–	–	–	–	–	–	4,500	4,500	502	112,817
Wyoming	70,265	1,238	1,841	–	274	1,027	34	1,056	1,933	135	62,727
Subtotal	221,998	1,498	2,001	–	325	1,027	34	5,556	6,433	637	204,487
Great Basin											
Idaho	3,392	–	–	–	–	–	–	12	–	–	3,380
Nevada	92,903	29,225	1,433	17	1,064	58	–	1,925	94	–	57,004
Utah	41,563	7,051	229	320	1,784	54	–	9,494	–	–	22,631
Wyoming	1,514	–	–	–	–	–	–	–	–	–	1,514
Subtotal	139,372	36,276	1,662	337	2,848	112	–	11,431	94	–	84,529
Upper Colorado											
Arizona	6,927	–	–	–	1,451	2,805	14	378	1,665	34	580
Colorado	38,525	–	328	440	–	91	–	–	–	–	37,666
New Mexico	9,937	–	–	–	–	–	–	–	–	–	9,937
Utah	36,903	1,471	5,019	3,185	139	157	53	150	–	–	26,729
Wyoming	21,049	2,354	2,472	–	188	200	–	2,260	2,473	–	11,102
Subtotal	113,341	3,825	7,819	3,625	1,778	3,253	67	2,788	4,138	34	86,014
Lower Colorado											
Arizona	106,982	–	–	–	15,217	43,663	1,416	7,971	6,611	4,745	27,359
Nevada	12,382	2,864	1,735	–	–	218	–	–	–	–	7,565
New Mexico	13,478	–	–	–	–	280	63	–	31	–	13,104
Utah	3,491	9	–	350	–	–	–	–	–	–	3,132
Subtotal	136,333	2,873	1,735	350	15,217	44,161	1,479	7,971	6,642	4,745	51,160
Rio Grande											
Colorado	7,526	36	–	–	–	–	–	496	–	–	6,994
New Mexico	74,751	–	–	–	1,092	6,957	1,077	375	111	263	64,876
Subtotal	82,277	36	–	–	1,092	6,957	1,077	871	111	263	71,870
Arkansas-White-Red											
Colorado	28,411	1,188	666	–	–	–	–	–	–	–	26,557
New Mexico	17,793	–	–	–	–	–	–	–	–	–	17,793
Subtotal	46,204	1,188	666	–	–	–	–	–	–	–	44,350
Texas Gulf											
New Mexico	5,913	–	–	–	–	–	–	–	–	–	5,913
Westwide Total	1,184,399	62,471	21,682	4,312	27,617	56,388	2,657	41,866	18,306	5,679	941,338
Arizona	113,909	–	–	–	16,668	46,468	1,430	8,349	8,276	4,779	27,939
California	158,693	13,497	6,800	–	5,990	800	–	6,900	140	–	124,566
Colorado	103,876	1,484	1,154	440	51	91	–	496	–	–	100,160
Idaho	83,557	–	–	–	266	78	–	290	242	–	82,681
Montana	147,471	–	–	–	–	–	–	4,741	4,510	502	137,718
Nevada	110,440	32,186	3,168	17	1,064	276	–	1,925	94	–	69,627
New Mexico	121,872	–	–	–	1,092	7,237	1,140	375	142	263	111,623
Oregon	97,037	–	–	–	–	–	–	5,830	496	–	90,711
Utah	82,333	8,531	5,248	3,855	2,024	211	53	9,644	–	–	52,767
Washington	67,303	3,181	999	–	–	–	–	–	–	–	63,123
Wyoming	97,908	3,592	4,313	–	462	1,227	34	3,316	4,406	135	80,423

Source: Developed from Soil Conservation Service Field Office data.

August 1974

Table IV-12.—*Runoff, sediment load, and salt load at selected stream gages*

River system and stream gage locations	Drainage area (Mi^2)	Average annual runoff (1,000 AF)	Average annual suspended sediment		Average annual salt load (TDS)	
			1,000 tons	Tn/Mi^2	1,000 tons	Tn/Mi^2
Colorado River near Grand Canyon, AZ	137,800	12,300	149,000	1,082	7,400	54
Colorado River at Cisco, UT	24,100	4,906	11,150	460	4,120	172
Columbia River at Vancouver, WA	241,000	146,250	10,700	44	20,500	85
Rio Grande near Bernardo, NM	16,300	550	2,760	170	400	25
Rio Puerco near Bernardo, NM	6,200	150	7,040	1,130	75	12
Pecos River near Puerto de Luna, NM	3,970	145	2,590	652	270	68
Pecos River at Red Bluff, NM	19,540	—	—	—	890	46
Arkansas River at Caddoa, CO	18,130	310	2,220	122	360	20
Fountain Creek at Pueblo, CO	930	40	620	670	130	140
Yellowstone River near Sidney, MT	69,100	9,300	27,380	400	5,990	87
Powder River at Arvada, WY	6,050	200	4,940	820	460	76
Eel River at Scotia, CA	3,110	5,260	13,390	4,300	910	293
Thomes Creek near Paskenta, CA	190	210	700	3,605	30	149
Md. Fk. American River at Auburn, CA	610	975	230	373	300	494

PROBLEM RESOLUTIONS

A number of ongoing Federal programs have been dealing with soil erosion and sedimentation problems for several years. These include technical cost-sharing and credit assistance programs of the Department of Agriculture for privately owned lands. These programs are being carried out cooperatively with State and local organizations such as conservation districts and through the efforts of the landowners and operators. The Bureau of Indian Affairs provides similar assistance for Tribal lands. Erosion and sedimentation control measures have been a part of multiple-purpose water and related land resource projects of the Corps of Engineers, Bureau of Reclamation, and the Soil Conservation Service. Land managing agencies such as the Forest Service and Bureau of Land Management have soil erosion programs. In recent legislation the Corps of Engineers has been authorized to carry out erosion control programs for streambank and coastal areas. These programs adequately applied can implement treatment measures needed to minimize erosion and sediment damage. However, greater emphasis needs to be placed on the water-quality aspects of these problems. Control programs under the Federal Water Pollution Control Act and related State programs will give consideration to these water-quality aspects.

Treatment opportunities are related to climatic environment and kind of erosion occurring. Most of the rapidly eroding range, grassland and forest-covered soils occur where natural geologic erosion is dominant. Some of these areas are not treatable or are subject only to long term management. The opportunity for the greatest reduction in sediment load in watersheds lies in the treatment of areas where the sediment yield is highest. Structural treatment measures which trap sediment, such as debris basins, streambank and gully protection, grade control, etc., would effect the greatest sediment reduction but would be most expensive. Over a long period, the most effective treatment measures will be those that will result in improved cover of vegetation. Such measures would include change in land use, controlled grazing and management of range and forest lands, grass seeding on steeply sloping lands, tree planting on timber lands, and other primarily vegetative improvements.

Intensive use of structural, vegetative treatment and good management will be required on the areas of high-sediment yield. Areas with low-sediment yield require local treatment of problem areas and management practices to be most effective in improving water quality. The erosion control treatment of saline soils derived from shale will also have an effect on salt loading.

From a quantitative standpoint, the most marked reduction in sediment yield would be possible in the wheatland area of the Columbia River where about 4 million acres are subject to critical water erosion. Reduction up to 75 percent is possible with land treatment, supplemental structures, and conversion of steeper slopes to grassland. Change in land use is difficult to achieve when demand for food production is high and economic return is well in excess of production costs.

Table IV-13 tabulation presents the potential treatment opportunities for erosion, sediment, and salt control and water-quality impacts of implementing such a program.

CONCLUSIONS

1. Substantial areas of both natural and man-caused erosion still exist in the Westwide area.

2. The most critical man-caused problems will require land use changes, vegetative and structural treatment in addition to any applicable provisions of State water pollution control programs.

3. Land managing agencies and landowners need to carefully manage lands and streams subject to natural geological erosion to minimize the adverse effects downstream.

4. The relation between sediment, runoff, and salt loading needs detailed analysis to help determine the effects of erosion and sediment control practices on salinity reduction.

5. The relation of sediment to the occurrence and transport of all forms of pollutants needs to be better defined.

RECOMMENDATIONS

1. Ongoing erosion control programs of Federal, State agencies, and local conservation districts should continue as the primary public effort to control erosion and sediment damage.

2. The Department of Agriculture in cooperation with appropriate land managing agencies, other Federal agencies, and the States undertake a study of natural diffused land sources of salts in the Colorado River to determine those erosion and sediment control practices which would be most effective in reducing the salinity in the river. This can be a cooperative effort with the Bureau of Reclamation's Colorado River Water Quality Improvement Program.

3. The States in cooperation with the Department of Agriculture, the Environmental Protection Agency, and others undertake studies to identify critical erosion and sediment producing areas as a part of State water pollution control programs.

4. Erosion and sedimentation studies for specific basins should be carried out as a part of level B and special studies recommended in chapters V and VI.

WESTWIDE NO. 13 – MEETING WATER DEMANDS THROUGH CONSERVATION AND REUSE

SUMMARY

The conservation and reuse of existing water supplies should be a major consideration in developing plans to meet future water demands in the West. Where water is in short supply and water use efficiency is low, conservaton and reuse has the greatest potential to alleviate serious economic dislocations and adverse water quality conditions. Conservation can be achieved in all uses of water and will be brought about by adopting new technology and better management practices in watersheds and distribution and use systems. A major effort is needed in irrigated agriculture which accounts for over 80 percent of the water depletion in the West today.

DISCUSSION

Water conservation is probably one of the more important considerations in water planning today. It has wide application and can be practiced wherever water is used. The reuse of water before it is returned to the stream system is equally important as it reduces the expenditures required for new withdrawal systems and reduces the total amount of pollutants returned to the streams. While the list of opportunities for water conservation and reuse is long a few of the more important ones are discussed below.

The significance of water conservation is pointed out in many places in this report. Information on overall water shortages can be developed from data presented in tables II-22, II-25, and II-27. A comparison of water depletions with water supplies shows that 6 of the 11 Western States have depletions in excess of one-third of the water supply in the State. They are Arizona, California, Colorado, Nevada, New Mexico, and Utah. The more limited future supplies exist in Arizona, New Mexico, and Nevada. Even in States where total water supplies are relatively abundant, there are areas of

Table IV-13.—*Potential treatment opportunities and reduction in sediment yield and salt load by region and State*

Region and State	Treatment needed: Change land use	Treatment needed: Management only	Treatment needed: Management and land measures	Treatment needed: Streambank erosion control	Impacts: Reduction in sediment: Private	Reduction in sediment: Federal	Reduction in sediment: Total	Impacts: Reduction in salt load: Private	Reduction in salt load: Federal	Reduction in salt load: Total
	(thousand acres)			(bank miles)	(acre-feet per year)			(tons per year)		
Columbia-North Pacific										
Idaho	740	28,280	7,620	9,050	3,380	1,440	4,790	11,400	5,190	16,590
Montana	270	810	750	3,730	490	90	580	N/A	N/A	N/A
Nevada	0	2,460	800	240	10	50	60	N/A	N/A	N/A
Oregon	990	32,680	8,000	8,130	4,860	520	5,380	N/A	N/A	N/A
Utah	0	50	50	20	10	0	10	680	470	1,150
Washington	180	11,890	16,380	8,930	790	270	1,060	N/A	N/A	N/A
Wyoming	20	290	410	310	40	20	60	N/A	N/A	N/A
Subtotal	2,200	76,460	34,010	30,410	9,580	2,360	11,940	N/A	N/A	N/A
California										
California	0	0	2,920	8,230	1,930	1,290	3,220	N/A	N/A	1,447,260
Oregon	50	2,950	160	70	220	0	220	N/A	N/A	N/A
Subtotal	50	2,950	3,080	8,300	2,150	1,290	3,440	N/A	N/A	N/A
Missouri										
Colorado	940	3,610	2,810	550	1,200	10	1,210	10,730	10	10,740
Montana	550	640	36,530	2,210	4,010	7,100	11,110	N/A	N/A	N/A
Wyoming	0	36,630	7,230	7,040	3,720	960	4,680	N/A	N/A	N/A
Subtotal	1,490	40,880	46,570	9,800	8,930	8,070	17,000	N/A	N/A	N/A
Great Basin										
Idaho	20	1,100	520	660	430	50	480	2,130	250	2,380
Nevada	70	44,700	9,040	2,880	50	430	480	N/A	N/A	N/A
Utah	600	12,530	2,620	8,490	450	790	1,240	49,300	66,420	115,720
Wyoming	0	680	180	90	50	40	90	N/A	N/A	N/A
Subtotal	690	59,010	12,360	12,120	980	1,310	2,290	N/A	N/A	N/A
Upper Colorado										
Arizona	0	2,910	740	10	370	20	390	6,500	0	6,500
Colorado	610	3,010	3,220	1,190	580	1,170	1,750	13,600	33,830	47,430
New Mexico	0	500	1,410	860	300	130	430	5,550	2,380	7,930
Utah	380	11,570	2,890	22,690	800	1,960	2,760	51,440	122,010	173,450
Wyoming	0	9,360	1,500	2,710	780	180	960	N/A	N/A	N/A
Subtotal	990	27,350	9,760	27,460	2,830	3,460	6,290	N/A	N/A	N/A
Lower Colorado										
Arizona	10	31,630	15,370	2,330	3,280	2,410	5,690	97,500	95,500	193,000
Nevada	0	5,760	2,210	630	10	80	90	N/A	N/A	N/A
New Mexico	0	50	750	1,220	370	160	530	0	0	0
Utah	40	1,230	140	1,960	70	150	220	5,030	10,850	15,880
Subtotal	50	38,670	18,470	6,140	3,730	2,800	6,530	N/A	N/A	N/A
Rio Grande										
Colorado	70	710	590	10	30	10	40	100	10	110
New Mexico	0	3,140	5,730	10,160	2,270	1,510	3,780	112,020	74,600	186,620
Subtotal	70	3,850	6,320	10,170	2,300	1,520	3,820	112,120	74,610	186,730
Arkansas-White-Red										
Colorado	720	5,010	2,820	1,560	2,360	160	2,520	29,720	2,260	31,980
New Mexico	0	–	660	1,170	300	0	300	1,080	0	1,080
Subtotal	720	5,010	3,480	2,730	2,660	160	2,820	30,800	2,260	33,060
Texas-Gulf										
New Mexico	0	0	0	220	40	0	40	0	0	0
Westwide Total	6,260	254,180	134,050	107,350	33,200	20,970	54,170	N/A	N/A	N/A
Arizona	10	34,540	16,110	2,340	3,650	2,430	6,080	104,000	95,500	199,500
California	0	0	2,920	8,230	1,930	1,290	3,220	N/A	N/A	1,447,260
Colorado	2,340	12,340	9,440	3,310	4,170	1,350	5,520	54,140	36,110	90,250
Idaho	760	29,380	8,140	9,710	3,810	1,460	5,270	13,530	5,440	18,970
Montana	820	1,450	37,280	5,940	4,500	7,190	11,690	N/A	N/A	N/A
Nevada	70	52,920	12,050	3,750	70	560	630	N/A	N/A	N/A
New Mexico	0	3,690	8,000	13,630	3,280	1,800	5,080	118,650	76,980	195,630
Oregon	1,040	35,640	8,160	8,200	5,080	520	5,600	N/A	N/A	N/A
Utah	1,020	25,380	5,700	33,160	1,330	2,900	4,230	106,450	199,750	306,200
Washington	180	11,890	16,380	8,930	790	270	1,060	N/A	N/A	N/A
Wyoming	20	46,960	9,320	10,150	4,590	1,200	5,790	N/A	N/A	N/A

Source: Developed from SCS Field Office data. August 1974 water shortages. These local shortages may exist as a result of inadequate development of available supplies, poor distribution of water supply both locationally and seasonally, poor water quality, a result of over-development, or a combination of these. As an example, the extent of irrigated acres with short annual or seasonal supply is shown in table IV-14. In a number of irrigated areas, the adoption of conservation measures combined with better management would result in significant reduction of shortages. In other areas with highly regulated water supplies, it would permit stretching the supply to serve a greater irrigated acreage.

Table IV-14.—*Annual or seasonal irrigation water supply shortages by State*

State	Area affected (acres)	Percent of total	Equivalent diversion shortage[1] (acre-feet)
Arizona	2		2
California	2		2
Colorado	1,220,000	31	2,400,000
Idaho	470,000	14	860,000
Montana	640,000	26	740,000
Nevada	500,000	54	470,000
New Mexico	2		2
Oregon	790,000	38	1,620,000
Utah	980,000	75	1,140,000
Washington	190,000	12	200,000
Wyoming	700,000	40	870,000

[1] Assuming about a 50 percent system efficiency (consumptive use divided by diversion).
[2] Data not applicable because irrigated acreage is normally modified to fit annual or seasonal short water supplies.
Source: Developed by Department of Agriculture Westwide Study staff from Soil Conservation Service Field Office data and other miscellaneous sources.

Irrigated Agriculture

A major concern currently is water use efficiency in agriculture. Irrigation water budgets for 1970 for each of the 11 Western States are shown in table IV-15. Of the total depletions of 78.5 million acre-feet in the 11 Western States, irrigation diversions account for from 80 to 85 percent of total consumptive use. Of this 66 percent or about 52 million acre-feet is consumed by growing crops. The remainder or about 17 million acre-feet is water consumed as a result of losses in the irrigation process. Much of this consumption is by vegetation which is often beneficial for wildlife habitat and aesthetic purposes. (Most seepage losses from irrigation systems if not consumptively used will return to the surface or ground-water supply.) A program of improved efficiency in irrigated agriculture would not change consumptive use by the crops but would reduce system and farm losses and thereby reduce non-agricultural consumption.

Table IV-16 illustrates the current water use rates and efficiencies in irrigated agriculture in the West.

Within appropriate environmental, institutional, and social guidelines, water planning must be concerned with efficiency in water use or the productivity of water. The concept of "productivity increases," long used with regard to labor and land, should be applied to water. Where water is a limiting factor to a farmer, an industry, a recreatioal or urban development, plans should be developed to maximize the output of goods and services per unit of water use.

Studies on the South Platte River in Colorado, for example, have shown that in the last 30 years water used for irrigation increased 60 percent, and the value of crops produced (constant dollars) increased 350 percent. The increased use of water through more adequate water supplies, improved systems, and more timely application of water accounted for much of the increased production, but other factors were important also. Improved crop varieties, better management, fertility practices, and soil conservation practices, along with selection of higher value crops, also helped increase output. The "productivity increases" concept must be applied to all water uses if future demands are to be met.

Municipal and Industrial

Inefficient water use is a matter of definition and requires separate evaluation for each type of use. Some uses degrade the quality of return flow if not treated but consume a small percentage of the diversion. These uses may include municipal and industrial, electric power cooling, and mineral production. Reuse or successive use of diverted water for these purposes may not change the total amount of consumptive use but may have a favorable impact on water quality and will reduce the amount of diversion required. A reduction in consumption in these types of uses will probably require a change in the characteristics of the use. For example, new urban area design could emphasize the use of grasses and shrubs which thrive in semiarid or arid conditions in place of irrigated lawns and parks. Open space does not have to be green to be useful and attractive. A reduction in unit water requirements in

Table IV-15.—*Irrigation water budget for 1970 by State*

State	Normalized 1970 irrigated cropland and pasture			Withdrawals or diversions	Off-farm conveyance loss	Farm delivery	Consumptive use		Return flow
	Total[1]	Idle	Irrigated				Crop and pasture	Noncrop[2]	
	(1,000 acres)			(1,000 acre-feet)					
Arizona	1,670	570	1,100	8,400	1,700	6,700	3,800	[3]1,800	2,800
California	10,340	2,140	8,200	34,700	5,500	29,200	21,000	[3]6,000	7,700
Colorado	3,980	180	3,820	14,900	3,900	11,000	5,200	1,200	8,500
Idaho	3,770	370	3,400	19,500	4,500	15,000	6,100	1,100	12,300
Montana	2,630	130	2,500	12,900	6,500	6,400	2,800	700	9,400
Nevada	920	20	900	3,900	400	3,500	1,700	2,000	200
New Mexico	1,250	250	1,000	3,200	600	2,600	1,700	900	600
Oregon	2,250	150	2,100	9,600	3,100	6,500	2,600	500	6,500
Utah	1,660	360	1,300	4,900	1,100	3,800	1,700	400	2,800
Washington	1,710	110	1,600	7,700	2,200	5,500	3,200	[3]1,400	3,100
Wyoming	1,750	150	1,600	7,700	2,400	5,300	1,800	900	5,000
Westwide	31,930	4,430	27,500	127,400	31,900	95,500	51,600	16,900	58,900

[1]Acreage for the 1970 level of development. Acreage does not include double cropped.
[2]Includes consumptive use through nonrecoverable deep percolation, evaporation, and wildlife habitat. Associated wildlife habitat and phreatophyte vegetation within irrigated areas. Generally does not include 12 to 14 million acre-feet of use by phreatophyte and hydrophyte vegetation outside irrigated areas.
[3]Includes ground-water buildup not "readily recoverable"; 9.9 million acre-feet—Arizona; 2.0 million acre-feet—California; 0.8 million acre-feet—Washington (Columbia Basin Project Area) when the water table stabilizes, return flow to Columbia River will increase.

Source: Developed by Department of Agriculture Westwide Study staff from Soil Conservation Service field office data and other miscellaneous sources.

industrial and cooling processes requires a change in the industrial process itself; more air cooling in place of water cooling, for example. Because municipal and industrial economic activity will increase at an increasing rate in the future, it is important that technology to improve efficiency in water use, including reuse, be given high priority in research and development.

Technology Improvements

The role of changing technology in conservation and reuse of water is varied and complex. Improvements in technology affect all water uses and can result in more water used per unit of output in some instances and less water used in other cases. The transport of coal or other solids by water slurry pipelines and the irrigation of timber lands are two activities which, if undertaken to any significant degree in the West, would greatly increase water demand.

However, most industrial technology on the board would improve the output of goods and services per unit of water use. Electric power generation will be increasingly a major water user in the West. The major alternatives in producing power needed in the future will tend toward water conservation. Gas-cooled nuclear reactors and nuclear fusion are two cases in point. Even in fossil fuel electric power generation, there is the possibility that dry cooling systems as new plants are built. Up to 95 percent of the water needs of a coal-fired plant using wet cooling is for the cooling system. As little as 500 acre-feet per year of water may be needed for plants utilizing dry cooling. Also, coal gasification will require less water per unit of energy produced than does thermal electric generation using evaporative cooling.

As new water supplies become more scarce and costly, industrial processes which require less water per unit of output will be utilized. In fact, this will be required in many areas of the West if the agricultural industry is to be maintained.

Vegetative Management

The potential for increases in water yield through vegetative management has been demonstrated through

Table IV-16.—*Relative irrigation water rates and efficiencies by State*

State	Irrigated acres (million)	Withdrawals		Conveyance loss (%)[1]	Farm delivery (%)[1]	Consumptive use			Return (%)[1]
						Crop		Associated (%)[1]	
		(m.a.f.)	(AF/A)			(%)[1]	(AF/A)		
Arizona	1.1	8.4	7.6	20	80	45	3.5	22	33
California	8.2	34.7	4.2	16	84	60	2.6	17	22
Colorado	3.8	14.9	3.8	25	75	35	1.3	8	57
Idaho	3.4	19.5	5.7	23	77	31	1.8	6	63
Montana	2.5	12.9	5.2	50	50	22	1.1	5	73
Nevada	0.9	3.9	4.3	10	90	43	1.9	51	6
New Mexico	1.0	3.2	3.2	19	81	53	1.7	28	19
Oregon	2.1	9.6	4.5	32	68	27	1.2	5	68
Utah	1.3	4.9	3.8	22	78	35	1.3	8	57
Washington	1.6	7.7	4.8	29	71	42	2.0	18	40
Wyoming	1.6	7.7	4.8	32	68	23	1.1	12	65
Average			4.6	25	75	41	1.9	13	46
Range			3.2 to 7.6	10 to 50	50 to 90	22 to 60	1.1 to 3.5	5 to 51	6 to 73

[1] Percent of withdrawals.

Source: Developed by Department of Agriculture Westwide Study staff from Soil Conservation Service Field office data and other miscellaneous sources.

research. In the West, this potential exists on forested and associated brush and range lands. However, there is need for total cost information, including environmental impacts before effective large-scale water-yield improvement programs can be initiated with predictable results. A major challenge in the future will be to find ways to bring the diverse management objectives of public and private lands and the specific interests of the downstream water users together into a mutually beneficial multipurpose management program.

At one time estimates were made showing about 12 million acre-feet per year potential increase in water yield in the West through vegetative manipulation. More recent estimates indicate this to be 4 million acre-feet. This downward adjustment undoubtedly reflects better facts on resources and conditions but also reflects a recognition of changing public attitude towards the type of land management practices that would be needed to fully develop this total water yield potential. It is now recognized that in some instances vegetative management is actually a conversion of water use from one set of public purposes – recreation, fish and wildlife, aesthetics – to another set of public purposes – agricultural and municipal and industrial.

The cost of water runoff increases through vegetative management varies widely but for the West has been shown to average a little over $20 per acre-foot. Where increases in water yield through this process can be carried out in harmony with other land resource management objectives, it represents an economic means of helping to meet future water requirements in the West.

Suppression of Reservoir Evaporation

Reduction of evaporation losses from reservoirs is a physical possibility but has not been implemented except on a testing basis because of high costs. Evaporation losses are significant in highly regulated basins and contribute to increasing salinity levels and a reduction in water supply. In the Colorado River basin, for example, about 2.0 million acre-feet per year are lost from reservoir evaporation. Any reduction in this loss would help prolong the adequacy of the supply in this water-short basin.

Technology which is applicable to reducing evaporation from large reservoirs is the use of long-chain fatty alcohol monolayer films applied to the water surfaces The films can be applied by aircraft spraying, boat spraying, or by point dispensers, depending on the size of the reservoir and climatological and physiographic conditions. Field tests indicate that the efficiencies of these films are about 12 percent under favorable conditions. Tests indicate also that these materials are not toxic to man and have no effect on the water quality, fish population, bottom-dwelling organisms and cause little change in the general ecology of reservoirs and streams.

The cost of water saved by this method would be around $60 per acre-foot under favorable conditons. However, application costs are rising and wind effect remains a problem yet to be solved. It appears that this method of water conservation is currently feasible only in those areas where water costs are extremely high.

PROBLEM RESOLUTION

It is important that action be considered to accelerate the adoption of waste-water conservation and reuse practices in the next year or so because of the growing problems with meeting existing and future water demands. Also the adverse effects of salinity, both from an economic and environmental standpoint, must be considered. Water conservation and reuse programs will have varying impacts on salinity. Water reuse without treatment will tend to concentrate salts in return flow but not necessarily add to salt loading. Water conservation through more efficient use of water will undoubtedly result in return flows of higher salt concentrations but will result also in reduced return flows, the net effect being a reduction in total salt loading, particularly from irrigated agriculture. This is accomplished in two ways: (1) through reduced salt pickup in salt-laden substratum and shallow groundwater aquifers and (2) through a precipitation of some salts into nonsoluble forms as a result of very low leaching fractions. The effect of water conservation and reuse on water quality, as well as water supply, must be considered in meeting future water demands.

Various potentials and actions which might be taken are outlined below.

Agricultural

A number of recent studies have shown that opportunities do exist for improving water use in irrigated agriculture. There are irrigation system technologies developing that may change the unit water requirements for agriculture crops. Drip irrigation for example would reduce the evaporation and thereby reduce total water use for some types of crops where this type of water application can be economically used. Improved management and better design and layout of existing systems offer perhaps the greatest opportunity for water savings and resulting water quality improvements. Table IV-17 shows irrigation system and

Table IV-7.—*Irrigation systems and management improvement needs, costs, and improvements by State*

State	Needs				Improvements[1]		
	Off-farm canal and lateral improvement (1,000 feet)	Onfarm improvement		One-time cost ($1,000)	Possible onfarm efficiency (percent)	Reduction withdrawals (1,000 acre-feet)	Seepage reduction (1,000 acre-feet)
		Systems (1,000 acres)	Management (1,000 acres)				
Arizona	7,320	1,150	1,230	330,740	58	1,640	790
California	N/A	6,800	6,600	881,500	69	4,870	2,560
Colorado	39,200	2,370	2,450	905,610	65	5,130	3,780
Idaho	12,640	2,370	2,570	503,640	54	4,280	2,430
Montana	24,160	1,970	2,290	727,670	55	4,120	3,170
Nevada	780	660	740	102,530	53	330	320
New Mexico	3,380	430	370	105,640	57	370	450
Oregon	20,830	1,330	1,370	1,061,230	58	2,590	1,920
Utah	13,730	1,060	1,060	294,900	45	210	1,140
Washington	14,240	630	930	399,300	61	800	610
Wyoming	13,220	1,310	1,320	343,800	44	1,510	1,390
Total	149,500	20,030	20,930	5,656,560	–	25,920	18,560

[1] Implementing this program will reduce salt loading an estimated 20 percent or 13 million tons annually and reduce sediment loading an estimated 30 percent or 30 million tons annually.

Source: Developed by Department of Agriculture Westwide Study staff from Soil Conservation Service Field Office data and other miscellaneous sources.

management improvement needs, costs and impacts. While the data at this time are preliminary and requires checking and refinement, they do show that substantial improvements in irrigation efficiencies (compare with table IV-14) can be obtained if improvement needs are made. Significant impacts in the form of reduction in withdrawals, seepage and salt loading would be achieved. A major portion of these impacts could be achieved if the following actions were taken:

Local and Private. – Agricultural water user districts and irrigation farmers will need to utilize the best available assistance and technology in water conservation and reuse practices. Many systems can be modernized and updated over a period of time at a moderate annual capital cost. Individual landowners could change, modernize, or maintain onfarm water distribution and application systems utilizing new technology as a part of their cost of operation. Costs spent in this manner have been shown to pay off through increases in production and land values in addition to the benefits received in water conservation and quaity improvement. Water pricing could also be used to discourage unreasonably high water applications in excess of plant requirements.

State. – Again, State water rights laws are an important factor in securing efficient use of water in agriculture. While these laws vary from State to State, they do encourage the use of the water right each year whether required for crop consumptive use or not. As a result, water may be wasted or used in excess resulting in deep percolation, high return flows, creation of swamped areas, and soil erosion. Changes in water rights laws that would encourage conservation of water without penalizing the right holder could be a major improvement and could result in substantial water savings. State land-use planning which would encourage that the best agricultural lands remain in agricultural and which would permit only the best suited lands to be brought into new irrigation would also improve the efficiency of resource use.

Federal. – Ongoing action programs of the Department of Agriculture and the Irrigation Management Services Program of the Bureau of Reclamation are designed to bring about water conservation and to improve irrigation efficiencies. These programs could be accelerated. Research programs of the Agricultural Research Service, Environmental Protection Agency and the Bureau of Reclamation could further emphasize the development of improved technology, systems, and cultural practices which can be implemented by landowners and irrigation districts. Further evaluations could be made emphasizing their overall effects on water conservation and reduce salinity, as well as other water-quality improvements and production increases. There is a need for Federal assistance programs to inventory, on a systematic basis, the extent of the water conservation problems in irrigated agriculture throughout the West. Where existing contracts are to be renegotiated, there could be opportunities for effecting water savings through water pricing policy.

Municipal and Industrial

Local and Private. – All local and private water users could consider water in short supply in their long-range planning and attempt to maximize output per unit of water input. Research and development work could give more stress to new water conservation and reuse technolgoy. Local water districts ccould give more consideration to water pricing policies which would make it economically desirable to curtail the inefficient use of water. Technology is now available to utilize urban waste waters in such uses as irrigated agriculture, greenbelts, recreation and open spaces. More use could be made of these practices. Successive use of water in municipal and industrial processes is now in use but further research and development are needed. All major M&I users could determine the extent to which successive use can be applied in their water systems. The health and social aspects probably require the greatest effort before substantial successive use programs can be undertaken.

State. – State water rights laws, health regulations, and water plans could be revised to encourage and bring about water conservation and reuse by M&I users as one of the means for meeting future water demands. Updated and improved State land-use policies could help direct urban and industrial growth in areas where water supply is more readily available. Maximized output per unit of water use is an important consideration in approving new land developments in the West.

Federal. – Programs of assistance to municipalities and industries could give further stress to conservation and reuse practices. Federal grants, technical assistance, or construction projects could require these practices be utilized to the extent applicable. Assistance for new or modified water or sewer systems could be made contingent upon inclusion of the best available technology in water conservation and reuse as a part of the water system. New water-supply projects could be made dependent upon whether local sponsors have developed and assured that conservation and reuse practices be adopted to provide the initial increment in meeting their water needs. Similar requirements could be established by USDA and others in meeting the domestic water needs of small town and rural areas.

CONCLUSIONS

1. The concept of increased productivity applied to existing water supplies should be a major objective in future water planning. Maximizing output per unit of water input is most important in watershort areas.

2. Legal and institutional changes are needed to improve water allocation and use through such means as updating definitions of benefits contained in State water rights laws and through water pricing.

3. Further incentives for water users and local water districts may be needed to assure installation of measures to conserve and reuse water.

4. Current Federal programs require acceleration or redirection to help meet future water requirements through conservation and reuse.

RECOMMENDATIONS

State and local entities need to initiate studies to evaluate needed changes in State water right laws and water pricing. Specific actions which should be taken by Federal agencies are as follows:

1. Accelerate ongoing research efforts in irrigated agriculture to provide more precise answers in salt leaching functions, improved application systems, automation, and soil management.

2. Accelerate efforts to bring about water conservation and improved efficiencies by farmers and ranchers. Important here is education and technical assistance to bring improvement in onfarm irrigation systems and better scheduling of water application.

3. Continue salinity control studies in areas where water conservation and improved management measures can contribute substantially to reducing salinity.

WESTWIDE NO. 14 – WATER REQUIREMENTS FOR PUBLIC LANDS

SUMMARY

Multipurpose use of federally managed public lands in the West requires that adequate water remain available for the uses established for the land. When water supplies are scarce, diversions from public lands may limit their availability for providing alternative uses such as food and fiber products, recreation, and other uses involving environmental values. The amounts of water required to establish and maintain multipurpose use on public lands have not been completely documented by all agencies. Unless such water requirements are established, other uses may prevent proper management of these lands. Water requirement determinations are especially needed in areas where development of energy and power from mineral reserves appears likely. An accelerated program is needed to describe water requirements for public lands and to obtain recognition of those requirements in Federal and State water law and administrative arrangements.

DISCUSSION

The consumptive and nonconsumptive needs for water on all public lands have never been fully documented. The principal Federal land management agencies involved are the Forest Service, the Bureau of Land Management, the National Park Service, the Fish and Wildlife Service, the Bureau of Reclamation, and the Department of Defense. Federal lands in the West geneally cover large geographic areas. In many instances they are intermingled with State and private lands, or are adjacent to Indian lands. Although the problem has been recognized for some time, the entire water requirements picture is still incomplete. The Forest Service has had an ongoing program for making determinations of consumptive and other diverted water needs. These are being quantified on a current and projected basis. The National Park Service and the Fish and Wildlife Service have established requirements in certain critical areas. The Bureau of Reclamation should also identify water requirements on lands under its management. The Bureau of Land Management has developed estimates of consumptive water requirements for livestock wildlife and recreation, and in 1972, undertook a preliminary survey of all consumptive water needs on Bureau of Land Management lands.

Amounts of water required for nonconsumptive uses are difficult to establish. These include water for maintaining streamflow for fisheries; adequate natural lake, reservoir, and other impoundment levels for recreation and aesthetic purposes; and wetlands for wildlife. Techniques are still being refined for making adequate instream flow and use determinations. The numerous proposals that have been advanced call for coordinated action between the States and the Federal agencies concerned. Resolution of the problem may involve changes in Federal and State laws and policies. Additional discussion on the information needed to establish such requirements is contained in the discussion on Westwide No. 5, Need for Adequate Environmental Information for Water Planning. A number of instream problem areas were identified in the 1972 survey of the Bureau of Land Management. This data does not lend itself to statistical summarization, but is of vital importance in the management and development of the water and land resources.

The current National energy shoratage has renewed interest in increasing energy production through the use of mineral reserves on public lands. High priority is being given to the use of coal in the Northern Great Plains, and geothermal stream development in several areas. Urgent and critical energy requirements have caused questions to be raised as to whether or not the Federal Government has the responsibility to provide water for development of the mineral reserves located on both public and private lands where the Federal Government has retained the mineral rights. The Federal Government has placed the responsibility of obtaining these water rights on the individual who must obtain these rights from the State. Additional discussions of the water requirements for energy production are included in discussions of other Westwide, Regional, and State problems.

The Bureau of Land Management, under various Acts of Congress, is responsible for the management, development and disposition of the national resource lands. The management of the many uses of these lands and their resources requires an available water resource of appropriate extent. Sources of water include surface flow, surface storage, and subsurface sources. Resource management requiring water include programs and operations for domestic livestock grazing, fish and wildlife, utilization, watershed protection, outdoor recreation, timber nurseries, fire protection, road construction and maintenance, maintenance of administrative sights, and impoundments for livestock, wildlife and other uses. Consumptive uses by BLM do not include water requirements for mineral extraction nor the amount used by natural stands of vegetation through evapotransportation. Evaporation from open bodies of water is included and constitutes, by far, the greater part of the water demand shown in table IV-16.

The Forest Service manages land in accordance with its legal authority to provide for the development, use, and management of lands within the National Forests and Grasslands Systems with due consideration for the need of all water users. Water is required for such broad purposes as improving the forest environment and providing a sustained yield of timber, and securing favorable conditions of waterflow for both water quality and water quantity. The lands are managed by multiple-use management as identified in the Multiple Use-Sustained Yield Act of 1960. Water management is required for a variety of uses including domestic, municipal, and administrative sites; recreation; livestock grazing; wildlife and fisheries habitat conservation and management; firefighting and fire prevention; timber stand improvement; road construction and maintenance; wilderness preservation; flood and soil erosion control; and preservation of aesthetic and other public values.

PROBLEM RESOLUTION

The Forest Service is developing methodologies for determining instream flow requirements for fisheries, aesthetics, recreation, and water quality. The techniques will be applied initially at points of diversion or "critical" stream reaches. Studies are planned to (1) determine the location of existing diversions; (2) determine where fishery, aesthetic, and recreation problems may occur; (3) analyze and evaluate the nature, extent, and effect of problems identified; and (4) determine amounts of water required to meet "reasonable" needs. These instream requirements are essential not only for optimum environmental quality but also to maintain or enhance the existing socioeconomic basis of local and regional life styles. Preliminary estimates of water requirements for lands managed by the Forest Service for current (1970) and year 2000 are shown by State in table IV-18.

Preliminary consumptive water requirements for Bureau of Land Management lands are also shown on table IV-18. Requirements for refining consumptive and nonconsumptive water needs on National resource lands are being incorporated in the Bureau of Land Management internal planning system for development of multiple-use management framework plans for all planning units and resource areas administered by that agency.

Table IV-18.—*Estimated water requirements—public lands administered by U.S. Forest Service and Bureau of Land Management by State*[1]

By State	Present U.S. Forest Service[2]	Present Bureau of Land Management[3]	Present Total	2000 U.S. Forest Service	2000 Bureau of Land Management	2000 Total
	(1,000 acre-feet)					
Arizona	94.7	4.0	98.7	103.0	17.3	120.3
California	89.4	338.1	427.5	176.1	378.2	554.3
Colorado	193.4	71.3	264.7	212.3	75.3	287.6
Idaho	58.0	42.9	100.9	136.4	43.9	180.3
Montana	185.8	82.4	268.2	285.1	127.9	413.0
Nevada	44.5	260.5	305.0	63.9	329.8	393.7
New Mexico	10.5	18.7	29.2	20.0	26.3	46.3
Oregon	63.6	142.0	205.6	150.5	155.7	306.2
Utah	47.4	171.1	218.5	70.6	190.2	260.8
Washington	34.9	10.9	45.8	98.7	11.0	109.7
Wyoming	25.6	52.1	77.7	34.5	63.1	97.6
Total	847.8	1,194.0	2,041.8	1,351.1	1,418.7	2,769.8

[1] Data from other agencies not available; does not include requirements for energy sources on public lands.
[2] U.S. Forest Service—Present time 1970.
[3] Bureau of Land Management—Present time 1972.

As part of the inventory, nonconsumptive use requirements for streams and lakes and impoundments were developed on a preliminary basis for each location where water supplies may become critical at any time of the year. These data were compiled from available information and may be modified by additional studies and instream flow requirement information.

While the consumptive water needs of existing National wildlife refuges and fish hatcheries have been established, generally water needs for expansion of these facilities or the establishment of new facilities have not been determined. Particularly in those areas where energy developments will place heavy demands on limited water resources, the future needs for additional consumption to meet Fish and Wildlife Service responsibilities in the areas of waterfowl management, endangered species protection, and fish stocking in Federal waters must be determined so that overall water resource planning can include these critical considerations.

The water requirements for lands managed by the National Park Service have been established only in cases where previous use has conflicted with management objectives and the problem required immediate resolution. Additional conflicts are foreseen as water use becomes more critical.

In many areas National Parks are located in the headwaters of stream drainages and are the "first users" of water. Preservation of natural conditions is threatened in some of these areas by proposed upstream diversions that would change both the quantity and quality of the water supply. For these areas a determination of water requirements is especially important.

Determination of allocations of water based on requirements for public lands could be handled as in the past by consideration of issues on a case-by-case basis. Where specific conflicting use proposals are initiated, specific studies can be conducted to support decisions on the distribution of the water supply. At best, such decisions are slow, costly, and time consuming.

Alternatively, if water requirements were documented, the basic data for water allocations would be available when conflicts occur. Decisions could be made based on more factual information and effects on public land management programs could be quickly shown.

CONCLUSIONS

1. The water supplies required for management of Federal Land in the West are important to the wise use

and conservation of valuable resources. Water must be available if such lands are managed for multiple-use purposes.

2. Determination and documentation of the amounts of water required will facilitate decisions on the alternative uses of these lands as well as assist in allocation of water between public and private lands and projects.

RECOMMENDATIONS

1. Federal agencies having land management responsibilities should initiate and complete efforts to document by 1980 the water requirements for the uses anticipated on public lands. If necessary, additional funding should be provided to accomplish this task.

2. Land management agencies should keep water requirements updated in accordance with established or proposed changes in lands use.

3. Water requirements for State-owned lands should be compiled in the same manner and time frame and made available.

4. State-Federal interagency guidelines and approaches should be developed and used to assume consistent results so that data for water requirements of Federal, State, and private lands can be comparable.

5. Water needs for mineral development processes should be further refined and continued study of these requirements should be undertaken cooperatively among Federal and State agencies and private entities. (More specific recommendations on mineral fuels are discussed separately as part of the energy problems in other Westwide, regional and State problem discussions.)

WESTWIDE NO. 15 – COORDINATING LAND USE AND WATER PLANNING

SUMMARY

The varied land resources of the 11 Western States characterized by vast open space are one of the Nation's most important assets. For the majority of the West, a major limiting factor on land use is the availability of adequate supplies of water. Any major effort to develop broad plans for the use of large tracts of Western lands must include planning to assure the availability of water supplies required to support desired land uses. In the past, development of water projects and programs has influenced the character of Western development. There are differing opinions of just what role water played in determining land use and whether the resulting patterns are the most desirable. Now emerging is the viewpoint that considering the advanced development of the West, water will not play as dominant a role, but must be considered as a necessary service, except perhaps in special localized situations. Nevertheless, as broad land use planning efforts materialize, they should be fully coordinated with water planning efforts so that the food and fiber, energy, economic, environmental, and social needs of the West and the Nation can be met. Adequate information on the amounts of water necessary to support and maintain desired alternative land uses is an important requirement. Mechanisms for full coordination of land use and water planning must be strengthened at the local, State, and Federal level.

DISCUSSION

A general description of the land resource base of the 11 Western States is included in chapter II. Approximately 53 percent of the western lands are administered by Federal, State, and local governmental entities. Of the remaining private lands, 42.6 million acres are held in trust for Indians. The total Westwide area includes 752 million acres of land and 8 million acres of water surface.

Major land uses include range and grass land (53.7 percent), forest (32.4 percent), and cropland (8.6 percent). Other uses account for 4.2 percent of the total area. About 1.1 percent of the lands of the West are covered by urban development.

Present ownership and use patterns are a result primarily of topographic features and availability of resources associated with the land base. In the earlier development of the West, private land holdings were associated with mining, direct diversion irrigation, logging and grazing. Under Federal land policy, land was inexpensive and resources were developed and exploited at considerable economic gain to some entrepreneur. Later land policy has resulted in reservation of land established and managed as National forests, parks, monuments, wildlife refuges, wilderness primitive and natural areas, wild river corridors, and recreation areas.

Developmental uses of land are now competing with recognized environmental land uses such as parks and recreation, wildlife habitat, historical and cultural uses, and others for allocation of surface and ground water supplies. Supplies of land were once considered plentiful but now proposed uses overlap and viable decisions on land and water use are becoming extremely difficult.

The need for coordinated land use planning has been widely recognized and the establishment of both Federal and State land use legislation has been gaining momentum throughout the Nation. The emerging pattern is an increasing public influence over public land use decisions. The major resistance to such controls is the concern for protection of the rights of private property owners to realize economic gains from their land.

All of the Western States have moved into some phase of regulation of land use. The general areas where this regulation occurs at present are indicated in table IV-19.

National land use legislation was considered in the last two Congressional sessions but has not been adopted. The considered legislation was designed to provide financial assistance to the States, initially to establish a land use planning process and ultimately to implement that process. Now legislation would complement and tie together recent legislation such as the National Environmental Policy Act of 1969, the Wild and Scenic Rivers Act of 1968, the Land Sales Full Disclosure Act

Table IV-19.—*Proposed and existing legislation for land use and related regulations by State*[1]

State	Comprehensive land use planning	Mined land reclamation	Power facilities siting	Environmental quality general	Water quality	Air quality	Historical scenic and recreational sites
Arizona	x	—	x	x	x	x	x
California	x	—	x	x	x	x	x
Colorado	x	—	—	—	x	x	—
Idaho	p	x	—	—	x	x	x
New Mexico	p/x	x	—	x	x	x	x
Oregon	p/x	x	x	x	x	x	x
Montana	x	x	—	—	x	x	—
Nevada	p/x	—	—	—	p/x	x	x
Utah	x	—	—	—	x	x	x
Washington	p	x	x	x	x	x	x
Wyoming	p	x	—	x	x	x	x

State	Agricultural practices	Highway planning and zoning	Airport zoning	Coastal zoning	Unstable soils and seismic activities	Forest practices
Arizona	x	x	x	—	—	—
California	x	x	x	x	x	x
Colorado	x	x	x	—	—	x
Idaho	x	x	x	—	—	x
New Mexico	x	x	x	—	—	—
Oregon	x	x	x	x	—	x
Montana	x	x	x	—	—	x
Nevada	x	x	x	—	—	x
Utah	x	x	x	—	—	x
Washington	x	x	x	x	—	x
Wyoming	x	x	x	—	—	—

p—Proposed legislation
x—Some form of enacted legislation
p/x—Proposed legislation to amend existing legislation
[1]Prepared from detailed summary prepared by Western State Water Council, "Land Use Planning Legislation, State Requirements, and State Responses," August 1973.

of 1968, the Federal Water Pollution Control Act Amendments of 1972, the Clean Air Act of 1970, and the Coastal Zone Management Act of 1972. Additional pending Federal legislation which would have important impacts on Federal and State land use planning covers such areas as land use policy assistance, nationwide strip mining control, National growth policy, flood insurance, powerplant siting, Federal lands management, and comprehensive planning. An important need which may be met by the existing and pending legislation is the establishment of a National land use policy to guide both land and water planning.

A basic problem at both the Federal and State levels is that many agencies and departments have pursued separate and sometimes single objective missions without adequate coordination and guidelines, and with inadequate land use information. States have the basic constitutional authority for control of the use of private lands and a major voice in the management of Federal lands within their State. Federal interests are limited principally to Federal lands. Historically, States have delegated land use management authority to units of local government. In many instances, this has resulted in land use and management decisions based on expediency, tradition, and short-term economic considerations. On the other hand, local people have to live with their decisions and therefore are guided primarily by the impact of those decisions on their community. Land use decisions made by the Federal Government have not always included adequate and effective participation by State and local governments.

Planning Procedures

In comparison to land use planning, procedures for water planning are well established as indicated in the approved Principles and Standards. These Principles provide for the identification of water and related land needs, and full analysis of alternative plans considered viable. Land use aspects are considered to the degree that they may be directly affected by water planning or where land use plans themselves influence water plans. The Principles and Standards require coordinated studies by Federal, State, and local governmental entities together with private interests and organizations. Public involvement in all phases of the planning process is encouraged.

While a nationally consistent approach for water planning has been promulgated, the land use planning process is still widely variable. Even though some Federal land management agencies have established processes to facilitate accomplishment of their water and land missions, few State or local entities have developed the methodology for consideration of the broad range of interests that may be present in their jurisdictions.

Before an acceptable land use planning process can be implemented, agreement must be reached on several important factors. These include methodology for evaluating land use needs; methods for consideration of aesthetic and environmental values; and definition, identification, designation, and regulation of areas of critical concern – large-scale developments, key facilities, and areas of State, regional, and national interest. Also general agreement is required on what constitutes an adequate data base for acceptable land use decisions and the approach to public participation in the planning process.

Organization

While water planning efforts have, over several years, been organized into identifiable work segments, land use planning has proceeded with little central coordination. The Water Resources Council is organized to unify water and related land planning efforts of the States and the several Federal agencies involved. The central policy guidance and direction provided have assured that both comprehensive and implementation plans are coordinated among the agencies and that duplication of effort is minimized.

The overall need for developing integrated land and water planning is common throughout the Western States. This need has been accentuated in some areas by the need for increased development of minerals and energy production facilities. Specific areas of urgent criticality where immediate coordinated planning efforts are needed include the Southwest and the Northern Great Plains where coal and oil shale developments are contemplated.

These are deficiencies in planning coordination among States and entities within States, as well as among Federal agencies and among States and Federal agencies. Close Federal-State interagency coordination of water planning efforts occurs in the Pacific Northwest where the Pacific-Northwest River Basins Commission serves a coordinating function and provides for the needed interaction between Federal, State, and private organizations having resource management and planning responsibilities. The recently established Missouri River Basin Commission is expected to function in a similar manner.

The Arkansas-White-Red Basin, the Colorado River Basin, the Rio Grande Basin, the Great Basin, and the California Region are presently covered by existing

Federal-State interagency committees for coordination of water planning.

Some of the Western States have stated the need for a State-Federal interagency group to be the responsible and responsive entity for guiding and coordinating water and land use planning efforts within the State. Several States are continuing the State-Federal study teams used during the Westwide Study. In the Pacific Northwest, State-Federal study teams were organized and actively engaged, through efforts of the Commission, prior to the initiation of the Westwide Study. Since some states cover more than one river basin, (e.g. there are five in Wyoming) it may be most expedient to organize and coordinate land and water planning efforts by political boundaries as well as by hydrologic region.

With some 47 percent of the land area in the Western States owned and managed by the Federal Government, it is critical that Federal and State land use and water plans are developed in the best coordinated effort. Also, Federal mineral rights affect millions of acres of privately owned lands, which adds a further complicating factor. This requires the best leadership and expertise available and the continuity of representative participation as well as clarification of Federal responsibility. The spasmodic and fragmented participation common to many past efforts has not resulted in needed coordination. Agency representation should be of the level of responsibility necessary to implement and carry out the coordinated planning activities required. Each major Federal agency having planning responsibilities at the regional level should consider providing regional coordination and direction for developing needed planning efforts.

The development of needed programs for land and water planning would require substantial funding. However, if plans can be developed on a regional basis and priorities established in accord with issues requiring immediate solution, the year-to-year costs could be contained within reasonable budget constraints. A realistic program of near-term needs could be established for implementation in accordance with National policies and directives while long-term planning could be initiated as National policy, planning methodology, legislation, and base information are developed.

Land Use Policy and Water Planning

When a National land use policy is better defined, vigorous effort will be required to coordinate the policy among the interests involved and carry out the planning. Some proposed bills now being considered by the Congress would provide for State land use plans that are compatible with Federal guidelines. Planning by Federal agencies will, of necessity, have to be coordinated with State land use plans and decisions. This emphasizes the need for increased State and Federal land and water planning efforts. Some States may have to upgrade their expertise in land use planning. Federal agencies should assist in such efforts. The deficiencies in land use and environmental information should be rectified so that the data for adequate plan formulation and evaluation are available. Some water and land information, such as hydrology and soil surveys, has been developed to a high degree of sophistication, while there is a critical imbalance between other data required for planning. In order to make the necessary economic, environmental, and social evaluations, additional data and methodologies are required. Since each Federal and State agency uses its own data base as well as data developed by other agencies, there is the need to develop consistency in the overall use of the data available.

CONCLUSIONS

1. Comprehensive land use planning requires full coordination with planning for water and land use to resolve present and future conflicts and competitions for use. Such planning would involve all interests and result in more acceptable plans for resource use development for all purposes. It would also assure that individual decisions and actions would be an approved part of any existing master plans.

2. Many of the conflicts which have centered around incompatibile uses of the same land resource are the result of inadequate planning where important issues of priorities, goals, and objectives have not been clearly decided. Conflicts have resulted from a lack of coordination, failure to relate National programs to local and State aspirations, and an institutional inability to conceive the full range of local, State, and National values as a part of the planning process.

RECOMMENDATIONS

1. A Federal agency, office, or organization should be assigned the responsibility for coordination and establishment of consistent guidelines for land use planning and for coordination of land use planning with water planning efforts.

2. Each State should develop a land use planning process in cooperation with and the assistance of Federal agencies that have responsibilities for management of Federal lands in the State and can provide expertise useful to land use and water planning.

3. A National land use policy should be developed for planning guidance.

4. Adequate Federal funding assistance should be provided to State land use planning organizations and adequate funding should be made available to responsible Federal agencies for development of viable land and water use plans.

WESTWIDE NO. 16 – THE CHANGING FEDERAL ROLE IN DEVELOPING IRRIGATION PROJECTS

SUMMARY

Past Federal policies toward irrigation development were based on the need to promote settlement and economic development of the West. About one-third of the irrigated land in the West receives water from Federal projects, and many other areas benefit from improved systems through Federal assistance. Irrigated agriculture is one of the key factors underlying the present economy of the Western States. In recent years, several factors have combined to call into question the need to continue past irrigation policies as related to Federal involvement. These include conflicts with Federal programs to control supply and reduce crop surpluses, increases in the amount of Federal assistance required, the maturing of Western economies to the point where irrigation development is questioned as being the key to economic growth, and environmental concerns over desirability of constructing major facilities. On the other hand, there have been marked depletions of world food reserves, greater recognition of the economic and political advantages of producing abundant supplies to maintain a favorable balance in international trade and promote world peace, and increased interest in rural development and population distributions. Consequently, the questions arise as the role of Federal assistance to irrigation development in the West to meet future national food and fiber needs and changing national goals.

DISCUSSION

The National Water Commission Report of 1972 focused much attention on this and other pertinent water issues. In essence, the report contends that Federal involvement in irrigation development is no longer required to meet current national goals and that some of the water supply now used for irrigation in the west should be transferred to higher valued use. Ironically, issuance of the National Water Commission Report coincided with several unexpected changes in American agriculture which have caused dramatic effects in national agricultural policy. Increased export trading and reduced harvest have virtually eliminated excesses of agricultural supplies. Quantities of some commodities are such that prices have more than doubled, and export embargoes have been enacted to protect domestic markets. Within a very short time frame, agricultural policy has changed from one of restricted production to one of encouraging increased production. The thrust of the recent policy is to assure consumers of plentiful food supplies at reasonable prices, expand and firm up the export market to give a much needed assist to our balance of payments, and stabilize farm income without dependence upon Government price-support programs.

Public concern for the environment of recent years has generated an awareness of impacts associated with construction of major dams and reservoirs and irrigation conveyance works that often were located in recreation and scenic areas. Measures to accommodate environmental objectives in multiple-purpose proposals in some instances have not been viewed as acceptable alternatives to nondevelopment. Demands for stabilization of existing reservoir levels and increased downstream flows could affect the availability of water for the initially authorized purposes such as irrigation.

Over the years, the costs of developing irrigation projects increased because more complex engineering designs were necessary to develop remaining land and water resources. The impact of rising environmental concerns is certain to further increase the costs of Federal irrigation projects. Concurrently, prices and values for agriculture products tended to remain static, resulting in a marked increase in subsidies for Federal irrigation development. With ample supplies of food at reasonable prices on supermarket shelves, other pressing economic and social demands for Federal funds captured the attention of the public and responsible Government officials. A major emphasis in Federal irrigation development is not expected to occur unless food shortages persist and cannot be corrected with other lower cost short-term measures.

Data from the Department of Commerce emphasize that industrialization has replaced agriculture as the predominant factor in the western economy. Further industrial growth will place even greater demands on water supplies in direct competition with existing and future irrigation needs. In a free market situation, municipal and industrial uses will have no problem in purchasing needed supplies except for legal and institutional factors which in most states give certain preferences to agricultural use.

The recent dramatic shifts in demand for food and fiber further illustrate the fact that any Federal policy directing irrigation development be very broad, balanced, and flexible in order to meet the changing needs and priorities that are certain to characterize our society in the years ahead. Population levels, world trade, socioeconomic factors, technological advancement, and environmental considerations are just some of the dynamic variables that have a direct bearing on the future of irrigation development.

Another concern involves the existing 31 million acres of irrigated land in the West. Many of the private and early federally developed systems need rehabilitation and updating to conserve water and meet the requirements for maintaining water quality. Federal assistance could help keep these existing irrigated areas as sound productive units and enhance rural areas and contribute to the efficient use of water resources.

The Problem and Its Dimensions

Several federally funded programs have played a part in the development of irrigation in the West. These may be roughly categorized as "action" programs and "technical assistance" activities, each designated to meet a particular pressing goal or need.

Action programs include the major storage and irrigation distribution works constructed by the Bureau of Reclamation and the smaller watershed projects developed by the Soil Conservation Service. In each of these programs, active participation by the local water users is an essential ingredient to successful planning and operation of the project, including sharing of costs.

Technical assistance activities are very broad, covering numerous onfarm needs with respect to water management, erosion control measures, research, and education aids of various kinds.

It is difficult to measure the impact that each of these federally assisted programs and activities has made toward irrigation in the West, but there can be little disagreement that the total effect has been very significant. With respect to acres irrigated, however, it is interesting to note the importance of non-Federal development. Data from the census of agriculture indicate that of 30.9 million acres irrigated in the 11 Western States in 1970, including irrigated pasture, about 10 million were under Federal projects. About 90 percent of that amount is served in Bureau of Reclamation projects and the balance by Soil Conservation Service development. With recent restrictions in Federal funding for irrigation, there is little doubt that the prominence of non-Federal irrigation is increasing. Non-Federal irrigation stems primarily from diversions of natural flows and ground-water pumping, whereas, Federal projects represent the majority of lands irrigated from storage sources and multiple-purpose projects.

Irrigation's contribution to production is more significant than the acreage data indicate because of relatively greater yields and type of crops grown. Of the Nation's total annual domestic consumption, 25 percent of citrus fruit, 60 percent of noncitrus fruit, 75 percent of dry beans and peas, 50 percent of fresh vegetables, and 50 percent of potatoes are produced in the 11 Western States. Virtually all of these crops are produced under irrigation because of natural arid conditions and from areas where Federal projects predominate. Irrigation also contributes an indeterminate amount of feed grain and forage production to support and stabilize an important livestock industry.

Data are not available to measure the importance of irrigation as a tool for meeting specific social goals, rural development, etc. In a very general way, it may be noted that many of the thriving cities of the West such as Phoenix, Arizona; Boise, Idaho; Yakima, Washington; Grand Junction, Colorado; and Fresno, California; receive their primary impetus from surrounding Federal irrigation projects. Other smaller cities and towns have not followed a common national pattern of rural decline where economic stability and opportunities are afforded by irrigated agriculture. There are a number of Federal projects that have been established for the benefit of the Indian population, primarily to meet social and economic needs and goals. Continued development is dependent on resolving water right claims and determining water requirements.

Impact studies from several reliable sources illustrate the important contribution that irrigation generates for the economy and the well-being of people. A 1963 study by the University of Nebraska Bureau of Business Research found that each dollar of added production from irrigated agriculture in Nebraska generated nearly $6 worth of new business activity and jobs from the beginning of production to delivery to the final consumers. Even more dramatic effects were noted in a 1966 study of a Columbia Basin area by Washington State University. A summary of those findings is given in table IV-20.

Factors Influencing the Future Federal Role in Irrigation

The cropland area of the United States is reported to be less than 450 million acres. Approximately 50

Table IV-20.—*Economic indicators per 10,000 acres of cropland, Columbia Basin project area and comparison area*

Indicator	Project area	Comparison area	Ratio
Population	1,900	110	17 to 1
Business establishments	48.1	2.8	17 to 1
Workers[1]	480	22	22 to 1
Wages	$2.17 mill	$.11 mill	20 to 1
Property tax base[2]	$2.57 mill	$.40 mill	6 to 1
Postal receipts	$16,700	$960	17 to 1
Retail sales tax collections	$112,000	$6,470	17 to 1
Business and occupation tax collections	$25,100	$1,320	19 to 1
Federal income tax payments	$714,400	$41,300	17 to 1

[1] Does not include farm operators
[2] Data for 1962

million acres of this cropland are not considered productive for one reason or another on any given year. There are also about 860 million acres of pastureland in the United States of varying productive capability that contributes significantly to our food and fiber production. Irrigation has been widely used to intensify the use of these lands and increase production.

The 1969 Census of Agriculture reported about 23 million acres of irrigated cropland and about 8 million acres of irrigated pasture in the 11 Western States. The potential for increasing this irrigated cropland is significant with water being the major limitation.

A significant amount of current irrigated acreage is dependent upon ground-water pumping. As a result, severe ground-water mining has occurred in many Western States, including large areas of Arizona, California, Idaho, and New Mexico. Curtailment of production from these areas, that seems highly possible in coming years, would leave a serious gap in production that would be difficult to replace in a short time.

There has been a steady expansion of urban development which has removed prime cropland from the agriculture base. The reduction in cropland from all competing uses for the 1970-2020 period as estimated in the OBERS Projections – Series E of April 1974 is tabulated in table IV-21.

The past decreases in cropland base have been mitigated by expansion and intensification of our agricultural production. However, agricultural demand in recent years has been accelerating, prompting the Government to release millions of set-aside acres that previously had been withheld from crop production. The 1972 OBERS projects additions to the total cropland base of 13,235,000 in 2000 and 17,938,000 acres by 2020. Estimated additions of irrigated cropland by 2000 in the 11 Western States total 1,693,000 with 3,677,000 acres in 2020. The total cropland base included the estimated 60 million acres of land that was considered surplus as recently as 2 years ago. OBERS projections assumed that this amount would be gradually absorbed as needed through the projected period. To meet current requirements, it is estimated

Table IV-21.—*Reduction of cropland because of competing uses*

	1970-1980	1980-2000	2000-2020	Total
	Acres			
United States	6,537,700	6,308,900	4,586,800	17,433,400
Average acres/year	594,300	315,400	229,300	–
11 Western states	384,700	538,100	459,700	1,382,500
Average acres/year	35,000	26,900	23,000	–

that all but about 12 million acres of the 60 million acres in long-term retirement and set-aside programs were placed into production in 1972 and that amount would be reduced to zero in 1974. Adjustments in the major uses of land would be required to meet additional requirements for food and fiber.

Water Availability

Even though areas with surplus water supplies exist, water demand exceeds supplies in many areas because of the variability in supply and time of occurrence. Over 6 million acres of irrigated land in the 11 Western States experience water shortages annually.

Available water supplies would have some rather significant implications for future Federal roles in irrigation policy. Data indicate that any large expansion in new irrigation in the 11 Western States must occur in the Northwest Region where major supplies of both water and land are available, or means must be provided to transport surplus water to other available land areas.

Future Food and Fiber Needs

The National Water Commission model indicated there would be no further need for irrigation in the West to year 2000. Basic criteria built into the model assumed different levels of population growth, no increase in exports, and return of most of the surplus acres to crop production. OBERS 1972 projections based on level C population growth assumed that 1,693,000 additional acres would be irrigated acres in the 11 Western States by year 2000. Assuming a lower level of population growth would, of course, require a reduction in the projected production base.

State disaggregations of OBERS estimates of crops and livestock production and available land and water resources were reviewed. The examination revealed that in the 11 Western States a substantial deficit of feed units produced when compared to red meat production. About two-thirds of this shortage would occur in pasture and roughage production and the remainder in feed grains. The magnitude of the imbalance in terms of feed units could amount to the equivalent of up to 8 million acres in 2000.

From this observation it would appear that one or a combination of the following conclusions may be drawn. (1) The anticipated production exceeds the resource base; hence, the meat for regional export would be produced in states further east. (2) A considerable increase in the quantities of grain and hay transported into the region would be required for livestock feeding. (3) Large acreages of irrigated or dryland would need to be developed to meet the expected demand for livestock feeds. Existing patterns of regional production and transporting feed and livestock may be influenced significantly by energy shortages.

The International Picture

Since 1971, the export market for United States agricultural products has changed dramatically. The value of agricultural exports has risen from $5.7 billion in fiscal year 1969 to $12.9 billion in fiscal year 1973; an increase of more than 100 percent.

Devaluation of the dollar has stimulated trade by decreasing the price of the United States' products to many of the major importing countries. The effect of devaluating the dollar amounted to 15 percent on the average. For Japan, it was a 27 percent decrease; for West Germany, 33 percent.

One important aspect which explains much of the strong export demand is that countries in Western Europe, Eastern Europe, the Soviet Union, and Japan have experienced rapid economic advancement in the past decade. As incomes continue to rise in this group of countries containing some two-thirds of a billion people, a sizable share of the additional income is being converted into demand for livestock products, particularly beef. The increase in demand for meat has raised the demand for livestock products and for feed grains and supplements with which to expand livestock production. It takes from three to four times the amount of grain for indirect consumption through meat as opposed to direct human consumption.

Trade agreements recently promulgated with the Soviet Union and the People's Republic of China have increased the market potential for the United States' products. In 1972 even without trade with these two countries, United States' exports would have been a record high.

The People's Republic of China offers a new important outlet for cotton as well as food grains. Another recent development that has brightened the United States' trade outlook is the end of the preferential tariff arrangements under the British Commonwealth system, which resulted when Britain entered the European Common Market. United States' sales have shown substantial increases to those countries in the Common Market in the first half of 1973.

Table IV-22 shows the position that the United States has in the World Market with regard to producing and exporting major commodities. The relatively strong position indicates that the United States should have a dominant role in supplying world needs in the future.

Rural Decline and Population Dispersal

The number of people and the percent of population engaged in agriculture has been decreasing markedly for many years. In 1970 there were less than 10 million people in farming which was less than 5 percent of the population. This transition has resulted in a significant rural decline as evidenced by a continuing loss in economic opportunities, particularly for young people; a reduction in social services, educational opportunities, medical care, etc.; and a rapidly diminishing political influence so there is little chance for rural people to reverse this adverse situation through available legislative processes.

The increase in productivity in agriculture has resulted in rapid migration from the farm and has compounded urban problems associated with overcrowding, inadequate housing, unemployment, increasing crime, pollution, and general environmental deterioriation. Most of the rapidly growing metropolitan areas are finding it nearly impossible to keep up with the demands for even basic needs and services to say nothing of the additional needs to maintain or improve the quality of life. Efforts to meet these needs result in increased taxes, inflationary pressures, welfare burdens, and a general reaction of frustration and pessimism. These social problems of urban concentration are recognized to be of major national concern. Programs which serve to build up sparsely settled areas and disperse population can have a beneficial effect in lessening the impacts of further rural decline.

Irrigation Water Use Management

Water use management includes all types of water and related resources such as lakes, ponds, underground supplies, clouds, and oceans. Useful functions utilizing water include urban use, irrigation, recreation, fish and wildlife, control of pollution and floods, navigation power production, and aesthetics. Some of the implications of water-supply management for a specific use are the development of new supplies not otherwise utilized; transfer of water from other uses or areas; and treatment, reuse, or more efficient use of existing supplies.

As irrigated agriculture is the single largest user of water in the West, the availability of sufficient water to meet other demands is related to efficiency of water use in agriculture. Accordingly, a program for irrigation management has been initiated to improve onfarm water use efficiency. It would appear that this type of role in regard to irrigation should continue under Federal sponsorship in the years ahead.

Other Important Factors

Changes in income and diet in the United States are having a significant effect on food consumption and production requirements. The total per capita disposable income changed from $1,364 in 1950 to $3,420 in 1970. During this same period, beef consumption per capita changed from 63 pounds to 116 pounds. The percentage of income spent on food during this same period dropped from about 24 to 15 percent. Projections from Agricultural Economic Report No. 138, Washington, D.C., January 1971, entitled "Food Consumption Prices and Expenditures," indicate that the only signficant increase in per capita consumption projected to year 2000 is in beef and veal.

The projected amount is 41 pounds per capita, or a 35 percent increase during the 1970-2000 period. This change in diet will require a very marked increase in the production of livestock feed grains and forage,

Table IV-22.—*United States' share of world production and exports of selected agricultural products, 1971*

Commodity	Production (1,000 metric tons)			Exports (1,000 metric tons)		
	U.S.	World	U.S. %	U.S.	World	U.S. %
Wheat	37,286	387,916	13.0	19,813	53,806	36.8
Corn for grain	104,120	251,576	41.4	13,082	25,909	50.5
Soybeans	31,815	43,627	73.0	11,784	12,601	93.5
Rice, rough	3,820	288,650	1.3	1,695	7,131	23.8

Source: Lester R. Brown, Population and Affluence: Growing Pressures on World Food Resource, Population Reference Bureau, Inc., Washington, D.C., 1973, p. 20.

some of which may be provided from an enlarged irrigated acreage.

Technology and management resulting in varying crop yields constitute one of the more critical factors in estimating future land-base requirements and agricultural supplies. Limitations on the use of farm chemicals and, hence, land productivity, may be necessary for reasons of reducing contamination of the environment. Agricultural production is also affected by the broad acceptance and use of labor-saving machinery. Yield increases are tied to continued variety improvement, availability of purchased inputs, and continuation of improved management.

The net result that can be anticipated from an increasing dependency on new farm technology and management is more production, but the unpredictable elements of expansion must be recognized. As the rate of technological advance slows, it may be necessary to increase the cropland base by intensifying use of pasture or other marginal lands.

Flood and drought are natural climatic forces that have significant effects on agricultural production in individual crop years. Research and experience have evolved many improved cultural practices, plant varieties, and technology to help cope with the vagaries of weather. Even so, weather still causes extreme fluctuations in the production and supply of agricultural commodities.

One of the more effective means of mitigating the effects of weather and stabilizing agricultural production is through irrigation. Not only are crop yields maintained at higher levels, but with irrigation there are more possibilities for diversification to permit a quick adaptation to changing needs and demands. The improvement in dependable crop yields through irrigation is well documented by agricultural statistics published jointly by States and the Statistical Reporting Service of the Department of Agriculture.

In Nebraska during a 12-year period (1955-66), the annual coefficient of variation in corn yields with irrigation was approximately half of that reported for nonirrigated corn, while the average yield was about doubled. When soil moisture is adequate, all other factors of production can be used more efficiently.

The importance of strategic reserves in a dynamic world situation such as we face today can scarcely be overemphasized. The logic of an agricultural commodity reserve is to protect and stabilize the domestic market for consumer benefit and to meet initial needs during national emergencies. Grain surpluses were advantageous when the 1972 world crop was short. Had stocks been available in 1973, there would not have been the doubling in price in July and August and subsequent wide variations. Fluctuations of this magnitude hinder efficient movement of commodities from the producer to the consumer.

While National policy on strategic reserves of grain has not been clearly defined, it appears that trends established in the 10 years in agricultural export will prevail in the future. Such trends will require greater production than those shown in the 1972 OBERS Series E projections.

CONCLUSIONS

1. In defining the future Federal role in irrigated agriculture, many variables may affect the demand and need for irrigation development. Population levels, world trade, socioeconomic factors, technological advancement, and environmental considerations are just some of the key variables. The interrelationships of these and other variables demand that Federal policies directing irrigation development be very broad, balanced, and flexible in order to meet the changing national needs and priorities. An important policy question, in the face of increasing demand, is to determine where the comparative advantage lies so that additional production can be accomplished as required in a most efficient manner.

2. Settlement and economic development of the West through federally supported irrigation development are no longer primary national goals, nevertheless, there is still national concern for development in rural areas of low growth or depressed economies. Quality of life and environmental considerations will receive significant emphasis in future irrigation planning. Population dispersal and income distribution are other important national goals to be considered. It is clear from the previous discussion that the West can no longer be considered an undeveloped area, and past settlement policies such as the Reclamation program need a change in direction and emphasis in order to be responsive to western and national needs and priorities. Nevertheless, there are still many areas in the West where there is need for rural development to build and stabilize the economy, to diminish rural decline, and offer some opportunities for population dispersal from the more congested areas.

3. Recent worldwide food and fiber shortages and the dynamic international trade situation emphasize the importance of strategic reserves and focus attention on

the advantages of stabilized food production and the contributions that federally supported irrigation could make.

4. In many rural areas, particularly in the Northwest, water and land coexist in abundance, but the ramifications associated with large-scale multipurpose development suggest it will not be accomplished without Federal assistance. Comprehensive planning and multiple-purpose use of the resources will be essential because of the pressing economic, social, and environmental needs and goals that are involved.

5. Recent historical projections of the future (OBERS) and economic models (National Water Commission) provide some provocative information but also have generated considerable controversy concerning the basic assumptions made and conclusions drawn with respect to future food and fiber requirements and the suggested measures for meeting these needs. The variance in the results and implications of these studies, the inability to determine whether the current shortage in food and fiber requirements is temporary or long term, and insufficient knowledge on the comparative advantage in production, preclude making enlightened decisions for National policy.

RECOMMENDATIONS

1. In the absence of clear-cut national direction, and the severe impacts that would accompany any long-term shortages of agricultural commodities, contingency planning for future food and fiber needs calls for the continuance of the development of alternative water resource plans which incorporate federally supported irrigation. Development of such plans should be concentrated in those areas having substantial undeveloped water and land resources, with potentials for combining irrigation with benefits from other purposes and objectives. Areas with low population density, and those exhibiting rural decline, instability, and social deterioration among minority or disadvantaged groups, should be given high priority.

2. An independent study should be conducted by a non-Federal group of outstanding professionals in related field of economics, agriculture, sociology and environmental sciences, with participation and assistance by Federal entities, to analyze the Federal role in developing irrigation. Consideration should be given to future national and international food and fiber needs and whether projects with irrigation and other benefits provide a useful tool to meet social goals such as rural development and population distribution.

WESTWIDE NO. 17 – WATER SUPPLY POTENTIALS FROM WEATHER MODIFICATION

SUMMARY

There is rapidly growing interest particularly in the Western States in cloud seeding as a feasible means of augmenting water supplies. Preliminary results from Federal research and commercial operations indicate that (a) techniques for increasing precipitation have advanced to a level and certainty for limited or emergency use; (b) potential benefits are so large and the chance of obtaining them so favorable that large-scale demonstration projects in selected areas should be pursued promptly to verify preliminary results and findings; (c) major adverse environmental impacts are not indicated to date although further study is needed for positive confirmation; (d) downwind effects frequently are positive and (e) benefit-cost ratios are likely to exceed 10:1. Although knowledge and the implications of weather modification are presently incomplete, early application of the available techniques in water-short areas can provide both additional water benefits and future scientific advances.

Experimental results from eight completed Project Skywater and other winter research projects and early evaluations from two major pilot projects still in progress indicate snowpack augmentation of 10-20 percent is possible in mountainous areas. Seeding suitable winter clouds over the mountain headwaters of western rivers can add millions of acre-feet of streamflow annually from snowmelt. In general, the goal of winter seeding is to improve water supplies in years of below normal snowfall. Public experience with field projects and environmental studies indicates this goal is usually socially acceptable and minimizes possible adverse ecological effects.

DISCUSSION

An immediate goal in research on the modification of weather is to develop the capability for increasing or redistributing precipitation. Key features are the development of the technical systems to accomplish the desired precipitation enhancement and the management techniques for beneficially integrating the technical capabilities with our environment and society.

A major part of the research and development efforts by the Bureau of Reclamation to date has been directed toward cloud physics investigations to determine how to make clouds precipitate more efficiently (microphysical processes) and how to make clouds grow larger and last longer (dynamic processes) to increase precipitation through field experiments, laboratory research, and computer modeling. New, more effective and efficient cloud seeding materials and equipment have been developed and tested. There is continuing emphasis on lower cost materials necessary for economic large-scale seeding.

Integrated weather modification systems including forecasting and centralized operational control with computers for improved forecasting and direction of seeding activities during rapidly changing weather conditions have been designed and tested. Instruments and data systems for measuring atmospheric parameters in the detail and speed required for weather modification operations and evaluations continue to be developed and adapted.

Comprehensive field experiments have provided most of the development and field testing of techniques in different areas under different cloud conditions. Winter snow augmentation experiments have been carried on in eight states. Experiments during the 1973-1974 winter season have been conducted in Colorado, Utah, and Nevada. Summer cumulus seeding experiments have also been carried out in seven states over the past 12 years. Current plans are for an extensive High Plains experiment on the modification of cumulus clouds over the next 5 to 7 years.

Increased publicity over the past few years has educated a significant portion of the population about the capabilities and potentials of precipitation management. With this increased awareness has come increased concern about its effect on the environment and on man himself. The ability to respond to these concerns is an important part of developing a comprehensive precipitation management technology.

Experience in conducted cloud seeding projects has taught that most of the sociological problems can be resolved when an effective education program is coupled with an honest attempt to involve local people in the planning and decisionmaking phases. Local officials and interested citizens have formed advisory committees to make decisions when and where to seed clouds. After the seeding project is under way, periodic progress reports are issued to the public.

The legal aspects of precipitation management are very complex at the present time. Some States have specific laws to regulate weather modification (one State prohibits it altogether); others simply require the reporting of activity; still others have no laws whatsoever. To date, there is little in the way of judicial precedent to use as a guide. The question of liability has not been resolved and companies which insure cloud seeders have little or no experience with cloud seeding claims upon which to base their rates.

To date over $3 million has been expended by the Bureau of Reclamation for ecological and associated studies on the environmental effects of additional precipitation from cloud seeding. These studies have not defined any significant environmental impacts of the short-term experimental projects, either from the additional water or the silver iodide used as the seeding material. The studies thus far indicate that while cloud seeding in below normal years may not cause more than minor immediate effects on animals and plants, the overall stabilization and increase in the average annual precipitation may cause both beneficial and detrimental impacts. Ecological models are being developed that will be able to estimate the effects of prolonged precipitation enhancement. There is no evidence that cloud seeding creates irreversible effects on any natural system.

Environmental concerns have been incorporated into the operating criteria for research projects and will be incorporated into large-scale operational cloud seeding programs to reduce possible hazards and environmental stress. Suspensions of cloud seeding during periods of much above-normal precipitation when there are flood or avalanche potentials, during big-game hunting seasons, and during critical harvest periods are examples of environmental and social restrictions enforced to date.

The potential of winter cloud seeding for increasing the water supply in the 11 Westwide States has been investigated for 12 major mountain areas and the related river basins. This study provides information about potential increased water resources in both dry and wet years taking into account the frequency of occurrence of mountain precipitation and related key airmass parameters. Table IV-23 summarizes the estimated average annual potential water-supply increases in the areas investigated from (a) the effect of increasing precipitation efficiency of which most is known and can be considered a "conservative" estimate and (b) precipitation efficiency effect increase plus effect of increased cloud growth, particularly of embedded convective cells of which less is understood. These estimates conform to the most recent analysis of results from field seeding projects and latest cloud modification models.

Table IV-23.—*Twelve basin investigation estimated average annual potential water supply increases from weather modification (1,000 acre-feet)*

Basin	(a) Conservative potential	(b) Total effect potential
Upper Colorado River Basin		
Colorado River inflow to Lake Powell	903[1]	1,315[1]
Rio Grande Basin		
Rio Grande at Cochiti	88[2]	209[2]
San Luis Valley	26	46
Truckee, Walker, Humboldt Basins		
Truckee River at Farad	99	129
Walker River total	66	82
Humboldt River near Carlin	98	98
Sacramento Basin		
Sacramento River at latitude of Sacramento	1,410	1,858
North Platte Basin		
Inflow to Seminoe Reservoir	155	164
Laramie River near Lookout	40	42
Gila River Basin		
Total Gila River	154	239
Snake River Basin		
Total Snake River	903	1,056
Upper Missouri Basin		
Total Upper Missouri Basin	1,408	1,837
San Joaquin Basin		
Total contribution to San Joaquin River	1,249	1,517
Deschutes Basin		
Deschutes River total above Culver	220	244
Bear-Wasatch Basin		
Total contribution to Bear-Wasatch	544	579
Yakima Basin		
Yakima River near Parker, Washington	283	352
Total of the 12 basins studied	7,646	9,757

[1] A 9.1 and a 13.2 percent increase in runoff based on 1952-1971 actual published runoff.
[2] A 11.0 and a 26.1 percent increase in runoff based on 1952-1971 actual published runoff. (These are unadjusted.)

CONCLUSIONS

1. Although research has shown cloud seeding to be more complex than was originally thought, the basic concepts, approaches and techniques have been identified and tested. Verification of long-term, widespread effects has yet to be established, however.

2. Precipitation management projects can only rarely be limited to areas owned or controlled by a single person or organization. Many people with diverse interests are affected by most projects, and it is important to coordinate the planning and execution of precipitation management projects so that the rights of all parties are recognized. During the planning phase, coordination among individuals and local, state, and national organizations is necessary to be sure that costs and benefits are fully understood, that precipitation management fits properly with other water development techniques, and that appropriate environmental and social issues are considered.

3. To resolve the complex social, economic, environmental, and legal questions, the Bureau of Reclamation has:

a. Had environmental and other comprehensive studies preceding and performed concurrently with major projects (Colorado River Basin Pilot project, High Plains Cooperative Program and Sierra Cooperative Program).

b. After open public meetings, adjusted project designs and operating safeguard critiera to help meet local interests and protect the public and environment in periods of possible stress.

c. Sponsored legal studies and participated in planning discussions and review of State legislation.

d. Involved local groups in the continuing operational decision processes. Although good progress is being made in measuring and analyzing the environmental impacts of weather modification, further research and study are needed before final conclusive results will be available.

4. The advantages of using weather modification to increase mountain snowfall as a means of water-supply augmentation are: a source of high-quality water which does not deplete water supplies in other areas, increased water at high elevations permitting maximum hydropower generation, and water-supply enhancement at a relatively low initial investment and low annual operating costs. While limited studies thus far have not identified major direct ecological disadvantages, further study is needed on the direct and indirect effects on the environment of long-term weather modification programs. Taking into consideration availability, quantity, quality, and cost of the augmentation alternatives, weather modification appears to be the most promising source of new water supply in the Western States.

RECOMMENDATIONS

1. Additional research to improve techniques, verify large-scale runoff increases, measure, environmental impacts, and establish management policies and procedures is recommended before major commitments to operational cloud seeding are made. Two comprehensive research projects with accompanying social-environmental studies are recommended during the next 10 years.

a. A demonstration program in the Colorado River Basin – total cost $30 million.

b. A cooperative pilot program in the northern Sierra Mountains supported by the State of California and commercial interests – total shared cost $7,300,000.

2. A scientifically oriented pilot project in the North Platte or Rio Grande basins should be considered as soon as possible to develop new techniques and cloud seeding systems.

CHAPTER V
REGIONAL PROBLEMS
INTRODUCTION

Critical water problems of a regional nature were also delineated as a part of the Westwide Study. Regional water problems are defined as encompassing an interstate hydrologic river basin or located within several – two or more – contiguqus states. The problem dimensioned could be a specific issue; for example, salinity in the Colorado River; or, a source of interrelated issues such as those involved in operating and managing the Columbia River main stem system.

These problems, though regional in geographic scope, still require discussions on specifics for resolution. Thus, concentration has been given to reducing the level of generalities to a point where localized action programs can be identified. This chapter, then, focuses on those critical problems or combinations of problems for which new studies are needed to bring forth viable solutions, or where ongoing action programs are underway for resolution.

Though several of these regional problems could be further combined because they are interrelated, more logical action programs can be recommended where needed and a more definitive analysis of the programs presently underway can be made by keeping them separate and analyzing each on their individual merits. As with the Westwide problems, the recommended programs of study for regional problems are presented at the conclusion of Chapter VI in an inclusive set of study schedules.

The regional problems are:

1. Water Supply Problems of the Colorado River,

2. Increasing Salinity in the Colorado River,

3. Water Requirements for Oil Shale Development in the Upper Colorado Region,

4. Managing Water and Related Land of the Lower Colorado River Main Stem,

5. Operation and Management of the Columbia River Main Stem System to Meet Total Water Uses,

6. Water Management Problems of the Columbia River Estuary,

7. Maintaining and Improving Anadromous Fisheries in the Northwest,

8. Conflicts of Water Use in the Hells Canyon Reach of th Middle Snake River, and

9. Erosion and Sedimentation in the Palouse Region of the Northwest.

REGIONAL NO. 1 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

SUMMARY

The Colorado River is one of the most highly controlled rivers in the world. It is approaching that point when little usable water, if any, will ever escape from the basin to the Gulf of California. It is approaching that point also when the natural water supply of the river will be inadequate to meet all of the demands placed upon it.

Although the water supply of the river is adequate to meet quantitative needs today and in the years immediately ahead, this does not mean that there are no current problems related to water shortage. To the contrary there are and they are severe. If the Upper Basin States are to develop their resources at a rate commensurate with their expressed aspirations it is a certainty that shortages will develop within a time frame that directly affects decisions which need to be made today. Most resource development undertakings, be they for agriculture, industry, or other purposes, require an assured water supply for at least 40 years to justify making initial investments. The fact that there is no actual shortage of water today nor will there be one in the immediate future is of little comfort to those interest whose future depends upon an assured water supply for the next 40-50 years. The current emphasis in exploring the potential for oil shale, coal, and other energy resource development underscores the concerns over future water shortages.

Studies indjcate that with fairly intensive future development and growth in the Upper Basin, water shortages in the Lower Basin could occur as early as 1900 and grow continually more severe thereafter. Shortages will occur on Upper Basin tributaries above major storage reservoirs periodically. The occurrence

and magnitude of future shortages will depend upon actual rates of growth, hydrologic conditions, and storage provided on the tributaries.

When shortages occur the principal alternatives will be (1) to pattern the economy of the basin on the natural runoff with choices of trade offs between irrigation and other development such as energy resource exploitation, and (2) to augment the natural flows of the river to accommodate further water-based development. All practical means of water conservation and measures to optimize water use should, of course, be adopted before considering expensive augmentation measures, including the adoption of measures to use existing supplies more efficiently and the implementation of programs such as land use planning to guide growth where potential demands are expected to exceed water supplies. Possibilities for augmentation include weather modification, desalting of geothermal brines, and desalting of seawater. Importation of surface waters from outside the basin states was not considered in the Westwide Study due to limitations in the Colorado River Basin Project Act.

The cost of desalted seawater at this time seems prohibitive. The costs of desalting geothermal brines also appear high but research in this field is just getting under way. This potential needs full exploration.

Both from physical and cost standpoints weather modification appears well adapted to meet augmentation needs. Serious environmental, legal, social, and other problems, however, still remain to be resolved.

Continued study by Federal, State, and local interests is required to determine what the future economic and social climate of the Colorado River Basin should be, what the associated water demands will be, and how such demands can best be met.

DISCUSSION

The Colorado River system (fig. V-1) is one of the more water-deficient river systems in the nation. The Colorado River, supplying water to such metropolitan complexes as those along the Coast of southern California, the eastern slope of the Rocky Mountains in Colorado, in the Upper Rio Grande of New Mexico, and along the Wasatch Front in Utah, has a service area extending far beyond its physical drainage basin. In spite of its very meager water supply, a greater percentage of its water is exported from this system than from any other major system in the United States. In terms of population over half of the West depend to a large extent on the Colorado River as a source of water.

Though the demands on the Colorado River are large and growing rapidly the long-time average annual virgin flow of about 14.9 million acre-feet is small compared with the 180 million acre-feet of the Columbia River or the 440 million acre-feet of the Mississippi River.

The Colorado River is not only one of the most physically developed and controlled rivers in the nation, it is also one of the most institutionally encompassed rivers in the country. There is no other river in the Western Hemisphere that has been the subject of as many disputes of such wide scope during the last half century as the Colorado River. These controversies have permeated the political, social, economic, and legal facets of the seven Colorado Basin States. The many lawsuits and interregional and interstate compacts have resulted from a water supply which is inadequate to meet the existing and potential water demands within the seven Colorado River Basin States.

Two primary factors have led to the present water supply problems of the Colorado Basin. The first is that the Colorado River Basin simply does not yield sufficient water on a natural basis to permit full development of the basin's vast land and mineral resources, to meet domestic, municipal and industrial needs, to provide for fish and wildlife and recreation, and to service other needs. The second is that the negotiators of the Colorado River Compact apportioned a water resource that, at the time of negotiations, appeared much larger than the river has subsequently yielded. The unprecedented population growth

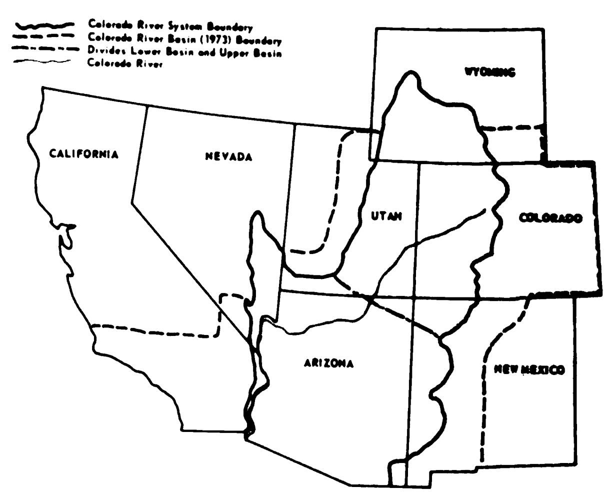


Figure V-1. The Colorado River system.

in the Southwest since World War II, resulting largely from inmigrations, has drastically stepped up the timing of these various demands. An additional factor which could further accelerate the point in time when water shortages will occur in the region is the renewed attention being given to development of the tremendous oil shale and coal reserves of the Upper Colorado Basin.

To provide a basic understanding of the various facets of the Colorado River water supply problem a brief discussion of the principal historical events and factors leading to the present situation is presented.

The waters of the Colorado River are divided among the Upper Colorado Basin, the Lower Colorado Basin, the Republic of Mexico, and among the States of the Upper and Lower Basins by interstate compacts, and international treaty, a Supreme Court decision, and by State and Congressional legislation. Additional Congressional legislation, agreements with Mexico, and other documents affect and, in some instances, dictate how the river shall be managed and operated. Collectively, these various agreements, guides and directives are known as the "Law of the River."

Legal Considerations

Colorado River Compact, 1922. – Major benchmarks in the "Law of the River" began in 1922 when negotiations among the seven basin States were initiated for the purpose of dividing the waters of the Colorado River system. The Compact became effective in 1929. In essence the Compact:

1. Apportions for annual beneficial consumptive use 7.5 million acre-feet of the flows of the Colorado River system to each – the Upper Basin and Lower Basin. (The Upper Basin is defined as that portion of the basin drainage above Lee Ferry, a point 1 mile below the mouth of the Paria River near the Arizona-Utah border. See figure V-1.) It also gave the Lower Basin the authority to increase its beneficial consumptive use by one million acre-feet per year.

2. Provides that water for delivery to Mexico be supplied from surplus flows about the aggregate quantities specified in 1. above, and that when there is insufficient surplus flow to meet the Mexican water obligation the deficiency shall be borne equally by the Upper and Lower Basins.

3. Provides that the Upper Basin shall not cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75 million acre-feet in any 10-consecutive-year period, and that the Upper Basin shall not withhold water nor shall the Lower Basin require delivery of water which cannot reasonably be applied to domestic and agricultural uses.

Boulder Canyon Project Act, 1928. – This Act authorized the construction of Hoover Dam and Powerplant and the All-American Canal. The Act also authorized the States of Arizona, California, and Nevada to enter into an agreement whereby the 7.5 million acre-feet of water that was apportioned for annual use to the Lower Basin by Article III(a) of the Colorado River Compact would be apportioned as follows:

To California – 4.4 million acre-feet
To Arizona – 2.8 million acre-feet
To Nevada – 0.3 million acre-feet

Before becoming effective, the Act required that California agree to limit annual use to 4.4 million acre-feet plus not more than one-half of the surplus water. The California Limitation Act of 1929 met this requirement. However, the States never entered into an agreement dividing the Lower Basin waters. Provisions were also made for sharing surplus waters. The Act also authorized the Secretary of the Interior to execute contracts for water made available by the Boulder Canyon Project, subject to the terms of the Colorado River Compact.

Upper Colorado River Basin Compact, 1948. – This compact among the States of Arizona, Colorado, New Mexico, Utah, and Wyoming apportions the water of the Upper Colorado River Basin which was allocated to the Upper Basin by the Colorado River Compact of 1922.

Of the Upper Basin allocation, the State of Arizona was apportioned 50,000 acre-feet and the other basin states were approtioned the following percentages of the remainder:

Colorado	– 51.75	Utah	– 23.00
New Mexico	– 11.25	Wyoming	– 14.00

Mexican Water Treaty, 1944. – In 1941 the State Department undertook negotiations with Mexico for a treaty to encompass both the Rio Grande where a significant portion of the water originates in Mexico but is largely used in the United States, and the Colorado River, where all the water originates and is regulated in the United States but is used in both the United States and Mexico.

Under the Mexican Water Treaty the United States is obligated to deliver to Mexico 1.5 million acre-feet annually in the limitrophe section of the Colorado River (that stretch where the Colorado River is the boundary between the United States and Mexico), and some additional quantities if available. However, in some cases of serious drought or a significant failure in delivery system, Mexico could receive less than 1.5 million acre-feet.

Colorado River Storage Project Act of 1956. – This Act authorized the construction of several long-term carryover reservoir storage units in the Upper Basin, since constructed and in operation, which permit the Upper Basin to make required deliveries of water to the Lower Basin and at the same time to maximize the consumptive use of water within its Colorado River compact apportionment.

Decree of the Supreme Court of the United States in Arizona v. California 376 U.S. 340 (1964). – The Court held that, on a consumptive use basis, the appropriate apportionment of the Lower Basin mainstream water supply of 7.5 million acre-feet per year when available was:

4.4 million acre-feet to California
2.8 million acre-feet to Arizona
0.3 million acre-feet to Nevada

Included in these apportionments is a diversion requirement of approximately 1 million acre-feet for the five tribes located along the Lower Colorado River. This decision also provided that the Secretary of the Interior may choose among recognized methods or devise reasonable methods to apportion shortages subject to plenary powers of Congress. It also made provision for use of water in excess of 7.5 million acre-feet, when available.

Colorado River Basin Project Act (P.L. 90-537, 1968). – This Act, in addition to authorizing the construction of a number of Federal projects, including the Central Arizona project, provides that in the event of a shortage in the Lower Basin's 7.5-million acre-feet apportionment, diversions to the Central Arizona project shall be so limited as to, in effect, guarantee California the use of 4.4 million acre-feet annually. The act declares it an objective to provide a program for the comprehensive development of the water resources of the Colorado River Basin and for the provision of additional water supplies for use in the Upper as well as in the Lower Colorado River Basins. It further declares that the satisfaction of the Mexican Water Treaty from the Colorado River constitutes a national obligation which shall be the first obligation of any water augmentation project planned pursuant to the Act.

Water Quality Legislation. – Of primary significance is the 1972 Amended Federal Water Pollution Control Act, P.L. 92-500. Section 101(a) of the Act states: "The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters * * *." In general, the Act directs the administrator of the Environmental Protection Agency to administer the Act which contains implementary authority and incentives in the form of cost-sharing grants.

Minute No. 242, August 30, 1973. – This Minute of the International Boundary and Water Commission which replaces Minute No. 241, was agreed to by the United States and Mexico August 30, 1973. Minute No. 242 requires the initiation of several actions which will reduce salinity with respect to water deliveries to Mexico under the Mexican Water Treaty.

Colorado River Basin Salinity Control Act (P.L. 93-320, 1974). – This Act, through Titles I and II of the Act, requires the Secretary of the Interior to implement several programs to improve the water quality of the Colorado River.

Title I – Programs Downstream from Imperial Dam – includes the construction of a desalting complex in the vicinity of Yuma, Arizona; reduction of irrigation return flows through acquisition of lands and implementation of irrigation efficiency improvement programs; lining 49 miles of the Coachella Canal or constructing a new concrete-lined canal to replace the unlined portion; and constructing a well field near the Mexican border capable of pumping approximately 160,000 acre-feet of water per year.

Title II – Measures Upstream from Imperial Dam – authorizes the Secretary of the Interior to construct the following salinity control units: Paradox Valley, Grand Valley, Crystal Geyser and Las Vegas Wash, and expedite completion of planning reports on several other salinity control units. Title II also establishes the Colorado River Basin Salinity Control Advisory Council.

Water Supply

In each of the above documents where water supply is allocated or divided between Basins or States, an average annual virgin flow (water supply) was assumed for negotiation purposes. Following is a summary of the water supply data used for the more significant documents:

Colorado River Compact, 1922. – For the Colorado River Compact negotiations, the record from 1896 to 1920 were available. These records were available on the principal Upper Basin tributaries and continously since 1902 at Yuma, Arizona, in the Lower Basin.

In determining the average annual natural flow at Lee Ferry, considerable engineering judgment was used and many correlations and studies were made. Lee Ferry is the dividing point between the Upper Basin and Lower Basin, as defined in the Colorado River Compact. The actual gage which was established in June 1921 is located at Lees Ferry, 1.4 miles upstream from Lee Ferry. As a result of the studies, it was estimated that the long-term average annual natural flow of the Colorado River at Lee Ferry, for the 1903 to 1920 period of record, was in excess of 18 million acre-feet. This assumption was the basis for compact negotiations, and in retrospect is one of the causes of many Colorado River problems today.

Mexican Water Treaty, 1944. – By the time the Mexican Water Treaty negotiations began in 1941, additional data were available. Using these new data, the long-term average annual natural flow at Lee Ferry for the 1897 to 1940 period of record was estimated to be about 16.2 million acre-feet at Lee Ferry.

Upper Colorado River Basin Compact, 1948. – As the basis for the interstate compact, the Upper Colorado River Basin Compact Commissioners used the 1914-1945 streamflow records which indicated an average annual natural flow of 15.6 million acre-feet per year. The engineering advisory committee reviewed and revised all previous estimates made by the Bureau of Reclamation of virgin flow at Lee Ferry. The new estimates average somewhat lower than than the previous ones.

Colorado River Basin Project Act (P.L. 90-537), 1968. – Hearings on the Colorado River Basin Project Act, P.L. 90-537, reopened many old areas of argument and one of these was water supply. For the hearings, new water supply data were available, and therefore a new assessment of availability was made by the Bureau of Reclamation using the 1906-1965 period of record. For the 1906-1965 period of record the long-term average annual natural flow was estimated to be about 14.9 million acre-feet at Lee Ferry.

Present Water Supply Data. – The addition of 1966-1970 data has not changed the 1906-1965 average significantly. With these new data, the 1906-1970 average annual virgin flow is estimated to be about 14,950,000 acre-feet.

Summary. – The above information does not tell the whole story with regard to Colorado River water supply. Of major importance to the Basin and planners is that large variations in flow have occurred in the Colorado River both annually and over long periods of years. Annual virgin flow as shown on figure V-2 has varied from 5.6 million acre-feet in 1934 to 24 million acre-feet in 1917. For the period of 1906 to 1970, the average virgin flow at the Compact Point (Lee Ferry, Arizona) is estimated at 14.95 million acre-feet per year. However, for the period of 1931 to 1964, this flow averaged only 12.92 million acre-feet per year. Since the projected water demands of the Colorado Basin exceed the most optimistic estimates of supply and since the legal entitlements of the Upper and Lower Basin States and Mexico exceed the long-term annual virgin flow, this 2.0 million acre-feet variation is of vital importance. For information purposes average annual flow for various periods of record are presented below.

Annual Average Virgin Flow

Period of record	Acre-feet
1906-1970	14,950,000
1923-1970	13,800,000
1941-1968	13,500,000
1931-1964	12,920,000

Water Quality

As the waters of the basin increasingly are put to use and consumed the salinity of the remaining waters is increasing. Recently this has become a matter of concern between the United States and Mexico. Present salinity conditions at various points in the system are as shown in table V-1.

The weighted average annual salinity of the Colorado River made available to Mexico at the Northerly International Boundary in 1970 was 1,260 p/m. Projections have been made which indicate salinity could rise to 1,100 to 1,200 p/m at Imperial Dam by the year 2000 with corresponding increases at the Northerly Boundary. The salinity problem is discussed in greater detail in Regional Problem No. 2.

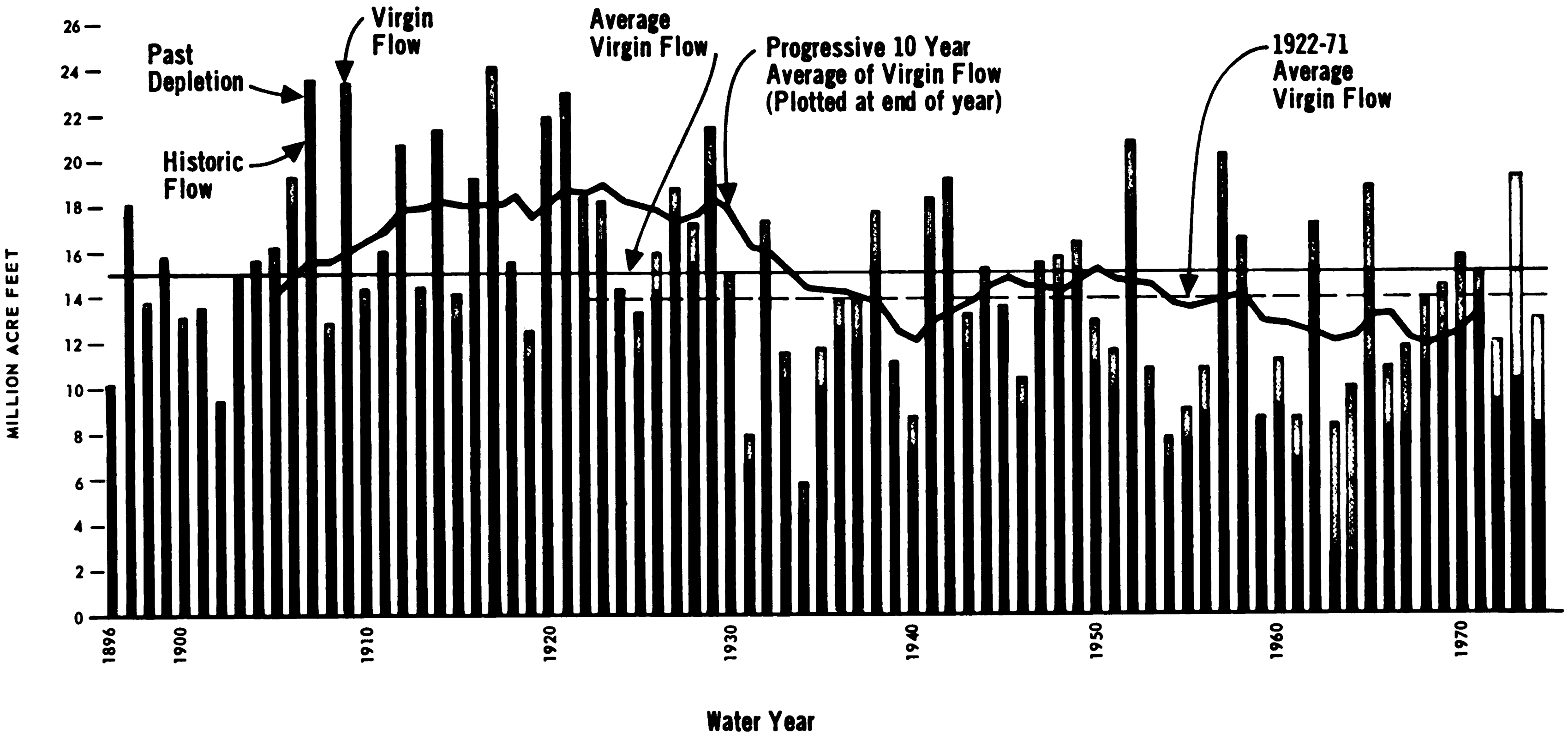


Figure V-2. Colorado River flow at Lee Ferry, Arizona.

Table V-1.—*Salinity conditions at measurement points*

Measurement point	Average salinity, mg/l 1941-1972	1972
Upper basin		
Green River at Green River, Utah	456	461
Colorado River near Cisco	612	708
San Juan River near Bluff	447	593
Colorado River at Lees Ferry	558	667
Lower basin		
Colorado River near Grand Canyon	618	616
Colorado River below Hoover Dam	693	723
Colorado River below Parker Dam	695	747
Colorado River at Imperial Dam	757	879

Apportionments and Problems

With the above background in mind, attention can be focused on the water supply problems of the Colorado River Basin. Today and for some years to come, the Colorado River should be able to meet all quantitative physical water demands. The Upper Basin States are meeting their Compact requirements and demands being placed on the river are being met. Lake Powell and Lake Mead are filling and, assuming average annual runoff conditions for the next few years, Lake Powell and Lake Mead will "spill" in the sense that they will be required to release water, to meet the Lake Mead flood control operating criteria. However, assuming a long-term average annual supply of 14.9 million acre-feet, sometime after the Central Arizona project is fully operational the Colorado River will not yield enough water under normal circumstances to meet Upper and Lower Basin demands, Mexican Treaty obligations, and system losses. Thus, the Colorado River Basin faces future water shortages unless its natural flows are augmented or Basin development is curtailed. The extent and timing of these shortages will depend on the rate of future consumptive use development and the volumes of annual runoff.

There are several categories of shortages:

(1) When California is first cut back from its present 5.1 million acre-feet annual consumptive use of 4.4 million acre-feet consumptive use a legitimate current demand on the river will not be met in full because of limitations on basin water supply. Although California would still be receiving its basic Colorado River supply and even though it has available more expensive alternative supplies to offset the cutback, it could be said that a shortage exists.

(2) At that time when the total water demands of the basin, including reservoir evaporation and other annual water losses, exceed the long-term average annual water supply, the basin will be in a water shortage status even though the shortages could be met for a limited period by drawing on the reservoir storage.

(3) When Arizona must reduce its Colorado River consumptive uses below 2.8 million acre-feet per year, a new shortage will occur.

(4) When the Upper Basin reaches its annual assured consumptive use of 5.8 million acre-feet annually a still different type of shortage will be reached. (The assured amount remains for use in the Upper Basin under adverse runoff conditions after it has met its obligation to deliver 75 million acre-feet to the Lower Basin each 10 years and if it is required to contribute 750,000 acre-feet annually towards meeting the Mexican Water Treaty obligation. The assured supply thus estimated is not to be construed as the limit of the Upper Basin apportionment as it is recognized that there is not agreement among the States of the Colorado River Basin on how the Mexican Treaty obligation is to be shared prior to the time augmentation of the Colorado River is accomplished under the terms of the Colorado River Basin Project Act of 1968.) Because of the long-term carryover storage of Lake Mead and the Upper Basin Storage Project reservoirs whenever shortages occur in the above categories such shortages likely will span several years.

(5) Another category of shortage common to river systems can occur in the Upper Basin tributaries above main storage units where the water supplies are not sufficiently regulated by long-term carryover storage. In these circumstances shortages can vary from as little as a month at a time to a year or more.

(6) Still another category of shortage is represented by the Gila River Basin where the present consumptive uses far exceed the combined surface flows and ground-water recharge of the basin. A shortage has existed here for years.

Colorado River Simulation Model

To help predict future situations relating to both water supply and water quality under varying assumptions, including the timing and extent of future potential shortages, a mathematical model of the Colorado River referred to as the Colorado River Simulation Model (CRSM) was developed.

A brief description of the model is presented here. A more thorough detailed description will be provided in a separate document at a later date.

The CRSM utilizes the model concept to represent the physical aspects of the river system and to measure system response. For the Colorado Basin each node, of which there are 17, represents a specific geographic area. The model consists of four major components.

1. Data generation
2. Demand data
3. System logic
4. Output

The data generation portion of the model generates monthly stochastic hydrologic inflow and quality data. The demand data section of the model reflects the assumptions made with respect to future development within the Basin. The system logic component contains all the simulation logic and operating criteria for each node in the system. The output component reflects the response of the system to the hydrologic water supply and demand data assumptions. Through a tape edit routine, selected data can be summarized in either tabular or graphical form.

Up to 10 inflows and 10 different demands (variables) have been identified within each node. Based on projected time/water demand relationships made for each demand point, the impact on system water supply and quality can be analyzed. In the Upper Basin, each demand input generally represents one of the following functions:

1. Thermal power generation
2. Food and fiber production
3. Fish, wildlife, and recreation needs
4. Mineral extraction and processing
5. Livestock and stock-pond evaporation
6. Municipal and industrial use
7. Exports
8. Coal gasification operations
9. Oil shale extraction and processing

In the Lower Basin, each demand input generally represents a particular user, such as the Metropolitan Water District, Central Arizona project, etc. Figures V-3 and V-4 show the nodes included in the present model. The demand inputs associated with each node are covered in more detail in a report to be prepared at a later date. While the model has been tested only on consumptive uses it could be manipulated to cover the critical aspect of instream flows for water quality and recreational and environmental purposes so that the effects of meeting these flows on water availability for other purposes can be determined.

PROBLEM RESOLUTION

The problem resolution involves first determining the extent and timing of potential shortages under varying assumptions of water supply and demand and then exploring means by which the shortages can be avoided or minimized.

Projected Water Supply

To explore various possible future Colorado River runoff conditions, hydrologic traces, or theoretical 30-year sequences of Colorado River flow are generated for selected stations over the entire Colorado River Basin based on statistical parameters derived from historical data and modified as necessary to reflect the runoff period of 1914-1965. This period of record was selected because the modified flow analysis for benchmark gaging stations were available. These data were prepared for the Upper Colorado Region Comprehensive Framework Study. A complete discussion of the philosophy and computations behind these generated flows is included in a report entitled *Application of Stochastic Hydrology to Simulate Streamflow and Salinity in the Colorado River*, prepared by John P. Hendrich and Albert E. Gibbs of the Bureau of Reclamation.

An almost infinite number of hydrologic traces can be generated. For the purpose of illustrating a range of possible future runoff sequences three hydrologic traces were structured. Trace A reflects a reasonably low runoff cycle with a 30-year mean estimated virgin flow at Lee Ferry of 13.2 million acre-feet. Trace C reflects a reasonably high runoff cycle of 15.5 million acre-feet. Trace B 14.1 million acre-feet reflects a reasonable intermediate situation. The range of annual flow and flow patterns for these three traces are shown in figure V-5.

Alternative Future Water Demand Schedules

The element of uncertainty in projecting the rate at which future water demands in the Colorado River Basin will occur is limited almost exclusively to the Upper Basin. In the Lower Basin the major important

Figure V-3. Nodes used for the Upper Colorado River basin.

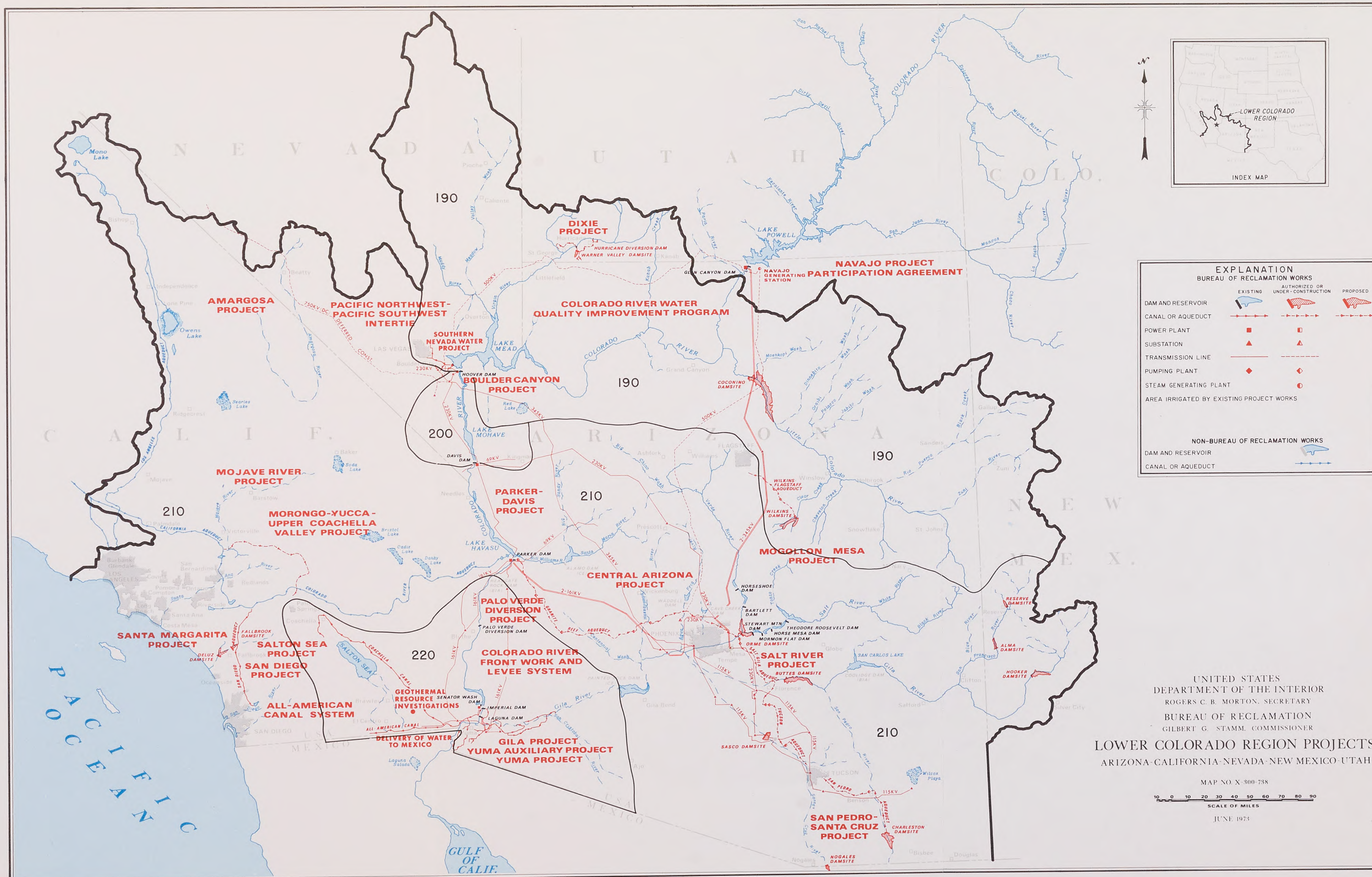


Figure V-4. Nodes used for the Lower Colorado River basin.

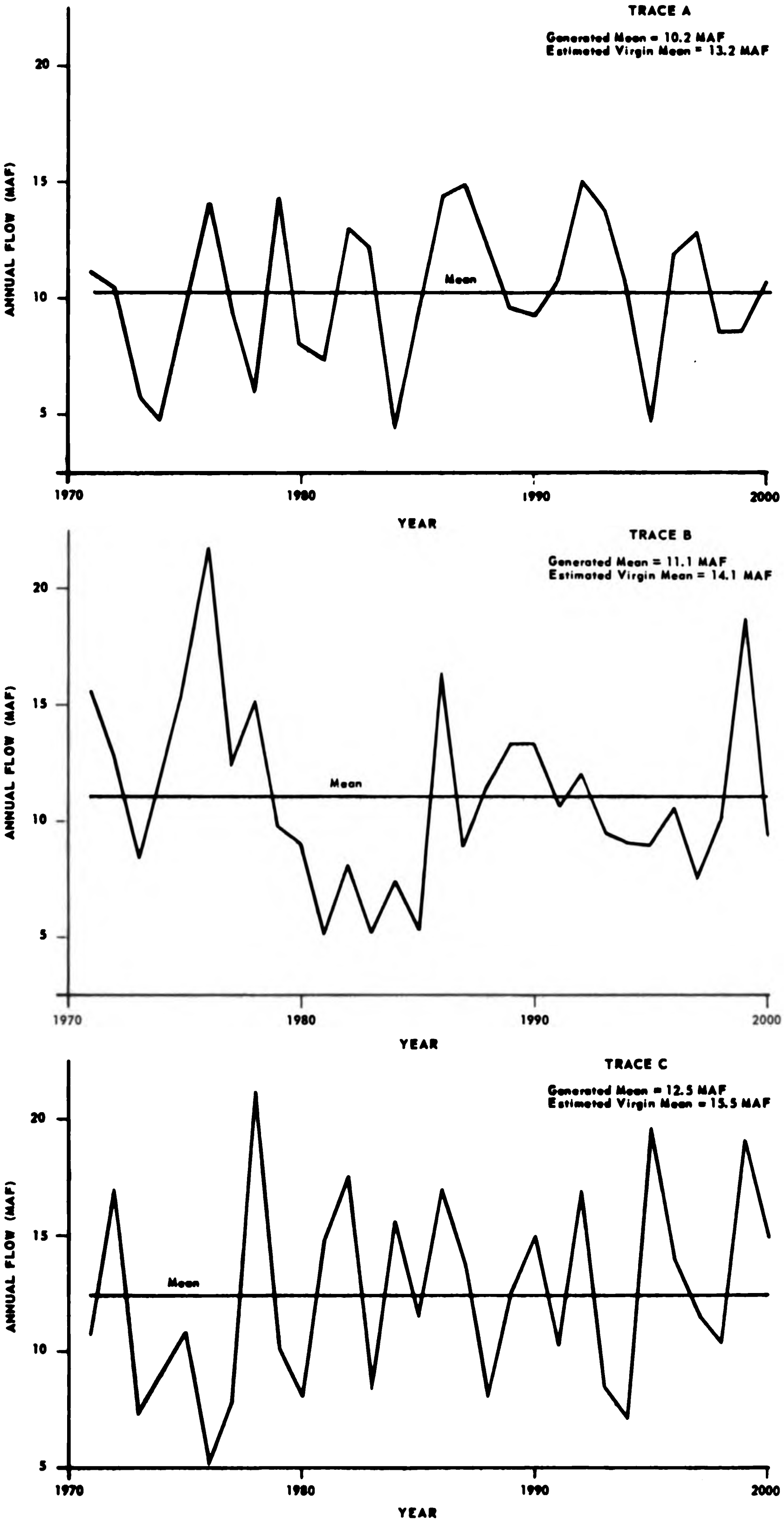


Figure V-5. Range of annual flow and flow patterns for three traces – Colorado River system.

factor is the date that the Central Arizona Project will start to divert water. Thereafter, Arizona and California will be diverting water to the limits of their entitlements. Projections for Nevada involve relatively small quantities. Thus, the future pattern of deliveries to the States in the Lower Basin is firmly established.

By contrast current Upper Basin uses are well below the assured Upper Basin water supply. This situation permits significant expansion of consumptive use before the Upper Basin reaches the ceiling attainable within the Compact. The rate of which Upper Basin water demands will grow depends upon several factors – the rate at which authorized Federal projects in the Upper Basin will be constructed and put into operation; the rate at which oil shale, coal, and other energy resources are exploited; the rate at which municipal and industrial uses will expand; the level of conversion of water now used for irrigation to other purposes; and the future availability of water.

To illustrate a range of possible future water demands three alternative water demand schedules though the year 2000 were structured.

Alternative 1 projects a reasonably slow rate of future water demand buildup in the basin. It provides for a low level of Federal project construction and for limited future water demands to service energy resource development in the Upper Basin. The Central Arizona project is estimated to divert water initially in 1987. Specifically, Alternative 1 provides that, in addition to the Federal projects currently under construction (Navajo Indian Irrigation project; Bonneville unit, Central Utah project; and the Fryingpan-Arkansas project), the five Upper Basin projects authorized in the Colorado River Basin Project Act would be constructed and in operation by 1987. It provides for a total of 22,630 MW of thermal power, 1,797 million cubic feet per day of coal gasification capacity, and the production of 680,000 barrels of oil per day from oil shale. All other functions and non-Federal development were projected to increase at a restricted rate.

Alternative 2 is a middle-ground projection. It anticipates a moderate level of Federal project construction and a moderate increase in water demands to serve energy resource development in the Upper Basin. It projects initial Central Arizona project diversions in 1987. Specifically it provides that, in addition to the Federal projects included in Alternative 1, the Lyman project would be constructed by 1980 and some Ute Indian deferral lands and the Jensen unit of the Central Utah project would be constructed by 1995. Thermal power development increased to 28,060 MW, coal gasification capacity to 2,373 million cubic feet per day and oil production from oil shale to 1,315,000 barrels per day.

Alternative 3 projects a high level of future construction of Federal projects in the Upper Basin together with sharply increasing water demands to service development of energy resources in the Upper Basin. It projects initial diversions from the Central Arizona project by 1985. Thus, Alternative 3 represents a reasonably high projection of future basin water demands. Specifically it provides for the construction of all Federal projects now authorized except those authorized in the Colorado River Basin Salinity Control Act of 1974 which have little effect on water quantities. Thermal power development increases to 32,560 MW. Coal gasification capacity is at 2,911 million cubic feet per day and oil production from oil shale is at 1,515,000 barrels per day. Other demands are also increased substantially.

In developing these alternative water demand schedules, extensive use was made of information in the Upper Colorado Region Comprehensive Framework Study. The projections of water demands for the energy function of thermal coal power generation, coal gasification and oil production from oil shale were based largely on information in the Report on Water for Energy in the Upper Colorado River Basin, prepared by the U.S. Department of the Interior.

It should be noted that for Alternative 1 only those plants reasonably sure of development were included and none subsequent to 1985 were included. For Alternative 2 no plants subsequent to 1988 were projected but for Alternative 3 potential plants through the year 2000 were included.

The three alternatives reflect three different rates of increase in future Upper Basin water use and are intended only for illustrative purposes to demonstrate the adequacy or inadequacy of Colorado River water supply under varying assumptions as to basin runoff and basin water demand. Consideration was not given as to whether projected water demands in the Upper Basin would exceed the Upper Basin's assured supply or whether such demands in any given State would exceed that State's allocation of Upper Basin water. It is realized that should such an event occur compensating steps would be necessary or water-based development restricted.

Water demand levels in the lower Colorado River Basin reflect two future situations: prior to initial operation of the Central Arizona project and subsequent to initial operation. In the former situation, full demand levels can be met within compact and other limitations, whereas in the latter case, full demand levels by Arizona and California cannot always be met because of water supply limitations.

Tables V-2 and V-3 summarize for each alternative demand schedule the assumptions made with respect to Federal development, thermal power, exports, oil shale, and coal gasification. Table V-4 translates the above assumptions into acre-feet and summarizes them by States and by alternative.

Results of Model Runs

The Colorado River Simulation Model is in its trial stages. With the change from a single historical runoff sequence to several theoretically possible sequences, more testing will be required before there can be complete confidence in its operation and the answers it provides. The results given hereafter, thus, should be considered preliminary and subject to further analysis. They are, however, considered adequate for the purpose intended – that of demonstrating the adequacy or inadequacy of Colorado River water supply under varying future conditions.

The model operation assumed Upper Basin deliveries at Lee Ferry of at least 8.25 million acre-feet annually. It took into account all inflow and reservoir and river losses below Lee Ferry. It followed the operating criteria promulgated under provisions of Section 602.(a) of the Colorado River Basin Project Act and accommodated the flood-control operating criteria established by the Corps of Engineers. It recognized surplus and shortage levels at Lake Mead which governed the amount of releases for Lower Basin consumptive uses.

With three different projected runoff sequences and three different projected levels of basin water demand buildup, nine different patterns of future water supply-water demand situations were delineated through the model runs.

The combination of Trace A (low runoff) and Alternative 3 (high-water demands) presents an extremely poor picture of future water supply adequacy. While the situation portrayed by this combination could occur the chances of it materializing are quite small.

By combining Trace C (high runoff) with Alternative 1 (low-water demands) a highly favorable picture of future water supply adequacy is presented. The chances of this combination occurring likewise are quite small but probably not as remote as the Trace A — Alternative 1 combination.

The combination of Trace B – Alternative 2 presents a middle-ground picture.

Table V-5 summarizes, for each alternative and function served, the total estimated consumptive use demands in acre-feet at the close of 1970, 1980, 1990, and 2000. Table V-6 summarizes the results of the model runs for the three alternative demand schedules matched against the three hydrologic traces.

The results of the model runs support the following observations:

1. Total basin water demands in all likelihood will exceed the long-term virgin flow of the Colorado River in the 1985-1987 time frame, coincidental with study projection dates for completion of the Central Arizona project.

2. Upper Basin water demands under the high-level growth projection could equal or exceed 5.8 million acre-feet in the 1990-1995 time period. However, in most cases, because of favorable runoff or storage conditions, the projected demands were met until after the year 2000.

3. Except under a runoff cycle higher than the long-term average, California's current water use will be cut back to 4.4 million acre-feet some time between 1985 and 1995, depending upon basin water demand growth and hydrologic conditions.

4. Except under a runoff cycle higher than the long-term average, Arizona's consumptive use could be reduced below 2.8 million acre-feet some time within the 1995-2000 time period, depending upon basin water demand growth and hydrologic conditions.

5. Should the virgin runoff at Lee Ferry for the next 25 years average 15.5 million acre-feet, all reasonably foreseeable basin water demands could be met through 2000, and both Lake Powell and Lake Mead would be full at that time.

6. Under any future runoff cycle other than an extremely adverse one, it is reasonably certain that the main Colorado River storage reservoirs will be full or nearly so when the Central Arizona project initially diverts water. By drawing on reservoir storage, the basic water demands of the basin under most circumstances could be met at least through the year 1995. However, by the year 2000 reservoir storage could be sorely depleted or exhausted, depending upon actual hydrologic conditions and growth of Upper Basin water demands. After that

Table V-2.—*Summary of Federal development programs, thermal power, and export assumptions*

State	Federal development programs in operation by year 2000				Thermal power megawatts				Exports (1,000) acre-feet		
	Program	Alternative 1	Alternative 2	Alternative 3	Year	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
Wyoming	Lyman	–	1980	1980	1970	163	163	163	7	7	7
	Savory-Pot Hook	–	–	1981	1980	2,593	2,593	2,593	15	15	15
	Seedskadee	–	–	1980	1990	5,023	5,523	5,523	25	25	65
		–	–	–	2000	5,023	5,523	5,523	31	31	131
Utah	Ute Indian Unit	–	1995	1995	1970	166	166	166	119	119	119
	Upalco	–	–	1995	1980	3,136	3,136	3,136	148	148	148
	Uintah	–	–	1995	1990	10,381	10,796	10,796	269	269	269
	Jensen	–	1990	1990	2000	10,381	10,796	10,796	269	309	402
Colorado	Animas-La Plata	1987	1987	1987	1970	168	168	168	467	467	467
	Dolores	1984	1984	1984	1980	1,428	1,428	1,428	664	664	664
	Dallas Creek	1982	1982	1979	1990	3,380	6,388	6,388	729	729	774
	Savory-Pot Hook	–	–	1981	2000	3,380	6,388	9,388	794	794	884
	San Miguel	1987	1987	1987	–	–	–	–	–	–	–
	Fruitland Mesa	–	–	1978	–	–	–	–	–	–	–
	West Divide	1985	1985	1985	–	–	–	–	–	–	–
New Mexico	Navajo Indian	1976	1976	1976	1970	2,162	2,162	2,162	110	110	110
	Animas-La Plata	1987	1987	1987	1980	3,852	3,852	3,852	110	118	118
	Hogback Expansion	–	–	1990	1990	3,852	5,352	6,852	118	118	118
	Gallup	1985	1980	1980	2000	3,852	5,352	6,852	118	118	118
Arizona	CAP	1987	1987	1985	–	–	–	–	–	–	–

Table V-3.—*Summary of oil shale and coal gasification assumptions*

State	Oil shale Total oil shale production in 1,000's of barrels per day (kbbl/d) by date shown						Coal gasification Total installed capacity in million cubic feet per day by date shown					
	Alternative 1		Alternative 2		Alternative 3		Alternative 1		Alternative 2		Alternative 3	
	kbbl/d	Year	kbbl/d	Year	kbbl/d	Year	Capacity	Year	Capacity	Year	Capacity	Year
Wyoming	–	–	125	1988	125	1988	–	–	–	–	250	1990
Utah	50	1983	50	1983	50	1983	–	–	288	1986	288	1986
	–	–	200	1988	200	1988	–	–	576	1988	576	1986
	–	–	–	–	300	1990	–	–	–	–	864	1990
Colorado	60	1978	60	1978	60	1978	–	–	–	–	–	–
	430	1983	430	1983	430	1983	–	–	–	–	–	–
	630	1984	630	1984	630	1984	–	–	–	–	–	–
	–	–	690	1985	690	1985	–	–	–	–	–	–
	–	–	790	1986	790	1986	–	–	–	–	–	–
	–	–	890	1987	890	1987	–	–	–	–	–	–
	–	–	990	1988	990	1988	–	–	–	–	–	–
	–	–	–	–	1,090	1990	–	–	–	–	–	–
New Mexico	–	–	–	–	–	–	547	1978	547	1978	547	1978
	–	–	–	–	–	–	797	1979	797	1979	797	1979
	–	–	–	–	–	–	1,297	1980	1,297	1980	1,297	1980
	–	–	–	–	–	–	1,547	1981	1,547	1981	1,547	1981
	–	–	–	–	–	–	1,797	1982	1,797	1982	1,797	1982

Table V-4.—*Total estimated demands by states and alternatives*[1] *(acre-feet in thousands)*

Year-end estimated total demand	Arizona[2] Alt-1	Arizona[2] Alt-2	Arizona[2] Alt-3	California Alt-1	California Alt-2	California Alt-3	Nevada Alt-1	Nevada Alt-2	Nevada Alt-3
1970	1,144	1,144	1,144	5,074	5,074	5,074	45	45	45
1980	1,297	1,407	1,404	5,074	5,222	5,407	134	150	173
1990	2,850	2,850	2,850	4,400	4,400	4,400	165	180	233
2000	2,850	2,850	2,850	4,400	4,400	4,400	183	202	286
	Colorado			New Mexico			Utah		
1970	1,786	1,786	1,786	233	233	233	695	695	695
1980	2,048	2,051	2,085	416	426	428	826	829	840
1990	2,446	2,564	2,694	580	598	628	1,081	1,157	1,213
2000	2,526	2,645	2,864	581	600	631	1,084	1,230	1,434
	Wyoming			Total					
1970	295	295	295	9,272	9,272	9,272			
1980	386	408	432	10,182	10,494	10,768			
1990	443	495	587	11,965	12,244	12,604			
2000	456	508	662	12,080	12,435	13,127			

[1] Does not include major reservoir evaporation or main stem river losses which exceed 2 million acre-feet.
[2] Includes Arizona's upper basin apportionment of 50,000 acre-feet.

date, serious water shortages could be common except in periods of high runoff conditions.

7. The basic keys to the extent and timing of future Colorado River water shortages are the runoff patterns and rates of growth of Upper Basin water demands after the Central Arizona project is completed.

Potential Solutions

In coping with the problem of potential future water shortages first attention should be directed to maximizing the yield and optimizing the use of the natural water supply of the Colorado River Basin consistent with environmental considerations. This can best be accomplished through a total water management program that includes such activities as:

1. Coordinated operation of all major basin structures and conjunctive use of surface- and groundwater supplies.

2. Increasing irrigation efficiency through such means as better onfarm system and management practices and improved distribution systems.

3. Waste water reclamation and reuse.

4. Increasing water yield through selective phreatophyte removal and control, reducing snowpack evaporation, and watershed management practices.

5. Reallocation of water supplies through institutional procedures.

6. Water pricing mechanisms.

Although the above listing is far from complete it does indicate the types of activities available in a total water management program to maximize water supply and to foster better use of that supply. Such activities do not create new water but they can "stretch out" present supplies.

It is evident that a total water management program can only delay and not prevent water shortages from occurring eventually. When such shortages do occur there appears to be two alternative courses open.

The first would be to accept the limitation in water supply and pattern the economic and social future of

Table V-5.—*Basin demands by function at end of 1970, 1980, 1990, 2000*[1] *(acre-feet in thousands)*

	Thermal power	Food and fiber	Demand functions: Fish, WLD and REC[2]	Minerals	Lvstk and STBD EVP	M&I	Exports	Coal gas	Oil shale	Total
Alt 11										
1970	51	7,096	39	56	33	1,294	703	0	0	9,272
1980	216	7,351	120	74	41	1,381	937	52	10	10,182
1990	380	8,978	120	86	44	1,026	1,141	72	118	11,965
2000	380	8,903	120	91	49	1,035	1,212	72	118	12,080
Alt 12										
1970	51	7,096	39	56	33	1,294	703	0	0	9,272
1980	222	7,625	122	74	41	1,403	945	52	10	10,494
1990	460	8,991	124	86	44	1,064	1,141	107	227	12,244
2000	460	8,941	125	91	49	1,183	1,252	107	227	12,435
Alt 13										
1970	51	7,096	39	56	33	1,294	703	0	0	9,272
1980	222	7,815	154	95	43	1,432	945	52	10	10,768
1990	469	8,870	157	146	46	1,292	1,226	139	259	12,604
2000	504	8,873	159	160	51	1,447	1,535	139	259	13,127

[1] Exclusive of reservoir evaporation and other system losses.
[2] Limited to consumptive uses at fish hatcheries and wildlife refuges.

the basin to that limitation. Such a situation could arise either from the desire of basin residents to restrict water dependent developments or through the impracticality of augmentation for physical, economic, environmental, national policy, or other reasons. Under this option there would still be choices of controlling the future economy of the basin though the transfer of irrigation water to other uses such as energy resource exploitation, municipal and industrial, and recreation.

The second option would be to augment the flows of the Colorado River thus increasing its water supply and permitting continued growth of water dependent developments. Study has been given as part of the Westwide endeavor, and independently, to means by which the river could be augmented including weather modification, desalting of seawater, and desalting of goethermal brines. Importation of water from resource regions oustide the seven Colorado River Basin States was not considered in the Westwide Study because of restrictions on import studies contained in the Colorado River Basin Project Act. Importation of water to the Colorado River from other basins in the seven Basin States does not appear practicable.

Weather Modification. – A detailed discussion of the potential of weather modification for increasing water supplies throughout the West is contained in Westwide Problem No. 17. A major part of the Bureau of Reclamation's weather modification research program has been carried on in the Colorado River Basin. In December 1970, after 2 years of preparation, the Bureau of Reclamation began seeding operations on the Colorado River Basin Pilot project. The project is the largest winter orographic seeding experiment in the United States. The main objective of the Colorado River Basin Pilot project is to provide sound scientific engineering evaluation of precipitation increases over a large area through application of cloud seeding techniques.

Evaluation of seeding results and related costs of the Pilot project are being carried out by a private contractor independent of other project operations. The final evaluation will not be completed until a year after the Pilot project ends in the spring of 1975. Preliminary results, however, indicate that the Pilot project is producing significant increases in

Table V-6.—*Results of model runs*

Alternative demands and hydrologic traces	Estimated 30-year average annual virgin water supply at Lees Ferry (million acre-feet)	Year CAP on line	Shortage conditions (1) California consumptive use cutback to 4.4 million acre-feet per year	(2) Year total basin water demands exceed long term average virgin flow of 14.9 million acre-feet	(3) Arizona consumptive use reduced to less than 2.8 million acre-feet per year	(4) Year Upper Basin demands equal to 5.8 million acre-feet	End of month contents December 2000: Lake Powell (million acre-feet)	Lake Mead (million acre-feet)
Alt-1		1987						
A	13.2		1994	1987	–	–	17.2	20.1
B	14.1		1988	1987	1999	–	16.3	20.1
C	15.5		–	1987	–	–	25.7	26.4
Alt-2		1987						
A	13.2		1989	1986	–	–	15.8	18.7
B	14.1		1987	1986	1999	–	16.4	18.2
C	15.5		–	1986	–	–	25.6	26.5
Alt-3		1975						
A	13.2		1985	1983	1991	1993	15.2	15.0
B	14.1		1985	1983	1990	1995	17.5	14.6
C	15.5		1998	1980	–	1994	24.9	26.7

[1] In 1998 California was cut back to 4.4 million acre-feet; however, deliveries were greater than 4.4 million acre-feet the following two years.

precipitation in the target area. Current estimates are that the water supply of the Colorado River could be increased from 0.9 to 1.3 million acre-feet per year by weather modification.

To verify the findings to date a demonstration project of several years duration covering some 40 percent of the seedable area of the Upper Colorado River Basin should be undertaken as soon as practicable. Such a program would cost $3 million annually and produce an estimated 500,000 or 600,000 acre-feet of additional water supply. The cost of the water produced would be about $5.50 per acre-foot which includes substantial research costs as well as the production costs. The revenue from the additional power that this added water would generate in the main stem powerplants of the Colorado River alone would be about $3 million or enough to offset the entire cost of the demonstration project. In addition water quality downstream would be enhanced, there could well be favorable impacts on the activities being carried out by the United States pursuant to Minute No. 242 to the Mexican Water Treaty recently agreed to by Mexico and the United States, and there would be some insurance against a potentially future adverse runoff cycle. Finally, the demonstration project should produce concrete results in defining the potentials and limits of weather modification to increase water supplies which would have beneficial application not only throughout the United States but throughout the World as well.

Geothermal Desalting. – Most of the potential United States geothermal resources are concentrated in the Western States. Recent Federal leasing of public lands has focused attention on the power potential of geothermal resources development in California. The successful development of the geyser area and expanded exploratory drilling activity in other areas is expected to accelerate power development in the State.

Outside of the Bureau of Reclamation's East Mesa test facility in the Imperial Valley, water recovery from geothermal sources is presently considered a byproduct. At the East Mesa test facility, however, freshwater has been produced directly on a limited scale from two production wells by the use of small scale desalting units of Multi-Stage-Flash (MSF) and Vertical Tube Evaporator (VTE) design. Extensive field testing is expected to continue over a 5-year period to evaluate the potential of the 400°F bottom-hole temperature brines estimated to be predominant in the Imperial Valley.

Basic knowledge of the geothermal resources in the Imperial Valley as to its extent, quality, and accessibility is very limited. Attempts to estimate the size of the resource are based on a few wells and other geophysical data. Recent estimates of "usable and recoverable" hot brine stored in the Imperial Valley range from 1.1 to 4.8 billion acre-feet. Usable and recoverable water of about 200 million acre-feet is available at a temperature of about 300° F or more.

Preliminary studies have indicated that with 300-400°F geothermal brines, a significant quantity of desalted water can be recovered from the brines while maximizing the production of electric energy. Both the lowest electric energy costs and the lowest water costs are expected to be attained with a multipurpose installation where well costs, surface plumbing, and heat exchange costs are shared.

Preliminary estimates based on 1972-1973 prices indicate that costs for development of 100,000 acre-feet of freshwater per year and about 400 megawatts of electric power are expected to range from $85 to $130 per acre-foot. For large-scale development of about 2.5 million acre-feet of water, expected costs of desalted water produced and delivered to the Colorado River would range from $100 to $150 per acre-foot.

Although private power interests are expected to conduct programs on the power aspects, the Bureau of Reclamation geothermal program in the Imperial Valley is essential in determining technical and economic feasibility of desalting geothermal brines. Moreover, the technical considerations of scaling control, corrosion rates, well yields, etc., are expected to benefit potential electric power production as well as the desalting investigation program. The East Mesa test facility, the largest, operational low-temperature geothermal test site in the United States, is expected to perform a major role in geothermal resources development.

A decision point has not yet been reached on either the technical or economic feasibility of providing desalted geothermal water from Imperial Valley for augmentation of the Colorado River. Due to the very nature of this resource spread over 2 million acres in the Imperial Valley recovery of large blocks of power and water may have some formidable physical constraints. In any case, water augmentation from geothermal resources must be tempered to long lead-time requirements, institutional considerations in multipurpose development, and the technological learning curve, all tending to defer the rate of large-scale water production.

Seawater Desalting. – Since 1952, Federal support for research and development of desalting technology has produced many advances in desalting processes such as distillation, reverse osmosis, electrodialysis, and freezing. Most of these processes are now considered commercially available for select applications. However, due to relatively high costs, lack of experience, and present availability of other water supply sources, United States desalting applications have been slow compared to current worldwide experience.

California's seacoast has been under recent intensive study to site large-scale seawater desalting plants. Recent reconnaissance studies have evaluated desalting plants at Diablo Canyon (40 Mgal/d), Encino-San Diego (40 Mgal/d), and San Diego Refuse Incinerator project (32 Mgal/d). The Orange County Water Factory 21 (3 Mgal/d) is now under construction. Ultimately, large-scale, dual-purpose, coastal desalting plants could not only augment local municipal and industrial demands but also export or exchange water to meet inland demands such as augmentation of the Colorado River.

In providing new water in large quantities for augmentation purposes, seawater desalting is viewed in a delayed time perspective, as long as relatively low-cost conventional water supplies are available. Under the present economics of water supply and increasing energy costs, any large-scale desalting plant should be integrated into a dual-purpose or multipurpose system.

Typical product water costs for large-scale, dual-purpose desalting plants are shown in table V-7, below. All costs shown are at-site costs based on 1972-73 nonescalated cost basis.

A research and development prototype plant for seawater desalting is still needed to demonstrate the economics of large-scale (100 Mgal/d or greater) dual-purpose operation. Future development with refuse or nuclear powerplants could bring new technologies together in an economic manner to minimize environmental impact and meet water augmentation requirements.

One of the major considerations in any future large-scale desalting application for water supply is primarily institutional in nature. New arrangements between the public utilities, governmental agencies, and private interests will be needed to address questions of cost sharing and product composition for multipurpose systems.

In short, seawater desalting for inland augmentation purposes is not economically viable in the near-term planning horizon. Due to the probabilistic nature of precipitation, population growth, and pollution, however, there is an urgency for continued development of desalting technology to supplement the hydrological cycle.

Table V-7.–*Water costs for two large desalting plants*

Project	Desalting capacity (Mgal/d)	Total product water cost	
		¢/1,000 gallons	$/acre-foot
Diablo Canyon	40	92	300
San Diego refuse incinerator	32	45-40[1]	147-163[1]

[1] Costs are dependent upon the credit allowed for disposal of waste refuse.

CONCLUSIONS

1. While there is ample water supply in the Colorado River to meet current demands on the river, water shortages will develop in the not too distant future if the desires of the basin states for growth of water dependent developments are realized.

2. Assuming a fairly intensive level of future Upper Basin development and a conservative long-term hydrologic cycle, the Colorado River water supply will not meet all water demands starting about 1990 and shortages will become progressively greater thereafter.

3. To assure the avoidance of serious water shortages in the Colorado River Basin, programs to augment riverflows or to otherwise match water supply with water demand should be in operation by the 1995-2000 time frame.

4. A total water management program should be instituted for the Colorado River Basin to maximize water supply and optimize water use within the constraints of existing compacts and treaties.

5. Augmentation of Colorado River flows by as much as 1.3 million acre-feet annually through weather modification appears physically and economically prac-

ticable. Environmental, legal, and social problems, however, must first be resolved.

6. Augmentation by desalting of geothermal brines may have long-term potential, but appears expensive. More research is needed.

7. Augmentation by desalting of seawater appears excessively expensive at this time.

RECOMMENDATIONS

1. The total water management concept for the entire Colorado River Basin should continue to be broadened and perfected.

2. Accelerate programs of assistance to water users to bring about the adoption of water management methods and practices to improve the efficiency of water use.

3. In conjunction with the States and other interested particies, a wide range of future water demand schedules should be projected to be matched on the Colorado River Simulation Model with varied projected hydrologic sequences and operating criteria to provide information on the extent and timing of potential future water shortages.

4. Investigations and activities to delineate the most appropriate means of augmenting the Colorado River, as envisioned in the Colorado River Basin Project Act of 1968, should be given the highest priority.

a. The weather modification program of the Bureau of Reclamation should be continued aggressively with emphasis on resolving remaining sociological, legal, and environmental problems. A demonstration program of several years, duration, as presently proposed under the weather modification program, should be initiated in the Upper Colorado River Basin as soon as practicable to verify the findings to date, particularly as to the magnitude of increases and results of the weather modification program in runoff.

b. The ongoing geothermal desalting program of the Bureau of Reclamation on the East Mesa of Imperial Valley should be continued aggressively.

c. Other means of augmentation such as the importation of surface water, directly or by exchange, should be investigated as early as such studies would be appropriate and justified.

REGIONAL NO. 2 – INCREASING SALINITY IN THE COLORADO RIVER

SUMMARY

The Colorado River rises high in the Rocky Mountains and flows for most of its length through arid and semiarid regions of the United States and Mexico. From its source in north-central Colorado, it travels nearly 1,400 miles in a southwesterly direction to the Gulf of California. Along its traverse, the river becomes more and more saline. It drains a vast area of 242,000 square miles in the United States one-twelfth the conterminous United States – and 2,000 square miles in Mexico.

The Colorado River Basin above the Grand Canyon contributes an average of about 70 tons of salt per square mile to the river each year. A comparison of flow and diversions reveals that the waters of the river are used and reused several times. Each use imparts a new increment to the increasing salinity concentration. Nearly half of the salinity concentration in Lake Mead results from natural sources, the remainder from man's use. This, then, is a basinwide problem with the major impacts falling on the three Lower Basin States and Mexico. Within this region, the high salinity adversely affects nearly 17,000,000 people and about a million acres of irrigated land now producing a variety of food of great importance to the Nation.

DISCUSSION

The increase of salinity in the Colorado River is not a new or unique situation in the history of western rivers. Water quality changes in the river were recognized as early as 1903. Today, the Colorado River is viewed as the forerunner of future conditions in other western rivers such as the San Joaquin, Rio Grande, Arkansas, Platte, and streams in the Great Basin similarly affected in different degrees by increasing salinity levels.

The concentrations of total dissolved solids in the lower main stem of the Colorado River are already approaching the threshold limits for some uses. In any river system, salinity concentrations arise from a salt-loading effect and a salt-concentrating effect. The former relates to the pickup of salts in the soil and substrata as water percolates to and through an aquifer to a surface outlet such as a natural waterway or artificial drain. The latter results from evaporation from free water surfaces, consumptive use by vegetation, and out-of-basin export of diluting flows. As a result of these effects, streams flowing through arid regions typically increase in concentration from the headwaters to the mouth. For the Colorado River system, a summary of the conditions is given in table V-8. The data portray the historical, present modified, and projected salinity concentrations using mean values for the period 1941-1970.

Table V-8.—*Summary of historical, present modified, and projected salinity. (Colorado River mean values 1941-1970, mg/l[1])*

Main stem location	Historical	Present modified	Projected[2]
Glenwood Springs	271	310	380
Lees Ferry	556	615	770
Below Hoover Dam	690	760	930
Imperial Dam	757	865	1,160

[1] Milligram per liter which approximates part per million (p/m).
[2] Based on 2 tons salt pickup per irrigated acre.

The present modified average represents the salinity level that would have resulted if the present (1970) level of depletion instead of actual depletion had occurred within each year of the 1941-70 period. The projected values represent conditions anticipated to occur as future non-Federal and Federal developments in the basin states move toward full utilization of the compact-apportioned waters. The values shown assume that no salinity control measures are taken.

Placing the mean salinity projections at Imperial Dam on a time scale suggests 930, 1,115, and 1,160 mg/l for the years 1980, 1990, and 2000, respectively. This trend as depicted by the Bureau of Reclamation is the most conservative estimate on adverse effects made. Other agencies have projected higher salinity increases. For example, the Environmental Protection Agency projects 1,060, and 1,220 mg/l for the years 1980 and 2010, while the Colorado River Board of California projects 1,070 and 1,340 by 1980 and 2000, respectively. If no salinity control measures are taken, the range of projected concentrations of total dissolved solids at Imperial Dam for the year 2000 will be 1,160 to 1,340 mg/l.

In general, these salinity projections deal with long-term mean values. When time intervals are reduced to a monthly basis, wider fluctuations can be expected. Monthly salinity values have greater significance than long-term means in relation to pragmatic matters such as impacts on land and crops, water quality standards, and water treatment.

Adequate studies have not been completed to accurately identify the quantitative contribution of salinity concentrations from various sources in the basin but the order of magnitude is (1) natural sources, (2) irrigation sources, (3) out-of-basin export, (4) reservoir evaporation, and (5) municipal and industrial sources.

The 1972 Joint Federal-State Enforcement Conference on the matter of Pollution of Interstate Waters of the Colorado River and its tributaries initiated new efforts to establish an overall salinity control policy for the river. The seven basin State conferees and Federal representatives concluded that such a policy would have as its objective the maintenance of salinity concentrations at or below levels presently found in the lower main stem. Implementation of the salinity policy objective for the Colorado River system would recognize that the salinity problem should be treated as a basinwide problem. It must be recognized that, in maintaining Lower Basin water salinity concentrations at or below present levels and continuing development of compact-apportioned waters in the Upper Basin, overall salinity levels may rise until control measures are made effective. Recommendations were also made to implement Reclamation's "Colorado River Water Quality Improvement Program" (CRWQIP) proposed at the 1972 conference to achieve a total reduction of 400,000 tons per year in the salt load of the system by 1977. The underlying concept to support an accelerated program was to demonstrate the effectiveness of salinity control measures before future salinity standards are established.

Another related matter highlighting the need for basinwide salinity controls was a recently executed agreement with Mexico in an effort to find a permanent, definitive, and just solution to the international salinity problem with Mexico. Under the agreement, water delivered to Mexico shall have an average annual salinity of no more than 115 mg/1 (plus or minus 30 mg/1) over the average annual salinity of waters arriving at Imperial Dam. This requirement became effective with the authorization of Federal funds under the Colorado River Basin Salinity Control Act of 1974 (P.L. 93-320) to construct works necessary to achieve the limited differential in salinity. Since no absolute salinity limits were set, if the river salinity further increases as forecasted the salinity level of water delivered to Mexico would also increase in corresponding amount. However, the 1974 Colorado River Basin Salinity Control Act enables the United States not only to comply with its obligations to

Mexico, but also to proceed with Upper Basin controls to protect and enhance the quality of water in the river for use by both countries.

In addition, another recent institutional consideration in salinity control is recognized in P.L. 92-500. The 1972 Federal Water Pollution Control Act Amendments have been interpreted by the Environmental Protection Agency to require numerical salinity standards on the Colorado River. Accordingly, the seven basin States have been requested to undertake studies and negotiations to develop such standards and detailed plans of implementation by October 1975. Moreover, the law provides that by 1977, the "best practicable" water pollution control technology shall be applied to carry out proposed control measures for point sources on the river.

The Secretary of the Interior has broad as well as specific responsibilities under applicable laws to manage the water resources of the Colorado River Basin to: (1) apportion the waterflows according to the Colorado River Compact of 1922, (2) meet commitments to Mexico under the International Water Treaty of 1944 with that Nation, (3) conform to the requirements of the Supreme Court Decree of 1964, (4) meet specific contractual obligations with water users in the United States, (5) develop and manage water resources in accordance with specific authorizing legislation and in the public interest, (6) protect the recreation, fish and wildlife, and environmental values, and (7) assist in implementing the provisions of the Water Quality Act of 1972.

Within the context of these responsibilities and legal requirements, certain considerations are paramount: (1) there can be fluctuations in the concentrations of dissolved solids in the river as a result of annual variations in precipitation and the management of the available water resources, (2) the total available water resources of the river are allocated by interstate compacts and the international treaty, (3) the treaties and decrees have apportioned water quantity but are silent on water quality, and (4) the Department of the Interior, the Environmental Protection Agency, the Colorado River Board of California, and the Water Resources Council have projected increases in salinity unless control measures are taken concurrently with development of presently allocated water.

In recognition of the effects of the proposed developments on the salinity of the river, the Congress specifically directed the Secretary of the Interior to make water quality studies and to devise plans for improvement. This is provided for in three Public Laws:

1. Section 15 of authorizing legislation for the Colorado River Storage project and Participating projects (P.L. 84-485).

2. Section 15 of the authorizing legislation of the San Juan-Chama project and the Navajo Indian Irrigation project (P.L. 87-483).

3. The Fryingpan-Arkansas project (P.L. 87-590). The responsibility for these studies and reports have been assigned to the Bureau of Reclamation, with coordination with other agencies of the Department of the Interior.

The total damages attributable to salinity in the Colorado River system for 1973 are about $53 million. The estimates of damage do not include effects below 500 mg/1 for municipal and industrial supplies and 750 mg/1 for agricultural use.[1] By the year 2000, these damages upon the total regional economy are expected to reach about $124 million per year if no control measures are applied. This is based on recent studies by the Bureau of Reclamation which estimated total direct and indirect economic losses of about $230,000 per mg/1 increase in salinity at Imperial Dam. The effects of increasing salinity on fish and wildlife and other environmental resources have not been determined.

The primary agricultural economic impacts would be on the high-income producing areas in the Imperial, Coachella, Gila, and Yuma Valleys where a wide diversity of crops are produced. With increasing river salinity, poorer water quality would be diverted to the Metropolitan Water District of Southern California and the Las Vegas Water District, and upon completion of the Central Arizona project, water users in the Phoenix and Tucson areas would be similarly affected.

Cost-sharing arrangements for non-Federal participation poses a sensitive issue that requires resolution for the Colorado River salinity program as well as other problem areas. Any such arrangements ought to assess salinity control costs equitably among all water users and beneficiaries. Currently there is no Federal policy other than P.L. 93-320 on cost sharing for salinity control. Any costs not assigned to specific individuals or groups, must be borne by the local, regional or national public. Candidates for sharing in these costs are: (1) polluters, (2) primary beneficiaries, (3) secondary beneficiaries (4) states and local agencies or districts, and (5) the national public. For appropriate cost-sharing arrangements, careful consideration must

[1] See Status Report, "Colorado River Water Quality Improvement Program" U.S. Bureau of Reclamation, January 1974.

be given to the water rights of upstream diverters, as well as downstream users and beneficiaries of salinity control who in fact are now experiencing economic losses as a result of salinity increases on the river. The many variables involved, and the difficulty of measurement of impacts and beneficiary identification which is compounded by sources of salinity, require additional study in developing equitable cost sharing formulas.

The overall salinity problem cannot be divorced from planned future development of the basin's water resources and the resulting water demands that are ultimately expected to exceed its dependable natural supply. Thus, the overriding issue of the Colorado River involves the interrelation between future water depletions and deteriorating water quality. Moreover, the rapid onset of the energy crisis is expected to result in accelerated consumptive use of Colorado River water in order to support oil shale development, electric power generation, and coal development and conversion. Subsequent energy development in the basin is expected to directly affect water quality and consequently emphasizes the need for an effective salinity control program.

PROBLEM RESOLUTION

There is no single solution to the complex problem described above. A salinity control program should be regarded as one element in a matrix of solutions which will ultimately form a comprehensive plan for total water management for the Colorado River Basin. The strategies involved in defining other elements include planning and control of interrelated structures, legal and institutional changes, new management techniques, and increased efficiency in present use and future development of basin water resources.

Water resource management and salinity control are inseparable elements in planning for economic growth and development of the resources of the Colorado River Basin. Salinity control adds another dimension to the comprehensive river basin planning and must be viewed in context with programs for augmentation such as weather modification, geothermal resources, vegetation management, and desalting. Weather modification is discussed in more detail as a Westwide problem in the preceding chapter; more information on geothermal and seawater desalting and vegetative management is presented in Regional Problem No. 1. From such studies, coordinated through the alternative planning approach, a basinwide management plan for optimum use of the water resources can be evolved. Improved efficiency in water use through conservation and reuse as discussed in Westwide Problem No. 12 is also important in this basin.

Based upon the studies accomplished as part of CRWQIP, estimates have been made of the potential salinity reductions that could be attained if the source control projects are found to be feasible and are placed into operation along with these allied programs. The results are summarized in table V-9. These are initial estimates based largely on prereconnaissance levels of investigation.

Status of Water Quality Improvement Programs

Solutions to the salinity problems on the Colorado River will result from the cooperative effort of all involved local, State, and Federal agencies and organizations. The primary effort underway at this time is the Bureau of Reclamation's CRWQIP. This program and other related activities are discussed below.

Working with several of the States and Federal agencies involved, a comprehensive investigational program was structured and launched by the Bureau of Reclamation in FY 1972. The program evolved from prior studies of the Bureau, the Environmental Protection Agency and its predecessors, and the Colorado River Board of California. Current technology and management skills were examined to select the salinity control measures to be studied. From this, emphasis was placed on controlling salinity from irrigation, diffuse and point sources. Within this array, nonstructural measures such as improving irrigation efficiency, river system management, water system management, and utilizing return flows are being given prime consideration.

The most promising near-term salinity control measures are improved irrigation efficiencies and water systems management. There are no significant structural requirements associated with these techniques; however, in many areas onfarm system improvements and delivery system improvements are needed before good water management can be accomplished. The initial costs of training personnel, developing and adapting computer programs to the service areas, and establishing irrigator cooperation are the major costs of the Bureau of Reclamation's Irrigation Management Services program (IMS). These costs are completely covered by the investigational funding of these units. The investigation schedule for these units anticipates that the local water user organizations will assume operation and funding for the IMS activities at the end of the developmental period. Ongoing Department of Agriculture programs of technical and financial assistance of landowners require acceleration to secure needed onfarm improvements.

Table V-9.—*Projected salinity reductions, Colorado River at Imperial Dam (Mg/l)*

	1970	1980	1990	2000
Estimated salinity level[1]	865	930	1,115	1,160[2]
Anticipated range[3]	(795-935)	(855-1,005)	(995-1,235)	(1,035-1,285)
Projected salinity reductions				
Source control program	–	(–39)	(–130)	(–130)
Other measures	–	(–26)	(–120)	(–165)
(Desalting, weather modification, vegetation management and other practices)	–			
Total reduction	–	(–65)	–250	–295
Estimated salinity level with control programs and other measures	865	865	865	865
Range	(795-935)	(795-935)	(795-935)	(795-935)

[1] No salinity control programs.
[2] Construction of all Federal and private developments other than salinity control. If Upper Basin develops the full 5.8 million acre-feet estimated to be available, then salinity could increase to 1,260 ±140 mg/l.
[3] Based on one standard deviation for period of record.
Source: Bureau of Reclamation, Status Report, "CRWQIP", January 1974.

The complete schedule for the CRWQIP program is presented in Figure V-6 and discussion pertaining to the elements displayed are given in the following paragraphs. Figure V-7 shows the location of the various program elements.

Under the 1974 Colorado River Basin Salinity Control Act, the Secretary of the Interior has been directed to expedite the investigation, planning, and implementation of the salinity control program under the CRWQIP. The Secretary was authorized to construct, operate, and maintain the following salinity control units as the initial stage of the CRWQIP: Paradox Valley unit, Grand Valley unit, Crystal Geyser unit, and Las Vegas Wash unit.

Point Source Control. – The investigation program includes evaluation of point source control projects at LaVerkin Springs, Paradox Valley, Las Vegas Wash, Crystal Geyser, Glenwood-Dotsero Springs, Blue Springs, and Littlefield Springs. Feasibility studies of point sources are underway at LaVerkin Springs, Las Vegas Wash, Nevada, Crystal Geyser in Utah, and Paradox Valley and Glenwood-Dotsero Springs in Colorado. The physical setting of Blue Springs suggests that a control plan would be very costly and perhaps unattractive from an environmental viewpoint.

Diffuse Source Control. – The diffuse source control projects which provide favorable prospects for salinity control include the Price River, San Rafael River, Dirty Devil River, McElmo Creek, and Big Sandy River. These projects have not as yet been sufficiently studied to formulate more than tentative plans for which costs have not been estimated. The basic concept to be employed is to selectively remove the saline flows (over 1,500 mg/1) from the stream and then to desalt and/or evaporate the water. The irrigated areas on these streams would also be investigated to determine if water system improvement and management programs or irrigation scheduling might contribute towards reduction of the salt load sufficiently to justify feasibility studies. Corollary programs of erosion and sediment control through improved land treatment and management are needed also.

Basic data collection for diffuse source control projects is underway on the Price, Dirty Devil, and

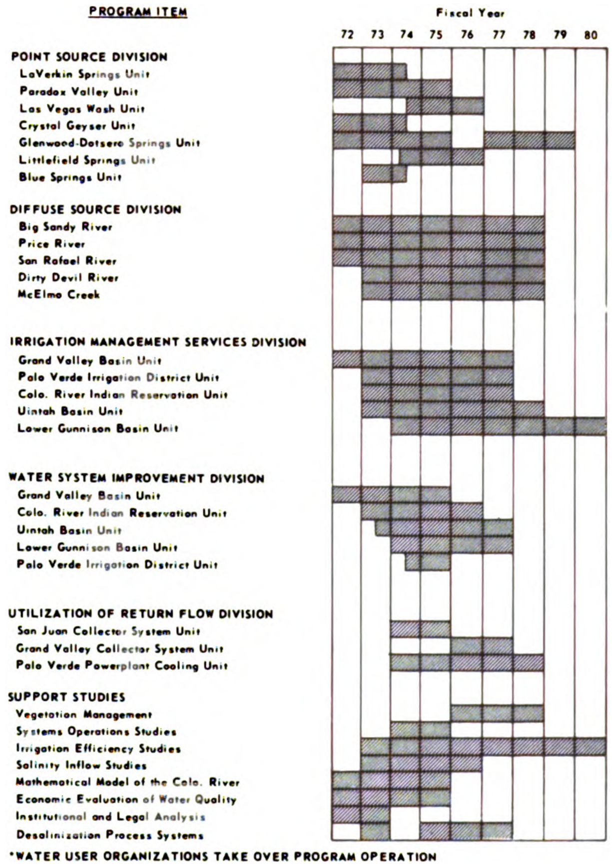


Figure V-6. ***Schedule for the Colorado River Water Quality Improvement Program.***

Figure V-7. ***Elements of the Colorado River Water Quality Improvement Program.***

San Rafael Rivers in Utah, Big Sandy River in Wyoming, and McElmo Creek in Colorado. Continued cooperation of Bureau of Land Management, Forest Service, Soil Conservation Service and other involved agencies is needed in this effort.

Irrigation Systems Improvement and Water Management. – The principal irrigated areas contributing salt are the Grand Valley and Lower Gunnison basins in Colorado and Uintah basin in Utah; the Colorado River Indian Reservation in Arizona; and the Palo Verde Irrigation District lands in California. The program contemplates conducting onfarm irrigation scheduling and water management, coordinated with water systems improvement and management programs within each of the areas. It also anticipates cooperative efforts on the part of Department of Agriculture for improving onfarm system measures. The onfarm activities would be aimed at reducing the volume of deep percolation entering the ground-water system. The reduction is expected to lessen the salt burden of the Colorado River. With increased efficiency a smaller volume of water per acre would be diverted to irrigate crops. Critical quantification of the effect of improved irrigation efficiency on concentration of the return flows has not been done and research on this problem is underway.

Onfarm system and management improvements may also provide increased net returns to the irrigators through greater yields, improved crop quality, and lower production costs. The primary water management technique to be employed is to schedule water amounts and time of application to replace water used by the crops. By developing an accurate crop water budget and giving operational considerations to soil water-holding capabilities in the root zone and consumptive use of the crop grown, deep percolation is reduced.

The IMS program is likely to be among the least expensive methods of reducing salinity levels. It is contemplated that the various irrigation districts will continue the programs after Federal initiation. Problems are involved in selling the program to irrigators, training personnel, and adapting computer programs for operation in the various areas. Nevertheless, about 200 farmers are expected to participate in the Grand Valley program during 1974. The program also became operational in the

Uintah basin, Palo Verde Irrigation District, and the Colorado River Indian Reservation during FY 1973. In FY 1974, it will be expanded to the Lower Gunnison basin.

An important corollary to the IMS program and related Department of Agriculture programs involves improvement of the water conveyance systems to reduce losses and increase operating efficiency. Under certain conditions, this would further curtail salt loading into the river. Engineering studies will be made of the irrigation systems as shown on the schedule for each of the aforementioned areas to identify the structural measures needed. The needs of water users to carry out good water management will be a primary factor in system redesign and improvement.

Utilization of Return Flows. – Investigations have not yet started but it is planned to examine the potential of treating or converting irrigation return flows to other beneficial consumptive uses such as thermal powerplant cooling and coal gasification within the basin to avoid returning them to the river system. However, downstream water rights are important factors in such undertakings.

Brackish Water Desalting. – Brackish water desalting is expected to play an important role in future methods of salinity control. In fact, the 100 million gallon-per-day desalting plant authorized as part of the Colorado River International Salinity Control project (Title I of P.L. 93-320) will be the largest membrane desalting plant in the world. In contrast to the normal desalting function of supplying new water, this plant is dedicated primarily to maintaining water quality of Colorado River water delivered to Mexico.

The membrane processes such as reverse osmosis and electrodialysis with chemical process such as ion exchange are expected to provide planners with a broad range of potential applications. Thus, desalting will provide new options which can be applied for pollution control along waterways, or at select delivery points. Finally, desalting technology is expected to be used in water recycling or water reclamation applications to conserve water supply and maintain water quality.

Support Studies. – A study has been completed to quantify the impact of increased salinity on the multiple water uses. A report is available which shows the negative dollar impact for each unit increase in dissolved solids concentration in the river. These results will be essential in evaluating other features of the Colorado River Water Quality Improvement Program.

An institutional and legal review of Federal law, State laws, power and water contracts, an international treaty, and a United States Supreme Court decree has been completed and a report of the findings is being prepared. This analysis will identify the constraints on the program and a legal setting within which salinity control measures can be more effectively pursued.

Two computerized mathematical models have been developed for use in the Colorado River Water Quality Improvement Program. The first of these models is salinity oriented and uses modified historic flow and quality data. With estimates of the point impact on salinity resulting with future additions to the system, the model serves as an accounting system for determining the effect of the change at various other points on the surface water system. The more comprehensive river basin model utilizes stochastic hydrology and simulates the operation of the river and reservoir system including the diversion and return of water to the system. Initial information developed from the comprehensive basin model is presented in Regional Problem No. 1.

Specific salinity control programs for the most advanced studies are dimensioned in the appropriate state narrative description of water quality programs.

CONCLUSIONS

1. The Colorado River Water Quality Improvement Program represents an intensive effort by the Federal Government to evaluate alternative solutions to the basinwide salinity problem. Implementation of effective control programs under Title II of P.L. 93-320, the 1974 Colorado River Basin Salinity Control Act, will yield direct salinity reduction benefits in the near term. This effort is being closely coordinated with related programs of Department of Agriculture and the land managing agencies.

2. In the long term, salinity control must be integrated with total land and water management, including any water supply augmentation programs to secure the most economic and environmentally acceptable program.

3. The economic justification of salinity control measures depends heavily on the quantification of economic

damages due to increasing salinity levels. At present, there is a wide disparity of salinity damage estimates which must be resolved with continuing research.

4. Legal and institutional changes in the Colorado River Basin may be needed to select the most effective means of salinity control.

5. New cost-sharing formulas are needed to attain an equitable distribution of both costs and benefits of salinity control.

6. Improved management and efficiency of water use in the basin under a total water management program could potentially provide more water of better quality for additional uses.

7. Limitation of depletions is not a presently acceptable alternative to the Colorado River Basin States.

RECOMMENDATIONS

1. The Colorado River Water Quality Improvement Program should be continued on an accelerated basis to implement those advanced investigation programs which are considered cost effective, demonstrate immediate program benefits and recognize environmental concerns. Related programs of Department of Agriculture land managing and other interested agencies should be accelerated as needed to meet salinity control objectives.

2. Continuing basinwide or regional planning efforts should be made to address the interrelated problems and requirements of salinity control and water supply augmentation. Future planning should continue to be carried out on a State-Federal interagency basis to assure effective program implementation.

REGIONAL NO. 3 – WATER REQUIREMENTS FOR OIL SHALE DEVELOPMENT IN THE UPPER COLORADO REGION

SUMMARY

Recent energy shortages and greater cost of local and foreign oil are contributing to increased interest in the oil shale reserves of Colorado, Utah, and Wyoming. The higher grade deposits cover about 16,000 to 17,000 square miles and can produce about 600 billion barrels of oil. These reserves are approximately 60 times present United States proved crude petroleum reserves. Several projections have been made with regard to when oil shale development will begin and the rate at which it will be developed. The Secretary of the Interior's two-phase development program began in January 1974 and is expected to end about 1985. The objective on Phase I is to learn more about the various methods of extracting oil from oil shale and at the same time produce about 500,000 barrels of oil per day (bpd). Phase II would build on the information obtained from Phase I.

Water is generally available from ground water and Federal reservoirs in Colorado, Utah, and Wyoming for the Phase I research and development activities, although storage and conveyance facilities and a compact on use of the White River may be needed depending on location of the demand. Expected extensive oil shale development in Phase II could require major new water supply facilities which in themselves could have important environmental impacts. A major problem may be decreasing quality water resulting from mining and shale processing activities which poses an additional threat to the water quality of the Colorado River.

DISCUSSION

Location and Size of Deposits

Oil shales are located in every continent of the world. In the United States, 30 states have oil shale deposits. However, the most extensive and richest deposits in the world are located in the Upper Colorado River Basin States of Colorado, Utah, and Wyoming. These deposits are located in the rock formation called the Green River Formation. The Green River Formation is the product of three ancient lakes: Lake Uinta (Colorado and Utah), Lake Gosiute (Wyoming), and a small unnamed lake located in western Wyoming (fig. V-8).

The higher grade deposits (at least 10 feet thick, averaging 25 or more gallons of oil per ton or rock) contain about 600 billion barrels of oil and cover an area of 16,000 to 17,000 square miles. About 80 percent of these high-grade deposits are located in the Piceance (Pee'-ahnts) Creek Basin of Colorado. Utah is assumed to have 15 percent and Wyoming 5 percent of the remaining high-grade deposits. As shown in figure V-9, most of the highgrade deposits are located on Federal lands.

To put the 600-billion-barrel estimate into perspective, it is estimated that Kuwait's Burgan Field, the world's largest oil field, contains estimated recoverable reserves

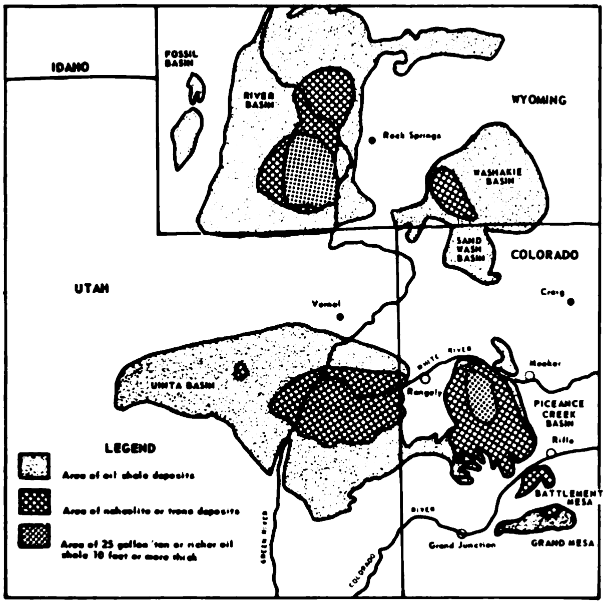


Figure V-8. Oil shale deposits in Colorado, Utah, and Wyoming.

Table V-10.—*Projected Phase I shale oil capacity – cumulative (thousands of barrels per day)*

Year	Colorado		Utah	Wyoming	Total
	Public land	Private land	Public land	Public land	
1978	–	60	–	–	60
1979	–	60	–	–	60
1980	–	60	–	–	60
1981	–	60	–	–	60
1982	–	60	–	–	60
1983	200	230	50	–	480
1984	400	230	50	–	680
1985	400	230	50	–	680
1986	400	390	50	–	840
1987	400	490	50	–	940
1988	400	590	200	125	1,315
1989	400	590	200	125	1,315
1990	400	690	300	125	1,515

of 55 to 60 billion barrels of petroleum. Alaskan North Slope reserves are estimated to be between 20 and 40 billion barrels.

Potential Development

To adequately assess the water problems associated with oil shale development, it is necessary to determine when development will start and the rate and ultimate level of development. Several projections have been made. The projection most often referred to is included in the Department of Interior's Final Environmental Statement for the Prototype Oil Shale Leasing Program (EIS) in which it is proposed that oil shale development take place in two phases: Phase I would be an experimental phase where different mining techniques, land and water disposal, reclamation schemes, and environmental programs would be tested. In this phase, the three States are expected to produce, by 1983, about 500,000 bpd. Of this, 250,000 bpd would come from private lands in Colorado. Phase II is envisioned to evolve from the Phase I research and development phase and thus could start between 1982 and 1986. Development would be continuous and dependent on Phase I technical results, the alternative cost of energy's extent of private development and other factors. About 500,000 bpd of capacity could reasonably be expected to be added in the early stages of Phase II by 1987 for a total oil shale industry of nearly 1,000,000 bpd. The oil shale development by states, as projected by the Interagency Oil Shale Task Force, is presented in table V-10.

Other projections have also been made by private organizations such as oil companies and research firms. The University of Denver Research Institute developed four different scenarios. Two of the scenarios assumed marginal success with an initial plant and, as a result, a long period of time would elapse before more development would take place. The other two projections reflected moderate and maximum levels of development. Under the moderate situation, 450,000 bpd would be produced by 1985 and under the maximum scenario, 850,000 bpd would be produced by 1985. One of the oil companies that won the right to develop Colorado's first test tract has projected that oil production from the first tract will begin by 1979 and reach full production of 300,000 bpd by 1984. Other oil companies project a 300,000 bpd oil industry by 1980, increasing to 1.2 million bpd by 1985 and 2.8 million bpd by 1990.

Because of slippages that have already occurred, it appears that production of oil under Phase I, the research and development phase, will probably begin in the 1978-1980 period. This is later than predicted in the EIS. Development on private lands could occur somewhat sooner. Initiation of Phase II and the rate and ultimate level of development that might be reached are largely unknown. However, based on recent information which indicates that initial production of oil under Phase I will be delayed about 4 or 5 years, Phase II could occur between 1983 and 1990. The rate and magnitude of Phase II development will basically depend upon the assessment of Phase I

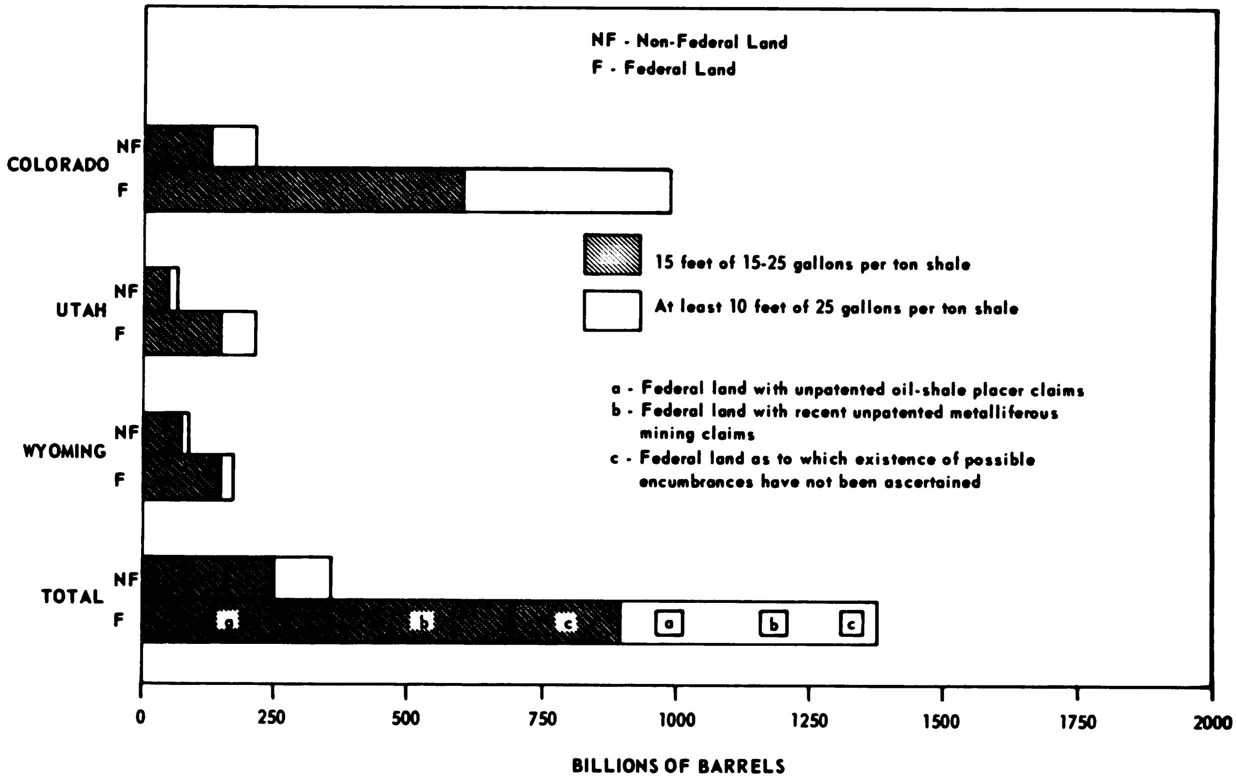


Figure V-9. Oil shale ownership by State.

results, demand for oil, availability of cheaper sources of oil, and additional water, land, social, and environmental studies.

The oil shale situation in Colorado, Utah, and Wyoming is summarized below. These State summaries are organized along the Phase I- Phase II breakdown. It is recognized that the time frames outlined may be optimistic. However, this does not negate the other aspects of the expected scenario.

Colorado

High-grade oil shale deposits are estimated at 480 billion barrels. The majority of these high-grade deposits along with the other significant mineral resources are located in the Piceance Creek Basin. Besides oil shale there are other significant minerals in this area: halite (common salt), nahcolite (sodium bicarbonate), and dawsonite ($NaAl(OH)_3CO_3$). Of particular interest is the mineral dawsonite. Dawsonite is a source of alumina from which aluminum can be easily extracted. Presently bauxite is the major source of aluminum. Most of the bauxite the United States uses is imported. If imports are restricted, dawsonite would be an attractive source of alumina. In the Piceance Creek basin, the reserves are enormous. It has been estimated that 1 square mile of land in the Piceance Creek basin contains 1.5 times as much aluminum as the total bauxite reserves in the United States. The future need for development of these resources should be considered during oil shale development.

Phase I. – For the initial development, Colorado is expected to produce 300,000 bpd to 150,000 bpd from private lands and 150,000 bpd from the Test Tracts C-a and C-b which are on public lands. Presently, it is estimated that 100,000 bpd will be produced on tract C-a and the remainder from tract C-b.

Water and land requirements vary with the production rate, mining technique, and method adopted for spent shale disposal. Municipal water for the increased population to support the oil shale activity will also be needed. However, this water is relatively minor in comparison to shale processing requirements. Both low- and high-quality water can be used in the production process. Estimated total water, including municipal needs, and land requirements for Colorado's two test tracts are shown in table V-11.

Table V-11.—*Water and land requirements*

Tract	Production (bpd)	Mining method	Water requirements and depletions (acre-feet)	Land requirements (acres)
C-a	100,000	Surface	13,400-20,000	4,600-6,650
		Underground	0	1,090-2,210
		In situ	0	775
C-b	50,000	Underground	6,800-10,600	1,090-2,210
		In situ	3,000- 5,700	790

Since in situ recovery of oil from oil shale on a large scale basis has not been proven technologically feasible, it is anticipated that surface mining will be adopted for tract C-a and underground mining for tract C-b.

Tract C-a will probably require high quality surface water within the first 5 years. On the other hand, there would be a surplus of low-quality ground water resulting from mining operations which would create a disposal problem. At tract C-b, it appears that there will be sufficient quantities of both high- and low-quality ground water available to meet all needs of 50,000 bpd industry for 20 or 30 years, however, substantial amounts of low-quality ground water would have to be disposed of or saved for future use. Ground water pumping will affect waterholes, springs, and flow of streams in the area which will result in decreasing tributary inflow to the Colorado River.

It should be pointed out that the above data reflect only about one-half of the total water and land requirements the oil shale industry will need to develop in Colorado by 1983. Land and water resources will also be needed for the 150,000 bpd that will be produced from private lands in Colorado. Not much is known about the extent of the private development, its sources of water supply, or potential impacts.

Socioeconomic Impacts. – Socioeconomic impacts will be significant. Assuming a 400,000-bpd oil shale industry by 1983, it is projected that the present population of 90,000 persons would increase by 60,000 people. A 750,000-bpd industry would increase population by 160,000 people. These increases will place heavy burdens on the existing housing, school, and public service segments of the area. Assistance in the form of planning for these increases and money to implement plans are needed.

Environmental Impacts. – The topography of the Piceance basin is characterized by parallel ridges and valleys. The elevation of the basin ranges from 5,250 feet along the White River to 9,000 feet on some of the ridges in the southern part of the basin. The alluvial valley lands support good hay crops where irrigated and sagebrush, greasewood, or saltbush elsewhere. The thicker upland alluvium supports sagebrush, grass, and mountain shrubs, and the thin upland soils generally support pinion and juniper. These vegetation types support a sheep and cattle industry, as well as providing forage for the large deer herds. The valley areas are critical winter ranges for deer.

The Piceance basin constitutes Colorado's most important mule deer range. The average annual harvest of deer during the period 1960-69 was 6,000. The present population of deer is estimated to be between 24,000 and 35,000.

There are hundreds of miles of high-quality trout streams at higher elevations in the Colorado River and the White River headwater areas. None of the streams in the oil shale test tract areas are good fishing streams. The White and Colorado Rivers are the habitat of two endangered species, the humpback chub and the Colorado River squaw fish, which thrive in these cold, fast-flowing streams. Both the White and the Colorado Rivers are on the list of rivers for study under Section 5(a) of the Wild and Scenic River Act.

There are no designated historical sites and no known archeological sites in the basin.

Land Impacts. – The principal impacts on lands of the Piceance basin are those directly involved with the amount and kinds of disturbances resulting from exploration, mining, processing, and spent-shale disposal activities. The soils, vegetation, topography, and watershed characteristics will all be affected by the surface activities. In addition, increased urbanization of the region will alter small surface areas in the vicinity of population centers. All mining activities will alter some volume of the subsurface strata.

The impact of mining on the land will vary by size and type of mine. The land surface disturbed in developing an open-pit mine for a 100,000-bpd industry would be 1,100 acres during 20 years of continuous operation. The surface facilities for processing the oil shale would require about 200 acres, and an additional 180 to 600 acres would be required for roads, powerlines, and pipelines. Land required for overburden disposal would be 1,000 acres, and land required for spent-shale disposal would be 2,800 to 3,000 acres.

Grazing lands for livestock would be reduced in proportion to the land required for the oil shale industry. The landscape would be irreparably changed by a large oil shale industry. Proper disposal of spent oil shale and revegetation of disturbed areas could minimize the adverse aesthetic effects. Deer hunting would be adversely affected in direct proportion to other adverse effects of oil shale development.

Water-related Impacts. – The oil shale development will have a major impact on water resources. Because the richest deposits of oil shale are between the principal aquifers or below the lower aquifer, large quantities of water may have to be pumped to keep the mines dry. Depending on the location of a mine and the hydrologic properties of the aquifers at that location, a pumping rate as large as 40 ft^3/s (18,000 gal/min) for a 100,000-bpd plant may be required the first few years to keep the mine dry. Part of the ground water can be used in the processing of oil shale, but an excess of saline ground water probably will have to be pumped and disposed of during the lifetime of the operation.

Release of excess saline water from dewatering of mines without treatment of processing would increase the salt load downstream in the Colorado River. Also, if evaporation is selected as the means of disposing of the excess saline water, then a lake of nearly 1,000 surface acres will be needed. Diversion of low-salinity water from the White or Colorado Rivers for use in the Piceance basin would cause an increase in the dissolved solids concentration of water downstream by removal of water that normally dilutes the more saline water that enters the Colorado River from other basins.

In addition, dewatering of a mine could cause the flow of perennial streams within a radius of 7 miles from the mine to be decreased or possibly stopped entirely. A small quantity of surface water that now flows into the White River could be intercepted by mine dewatering, causing a minor reduction of water in the Colorado River.

Also, since it is projected that the freshwater obtained from dewatering the mines would not meet freshwater demands, it will be necessary to either desalt the excess saline water or develop the supplies of the Colorado and White Rivers. Desalting the excess saline waters would require disposal of the concentrated brine. Development of Colorado and White River water supplies through construction of storage facilities would impact on all aspects of the environment. This includes segments of the Colorado and White Rivers which have been designated by both State and Federal agencies as river segments having free-flowing values, and in some instances potential wilderness areas would be affected if currently proposed projects were constructed.

Phase II. – As stated previously, Phase II development will depend upon Phase I results. Colorado, with 80 percent of the high-grade deposits, will share in a substantial portion of this development. Phase II will require development of additional surface water supplies and social, economic, land, and environmental impacts will be significant.

Utah

Utah's oil shale resources are located in the Uinta basin. The higher grade deposits in the eastern part of the basin cover an area of about 1,000 square miles and contain an estimated 80 billion barrels of oil.

Phase I. – Under Phase I, Utah is expected to produce 100,000 bpd from the two test tracts by 1980. Underground mining is expected to be used to extract the oil shale. Estimated total water and land requirements for Utah's two test tracts are 18,000 acre-feet per year for shale mining and processing and an additional 18,000 acre-feet annually for related municipal and industrial requirements.

The Utah test tracts do not have any significant ground-water resources, and therefore will need surface water. The closest source of supply is the White River. The Utah Division of Water Resources presently has applied for 250,000 acre-feet per year of water from the White River, its tributaries, and underground sources to meet estimated long-term needs of the area. However, a compact with Colorado is needed to clarify water supplies available to each state.

Because development will be only 50,000 bpd, socioeconomic impacts will be minor. If the in situ technique is adopted, then environmental impacts will be minimized. If underground mining or surface mining are adopted, there will be land use and environmental problems to deal with.

Phase II. – Utah, with about 15 percent of the high grade deposits, will probably experience some increase in oil shale activity under Phase II. Additional development will require additional surface water supplies. Also, land use and environmental problems will be intensified.

Wyoming

Wyoming oil shale deposits are located in southwestern Wyoming and very little is known about the quantity and quality of these deposits. The higher grade deposits are located in an area called the Washakie basin, and it has been estimated that the high-grade deposits could contain about 30 billion barrels of oil.

There are other significant mineral resources in the area such as trona which is a source of soda ash and coal. In the case of the trona, Wyoming deposits provide 22 percent of the Nation's soda ash requirements and more development is under way. Sixteen percent of Wyoming's recoverable coal reserves are located in the Green River Subregion. Development of this resource is under way and activity is increasing. Because not much is known about Wyoming's oil shale deposits, development is expected to lag behind the other two States.

Phase I. – For Phase I, 50,000 bpd are projected to be produced and the in situ method of extraction will be used on the two test tracts. Total water requirements are estimated to be about 2,200 to 4,800 acre-feet per year. Ground water or surface water from Fontenelle or Flaming Gorge Reservoirs is available to meet these demands.

Because the in situ method of extraction will be used, the surface area will not undergo extreme change. Some 1,600 acres of vegetation would be seriously damaged or destroyed.

Ground water could be adversely affected by this process. There is a slight possibility of toxic substances reaching Green River. If this should occur, the Green River trout habitat could be adversely affected.

Phase II. – Wyoming's share of Phase II development needs to be determined before water and land requirements can be determined and water requirements and environmental impacts assessed.

PROBLEM RESOLUTIONS

Problems associated with oil shale development will grow in intensity as the resource is developed. The magnitude of the impacts on the various resources such as water, land, environment, and socioeconomic structure of the region will depend upon the mining or extraction technique adopted, the method adopted in disposing of the spent shale, and size of development. Each State's situation is summarized below.

Colorado

Development of Colorado's oil shale deposits is underway. Development on private lands is proceeding and not much is known about these operations. However, oil production from private lands is expected to occur before production from public lands. From the water supply standpoint, several alternative approaches to meeting the water requirements of the two test tracts are available.

Municipal water related to oil shale development, although relatively minor in quantity, will not necessarily be required in the same location, thus creating additional distribution-related supply problems. The sources of water supply for private tracts is not clear at this time. Following is a brief summary of alternative water supply sources for demands created by development of the two test tracts.

In Phase I, Tract C-a will probably require additional high-quality surface water. There are several ways in which water demands could be satisfied. These include:

1. Ground-water pumping,

2. White River water,

3. Colorado River water from the FEderal Ruedi and Green Mountain Reservoirs (diverted and pumped into the Piceance basin),

4. Construction of the Federal West Divide Project (water diverted and pumped into the Piceance Basin),

5. Conversion of agricultural water rights to M&I use, and

6. Green River water from the Federal Flaming Gorge Reservoir.

The remaining high-quality water needs of tract C-a would probably be met through use of White River water or Colorado River water from Green Mountain or Ruedi Reservoirs. In all cases, conveyance facilities would have to be constructed to the test tracts. The White River is closer (about 18 miles from tract C-a), but may involve the construction of storage facilities to assure a firm supply.

For tract C-b, there doesn't appear to be a water supply problem. However, if additional oil shale developments take place, ground water may not be sufficient to meet all good quality water requirements, and therefore surface water supplies will need to be developed.

For Phase II, no firm conclusions can be drawn with regard to water supply or what the land, environmental or socioeconomic impacts might be. Other water supply alternatives will probably need to be considered for oil shale development beyond 1981. However, if storage facilities need to be constructed for Phase I, efforts should be made to determine what additional water will be needed for Phase II and these estimates should be incorporated in Phase I planning.

Utah

Utah's oil shale deposits, because they are not as rich as Colorado's deposits, are expected to lag behind Colorado in development. Sources of water supply for Utah oil shale development are outlined below.

In Phase I since ground water will not be available, water from the White River will be needed. Phase I development demands can probably be met without storage. However, if storage is needed for Phase I, it should also be planned to take into account Phase II requirements. Before this can be done a compact is needed between Colorado and Utah on the White River.

For Phase II, the EIS makes no specific observations with regard to water supply, land requirements, or environmental and socioeconomic impacts. Depending on the size of development, storage facilities will probably need to be considered for Phase II oil shale development. However, if storage facilities are needed for the initial development phase, consideration should also be given to these remaining alternatives and future increases in oil shale development.

Wyoming

Since little is known about Wyoming's deposits, development is expected to take place at a much slower rate. From a water supply viewpoint, ground water or water from Fontenelle or Flaming Gorge reservoirs is available to meet Phase I requirements. However, additional study and analysis of Phase II potentials is needed before the adequacy of existing water supplies can be determined.

CONCLUSIONS

1. Initial oil shale production in Colorado, Utah, and Wyoming is expected to begin about 1980. Because of the public lands involved and the overall Federal interest in the supply and quality of the Colorado River, close cooperation among State, private, and Federal interests is required. Major environmental, land use, and socioeconomic impacts are likely to occur as a result of oil shale development.

2. Major oil shale development is underway on private lands in the area, and much more needs to be known about the potential magnitude of these developments or their impacts since the Interior Department environmental impact statement does not address impacts of private development.

3. Oil shale planning efforts are now largely fragmented and not being coordinated to keep up with the pace of development occurring on both public and private lands.

Colorado

1. Colorado, with 80 percent of the high-grade deposits of oil shale, will experience the most severe environmental and economic impacts.

Phase I production of oil is expected to be between 400,000 and 600,000 bpd by 1984.

2. If ground water is not sufficient to meet Phase I water demands, surface water will be required to meet

high-quality water needs for Colorado's two test tracts. This water could be supplied from existing Federal reservoirs or from the White River.

3. The rate and magnitude of development of Phase II is dependent upon the results of Phase I and largely unknown at this time. However, because of Colorado's high-grade oil shale reserves, a substantial portion of development beyond Phase I is expected to take place.

4. Studies are needed now to determine Colorado's share of Phase II development and the corresponding requirements for water and land resources. Studies on environmental and social impacts are also needed.

5. Colorado oil shale deposits contain significant deposits of dawsonite, which could be an important potential source of alumina.

Utah

1. Phase I production of oil from oil shale in Utah is expected to be 100,000 bpd by about 1980 or 1981. White River water will be required for Utah's two test tracts. However, storage will probably not be needed for Phase I development.

2. The rate and magnitude of oil shale development after Phase I is uncertain. However, to support a large oil shale industry beyond 1980, additional storage will probably be needed to meet water requirements.

3. In Utah, oil shale decisions are tied in with the overall problem of how Utah should use its remaining Colorado River water entitlement. Therefore, even though full-scale oil shale development appears to be in the far term, studies are needed now to determine the time frame and size of Utah's oil shale industry so that water can be reserved for this purpose. In addition, this information will be needed for any White River Compact negotiations with Colorado.

Wyoming

1. Under Phase I conditions, 50,000 bpd of oil from Wyoming oil shale deposits are expected to be produced. Estimates of development beyond that have not been made due to lack of data, although Wyoming has earmarked 22,000 acre feet for oil shale uses.

2. For Phase I, water from Fontenelle or Flaming Gorge reservoirs could be used to meet water requirements.

3. Fontenelle and Flaming Gorge Reservoirs could also assist in meeting water requirements for any Phase II development.

RECOMMENDATIONS

1. For Phase I, initial development of 500,000-bpd oil shale plans, including water supply proposals, land reclamation plans, and environmental protection programs, should be reviewed and monitored by responsible State and Federal agencies. Data collection programs should be developed and implemented immediately to fill data gaps, especially with regard to ground water, air and water quality, and selected environmental benchmark areas. An assessment of private development potential and associated water, land, environmental, and socioeconomic impacts is needed. The environmental basic data program should include:

a. Instream flow needs for fish and wildlife, general environmental, and recreational uses;

b. Inventory of data on critical wetlands and riparian habitat;

c. Specific range and habitat requirements of rare and endangered animal and plant species;

d. Wilderness potential; and

e. Wild River potentials (See Westwide Problem. No. 7).

2. An interagency oil shale office including local and State interests should be established in the oil shale resource area to administer and coordinate the above programs and those proposed under Phase II.

3. For Phase II based on projections of oil shale development after 1980, a special study should be initiated in FY 1976 to determine water requirements, sources of supplies, and environmental and social impacts with the purpose of developing a comprehensive water and related land-use plan for the area. Geological Survey ground water studies should be expanded to cover the entire Piceance Creek Basin. Present studies only cover those areas where test-hole data are available.

4. In Colorado studies are needed to determine the need and possibility of developing the other mineral resources of the oil shale area, especially the dawsonite deposits. Negotiations and supporting water availability and use studies should be initiated as soon as possible for the purpose of Colorado and Utah arriving at a compact for the White River.

5. A joint Federal-State Study should be initiated to determine the alternative plans available to Utah for

using its remaining Colorado River water entitlement. This study is needed because of the coal and oil shale resources of the area, Indian water requirements, and municipal and industrial requirements along the Wasatch Front. The study as a minimum should take into account (1) future oil requirements and the portion of these requirements that will be satisfied from Utah oil shale; (2) transregional diversion requirements or needs, if any; (3) related coal development; (4) environmental needs; (5) other in-basin needs including Indian needs. The study should start in FY 1976.

6. In Wyoming studies should be initiated or continued by the Geological Survey and Bureau of Mines to determine the extent and quality of Wyoming oil shale deposits.

REGIONAL NO. 4 – MANAGING WATER AND RELATED LAND OF THE LOWER COLORADO RIVER MAIN STEM

SUMMARY

The limited water resources of the Lower Colorado River are being called upon to sustain rapidly expanding use and population pressures. The spread of urban and recreational home development along the main stem continues at an increasing rate. These developments frequently have significant impacts on the Federal lands, especially concerning recreational use and wildlife habitat values. Greater demands are placed upon the limited water supply and waste disposal associated with spreading developments presents a water quality hazard. The use of the Lower Basin reservoirs for recreation increases each year, requiring additional facilities for the health and safety of the public. The Colorado River and Mojave Indian Reservations are developing facilities to utilize their remaining share of Colorado River water through expansion of irrigation, recreation, and urban development. Land and water management problems include competition among various human uses ranging from municipal and industrial development to the enjoyment of the outdoor resources in a number of ways. The flow of the Lower Colorado River is entirely controlled by a system of Federal dams and reservoirs and much of the lands bordering the river is administered through various Federal agencies. A number of sites of natural resource lands in and adjacent to the area are being studied for possible transfer to the State of Arizona. In view of the river's acknowledged importance to the economic, social, and environmental wellbeing of the people of the Pacific Southwest, a water resource and related land coordinated management program is needed.

DISCUSSION

In the approximate 280 river miles from Davis Dam to the international boundary with Mexico there are wide variations in physical conditions and land use patterns. The relatively narrow strip of river channel and vegetative growth supported by its waters in a desert setting hosts a number of uses including conveyance of water supplies and drainage returns, irrigation along its borders, fish and wildlife habitat, recreational centers, and small urban developments. Over three-fourths of the area is in Federal ownership or Indian Trust. Objectives for managing the lower river have changed significantly in the last decade from one emphasizing control and regulation of the river primarily for water supply, sediment, salinity, and water salvage to a larger perspective embracing environmental factors, fish and wildlife enhancement, recreation development, and creating economic opportunities on Indian lands. Accommodating these broader objectives requires the resolution of problems of conflicting use, clarification of land titles, and control of unauthorized diversions of water and illegal occupancy of public lands.

Over 12 million people live within 4 hours driving time of the Colorado River. During 1973, 8 million visitor-days of recreational use occurred along the Colorado River from the headwaters of Lake Mead to the international boundary. There are still several reaches of the river below Davis Dam that remain relatively undeveloped. These areas have some of the best fish habitat along the river and provide many thousands of man-days of fishing each year. Water and heavy vegetative growth throughout the bottomlands provide a favorable wildlife habitat, with animal life concentrated in and adjaced to thickets. Marshlands provide a habitat which is rare in the arid southwest and support many species of resident and migratory wildlife. In addition to the numerous game species, several endangered species depend upon these areas. The preservation of this favorable habitat and its abundant wildlife is essential to the environmental quality of the valley.

Much of the rapidly increasing population growth in the area occurs along the river valley downstream from Davis Dam, where the towns of Bullhead City, Havasu City, Parker, and Yuma in Arizona; and Blythe and Needles in California, are located. Many stretches of the river in this area have a very heavy concentration of recreational use. Because of unsightly, unsanitary, and unsafe conditions, the stretch between Parker Dam and Headgate Rock poses serious problems of overuse and degradation of recreation opportunities. Careful planning and management will be necessary to provide long-range public benefits through the preservation and protection of the natural scenic and scientific features of the Lower Colorado River Valley. As most of the remaining lands suitable for potential resort and community use are federally administered, there are increasing demands that public lands be released for development. There is active State interest in obtaining lands to assist in meeting these needs.

The siting of several nuclear powerplants in the area is under active consideration. Irrigation return flows and waste water would be primary sources of cooling water. Ground water in some of the undeveloped basins along the river also offer potential sources of supply. Location of the nuclear stations and associated transmission lines could have important impacts on the management of water and land resources in and along the main stem of the Colorado River.

As mentioned previously in the preceding discussion under Regional Problem No. 2 on Colorado River salinity, the measures included in the CRWQIP are designed to control salinity levels in this lower reach of the Colorado River to acceptable levels. Negotiations with Mexico to maintain agreed upon salinity levels call for the construction of a large desalting plant, as well as other measures, all of which will influence the operation of the river system and related land management programs. Additional potential water quality improvement measures may also be identified which ultimately would have to be integrated into an overall plan.

In order to reduce the nonbeneficial water consumption associated with irrigation practices and to reduce irrigation return flows to the Colorado River, an irrigation scheduling and management program and an irrigation water systems improvement program have been initiated by the Bureau of Reclamation in the Lower Basin. The irrigation scheduling and management program is being carried out by providing technical assistance to irrigation districts to make more effective water use through timely irrigation application. These activities could also make contributions to the control of salinity.

There is a long history of Federal actions dealing with water and related land management problems along the Lower Colorado River. The river through Arizona is almost entirely under Federal control of administration. This control, however, is divided among many agencies, often with different authorities and management objectives. The Colorado River, Yuma, Chemhuevi, and Fort Mojave Indian Reservations occupy much of the river's banks. The Imperial, Cibola, and Havasu National Wildlife Refuges are managed by the Bureau of Sport Fisheries and Wildlife. In 1964 the Lower Colorado River Land Use Office of the Bureau of Land Management published its land use plan for development of the lower river. Since then that agency has assumed responsibility for implementation of the plan.

The Secretary of the Interior has required a Management Framework Plan to be prepared by the Bureau of Land Management, Yuma District, by June 30, 1975, for those natural resource lands which it administers. This study will, in addition to the land resources management proposals, also identify associated water requirements. In this connection, the Secretary has allocated a temporary amount of 1,800 acre-feet per year for recreation use in the area. Potential special uses of water, in addition to present decreed allocations, include:

Use by concessionaires,

Needs to meet State, county, and city park recreation areas,

Temporary agricultural occupancy leases,

Mineral and mining development,

Widespread recreational use growth on and adjacent to the area,

Urban growth, and

Additional development on adjacent Indian reservations.

The State of Arizona and the Bureau of Land Management have identified 19 areas covering about 200,000 acres that are to be studied for possible State selection. A major portion of these lands are in the proximity of the area discussed. Many factors to be considered in those studies are related to problems of water and land management of the Colorado River main stem.

The river's flow is entirely controlled by dams which are operated by the Bureau of Reclamation. In July 1971 a multidisciplinary task force of that agency reviewed its River Management Program and submitted a report[1] concluding that the multipurpose concept should be expanded and that increased attention should be given to such factors as recreation, fish and wildlife, environmental quality, and Indian programs.

[1] "Report of Task Force – Review of the River Management Program, Colorado River Front Work and Levee System," Bureau of Reclamation, July 1, 1971.

Reaches of the Lower Colorado River have been identified as having potential for designation under the National Wild and Scenic Rivers Act. There is also an active proposal to include a portion of the Lake Mead recreation area as a wilderness area.

PROBLEM RESOLUTION

A consistent and broadened data base is a necessary foundation for developing integrated water and related land planning in the Lower Colorado River and providing the means for monitoring and adjusting programs to fit a rapidly changing mix of resource problems. This should include social and economic factors as well as those affecting the environment. Input would be provided by the many Federal and non-Federal entities involved. New techniques of multispectral photography are available and can be updated at minor costs. From such an information base, ongoing and proposed programs could be assessed.

Multiobjective alternative plans to meet rapid recreational and urban development along the Colorado River which consider effects on water quality, fish, wildlife, recreation, environment, land use, and flood control would be developed. For example, designation of water supplies to these uses, construction of Federal and State parks, zoning, exchange of public lands, and other land use and management practices.

Water supply and waste disposal measures could be investigated for parks, municipalities, unincorporated communities, and other developments along the Colorado River considering alternative rates of growth.

Water salvage from river channelization, selective phreatophyte clearing and control, deepening of shallow arms, and other salvage operations could supply limited quantities of water for the expansion of parks, fish and wildlife refuges, and recreation land use areas and possibly supplemental water to communities along the river. Environmental impacts would have to be carefully considered.

Plans for specific facilities for fish, wildlife, recreation, and environmental preservation and enhancement could be formulated. Certain reaches of the river may have potentials for inclusion as scenic or recreational rivers and for expansion of wildlife refuges.

The potential for water conservation through additional onfarm irrigation water management and systems improvement programs should be evaluated. Upon identification of potential areas, recommendations would be made for inclusion in ongoing action programs.

As indicated in the Westwide and State problem discussions, in cooperation with the Bureau of Indian Affairs, assistance would be provided in planning for the development of Indian lands, communities, and recreational facilities. These programs would be coordinated with non-Indian developments along the river to optimize beneficial use of Colorado River water.

The impact of new townsites on the land and water resources, wildlife, land use, and environment of the area should be considered in the studies. Urban townsite developments have been proposed (i.e., Planet, Arizona, which has been rescinded), and others are expected to be proposed. In all probability, a land exchange with the Bureau of Land Management would be necessary.

CONCLUSIONS

1. There are a great number of complex and interrelated water resource and land use problems on the Lower Colorado River main stem that require analysis and resolution as an integrated system. They involve implementing measures for conservation, reuse, and salinity control of scarce water supplies; compliance with interstate and international agreements on apportionments of water quantities as well as control of quality; illegal occupancy and unauthorized water diversions; rapidly accelerating recreation use; protection of fish and wildlife habitat; greater demands for services for growing towns and cities; increasing water requirements for Indian reservations; new development pressures on public lands; and possible use of waste water for nuclear powerplant cooling.

2. There is a multiplicity of ongoing research, investigation, management, and implementation programs underway by various Federal agencies. An urgent need exists to organize a multiagency, multidisciplinary group with sufficient authority to establish a framework which will integrate and coordinate these various activities into cohesive yet flexible planning, operation, and management programs.

RECOMMENDATIONS

1. A Federal-State group comprised of resource experts with knowledge of the area should provide for the coordination of ongoing and new planning studies and a framework for integrating existing water and

related land management programs to maximize benefits from multiobjective and multipurpose use. This group should include representatives of all State and Federal agencies having designated responsibilities in the area as well as representatives of other public interests.

2. Task forces reporting to this group should initiate the development of a comprehensive data base. The Colorado River Simulation Model previously mentioned should provide important input.

3. Resource inventories and water requirement studies on Indian reservations, as recommended in the Westwide and State presentations, should be integrated into overall studies and management plans.

4. An active public involvement program should be initiated with broad representation from non-Federal interests working closely with the master Federal-State group as well as special task forces.

5. A special total water management study should be initiated in FY 1976 to provide the framework for developing alternative water and land use management plans. The study should recognize alternative futures including such factors as different levels of population growth, possible changes in State and Federal land use policies, and alternative levels of water use by various purposes served.

REGIONAL NO. 5 – OPERATION AND MANAGEMENT OF THE COLUMBIA RIVER MAIN STEM SYSTEM TO MEET TOTAL WATER USES

SUMMARY

In the past four decades, the Columbia River System has had a great number of major water resource development projects constructed by public and private organizations. Rapid economic and population growth of the region has imposed an increasing demand on the system to produce more electric power, provide more recreation opportunities, obtain better control of floods, furnish more water for municipal and industrial use and irrigation, and provide improved navigation. Many of these uses are not necessarily compatible. Present operations of the river are resulting in adverse effects on anadromous fisheries, wildlife, recreation, and navigation. Existing and planned future hydropower facilities on the river will increasingly be used for peaking as commercial thermal generating plants are introduced into the region. The impact of changed patterns of fluctuations in flows and water surface elevations on various functions, users, and uses must be evaluated. The ongoing Level "C" Columbia River and Tributaries Study of the Corps of Engineers is addressing these problems. However, the study needs to be expanded so that environmental interests can provide additional data on recreational use and fish and wildlife resources.

DISCUSSION

The Columbia River has undergone extensive development since the early 1930's. To date, well over 100 major water resource development projects have been constructed by a wide variety of entities including the Federal Government, State and local governments, private interests, and cooperative organizations. Additional water uses have been recognized since many of the projects were constructed. The system storage has more than doubled in recent years with the completion or near completion of four new reservoirs provided for by the Columbia River Treaty with Canada and completion of the Dworshak project on the North Fork Clearwater River. Development of a high-voltage intertie between the Pacific Northwest and Southwest together with the transition of the electrical energy base from hydroelectric generation to thermal generation will require major changes to the operation of the system and will require modification and additions to it.

Development of the Columbia River system has paralleled rapid economic and population growth of the Columbia-North Pacific Region. The growth and change in the region has placed increasing demand on the Columbia River system to produce more electric power, provide more recreational opportunities and better control of floods, furnish more water for irrigation and municipal and industrial use, and facilitate navigation. Many of these uses are not necessarily compatible and will require careful weighing of alternatives. New public attitudes and laws concerning the environment, both natural and social-economic, also broaden the perspective of the problem. The final goal must be to devise an optimum river management system and development plan so that all uses and desires will benefit equitably.

Power

The present Columbia River Power System is undergoing transition to an integrated hydro-thermal system as commercial thermal generating plants are introduced into the region. The impact of possible changed patterns of flows and water surface elevations which could arise as hydro projects carry more peakload must be evaluated. This evaluation of operational effects must include all functions, users, and uses. Available information indicates that large-scale thermal-electric plants will be required along with installation of hydro capacity to keep pace with the load.

Flood Control

Although each Columbia River flood peak is controlled to a different degree, the peak flows of major floods on the lower river can be reduced almost 50 percent. However, reduction of peak flows requires reservoir regulation that prolongs downstream flows so that river levels remain at higher stages for longer duration. Possible damage resulting from prolonged higher discharges should be determined. Also existing levee systems provide varying degrees of protection and need to be reevaluated under current conditions. The flood control potential of existing reservoirs constructed for other purposes needs to be determined. Consideration should be given to the desirability of transferring flood control storage between reservoirs in the interest of maximum economic efficiency in consideration of all economic and environmental factors. The use of flood plain management alone or in conjunction with storage or other structural means should be evaluated as a means of increasing overall flood control efficiency. A certain minimum annual floodflow may be desirable in the interest of maintaining stream clearance and natural stream flushing actions.

Navigation

Navigation solutions that have been identified include a restricting lock at Bonneville Dam, potential for extending barge navigation to Wenatchee, Washington, and possible deepening of the deep-draft channel downstream of Portland, Oregon. Solutions are needed to the disposal of dredged material and the determination of alternative means of passing small recreational craft around projects to save lockage water.

Irrigation

The irrigation function at existing and proposed reservoirs should be reviewed and transfer of storage among reservoirs considered. Sources of supply for new irrigated lands and supplemental water for land now receiving less than adequate supplies need to be determined. The practice of pumping for irrigation from existing pools should be recognized and the overall effects evaluated.

Fish and Wildlife

Fish and wildlife resources in the Columbia River basin support some 19 million user-days of recreational fishing and hunting and contribute annually to a regional commercial fishery valued at over $26 million. The effects of peaking operations on the movement, spawning, survival, and harvest of anadromous and resident fish must be determined. Long-term solutions to reducing levels of nitrogen supersaturation must be determined and their relationship with present and potential future projects developed. Methods to preserve or enhance habitat consistent with other essential development should be developed and their relationship with present and potential future projects determined. Such plans as they are developed will reflect Columbia River Tribes concern – economic, social and cultural – for maintaining a viable fishery resource in the river and its tributaries.

Recreation

The Columbia River basin is rich in natural expanse, environmental diversity, and scenic quality. Two basic programs are needed to meet outdoor recreation requirements: one to preserve existing natural attractions, and the other to develop recreational facilities to accommodate growing demand. An overall regional master plan of recreational needs should be prepared and a determination made as to the part existing and planned projects contribute to the plan. There is a need for evaluation of further recreational development at existing projects and the effect of changes in project operation on recreation opportunity.

Municipal and Industrial Water Supply

At present municipal and industrial water supply needs are not a major problem on the main stems of the Columbia River. Areas where M&I water supply will be needed in the foreseeable future should be recognized and relationships with existing or potential future projects evaluated.

Water Quality

Water quality problems occur in many tributary streams during periods of extreme low flows and below metropolitan areas as discussed in the appropriate sections of Chapter VI. Water temperatures and nitrogen levels can affect anadromous fish on the main stem and major tributaries of the Columbia River System.

Problems are compounded by irrigation depletions and the quality of return flows. Where low flow augmentation may be desirable, its relationship with existing or planned projects should be determined.

Columbia River Estuary

As with any major river system flowing to the sea, there is an important relationship between conditions and activities in the river and in its estuary. The Columbia River estuary has been treated as a separate regional issue.

PROBLEM RESOLUTION

The magnitude and complexity of the problem is such that no final solution can be developed. Solutions and operating criteria developed must be flexible and adapted to a time frame for use. Solutions to the problem must be accomplished in a logical sequence of study. Prior to initiation of detailed study, however, a base system and project operation description depicting problems, areas of concern, and future needs must be developed.

The needs of the region run the full gamut of water and related land resource development. Accordingly, alternative solutions are numerous extending from no change or improvement on one side of the scale to individual single purpose solutions on the other.

Final selection of plans of implementation must be accomplished by a thorough review of the trade offs available in consonance with the system as a whole; i.e., trade offs between power operation and other river and shoreline uses; between power and flood operating run of river projects; and among such functions as irrigation, flood control, recreation, fish and water quality at existing projects.

Not all problems have the same degree of urgency. However, because of the interrelationship of the individual problems on a system basis all of them should proceed concurrently to assure that all problems and solutions are given equal consideration.

The Corps of Engineers has underway a study entitled "Columbia Rivers and Tributaries" (CR&T). The main thrust of the CR&T study is towards analysis of the existing Columbia River system in consideration of today's needs, and it will emphasize the possibilities for modification of existing projects or their operation. The study will give equal recognition to all uses and purposes consistent with sound planning while examining all reasonable alternatives. Hydroelectric power generation, flood control and navigation are the main economic justification for the existing main stem projects. However, answers are needed on desired operational and developmental improvements for fish and wildlife, irrigation, recreation, water quality, water supply, and other water uses. The ongoing Corps study is scheduled for completion in FY 1978.

While the CR&T study is system-wide in scope, its primary emphasis will be on feasibility-level review and analysis of existing main stem projects and those tributary projects which significantly affect the overall system. It will complement and be compatible with the Columbia-North Pacific framework study by addressing, in feasibility scope detail, many of the more urgent needs and problems found in that study. It was designed to derive data from and provide input to the Comprehensive Joint Plan of the Pacific Northwest River Basins Commission and the Westwide Study of the Department of the Interior. The reduction of scope of both the Westwide Study and the Comprehensive Joint Plan has resulted in less base data being available. Four areas where this is most evident are the areas of recreational planning on a regional basis, fish and wildlife inventory data, update of projected needs for navigation and update of projected flood control damages for the main stem river reaches.

CONCLUSIONS

1. Study to develop a multiple-use plan for the Main Stem Columbia River is urgently needed.

2. The Corps of Engineers CR&T Study can provide the basis for multiple-use plans. However, greater participation in the study is needed by environmental and recreational interests.

3. The CR&T Study needs to be expanded to develop any basic projections and resource inventories which are required for review of Columbia River system management and development. Such studies should continue to be closely coordinated with the Comprehensive Joint Planning Studies and State water planning activities underway in the region.

RECOMMENDATIONS

1. In order to provide information and participation on the above environmental and recreational data gap, the Fish and Wildlife Service, the Bureau of Outdoor Recreation, and State agencies should be funded to do the necessary studies.

2. Federal funds should be provided in FY 1976 to the appropriate agencies and study results coordinated by the Pacific Northwest River Basins Commission and the Corps of Engineers.

REGIONAL NO. 6 – WATER MANAGEMENT PROBLEMS OF THE COLUMBIA RIVER ESTUARY

SUMMARY

The Columbia River estuary is the largest and one of the most significant estuaries in the Pacific Northwest. It provides a major commercial ship artery for Columbia River ports such as Astoria, Longview, Vancouver and Portland. The estuary is also the entrance for the world-famous anadromous fish runs of salmon and steelhead to the Columbia River and tributaries. The estuary is also the home of numerous other types of animal and plant life. Competition between using the estuary in its natural condition for recreation, cultural, aesthetic, and sport and commercial fisheries, and development and use of the estuary primarily for commerce is a major issue facing the Pacific Northwest. Through wise planning, this valuable estuarine ecosystem can be protected and at the same time provide for outdoor recreation, fishing, navigation, and commercial development.

The Columbia River estuary is not badly polluted and yet it is fairly sterile in terms of fishery and shellfish resources for reasons that are not known. There are many small boat harbors in the estuary with berthing space for over 1,000 small boats. Three to four million cubic yards of sand are removed annually by dredging, particularly beyond the outer bar, in order to permit ocean-going vessels to enter the navigation channels without grounding.

DISCUSSION

In order to provide a base upon which solutions to existing and future problems may be developed and planning and management decisions for the estuary can be made, a critical need exists for a review of all available resource information on the Columbia River estuary including: biological inventories; the effects of seasonal upstream storage for flood control, power, irrigation, and other uses of the aquatic life in the estuary; effects of dredging on plant and animal life including the deposition of spoils; erosion and deposition patterns influenced by navigation facilities such as channels and jetties; and the effects of landfills. These are prerequisites for any management decisions for the estuary. While much information has been developed for the Columbia River estuary, nearly all studies of the estuary have been single purpose in scope. There has been no comprehensive study of the overall character of the Columbia River estuary. A need exists to undertake a special study of the estuary which will evaluate the interrelationships including problems and use conflicts between land, water, and biological factors leading to a land and water management program for the estuary.

Planning and inventory programs for the Columbia River estuary have lagged behind other Pacific Northwest estuaries because of its large size and interstate nature. Neither Oregon nor Washington can independently plan for and manage this mutual resource. For this reason, both states recognize the critical need for a special study of the Columbia River estuary which would inventory the biological and ecological character of the estuary and result in an effective plan and management program for the estuary in the interest of both commerce and the environment.

The State of Oregon, through the recently established Land Conservation and Development Commission (LCDC), will be developing statewide land use planning goals and guidelines and will be coordinating local and state land use planning efforts. LCDC will also administer the Coastal Zone Management Act funds. Within this framework the Oregon Coastal Conservation and Development Commission is responsible for developing a coastal zone management program, including the Columbia River estuary area. Closely associated to and an integral part of these efforts is the development of a state water management program and establishment of water use policies which is the ongoing responsibility of the State Water Resources Board. Various other organizations including state and local planning groups are also involved in planning and management of individual aspects of the estuary and surrounding area. These efforts can only be completed and implemented effectively for the Columbia estuary area through a coordinated joint effort of concerned agencies of both the States of Oregon and Washington.

The State of Washington, through the Department of Ecology, is developing basin water management programs for the different basins of the State. The water management program for the Columbia River estuary will be developed in conjunction with the Shorelines Management Program of the State, also under the direction of the Department of Ecology. Coastal zone management funds will provide some capability for this combined effort. Various other State and local planning agencies are involved in the planning and management of various aspects of the estuary and surrounding area. To be truly meaningful and effective, these efforts must be combined with similar planning activities occurring in Oregon under an overall management program for the Columbia River estuary.

At the Federal level, the Coastal Zone Management Act of 1972 provides for grants to states for coastal planning and implementation. Only recently have funds been released through the Federal Act and meaningful planning can only occur after needed data gaps have been filled. The ongoing Corps of Engineers' Columbia River and Tributaries Study is focusing primarily on the upstream problems and needs. Additional attention needs to be given to the estuary and to the relationships between upstream flows and estuarine conditions. A large portion of the total storage facilities on the Columbia River are federally developed.

The Pacific Northwest River Basins Commission recently adopted a two-part Federal-State-local study program for the Columbia River estuary: Part I – a 2 year special study to develop an initial overall management program for the estuary and associated areas; and Part II – a special study program which would develop an adequate data base for completion of a long-range estuary management program.

A management objective and program definition statement is being prepared and an inventory of planning information will begin shortly. Success of this program will depend on adequate state and Federal agency funding.

CONCLUSIONS

1. The States of Oregon and Washington can effectively complete and implement planning efforts and management programs for the Columbia River estuary area only through a coordinated joint effort of concerned agencies from both the States of Oregon and Washington and the Federal Government.

2. Due to the size and interstate nature of the Columbia River estuary, planning and information collection programs by Oregon or Washington have lagged behind those of intrastate estuaries.

3. There are some gaps in data concerning overall environmental characteristics and future economic considerations of the Columbia River estuary.

4. No planning program looking at the overall character including problems and use conflicts of the Columbia River estuary has been undertaken.

5. Recent Federal and State legislation has given emphasis and priority to planning the best use of coastal estuaries.

6. Adequate funding is not yet available from either Federal or State sources to carry out extensive studies, planning, or plan implementation.

RECOMMENDATIONS

1. The proposed State-Federal study to be coordinated by the Pacific Northwest River Basins Commission should be undertaken of the Columbia River estuary resulting in a planning and management program for the estuary.

2. Federal agencies, including the National Marine Fisheries Service, the Fish and Wildlife Service, the Bureau of Outdoor Recreation, the Forest Service, Soil Conservation Service, and the Corps of Engineers, should provide technical assistance including biological inventories, recreation needs, fresh water inflow requirements, navigation needs, and management plans for the estuaries.

REGIONAL NO. 7 – MAINTAINING AND IMPROVING ANADROMOUS FISHERIES IN THE NORTHWEST

SUMMARY

Stocks of anadromous Pacific salmon and trout which contribute significantly to sport and commercial fisheries and the historical way of life of the Northwest tribes have greatly declined from historical levels because of losses in spawning habitat, installation of impediments to upstream and downstream migration, deterioration of certain water quality parameters, deleterious changes in streamflow patterns, and high fishing pressure. Potential measures to meet needs for energy production, water supply, flood control, food and fiber production, and navigation may further impair fish habitat and migration. A well-defined plan for maintaining acceptable levels of fish stocks and habitat is needed so that this objective can be given adequate consideration in overall water development planning concentrated on implementing plan.

DISCUSSION

Catches of salmon and steelhead originating from northwest stocks were greatest during the latter part of the 19th century before the development of rivers for other uses. It has been estimated that the Columbia River system alone yielded about 50 million pounds of fish annually. Commercial landings declined generally from 1911 to 1960 to approximately one-half of the original amount.

A major contributor to the decline in fish stocks was the development of water control and diversion facilities on the rivers. Portions of important tributary streams such as the main stem of the Columbia River included fish passage facilities, but these caused delays in migration timing and fish losses. Important habitat once used by spawning fish was inundated and extensive sections of streams were dewatered by diversions during critical seasons of the year. Water temperature changes, introductions of dissolved gasses and other toxic substances, and increased loads of silt and wastes also contributed to the decline.

The period 1960 to 1971 shows a slight reversal of the trend. Stocks of fish and sport and commercial landings slightly increased during this period. This reversal can be attributed to the fish conservation and protection measures that were applied. These measures include the construction of additional fish passage devices at existing structures and natural barriers, improved fish-handling facilities, installation of screens at diversion dams, improved operating procedures that decreased physical injury and limited supersaturation of dissolved gasses, development or improvement of spawning habitat, and the operation of an extensive artificial propagation program. Practical research programs conducted by State and Federal agencies, coupled with the cooperative efforts of public and private agencies responsible for operation of water control facilities, contributed to the successful effort.

Unless adequate consideration is given to maintenance of fish runs they could decline. Modification of low-head dams on the Columbia and Snake Rivers to increase both baseload energy production and peaking power capacity will complicate already difficult passage problems but may relieve problems caused by supersaturation of dissolved gasses. Potential installation of new conventional and pumped-storage hydroelectric projects may post additional problems. Several steam-electric plants, power by nuclear energy, with attendant waste heat disposal are expected to be installed in the mid-term future which may impair fish habitat and migration if once-through cooling is utilized. Increased diversions for municipal and industrial water supply, particular in the Puget Sound area, and diversions for agricultural uses may further deplete productive habitat.

Previous studies have identified important salmon and trout spawning areas and documented locations where physical barriers to fish restrict or impair upstream or downstream movement. The type 1 and 2 comprehensive framework studies conducted in the Northwest identified major problems and problem areas and suggested additional studies but did not identify or adopt a specific plan for conservation and development of anadromous fish. Current studies are focusing on ways to improve water-quality conditions and fish passage at specific problem areas in the region.

Protection and enhancement of the anadromous fishery resources of the Northwest are of vital importance to the region and the rest of the Nation. Additional effort is needed to provide an anadromous fish protection and enhancement plan that assures continued production of this important food and recreation resource. The plan should be comprehensive in that it covers all important spawning, rearing, and fish passage areas necessary to sustain production. Such a plan would not only assist in the conservation and development of anadromous fish resources but would aid in balancing this use of northwest streams with other existing and proposed uses such as power generation.

The anadromous fishery has contributed toward ceremonial, subsistence, and trade activities of Pacific Northwest Indian tribes since time immemorial. Indian fishing rights in the Pacific Northwest are therefore related directly to the anadromous fish resource. Resource management must recognize these Indian fishing rights in planning and development of fishery programs.

Indians have an exclusive right to fish within their reservations. Off-reservation fishing rights of Indians are based on a series of treaties negotiated between the United States Government and Indian tribes in the mid-1850's. The latest development concerning Indian fishing rights is the decision of U.S. District Judge George H. Boldt in the case of United States vs. Washington rendered in Tacoma, Washington, on February 12, 1974. Judge Boldt clarified the rights of treaty tribes to take up to 50 percent of the harvestable salmon in the Puget Sound and Olympic Peninsula drainages and to have a significant role in the management of this resource. Expanded knowledge of the anadromous fishery is mandatory in order to successfully manage the resource so needs of the tribes and non-Indian users are met.

PROBLEM RESOLUTION

Alternative solutions to the problem include: 1. Continue to fit fishery conservation measures into water development programs working on problems as they arise on a case by case basis. 2. Gather significant basic data and develop a long-range, multipurpose plan emphasizing the preservation and enhancement of anadromous fish resources in advance of or in conjunction with long-range planning of water development programs.

CONCLUSION

1. While much basic data on anadromous fishery resources exists there still has to be developed an overall anadromous fishery conservation and development plan for the Northwest so that analysis of water development alternatives could include in detail the needs of the anadromous fishery resource.

RECOMMENDATIONS

1. The cooperative studies of the Puget Sound area, the Columbia River and tributaries, and coastal streams should be carried to the point where an anadromous fishery conservation and development plan can be developed.

2. The ongoing studies of the National Marine Fisheries Service, the Fish and Wildlife Service, the Pacific Northwest River Basins Commission, the State fish and game agencies, and other agencies on resolution of specific problems, should be continued and adequately funded. Cooperative Federal aid to the States for fish and wildlife and anadromous fisheries programs are of invaluable assistance in this effort.

3. The National Marine Fisheries Service should gather and assemble supplemental data, which would include an inventory of fish resources where this is not available or where usable data are lacking, present use of the resources, and an evaluation of the resources. This portion of the study would take 4 years to complete and require Federal funding for the studies throughout the Pacific Northwest.

4. The ongoing Comprehensive Joint Plan of the Pacific Northwest Basin Commission should assure coordination with and among these ongoing studies. Since anadromous fish have interstate, national, and international importance, Federal agencies participate fully.

5. Once the special studies have been completed, the National Marine Fisheries Service and other Federal and State fishery agencies could recommend level C studies where warranted.

REGIONAL NO. 8 – CONFLICTS OF WATER USE IN THE HELLS CANYON REACH OF THE MIDDLE SNAKE RIVER

SUMMARY

The 108-mile reach of the Snake River from existing Hells Canyon Dam to Lewiston, Idaho, represents one of the country's outstanding rivers with important hydropower potential and whose remoteness, wildlife habitat, natural beauty and fishery resources merit its consideration as a scenic or national recreation river. Proposals for preservation of this reach are pending in Congress. Various combinations of dams have been proposed by both public and private groups to develop up to 4,000 MW of power. Congress is expected either to determine the future use of the river by September 11, 1975, the date an existing Federal Power Commission's deferral of action on dams expires, or to impose its own moratorium. Adequate engineering and economic data are available to Congress from previous studies on a multitude of structural alternatives. Some environmental data and information on instream flow requirements are available, but more study of environmental aspects is needed for multiple objective planning studies regardless of the final decision as to the future of Hells Canyon.

DISCUSSION

The Snake River, in forming part of the boundary between Oregon and Idaho, winds its way northward through numerous rapids and deep pools in the deepest canyons in the world and one of the most spectacular gorges on the North American continent – Hells Canyon. Two principal tributaries – the Salmon River on the Idaho side and the Imnaha River on the Oregon side – parallel the main river for some distance in deep canyons. Local relief varies from elevations of about 9,000 feet in the Seven Devils Mountains on the Idaho side of the canyon to less than 900 feet along the Snake River near the mouth of the Salmon River. Hells Canyon has a solemn beauty characterized by steep valley walls, prominent beaches in scattered locations, and occasional low sandbars. The upland areas traversing both sides of the Snake River are both high and rugged.

This 108-mile reach from Hells Canyon Dam to Lewiston, Idaho, is the longest segment of the Snake River not presently harnessed for irrigation or hydroelectric power. The future management of this unique resource has been the subject of widespread attention in recent years. Specifically, the problem is a classic example of development versus preservation. Structural development would be one or more storage dams, reservoirs, and powerplants primarily for the production of hydroelectric power, but with the capacity to serve other water resource purposes as well. Nonstructural development would be to designate and manage this reach as a wild and scenic river or a national recreation area including provisions of flow regulation. Preservation would dedicate this area to the enjoyment of future generations in its wild and untamed condition.

The magnitude of this situation can be dimensioned by an examination of the many proposals brought forth over the years. These proposals included structural developments, both Federal and non-Federal; moratoriums; legislation; and additional studies. The structural proposals shown in figure V-10 can be summarized as follows:

In 1964, the Federal Power Commission (FPC) issued a license to the Pacific Northwest Power Company (PNPC), a wholly owned subsidiary of four private northwest power companies, for construction and operation of the proposed High Mountain Sheep Project. Legal action was taken to enjoin this project, and in June 1967 the U. S. Supreme Court remanded the license back to the FPC for further consideration of the alternatives of Federal construction or preservation of the reach in a free-flowing condition. In January 1968, PNPC and the Washington Public Power Supply System (WPPSS), an operating agency composed of 16 public utility districts in Washington, filed a joint application with FPC for a project with alternatives to the High Mountain Sheep site. The alternatives included Low Mountain Sheep-Pleasant Valley and Low Mountain Sheep-Appaloosa. On February 23, 1971, the hearing examiner of the FPC ruled favorably on this application for construction with the condition that construction could not begin before September 11, 1975.

In 1968, the Department of the Interior reported on a multiagency resource study which appraised alternative developments at five sites: Pleasant Valley, Appaloosa, High Mountain Sheep, Low Mountain Sheep, and China Gardens. All of these alternatives were considered primarily as power developments and included the functions of fish and wildlife, recreation, flood control, and water quality. Water temperature control for enhancement of anadromous fisheries was assumed as part of one of the plans.

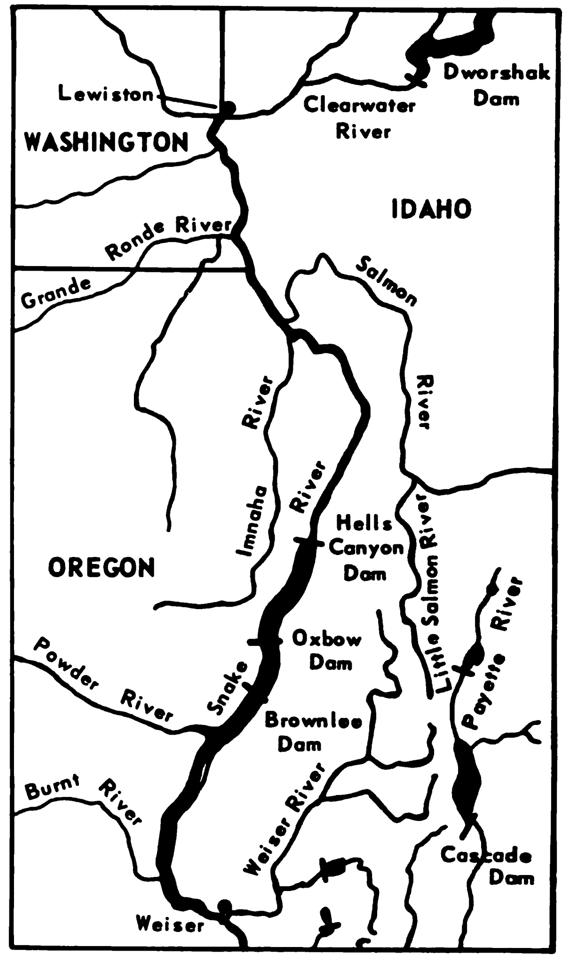


Figure V-10. Hells Canyon Reach – Middle Snake River.

Implementation of any of the dam plans, private or public, will irreversibly affect the natural environment and living resources of the Middle Snake. Unique, aesthetically important elements would be inundated, including wildlife habitat; sport fisheries for sturgeon, salmon, steelhead trout, smallmouth bass, and channel catfish; possible major archeological sites, and the last remaining unflooded segment of Hells Canyon.

Numerous proposals for nonstructural actions to preserve the river have been made in Congress. Identical bills to establish a Hells Canyon-Snake National River have been introduced every year since 1970. A bill to establish a Hells Canyon National Recreation Area has been proposed in the House of Representatives annually since 1970 and recently was also introduced in the Senate. A recent Bill introduced in both chambers brought forth a proposal to establish a Hells Canyon National Forest parkland. Annually, since 1969, proposals have been made to establish a moratorium on development of storage projects in the Middle Snake.

PROBLEM RESOLUTION

These several proposals differ in terms of boundaries, management concepts and objectives, and treatment of upstream water rights. None of these proposals have been approved by both Houses of Congress. Because of the widespread importance of and interest in the many ramifications of this issue, it must be considered in the near-term time frame. Alternative solutions seem to separate into these categories: reliance on Congressional action, reliance on Federal Power Commission action, or certain additional study.

Reliance on Congressional Action

The only existing moratorium – that of the Federal Power Commission – is scheduled to terminate in September 1975. It seems probable, in view of the intense National interest in the problems and alternative opportunities in the Middle Snake, that Congress will take some action prior to that date. Congress has already appropriated $4 million to the Forest Service for land acquisition from private holdings in the Middle Snake reach. Congress may decide to defer any final action by placing a moratorium to permit additional study if they feel additional answers are needed prior to a decision. However, the issue is clear – preservation of an outstandingly beautiful major river canyon in its natural state versus inundation of it or portions of it with reservoirs constructed primarily to produce hydro-electric power. It is doubtful if information additional to that which is available now would be helpful to the Congress in deciding this basic issue. Preferably, Congress should act promptly in resolving this issue so that firm plans for the future use of this important River can proceed.

Reliance on Federal Power Commission Action

Should Congress decide to take no action, it seems likely that the FPC would act on license applications for the projects in the Hells Canyon reach. It is also likely that, if a construction license is granted, a long, involved, court challenge would be forthcoming.

Additional Study

A multitude of studies have been made or are ongoing concerning the Hells Canyon reach of the Snake River. These are primarily engineering and economic studies of hydrodams. These studies cover the hydrodam potentials and with updating are adequate for decision-making and could be used for level C planning.

Through the CCJP and in cooperation with major Federal, State, and private interests, a study on the effects of varying flows in Hells Canyon has been made. The report has been issued. This study provides valuable information on instream flows. However, additional studies are needed to make the level of environmental data comparable to the engineering and economic studies.

If additional studies beyond environmental data gathering efforts are deemed as needed, they could be focused on a review of the existing studies, concentrating on a comparison of the recommendations made in each and an analysis and verification of the methodology and assumptions used and the results gained. Another study could be directed toward evaluation of the wild, scenic, and recreation values of this reach and make recommendations on inclusion in the National wild and scenic rivers system. It should be noted that most of the lands adjoining this segment of the Snake River are National Forest Lands, and thus, the Forest Service has full authority and responsibility for conducting a wild and scenic river study if and when such a study is authorized by Congress.

An important subissue relative to the alternative uses in the Hells Canyon reach deals with instream flows. Presently, the operation of the three upstream private power-producing dams, particularly at times of peak power, has a detrimental effect on boating and upon those recreational activities largely dependent upon boating. The existing Federal Power Commission's license for Hells Canyon Dam sets minimum flows at 5,000 ft^3/s or inflow, whichever is the least. Additional pressures have called for additional increases in the minimum flow in this reach of the Snake River. The State of Idaho has expressed concern that if these increased flows are honored as a fixed requirement, future upstream consumptive use development in Idaho could essentially be stopped or severely, curtailed.

CONCLUSIONS

1. The Middle Snake River is a highly regarded natural resource because of its environmental, fishery, and

recreational values in its free-flowing state, and because of its significant hydropower potential.

2. With some updating, existing engineering and economic data on hydrodam alternatives would be adequate.

3. Additional environmental data on instream flow value and other free-flowing values are not needed to permit the Congress to decide the basic issue of development versus preservation of the remaining undeveloped reach of Hells Canyon, but are needed for multiple objective studies of the Canyon regardless of how the basic issue is finally decided.

RECOMMENDATIONS

1. Congress should decide promptly the basic issue of development versus preservation of the remaining undeveloped reach of Hells Canyon at the Snake River.

2. Environmental studies, especially of instream flow values for recreation and fish and wildlife, should be expanded and conducted by the Forest Service, the Fish and Wildlife Service, the Bureau of Outdoor Recreation, the Bureau of Land Management, and the States as a basis for the multiple objective planning for the future use of Hells Canyon regardless of decision on the basic issue. The Pacific Northwest River Basins Commission should continue its role of coordinating these study efforts.

3. If Congress defers action and requires further analysis before making a final decision on the disposition of Hells Canyon, a multiple-objective planning study should be made. To be most effective, this study should be a level C interagency effort.

REGIONAL NO. 9 – EROSION AND SEDIMENTATION IN THE PALOUSE REGION OF THE NORTHWEST

SUMMARY

Nowhere are soil erosion and sediment production greater than in the nonirrigated grain lands of the Palouse region of the Pacific Northwest. Here, soil is wasted by erosion at one of the highest rates anywhere in the United States. Water, wind and improper tillage have stripped irreplacable topsoil from cultivated grain lands for more than half a century. Dust pollutes the air as much as a hundred miles downwind from the eroding fields and creates a traffic hazard on highways and roads. Soil washed from eroding fields ends up as sediment in highway ditches, ponds, reservoirs and streams. Once clear, mountain-fed streams have become polluted and unfit for human consumption, industry, recreation, or for use by fish and other wildlife.

DISCUSSION

The Palouse covers an area centered in 25 counties in eastern Washington, northwest Idaho and northeastern Oregon. Its nonirrigated grain lands comprise about 8.4 million acres of cultivated land. Slopes as steep as 50 percent are cultivated, the "average" slope being in the range of 15 to 25 percent. Rainfall ranges from 12 inches in the dry western portion to over 20 inches in the eastern mountain footslopes. Runoff varies from 0.5 inch to over 5 inches on an average annual basis.

The Palouse is blessed with an ideal climate and soil for production of grain and continues to be one of the Nation's most productive regions. The Palouse averages an annual output of more than 120 million bushels of wheat, produces 80 percent of the Nation's bluegrass seed, most of its lentils, and large quantities of barley and dry peas. Loss of this basic soil resource continues in a period when increasing population calls for ever-increasing world agricultural production.

The Palouse area has been identified as a major source of sediment in the Snake and Columbia Rivers. During the period 1961-1966, the Geological Survey has measured the sediment load on several streams in the area. During this time, the following maximum sediment loads for a single 24-hour period were measured:

- On the Palouse River at Hooper, Washington – 2,100,000 tons 2-5-63
- On the Tucannon River at Starbuck, Washington – 1,600,000 tons 12-22-64
- On the John Day River at McDonald's Ferry, Oregon – 3,800,000 tons 12-22-64
- On the Deschutes River at Moody, Oregon – 1,820,000 tons 12-23-64

The heavy sediment loads of the Palouse and Tucannon Rivers enter the Snake River in a reach which is being developed for navigation to the Clarkson-Lewiston area. Four major navigation dams have been or are being built in this reach. The Corps of Engineers originally considered location of water-based recreation sites of 27 places along the Lower Snake River in connection with the multipurpose dams being built there. Plans were abandoned for developing 24 of these because of acute sedimentation hazard. In a period of 9 years, sediment dropped at the mouth of the Walla

Walla River has resulted in the abandonment of two marinas.

Sediment washed from sloping lands accumulates in highway ditches, in ponds or reservoirs, or blocks rivers and streams. In Whitman County alone, $400,000 are budgeted annually to remove sediment from the county road system and this doesn't keep up with the problem. Information from the county engineers in the 13 counties in Washington indicates there are more than 15,000 miles of roads and highways under their jurisdiction. The engineers estimate that about 4,000-5,000 miles are frequently, if not annually, damaged by sedimentation originating on farmlands of the area. There are approximately 1,500 miles of primary or secondary State and Federal highways in the 13-county area. About half of this is subject to damage by water erosion and sedimentation. The State Highway Department uses special erosion controls, including vegetative and mechanical measures on their rights-of-way.

In this wheat-producing area, reservoir capacity must be doubled over that normally needed, with the additional capacity required to handle sediment which will be deposited during the expected life of the reservoir.

Since 1939, the Soil Conservation Service has made a survey each year of the amount of water erosion on the 1 million acres of cropland in Whitman County, Washington, typical of Palouse cropland. Twenty-nine years of records show the estimated average annual loss of soil has been 9.5 million tons, or 9.5 tons per acre. During four of these years the loss was estimated to be more than double that amount, with the greatest loss set at a figure of 21.7 million tons. Total soil loss loads calculated by SCS are higher than stream loads because soil loss includes all soil that has been moved, not only that reaching the stream channels. It is estimated that downhill plowing and other cultural operations will eventually remove all topsoil from about 25 percent of the land if it is kept under cultivation. (See table V-12.)

Table V-12.—*Annual soil loss by water erosion Whitman County, Washington*

Erosion year[1]	Precipitation during runoff season[2] (inches)	Soil loss[3] This year (millions of tons)	Soil loss[3] Five-year moving average (millions of tons)
1939-40	14.56	11.5	–
40-41	18.10	8.0	–
41-42	13.86	20.0	–
42-43	18.88	12.0	–
43-44	8.34	2.0	10.7
44-45	12.96	2.0	8.8
45-46	21.47	20.0	13.2
46-47	12.58	1.0	7.2
47-48	21.71	16.0	8.2
48-49	16.46	5.0	8.8
49-50	17.49	9.0	10.2
50-51	17.31	10.0	8.4
51-52	16.98	7.0	9.4
52-53	17.77	7.5	7.7
53-54	14.22	5.0	7.7
54-55	10.68	6.0	6.9
55-56	18.79	9.0	6.9
56-57	12.14	5.0	6.5
57-58	14.10	8.5	6.7
58-59	16.14	9.5	7.6
59-60	13.13	11.5	8.5
60-61	–	8.5	8.6
61-62	–	11.3	9.9
62-63	–	21.9	12.7
63-64	–	7.8	12.5
64-65	–	15.9	13.2
65-66	–	3.4	12.1
66-67	–	3.4	10.5
67-68	–	17.6	9.6

[1] Period September 1 through March 31.
[2] U.S. Weather Bureau data for Colfax, Washington.
[3] Data compiled by Field surveys – Verle G. Kaiser, agronomist, SCS.

The detailed soil surveys in the Palouse area indicate that in 70 years of farming all of the original topsoil has been eroded from about 10 percent of the land and from one-fourth to three-fourths of the original soil has been removed from an additional 60 percent of the cultivated area. Many fertile bottomlands are covered with silt deposits up to 5 or 6 feet deep.

Three factors interrelate to cause water erosion in this area. They are (1) soil and slope characteristics, (2) climate characteristics, and (3) man's treatment of the land. In virgin condition under perennial grass cover, the soil resisted erosion quite well. It had a deep moisture-storing profile, and the surface soil absorbed water readily because of the high content of organic materials. In 70 years of cultivation, about half the original organic matter and much of the soil structure have been destroyed on lands vulnerable to erosion, and the resulting soil surface is less permeable, more subject to freezing, and is eroded more easily by runoff. Many soils are underlain by finer textured materials, pumice, caliche, or other conditions which aggravate runoff when exposed to the surface.

Frost in the ground at the time of heavy precipitation or snowmelt increases runoff and erosion. Research indicates that in silt loam soils, little or no water penetrates the soil when temperatures are 28° F or lower. Ice crystals fill the air space in the soil and block water movement. Much of this area can expect frozen soil 6 to 8 winters in each 10, and practically all of the area has frozen soil 3 to 5 winters in 10.

With frozen ground, runoff from rain will occur on practically all slopes. It is a strange paradox that crop yields would be increasing in an area with declining soil resources, but this is true in much of the Palouse region grainlands. And, the complacency this induces in farmers and the public alike is an important block to getting more soil and water conservation applied on the land.

A critical analysis of grain yields reveals there is cause for alarm about the heavy soil loss, and that ultimately continued erosion will seriously damage the productive capacity of the land.

Since 1934, the average yield of wheat per acre in Whitman County has increased from about 26 bushels per acre to over 50 bushels per acre. During the same period, erosion was removing an average of 9.5 tons of soil per acre each year. An average of 0.25 ton of soil was lost by erosion for every bushel of wheat produced during this period. About 30 percent of this erosion leaves the farm as sediment. A quick analysis shows that two to three times as much sediment is produced from farming in this county as there is wheat.

Even though yields have been increasing due to improved technology, most of this increase is coming from the good soil areas in each field – from areas where the original fertile topsoil has had only slight erosion damage. As an example hilltops with eroded topsoil produced an average of 15 bushels per acre in the 1930's. With today's improved technology, they produce an average of 35 bushels per acre, for an increase of about 20 bushels per acre. In both situations, grain yield barely paid or pays cost of production. Areas on lower slopes with about 2 feet of topsoil produced 50 bushels per acre in the 1930's and now produce 110 to 140 bushels per acre. This is an increase of 60 to 90 bushels per acre due to improved technology. (See table V-13.)

Wheat has long been the most profitable crop produced in the Palouse region nonirrigated area. Total income, as well as income per man-hour invested by the farmer, is highest from wheat. Therefore, the wheat allotment program which restricted wheat acreage has had a powerful influence on income, on land values, on cropping systems, and on land treatment.

Table V-13.—*A comparison of wheat yield and soil erosion on different areas of the typical Palouse hill*

Location on hill	Land capability	Wheat yields 1950-1960[1] (bu/ac)	Wheat yields 1960-1965[2] (bu/ac)	Erosion (losses[3] (tons/ac)
Lower south slope	II_e	50	110	5
Upper south slope	III_e	35	75	9
Hilltop	IV_e	15	35	15
Steep north slope	IV_e	25	40	30
Lower north slope	III_e	40	80	12
Foot slopes and bottomland	II_e	50	120	3

Data from a variety of published and unpublished materials.

[1] Using common varieties of wheat in use prior to Gaines and with limited fertilization.

[2] Using Gaines wheat with optimum rates of commercial fertilizers.

[3] Soil erosion losses are average for wheat-pea and wheat-fallow systems for wheat production year.

The original allotment was based on "wheat history" and this rewarded the farmer who had been raising wheat on the highest percent of his total acres, regardless of the suitability of such land for wheat production. On the other hand, farmers who, at the time allotments were set up, had less land in wheat, because they had planted grass on erosion-vulnerable fields, had a lower wheat allotment and thus reduced income.

This condition ultimately affected land values, and a farm with the highest "wheat base" sold for the most money regardless of the actual productive capacity of the soil since "wheat base" could be transferred from one piece of land to another under a single farm operation.

In spite of the fact most of these inequities have been corrected by adjustment of "wheat base," by instituting a "bushel control" in addition to "acre control" and by other means, the fear of losing allotment history by having part of the farm in grass at the time the base is established still exists in the minds of most farmers. It is a powerful force dissuading the planting of grass or trees on erosion vulnerable lands. These and many other reasons can be set forth to explain why past efforts at controlling erosion have not been successful in the Palouse. Table V-14 shows that as far as Whitman County, Washington, is concerned, soil loss is continuing at least at the rate as in prior years. Most of the classes VI_e and IV_e land which should not be cultivated is still in production and a very low percent of the needed conservation measures on the other cropland has been implemented.

PROBLEM RESOLUTION

Solutions to the erosion problems in the Palouse will be found in a combination of society's realization of the long range adverse effects of continuing current cropping practices and the implementation of the most effective erosion control and land and water management practices. Application of balanced livestock and grass-grain production enterprises would do much

Table V-14.—*Status of needed adjustments in land use, nonirrigated land (acres)*

County	Land poorly suited for cultivation[1]		Land not suited for cultivation[2]	
	Now cultivated	Now in conserving uses	Now cultivated	Now in conserving uses
Adams, WA	153,284	1,453	21,505	752
Asotin, WA	34,561	1,035	4,878	709
Benewah, ID	30,811	3,895	2,658	105
Benton, WA	36,889	194	6,591	2,626
Clearwater, ID	18,218	2,667	0	0
Columbia, WA	39,177	1,667	12,513	350
Douglas, WA	12,029	3,569	0	0
Franklin, WA	56,052	2,018	22,790	1,211
Garfield, WA	16,734	235	18,790	4,855
Gilliam, OR	5,318	483	8,449	444
Grant, WA	20,096	3,144	5,229	522
Idaho, ID	60,356	24,413	1,974	0
Klickitat, WA	11,352	415	1,059	830
Kootenai, ID	36,567	9,587	2,181	0
Latah, ID	144,546	11,889	30,999	3,111
Lewis, ID	76,758	4,576	1,306	0
Lincoln, WA	141,405	12,629	2,635	0
Morrow, OR	38,431	7,817	9,142	0
Nez Perce, ID	107,338	35,310	1,954	0
Sherman, OR	36,718	7,200	339	339
Spokane, WA	56,278	16,319	4,748	1,857
Umatilla, OR	40,815	6,500	17,070	1,687
Walla Walla, WA	81,844	2,465	9,501	616
Wosco, OR	32,044	2,709	2,826	285
Whitman, WA	181,966	15,201	63,797	3,640
Total	1,469,588	187,390	252,934	23,939

[1] Mostly class IV_e soils in this class are highly vulnerable to erosion; because of this severe limitation, they require erosion control practices and very careful management if occasionally cultivated.

[2] These class VI_e soils have erosion hazards so great that they are unsuitable for cultivation. Their use should be limited to range, woodland, wildlife or recreation.

Source: 1968 Washington CNI data (tentative)
1967 Idaho CNI data
1971 Oregon CNI data.

toward securing proper land use on the most hazardous acres. While many landowners have carried out effective erosion control practices as shown in table V-15 much work remains to be accomplished. A program that would result in acceleration of the implementation of erosion control measures is needed.

Although data have been collected concerning the onsite damage from erosion, similar data of the offsite sediment and water quality impacts are not available. The data are badly needed to support effective programs in this area.

CONCLUSIONS

1. The acreage allotment programs and the economic incentives of wheat farming in this region have outweighed the conservation incentives and efforts.

2. Full cost of the consequences of high soil erosion both of long-range land depletion and off-farm sediment damage has not been taken into account by the farmers.

3. More information and studies are needed to show the true value and consequences of land depletion over time and of sediment damage and water quality degradation.

4. More research and educational efforts are needed to show the value of a grass-livestock alternative in the areas with the steeper more erosive lands. (Washington is a beef importing State.)

5. Biologically, this area has been referred to as a "wheat desert." Land use changes which would bring about more grass, shrubs, trees and water would greatly improve the wildlife and recreational values.

6. The productive capacity of the best cropland must be protected and used to meet future food and fiber requirements. A conservation program carefully adapted to the regional problems involved is required because National conservation programs generalized to fit average conditions over the nation have not been sufficiently effective in this area.

RECOMMENDATIONS

1. The Washington Conservation Commission has recently requested funding from the Environmental Protection Agency for a pilot study to be made on the environmental impact of land use on water quality in the Palouse region. The request was turned down for the reason that similar studies are already under way in the Maumee River basin in Indiana and Ohio. Because there are no similarities between the hilly Palouse region and the lake bed Maumee River basin, the request of the Commission should be reconsidered and undertaken.

2. A detailed special sedimentation study of the streams in the Palouse region should be made. More information is needed on the sediment load carried by the streams entering the Snake River in this area and the impact of the sediment in the stream systems. Social costs of these offsite sediment effects are essential to formulate acceptable solutions.

3. The States of Washington, Idaho, and Oregon and Department of Agriculture should reconsider the priority for completing the ongoing type 4 studies in the Palouse area. The detailed sedimentation study should precede the completion of the type 4 studies. Information from the special studies will allow better formulation of plans and programs for implementation.

Table V-15.—*Selected erosion control practices on the land and needed in nonirrigated grainland area of the Palouse region*

Practice	Approximate amount now on the land[1]	Approximate percent of total needed[2]
Diversions and terraces	1,345 miles	5 to 10 percent
Stripcropping	116,160 acres	5 to 10 percent
Grasses waterways and outlets	43,250 acres	10 to 20 percent
Stubble mulch	1,530,000 acres	35 to 50 percent
Chiseling and subsoiling	824,300 acres	25 to 40 percent

[1] Data from SCS-99 Reports — 1967 FY.
[2] By estimation.

CHAPTER VI
STATE SPECIFIC PROBLEMS

INTRODUCTION

This chapter concentrates on those critical water and related resource problems found in each of the 11 Westwide States. The chapter is divided into 12 sections; 11 of these present information on the State specific problems, the final portion consists of a series of tables summarizing the studies recommended through the Westwide effort for initiation during the FY 1976-FY 1980 time frame.

Each of the State specific portions of this chapter contains a very concise setting, including details on the State's water supplies and overall water quality. The major portion of each State section is devoted to the critical problems. Some Westwide and regional problems are discussed in grater detail in the State sections where additional information is available.

Each State specific problem is dimensioned to the extent of a brief overall summary, a discussion of the problem, possible means of resolving it, conclusions reached, and recommendations drawn. It is important to recognize that only the more important unresolved water and water-related problems are being presented. There are many other problems in the West that are being addressed by ongoing action programs. Each of the 11 Westwide States has an active natural resources program and all are doing a commendable job in managing the water and related resource activities within their preview. As set forth in this report, the recommended study program is in no way an attempt at a complete treatise of all water and related resource study needs in the West.

ARIZONA

The desert Southwest has one of the fastest rates of population growth in the United States. The generally mild climate, the abundant recreation and scenic attractions, and the strong retirement appeal of the land have created a tremendous surge in population expansion and in commercial and industrial development since World War II.

Arizona's 1970 population was 1,772,000, ranking fifth in the 11 State Westwide area. However, the State's population increase of 36 percent between the 1960 and the 1970 census ranked third nationally. The State projects a 50.3 percent population increase during the 1970-1980 decade, while the Federal Office of Business Economics projects a 25 percent growth. The growth from April 1970 to July 1973 was 14 percent.

Economic growth in Arizona has been as dynamic as that of population. This fact is indicated by the gain during the past 10 years in nonagricultural employment of 77 percent, ranking first nationally. Arizona ranks second nationally in growth of personal income over the past 10 years, with a gain of 162 percent. The State's economy has diversified from a raw material base to one of manufacturing, tourism, agriculture, and mining. Arizona consistently produces over 50 percent of the Nation's copper.

The State remains one of open spaces with a population density of only 15.6 persons per square mile. With 114,000 square miles, it is the sixth largest State nationally. Over 75 percent of the population is concentrated in the metropolitan centers of Phoenix and Tucson, making this a densely populated area in the south-central part of the State.

The Federal Government owns 32 million acres or 44 percent of the land. An additional 20 million acres or 27 percent is in federally administered Indian Trust lands. Private ownership totals 16 percent, with State, county, and municipal ownership making up the balance.

There are approximately 114,000 Indians residing on the 19 reservations in the State. Though per capita income of the Indian population is less than half that of the non-Indian population, considerable progress has been made.

WATER SUPPLY

The annual renewable water supply available for use in Arizona totals 5.0 million acre-feet and consists of:

1. Entitlement to 2.85 million acre-feet of Colorado River water annually by a body of law referred to as the "Law of the River."

2. Local runoff amounting to 1.96 million acre-feet annually originating within the State. (Excludes runoff directly tributary to the Colorado River.)

3. Tributary inflow to the State of 215,000 acre-feet annually.

Water deficiencies are met through utilization of ground-water reserves where available. The pumping of these reserves has reached nearly 5 million acre-feet annually, resulting in an overdraft of 2.5 million acre-feet.

Surface Water

Nearly all of Arizona is drained by three interstate river systems: the Colorado River and its tributaries, the Gila River, and the Little Colorado River. Almost complete use of the water of the Gila River and its tributaries has been made possible by the impoundment of the variable runoff at the higher elevations and by making releases from storage at or near where the river emerges into the desert. Spills from the system originating from infrequent floods are estimated to produce an average outflow at the Gila subregional boundary of 100,000 acre-feet annually.

The total renewable water supply available in the Gila subregion totaled 1.7 million acre-feet annually while the estimated 1975 depletions total 4.2 million acre-feet, including the use of ground-water reserves. The completion of the Central Arizona project scheduled for 1985 will provide an average of about 1.2 million acre-feet annually to partially alleviate this deficiency. Tables VI-1 and VI-2 summarize Arizona's estimated 1975 depletions and water supply situation.

Ground Water

Nearly all of the ground-water overdraft occurs in the Gila subregion where nearly two-thirds of the water used is supplied from ground water. Overdraft has reached about 2.5 million acre-feet annually. Water levels are declining, pumping costs increasing, and ground subsidence has created serious problems in many areas.

In the lower main stem subregion, water drawn from the Colorado River by underground pumping is recognized as Colorado River water and must be accounted for under Arizona's apportioned share of mainstream river water.

There are undeveloped ground-water resources with potential to meet some of the State's water requirements. Remoteness, low yield, poor water quality, and low storage capacity of individual basins have been major deterrents to the development of the resource. Any significant pumping would be a mining operation of limited duration.

Ground-water development in the Little Colorado subregion is minor. Low yields of wells in some areas and the high salinity of the ground water in parts of the aquifers in other areas have discouraged extensive development.

Water Quality

Generally, the quality of local surface water is adequate for municipal, industrial, and agricultural uses. The quality of these local surface waters is expected to remain about the same in the future.

The most critical local water quality problems are expected to occur in the highly developed area of central Arizona. The deficient water supplies and probable high cost of future imported water dictate maximum water utilization, including recycling, with little or no allowance for transporting salts or waste loads from the area, resulting in the ground-water reservoir being the ultimate depository. The continual depletion of the ground-water reservoir further aggravates this situation as poorer quality water is encountered in the deeper aquifers.

Water quality in the Little Colorado subregion varies between high-quality water in the upper tributary areas to poor in the middle and lower reaches of the system. A major water quality problem is sediment. The chemical quality of the ground water also varies greatly with the dissolved solids content ranging from 90 to more than 60,000 mg/l.

On the lower main stem of the Colorado River, salinities in 1973 averaged 735 mg/l at Hoover Dam and

Table VI-1.—*Estimated 1975 surface water-related situation in Arizona*

(1,000 acre-feet)

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within sub-region or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Upper Colorado									
San Juan-Colorado	[5]50	[6]0	–	50	0	35	15	0	15
Total region	[5]50	0	–	50	0	35	15	0	15
Lower Colorado									
Little Colorado	31	364	–	395	[9]15	98	282	0	282
Gila	184	1,594	[9]15	1,793	–	1,693	100	0	100
Lower Main Stem	[7]2,800	0		2,800	0	1,100	1,700	[8]1,700	0
Total region	3,015	1,958	[9]0	4,973	[9]0	[10]2,891	2,082	1,700	[10]382
State Summary	3,065	1,958	[9]0	5,023	[9]0	2,926	2,097	1,700	397

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] Arizona's Upper Colorado River Basin Compact apportionment.
[6] Upper Colorado Region portion within northern Arizona is assumed insignificant as a source of supply and depletion area. For simplicity, depletions are assumed equal by 1975.
[7] Arizona's apportionment under the Colorado River Compact.
[8] All supplies are committed to Arizona Colorado River users or CAP Diversions.
[9] There are no out-of-state imports into Arizona. The 15,000 shown under the Gila subregion is an intersubregional import from the Little Colorado.
[10] Colorado River lower main stem system losses and reservoir evaporation of about 1,760,000 acre-feet are not included in depletions nor considered in determining modified and net water supply.

Table VI-2.—*Estimated 1975 total depletions*[1] *for Arizona*

(1,000 acre-feet)

Region and subregion	Function								Total depletions
	Irrigation	M&I including rural	Minerals	Thermal electric	Recreation[2] F&WL	Other	Reservoir evaporation	Consumptive conveyance losses	
Upper Colorado									
San Juan-Colorado	7	1	–	25	1	1	–	–	35
Total region	7	1	–	25	1	1	–	–	35
Lower Colorado									
Little Colorado	48	6	3	1	6	17	17	–	98
Gila	3,200	186	63	6	10	[5]650	120	–	4,235
Lower main stem	987	17	3	0	72	18	[3]3	–	1,100
Total region	4,235	209	69	7	88	685	140	–	5,433
State summary	4,242	210	69	32	89	686	140	–	[4]5,468

[1] Includes surface water, surface related ground water, and mined ground water.
[2] Exclusive of instream flow use.
[3] Does not include estimated Colorado River lower main stem and reservoir evaporation losses of about 1,760,000 acre-feet.
[4] Surface water depletions—3,001,000; ground-water depletions—3,122,000; includes 2,500,000 of mining in the Gila Subregion.
[5] Includes an estimated 600,000 acre-feet of losses associated with water reclamation and recycling in the Gila Subregion, livestock consumption and stock pond evaporation.

865 mg/l at Imperial Dam. With the higher Colorado River water supply in recent years, the average salinity at Hoover Dam was 705 mg/l in 1973 and 845 mg/l at Imperial Dam.

CRITICAL PROBLEMS

The major interfaces of the appropriate Westwide and regional problems in the State of Arizona are discussed in this section. The Westwide and regional problems dimensioned in this portion of the Arizona presentation provide additional State specific information not contained in the Westwide and Regional writeups in Chapters IV and V. This portion concludes with detailed presentations of State specific problems. Figure VI-1 presents the approximate locations of Regional and State specific problems found to be critical in Arizona.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – On the Colorado River a combination of water development projects and increasing population pressures has resulted in a deterioration of fish and wildlife habitat throughout a portion of the river's length. Located in proximity to two major population centers (Los Angeles and Phoenix), the river attracts many thousands of people annually for water-oriented recreational use. Recreation demands are continually increasing. There are no practical alternative outlets for the particular type of opportunities afforded by this area, and there is a special need to protect and manage the recreational and fish and wildlife resources. Along the Arizona-California border, only about 74 miles of the river remain that are not inundated by major river storage and diversion facilities. These reaches are (1) Topock – 14 miles, (2) Parker – 20 miles, and (3) Imperial – 40 miles.

There is a continuing interest in water salvage programs which would convert bottom land wildlife habitat including wetlands into cleared flood plains and which would channelize the river so that the water which now supports this habitat can be diverted to other uses. Similar interest in these programs exists in the Gila subregion with corresponding threats to big game, small game, waterfowl, threatened fish and wildlife species, and unique plant and animal assemblages related to very specialized habitats.

While ongoing and future water development studies will include funds for related environmental studies, there is an additional need to collect critical basic environmental data throughout the State. These data will be very useful at the initiation of water development studies for the formulation of environmental quality plans.

There is a special Federal interest and responsibility in riparian, wetlands, and stream environments in Arizona related to threatened fish and wildlife species and in waterfowl which depend on critical elements of these habitats. Specific environmental data needs are: instream flows on the Salt, White, and Black Rivers and headwater streams in Indian reservations and the completion of statewide wetlands inventory.

In this fragile, arid environment, remaining streamflows, both surface and subsurface, contribute to the quality of life and to the retention of the riparian nucleus of wildlife habitat. To provide adequate information to the planning process, the specific instream flow requirements to maintain fish and wildlife habitat throughout the year must be determined.

NO. 6 – NEED FOR ADDITIONAL FLAT WATER RECREATION OPPORTUNITIES. – The major recreation-oriented reservoirs are along the Mogollon Rim and on the Colorado, Salt, Aqua Fria, and Gila Rivers. The five major resources on the Colorado River are by far the most visited water-oriented recreation resources in the State. A unique situation exists with respect to the main stem impoundments of the Lower Colorado River. These reservoirs, although more than 150 miles from Los Angeles and Phoenix, nevertheless receive heavy recreational use from these population centers. As discussed later in this chapter, there are Federal reservoirs in California recommended for early priority study to determine their ability to provide for recreational demand.

In Arizona, reservoirs of the Salt River project located about 40 miles from Phoenix are also recommended for high priority study. They include Roosevelt, Apache, Saguaro, Canyon, Horseshoe, and Barlett reservoirs.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. – One Arizona river, the Salt, from its source to Stewart Mountain Dam, has been included in the

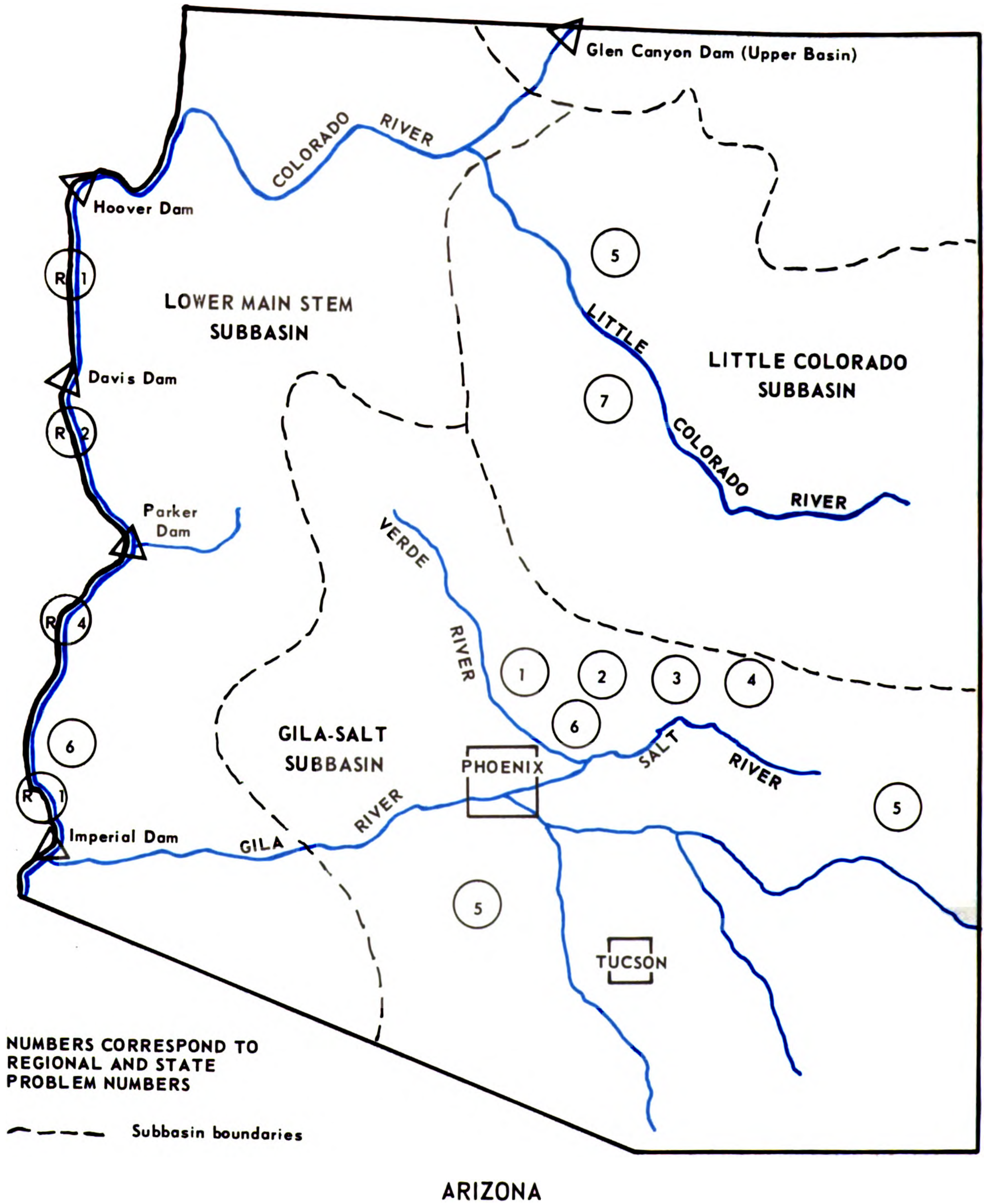


Figure VI-1. Critical water problems in Arizona.

new "Administration bill," supported by the Secretary of the Interior, which calls for study of 16 high-priority rivers within the Westwide States (in addition to 16 other rivers in other states) to determine their potential for addition to the Wild and Scenic Rivers System. Other Arizona rivers identified by the State Study Team as having significant free-flowing values include the Gila, White, Black, and lower Colorado.

Regional Problems

Arizona's direct interest in the regional problems relates to water quality and quantity in the Colorado River and management of the resouces of the lower main stem. Specific information can be found in the following Regional Problems which are presented in chapter V.

NO. 1 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

NO. 2 – INCREASING SALINITY IN THE COLORADO RIVER

NO. 4 – MANAGING WATER AND RELATED LAND OF THE LOWER COLORADO RIVER MAIN STEM

State Specific Problems

The particular problems which the Arizona State Study Team have identified and in which the Federal establishment has a major interest are those problems involving public lands, Indian land and water resources, use of the fragile desert environment, quantity and quality of water supplies, flood management, and potential energy development. The specific problems are:

NO. 1 – OVERUSE OF SURFACE AND GROUND-WATER SUPPLIES IN THE LOWER GILA-SALT RIVER BASIN

NO. 2 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 3 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 4 – CHRONIC FLOODING IN DEVELOPED AREAS OF THE STATE

NO. 5 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

NO. 6 – CONFLICT OF WATER ALLOCATION BETWEEN WILDLIFE RIPARIAN HABITAT AND OTHER USES

NO. 7 – INSUFFICIENT WATER SUPPLIES FOR ANTICIPATED OUTLYING URBAN GROWTH

NO. 1 – OVERUSE OF SURFACE AND GROUND-WATER SUPPLIES IN THE LOWER GILA-SALT RIVER BASIN

SUMMARY

The central Arizona water resource development situation is one in which the attractive climatic conditions and advantageous agricultural position have led to an economy in the Phoenix-Tucson area which is over-extended in its use of its water resource. As a nationally attractive home for more and more citizens, the competion for the limited water supply also involves land use competition as lands now in agriculture convert to other uses.

The present economic structure of Arizona is the product of past water resource development. Prior to the construction of Roosevelt Dam, completed in 1911, on the Salt River, less than 20,000 people struggled to survive in the desert of central Arizona. Today, nearly 1 million people living in the valley have far outstripped the water demands of safe water yields. Demands are being met through the mining of ground water. Currently, over half of the water use is supplied by groundwater mining. The favorable climate which permits activities such as irrigated agriculture, construction, tourism, and outdoor recreation the year around has stimulated growth. The mobility and affluence of today's society, earlier retirement, and the trend toward greater outdoor enjoyment continue to have an increasing influence on the immigration to the State with resulting increased water needs. The Framework Studies estimated that the water depletion requirements in Arizona would increase about 1.1 million acre-feet between 1965 and 2000.

DISCUSSION

Irrigated agriculture became of major importance to the economy of central Arizona in the early 1900's with the construction of the Salt River project. Another major impetus for expanding irrigation resulted from post-World War II technological improvements in ground-water techniques and from the increasing availability of low-cost power. With the physical and economic means provided for tapping the vast ground-water reservoir, cropped acreage increased. In 1971, there were 1,200,000 acres irrigated. Although some irrigated land has gone out of production because of declining ground-water levels and increasing urbanization, this has been offset by the development of outlying ground-water basins and the expansion of irrigation on Indian reservations.

At the present time, nearly all crop production in the State is dependent upon irrigation. About 95 percent of this is located in the lower semiarid desert areas, where a variety of crops can be grown. Vast areas are suitable for irrigation, but the major factor in determining the location and size of the cultivated lands has been the availability of suitable water supplies. The underground reservoir of good quality water has been tapped increasingly over the past two decades. By 1972, this had resulted in a net ground-water overdraft of 2.6 million acre-feet annually. While there is a large underground storage of water in Arizona, the major depletion has occurred in the irrigated areas.

The growing population and rapidly expanding manufacturing industries have also required increasing quantities of water. These supplies have been obtained from ground-water exploitation and from transfers of use from agricultural lands.

Extensive use has resulted in a serious lowering of the water table amounting to as much as 20 feet per year in some heavily pumped localities. In central Arizona, the water table had declined to an average of 250 feet below the surface. As ground-water supplies dwindle, electric power requirements for pumping increase, pumping costs rise, and valley floors subside. Thus, although deeper wells, more dams, and longer aqueducts have created an oasis in the desert, there has been a dangerous disequilibrium in water use and supply.

PROBLEM RESOLUTION

Because of the growing water shortage situation in the central Arizona area, the value of water conservation practices has long been recognized. Irrigation efficiencies are higher here than in any like area of the West. Water losses are being reduced by lining conveyance systems, automated water control for better management, and a number of programs aimed at increasing the efficiency of the farmer. Significant progress has been made in increasing the use of municipal and industrial waste water and brackish water. Watershed management programs have been conducted to increase watershed yield. Some elimination of vegetation in inner channels and flood plains has been practiced to reduce water losses.

Thus, within the Lower Gila-Salt River basin, water conservation, salvage, and reclamation practices are well along and efforts to expand and improve these practices will continue without outside stimuli. Future potential savings in water use or increases in water yield, however, will be modest in relation to the present and potential shortages.

Although the Lower Colorado River main stem is not in the Gila-Salt River basin, any savings in water use or water salvage would, in effect, accrue to the benefit of the central Arizona area by increased diversions through the Central Arizona project. The opportunities here for increased water savings through better irrigation practices and water salvage measures could amount to several thousand acre-feet annually. This, of course, would help but would not nearly comprise a solution to water shortage problems in the central Arizona area.

The potential of dispersing major water uses to ground-water basins outside the critical areas, or of transporting water from such basins to the critical areas, has not been adequately evaluated. Increased utilization of these basins would spread the ground-water overdraft over a larger area. Potential ground-water basins are in the Gila and four main stem subregions.

Augmentation of the Colorado River would assure Arizona the availability of its 2.8 million acre-feet allocation from the Colorado River and thus assure the central Arizona area of a permanent firm import of about 1.5 million acre-feet through the central Arizona project.

Taking into account the present ground-water overdraft of 2.6 million acre-feet in the central Arizona area, together with constantly increasing demands for water, it is evident that the central Arizona area will continue to face the situation where water demands are greater than long-term water supplies. The only way such full demands could be met is by importing additional water into the area. Inasmuch as the water supply available is far in excess of foreseeable demands for municipal and industrial purposes, the justification for such additional imports would have to rely on the value of water for irrigation. It is doubtful if such justification can be demonstrated in the foreseeable future. Thus, it appears that the future water supply of the central Arizona area should be planned on the basis of present water supplies enhanced by whatever additional conservation practices are feasible plus the potential imports from the Central Arizona project.

CONCLUSIONS

1. There will continue to be an excess of water demands over supply in the central Arizona area. Present use of ground and surface water exceeds renewable supplies by 2.6 million acre-feet per year. To maintain the present level of use requires the continual depletion of ground-water reserves. This activity over the last 20 years has caused ground-water levels to drop significantly and in some areas to uneconomic pumping levels. The Central Arizona project will supply additional water from the Colorado River but will not close the gap between demand and supply.

2. Following the development of all additional sources of water, there will continue to be a water shortage which will have to be handled in one of the following ways:

a. Continue present and future use rates upon demand and let economic impacts bring water supplies and use into balance, or

b. Control development and implement a management program for balancing water supply and use in the long-term time frame.

3. Even though efficiency in water use is relatively high in Arizona, there is some potential to increase the efficiency of water supply utilization and for water salvage and yield improvement. Possible methods include water reuse, precipitation management, and evaporation suppression. The evaluation of these potentials can best be accomplished through multiobjective study of selected areas. Although these are not expected to provide a total solution to water deficiencies, they could help reduce future water deficits.

4. The ground-water resource in outlying ground-water basins should be evaluated for its potential in meeting some of the State's water needs. This evaluation should be included in interagency multiobjective planning studies of selected areas within the State.

5. It seems unlikely in the foreseeable future that water imports in addition to the Central Arizona project will be justified.

RECOMMENDATIONS

1. The Central Arizona project should be completed as expeditiously as possible.

2. The State of Arizona should complete its development of a conjunctive ground- and surface-water supply plan to achieve a better balance between water supply and use.

3. Federal technical assistance should continue to be made available to the State for the completion of the State Water Plan by 1977.

NO. 2 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

Electric power consumption in Arizona has increased rapidly in the last 10 years. The peakload in 1965 of 2,000 MW is forecast to rise to more than 28,000 MW by 2000. By 1972, the installed capacity within the State has increased to 4,000 MW and planned additions would raise this to almost 15,000 by 1982. Energy sources are 20 percent hydro, 50 percent natural gas, and 30 percent coal and oil.

Over the next decade, hydroelectric sources are expected to account for only a minor addition to generating capacity. Gas plant additions will also be minimal due to high cost and short supplies. The siting of nuclear power generation plants presents difficulties and a source fo cooling water is an ever-present problem. Cooling water requirements in 1965 were about 7,000 acre-feet. The cooling water requirements for Airzona by 2000, as projected by the Western Systems Coordinating Council, are 274,000 acre-feet of which 224,000 acre-feet would be agricultural drainage water or municipal and industrial return flows and 50,000 acre-feet would be freshwater.

DISCUSSION

Large thermal plants are expected to meet 75 percent of in-State demands which are rising rapidly in the Phoenix metropolitan area. Contracts were recently awarded for the 3,900-MW Palo Verde Nuclear Generating Station to be built 50 miles west of Phoenix and for another 252-MW fossil fuel station near Phoenix. Cooling water will come from either agricultural and/or municipal waste water or the Granite Reef Aqueduct between Parker and Phoenix, and thus, immediate plant siting and water allocations are resolved. However, siting of the post-1980 thermal generating facilities and resolution of the water supply for cooling remains as difficult a problem for Phoenix as it has been for most major metropolitan areas.

Coal deposits from the Black Mesa field in northeast Arizona are already or will be supplying coal to Cholla, Navajo, Mohave (Nevada) stations and possibly coal-gas conversion facilities near Gallup, New Mexico. As such, Black Mesa is probably not available as a supply source for coal for other plants.

Planned thermal powerplant installations by electric utility conpanies serving Arizona, including those under contract, aggregate 9,600 MW. This would meet projected demand through 1982. As of this time, there are no firm indications of how or where future capacity would be provided, which by 2000 is projected to increase by another 13,000 MW.

The stretch of the Colorado River between Hoover Dam and Glen Canyon Dam offers excellent large-scale hydroelectric potentials which have been the subject of extensive study in the past. Proposals to construct dams in this reach – Hualapai, Marble Canyon, Prospect/Knaub Creek – both Federal and non-Federal, have created prolonged and heated controversies because of the adverse environmental effect such structures would have on the Grand Canyon section of the Colorado River. In 1968, these controversies culminated in provisions written into the Colorado River Basin Project Act that (1) prohibit licensing of hydroelectric plants in the Hoover-Glen Canyon reach of the Colorado River, under the Federal Power Act, until and unless otherwise provided by the Congress and (2) in effect prohibits Federal agency study of any dams in this reach without Congressional sanction. In light of these restrictions, the hydroelectric potential for that reach of the Colorado River between Hoover Dam and Glen Canyon Dam should not be viewed, at least at this time, as a source of power to meet Arizona's future energy demands.

CONCLUSIONS

1. Cooling by waste water offers some potential for needed thermal plants in urban areas but will be in competition with the use of waste water for ground water recharge and other consumptive uses. However, site selection will be more difficult than securing adequate water supplies.

2. Near-term needs are already planned by power utilities.

3. It is unlikely that the large hydroelectric potential of the reach of the Colorado River between Hoover Dam and Glen Canyon Dam will be developed in the foreseeable future.

4. Coal deposits at Black Mesa appear fully committed.

RECOMMENDATIONS

1. Arizona's State Water Plan should identify potential powerplant locations and indicate those Level C studies needed to develop specific site data.

2. A joint State-Federal utility powerplant site study should be made. (See Westwide Problem No. 1.)

NO. 3 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

The economic and social problems of Arizona Indians are closely tied to water. Historically, inadequate water supply both in quality and quantity is one of the factors which has constrained the tribes from keeping pace with non-Indian progress in the State. The shortage of water has a twofold effect on the tribes. First, it has deferred capital investments on Indian properties. Many firms have been hesitant to locate on the reservations for the simple reason that water supplies were unknown or inadequate to sustain their operations over a length of time. Secondly, it has interfered with the potential productive capacities of existing developments. For example, due largely to the lack of a full season's water supply, only about 60 percent of the lands irrigated in 1965 were harvested.

DISCUSSION

There are 19 Indian reservations in Arizona totaling nearly 20 million acres or 27 percent of the State. The Indian population of the State was 114,000 in 1970, an increase of over 37 percent during the previous decade. Table VI-3 presents the Indian population by reservations for Arizona.

Table VI-3.—*Arizona Indian population by reservation*

Reservation	Tribe(s)	1970 population	Reservation size (acres)
Ak-Chin (Maricopa)	Papago	248	21,760
Camp Verde	Yavapai-Apache	690	640
Cocopah	Cocopah	101	640
Colorado River	Mohave-Chemehuevi	1,730	225,920
Fort Apache	Apache	6,230	1,664,640
Fort McDowell	Yavapai	335	24,960
Fort Mohave	Mohave	336	23,680
Gila Bend	Papago	446	10,240
Gila River	Pima-Maricopa	7,992	371,840
Havasupai	Havasupai	370	3,200
Hopi	Hopi	6,144	2,472,320
Haulapai	Hualapai	1,033	992,000
Kaibab	Paiute	138	120,320
Navajo	Navajo	71,396	8,968,960
Papago	Papago	7,218	2,773,760
Salt River	Pima-Maricopa	2,345	46,720
San Carlos	Apache	4,709	1,854,720
San Xavier	Papago	2,090	71,040
Yavapai-Prescott	Yavapai	90	1,280

The Indian tribes in the State have established their own organization – the Indian Development District of Arizona (IDDA) – which is actively engaged in attracting business and industry to the reservations. IDDA also is assisting individual Indians in establishing their own businesses. The Indian in Arizona has grasped the opportunity for self-determination and is proceeding at an accelerating pace in economic development of the reservations. Indians long have been respected for contributions to America's social and political heritage, and now their role in the American economic picture is expanding also.

Although considerable economic progress has been made among the tribes, expected increases in Indian population could have substantial effects on that progress. Forecasts indicate the number of Indians living on reservations could triple by 2020. These increases will accentuate the current Indian problem of imbalances between water supplies and demand.

Without change, there will be little if any improvement in the living standards on the reservations. Unemployment is currently running close to 45 percent and the average family income is 70 percent below that of non-Indian families in the State.

Water is the key element in bringing about the desired changes. Adequate water supplies are needed by the reservations to sustain the present resource potentials; to hold and attract industry, thereby creating new jobs and raising family incomes; and to raise the health and living standards of the resident population.

There have been encouraging developments that assure or promise some of the Indian tribes water for resource development. Under court-decreed water rights, Indian reservations along the Lower Colorado main stem have secured water allocations sufficient to fully develop their irrigation potential. This irrigation hopefully will occur in the near time frame.

The Indian tribes residing in the Central Arizona project service area will receive significant new water supplies from the Central Arizona project although the exact quantities have not yet been determined. The Fort McDowell and Salt River Indian Tribes also will receive substantial benefits other than water supply from construction of the Central Arizona project.

PROBLEM RESOLUTION

Extensive investigations to categorize the ground-water supplies and to determine present and future Indian requirements have never been conducted for most Arizona reservations. Recently, the Bureau of Indian Affairs has initiated a number of Indian resource studies to answer this question. But, because of limited funding, the process of examination has been slow and it will take time before the Bureau and the tribes are able to properly identify all the State's Indian related water resource problems and potentials. The resolution of this issue is a necessity which will benefit the tribes as well as the State. Neither party will be realistically able to plan or implement programs until the Indians' supplies and demands for water are dimensioned – a determination which is required in order to ascertain which sources or amounts of water in the State will be available for further allocation and use.

CONCLUSIONS

1. An accelerated resource program is needed to complete ongoing studies and new studies initiated to cover all of the reservations where data are lacking.

2. Programs should be accelerated to permit the Indians to utilize water supplies available from the Lower Colorado River and from the Central Arizona project when it is completed.

RECOMMENDATION

1. The Federal Government, through the Bureau of Indian Affairs, should implement Level B studies in cooperation with the tribes and technical assistance from other Federal and State agencies, so that Indian water and related land resource requirements could be adequately reflected in the overall demand for water in the State.

NO. 4 – CHRONIC FLOODING IN DEVELOPED AREAS OF THE STATE

SUMMARY

Flash flooding, a climatic characteristic of the Southwest, has long been a significant problem in Arizona. In recent years, there has been a very high level of urban growth in Arizona thereby compounding the amount of losses when such flooding occurs. Many proposed remedial projects are delayed because local entities did not have sufficient resources to fulfill required local obligations under existing Federal assistance programs. To resolve the delay of construction, the Arizona Water Commission prepared a consolidated 15-year program of 47 projects which would provide needed flood control. Total estimated costs as of 1972 were $390 million of which $77 million were local costs. In the 1973 State legislative session, the State authorized $64 million in assistance to local entities for these flood control projects.

DISCUSSION

Although Arizona is one of the most arid areas in the United States, it has been constantly plagued by damaging floods. Streamflow is extremely variable both in time and location, and few of the tributaries of the lower Colorado River are perennial except where base flow is provided by springs. Major flooding is caused by general winter storms with low intensity rainfall over wide areas, often continuing for several days; by general summer storms with heavy rainfall over wide areas; and by local thunderstorms with high-intensity rainfall, usually of short duration over small areas. Flash floods, caused by thunderstorms, are well known in the Southwest and can occur at any time of the year but are most common during the late summer and fall. There have been 17 major floods since 1900, the most recent occurring in 1965, 1967, 1970, and 1972.

Flood damages could be reduced greatly by implementation of flood plain management programs which would limit development in unprotected areas. Flood insurance programs reduce the impact of catastrophic flood losses by converting losses to annual payments. Authorities exist which permit Federal agencies to provide flood hazard data to responsible entities for use in managing flood plains. The Arizona Legislature enacted, in 1973, a flood plain management statute which empowered agencies of the State and empowered cities, towns, and counties to establish appropriate regulations to implement a statewide flood plain management program.

Flood control improvements to protect existing development, or when associated with wise development of flood plains, could be constructed when economically justified. Authorities also exist for Federal flood control investigations and programs to provide flood control of improvements where economically justified. Many flood control projects have been authorized by the Congress. Several of these have been constructed and are contributing to annual flood reduction. Many others have been authorized for years but have never been constructed, primarily due to the inability of local interests to contribute the necessary funds for the purchase of rights-of-way and other local cost-sharing requirements.

PROBLEM RESOLUTION

The Arizona State Water Commission studied this problem and has developed a comprehensive program to achieve the construction of 47 projects previously authorized or currently under study, at a total cost of about $390 million. This program includes 19 Corps of Engineers' projects costing $192 million, 3 Bureau of Reclamation projects costing $154 million (all included as part of the multiple-purpose Central Arizona project), and 25 Soil Conservation Service projects costing $44 million. Construction of these projects would be programmed for completion by 1988. Cost estimates and construction scheduling are preliminary and do not necessarily represent the positions or priorities of the Federal agencies involved.

Identification of the projects included in the State proposal is incomplete, particularly since some projects are currently under study to (a) evaluate compatibility with the Central Arizona project and (b) to update data and consider alternatives in light of public desires.

The Federal projects are:

Corps of Engineers' Projects

1.	Indian Bend Wash	– Authorized
2.	Cave Creek Dam	– Authorized
3.	Adobe Dam	– Authorized
4.	New River Dam	– Authorized
5.	Augua Fria Channel	– Authorized
6.	New River Channel	– Authorized
7.	Skunk Creek Channel	– Authorized
8.	Arizona Canal	– Authorized
9.	Union Hills Channel	– Authorized
10.	Cave Creek Channel	– Authorized
11.	Glendale-Maryville and South Phoenix	– Study
12.	Salt River, Orme Reservoir to confluence	– Study
13.	Winslow	– Authorized
14.	Pinal Creek	– Authorized
15.	Camelsback Dam	– Authorized
16.	Safford Valley Channel	– Terminated
17.	Gila Drain	– Study
18.	Rillito Creek	– Study
19.	Indian Bend Wash upstream reach	– Review authorization needed

Bureau of Reclamation Projects

1.	Paradise Valley Dentention Dike	– Authorized
2.	Orme Dam	– Authorized
3.	Buttes Dam and Reservoir	– Authorized

Department of Agriculture Projects

1.	Williams-Chandler	Under construction or construction authorized
2.	Apache Junction	
3.	Buckhorn Mesa	
4.	Buckeye	
5.	Guadalupe	
6.	Vanar	
7.	Foote Wash	
8.	Wickenburg	Planned or planning authorized
9.	Cottonwood Wash	
10.	Harquahala	
11.	Queen Creek	
12.	Perilla Mt.	
13.	Eagletail	
14.	Dos Cabezas	
15.	St. David	Require planning studies (Level C)
16.	Piacacho No. 1	
17.	Salome-Wenden	
18.	Black Diamond	
19.	Cactus Forest	
20.	Picacho No. 2	
21.	Marana	
22.	Tonapah	
23.	Airport Wash	
24.	Casa Grande	
25.	Silver Creek	

For several reasons, including the need for assistance to local interests in providing required local funds for authorized Federal projects, the State Legislature adopted a new statewide flood control program. This program included the authorization for a period of 15 years for payment by the State of one-half of the local costs of land, easements, rights-of-way, and relocations necessary for federally assisted flood control projects. The estimated State expenditure is $65 million (escalation included). At the end of the 15 years, the State's participation in this flood control program will decrease to an amount proportional to the benefits to State property programs.

The State plan, together with the actions of the State Legislature, evince the high priority the State has assigned to flood control measures. The past funding problems of local interests should be resolved by the State's ability to participate in the local costs. This action will permit many of the now authorized projects to move closer to actual construction. This fact serves to remove what had been the primary obstacle in the past to the advancement of the State-recommended program. Because the State has taken action to remove the principal reasons for past delays, no additional Federal actions are considered necessary.

CONCLUSIONS

1. Expanding growth in Arizona has followed the traditional pattern of seeking streamside areas with the inherent threat of sudden loss due to flash flooding, compounded by natural floodway construction. A program to protect existing developments has been prepared and approved.

2. Level C planning studies are being programed by the respective Federal agencies under ongoing programs.

3. Implementation of the State program and authorization for funding local cost-sharing requirements should achieve relief from the chronic flood hazard.

4. Application of the State's flood plain management legislation should control future uses and development of the flood plains.

RECOMMENDATION

1. The Federal-State flood control program should be implemented over the 1974-1988 period. Ongoing Federal flood control programs should be continued. As local assurances are provided, the Federal agencies should seek the funds required to construct the authorized flood control projects.

NO. 5 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

SUMMARY

Naturally occurring conditions such as point source salt springs and surface flows across salt beds or saline soils adversely affect water quality and have adverse economic impacts on functional water uses. Because of the high cost of remedial measures, little has been done to eliminate or alter these contributions from natural salinity sources. However, downstream use and reuse of these saline surface waters infringe on subsequent Arizona users. Except for point sources (e.g., Blue Springs), salinity levels downstream are moderated by such storage reservoirs as San Carlos Lake on the Gila River. Impacts above such reservoirs accrue during low-flow periods. There are four primary causes of salinity increases: (1) incoming salinity from upstream development, (2) point source salinity from natural springs, (3) concentrations of salinity caused by water depletion, and (4) salt pickup through return flows. Each of these has subsequent adverse effects on other water users.

The present average salinity levels in some main stem areas are approaching a point which may adversely affect agricultural production and cropping patterns. When Colorado River water is diverted to Central Arizona, the quality of Salt River water supplies will be decreased due to mixing of the two supplies in the planned Orme Reservoir.

DISCUSSION

Since major use of water in the State occurs in the central Arizona area and there is little or no outflow of water from this area, essentially all salts and pollutants are being retained within the subbasin. These salts and pollutants – nutrients, chemical fertilizers, pesticides, and others–are ultimately deposited in the soil profile, in the underground water supplies, or both. The long-term environmental effect of this process is only partially understood and is difficult to accurately predict.

About 90 percent of the total water used in the State is used for irrigation. Even with construction of presently planned and authorized water projects, extensive reuse of available water will be necessary. A major impact of reuse of irrigation water on water quality is the salt concentrating effect from loss of water due to consumptive use. Examples of this process can be seen throughout the State. The Gila River just above San Carlos Lake has total dissolved solid concentrations of 1,370 mg/1; whereas measurements taken at the New Mexico-Arizona border upstream from the irrigated area show concentrations of 230 mg/1. Figure VI-2 shows the location of saline springs in Arizona.

In the headwaters of the Gila River, dissolved solids concentrations are generally less than 500 mg/1, while on the middle reaches below points of major diversions they range from about 500 to 1,000 mg/1. Although there are some salt springs (No. 8 on fig. VI-2) discharging to the Gila River, most of the increase in salinity results from the concentrating effects of consumptive uses. The tabulation in table VI-4 presents the amounts of salts from the springs shown on figure VI-2.

Mineral quality is generally good in most of the headwaters of the Little Colorado River, but the middle reaches of the Little Colorado vary considerably in salt content. Near its mouth, the Little Colorado River is very high in dissolved solids as most of the flow originates from saline springs in the lower

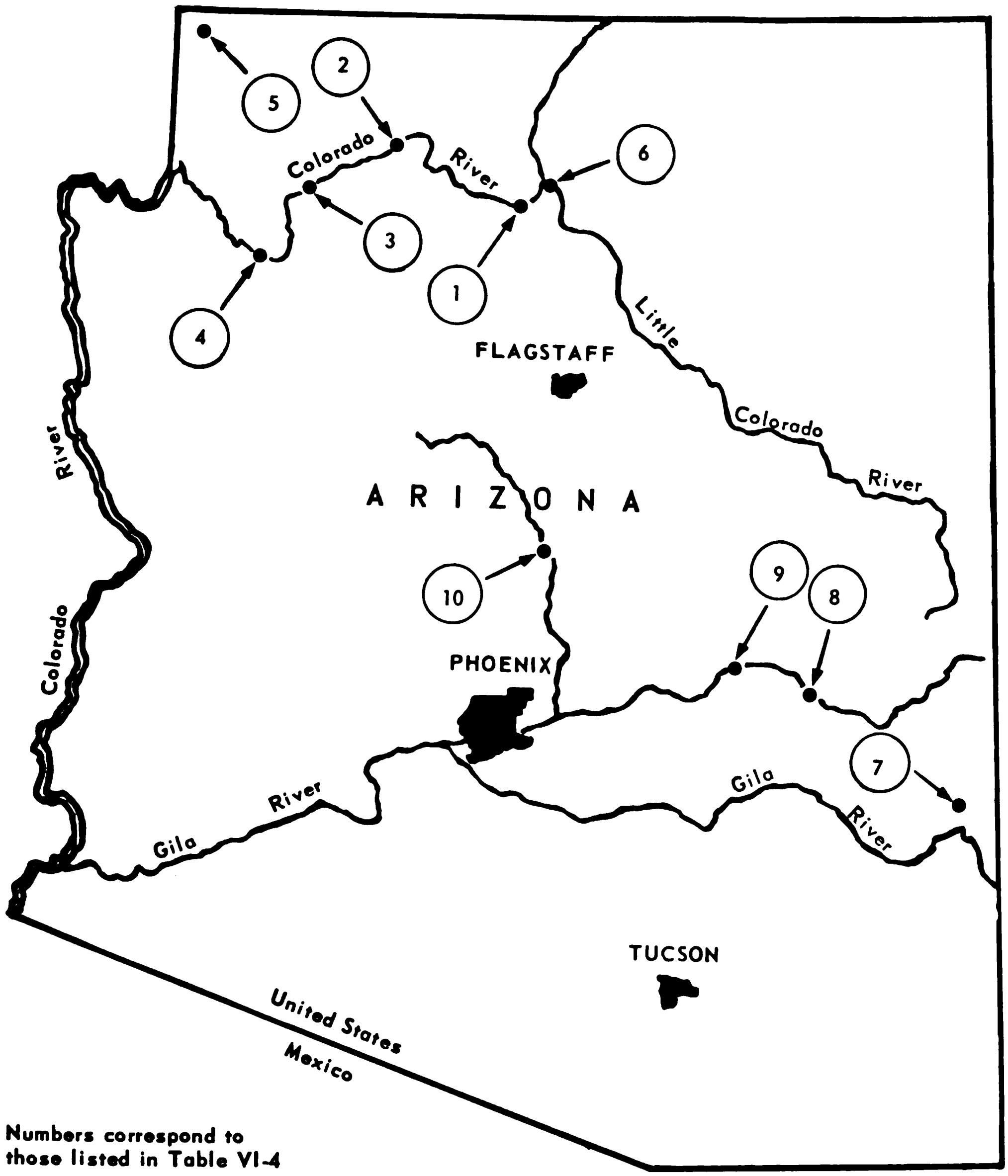


Figure VI-2. Major salt springs in Arizona.

Table VI-4.—*Salinity sources shown on Figure VI-2*

Source No.	Source Name	Flow (gal/min)	TDS (mg/l)	Salt load (tons per year)
		Lower Main Stem Subregion		
1	Spring	1	44,720	100
2	Spring	25	1,200	70
3	Vulcan Spring	2,240	884	4,350
4	Springs above Travertine Falls	23	937	50
5	Littlefield Springs	4,490	2,930	29,600
	Subtotal			34,170
		Little Colorado Subregion		
6	Blue Springs	98,750	2,500	547,000
		Gila Subregion		
7	Clifton Hot Springs	1,000	9,790	21,500
8	White River Salt	950	2,160	4,500
9	Salt Banks	14	27,200	840
10	Verde Hot Springs	10	3,100	70
	Subtotal			26,910
	Total			608,080

reaches of the River. Quality of the ground water is often poor, with major sandstone aquifers consistently containing water with more than 10,00 mg/1 dissolved solids.

Ground-water quality is declining in the Phoenix--Tucson area and may eventually become a major problem. The water resource system constitutes, for all practical purposes, a closed system. The wastes created by man through agricultural and industrial activities tend to accumulate and be carried gradually down into the ground-water formations.

The main sources of pollution of ground water from man's activities are deep percolation from fertilized fields, disposal of sewage effluent from municipal treatment plants, and disposal of water from mines and ore processing mills.

As pumping continues, the shallow water is depleted, and the quality of deeper zones is decreased through the concentration of pollutants.

In certain areas in the Gila-Salt basin, pumped-irrigation water returns to the ground-water reservoir along with its increased load of soluble soil salts and fertilizers and is trapped in the vicinity of the pumped wells and returned to the fields again by pumping. This recirculation of water causes an increase in the concentration of dissolved solids with time. Sewage effluent generally is released to dry streambeds, or it is used for irrigation of croplands, greenbelts, or recreation areas, such as golf courses. Part of this water and its increased load of dissolved solids returns to the ground water.

The Central Arizona project will initially bring about 1.5 to 1.8 million acre-feet annually of Colorado River water into the area. The present quality of Colorado River water is better than the average pumped water and slightly lower in quality than the local surface sources.

There are areas in central Arizona where, without careful management, a change in water quality may result in lower yields, change in crop, or drainage problems. The Harquahala Valley located in west-central Arizona is an example. Lands in this area have been irrigated for many years with pumped water of relatively low total dissolved solids but of high sodium content. The singular continued use of pumped water or the application of Colorado River water may not induce ill effects, at least in the short term. However, the mixing of the low salinity-high sodium pumped water with high salinity-low sodium Colorado River water may possibly create crop yield and drainage problems.

PROBLEM RESOLUTION

Pollution from man's activities could be better controlled by using desalting methods to remove objectional ions from sewage and mineral processing effluents or by preventing the return of these effluents to the ground-water reservoirs through use of sealed evaporation ponds.

To help forestall the near-term and mid-term consequences of further deterioration of Colorado River water, the various features of the Colorado River Water Quality Improvement Program, as found feasible, should be implemented. Salinity control studies presently feasible, should be implemented. Salinity control studies presently programed in Arizona are: (1) Irrigation scheduling and management program, (2) irrigation water systems improvement and management program on the Colorado River Indian Irrigation project, (3) Wellton-Mohawk Irrigation and Drainage District, and (4) Littlefield Springs on the Virgin River.

In the Little Colorado subregion, the near-term and mid-term program for water quality improvement could consist primarily of desalting of surface and ground-water sources.

The Framework Studies outlined a water quality management program for the Gila subregion consisting primarily of major reuse facilities for metropolitan Phoenix and Tucson. In the proposed program, all wastes from the urbanized Phoenix area would be treated to an equivalent secondary level and the effluent applied to the land to allow additional removals via ground-water discharge. A pilot project that is presently carrying out this idea is achieving encouraging results, and with the BOD, coliform, ammonia, nitrogen, and phosphorous removals now achieved, the water should be acceptable for use on all types of edible crops. The suggested waste-water treatment plan for metropolitan Tucson is similar to that described in Phoenix. The tertiary effluent would be discharged to a public aquatic park complex and to ground-water recharge. This additional treatment will minimize the nitrates entering the ground-water supply, a problem that currently exists north of Tucson.

Other approaches that may be considered are: (1) Mixing water of higher mineral content with water of lower mineral content, (2) extracting minerals from the water by one of the membrane processes or by ion exchange and discharging the concentrated brines outside to carry minerals from the area.

Opportunities to improve water quality through careful land management appear to be of the utmost significance. Pollution from poor land management activities are known to contribute to water quality problems. Sources of pollution include animal wastes, agricultural chemicals, infectious agents, turbidity, and heat.

CONCLUSIONS

1. Salinity is the most serious impending water quality problem in Arizona. The present quality of most surface and ground-water supplies is adequate for municipal, industrial, and agricultural uses though some localized problems exist. However, deterioration of water quality can be expected in the heavily developed ground-water basins of central Arizona from the salt-concentrating effect and in areas along the lower reaches of the Colorado River from increasing main stem salinity. Concentrations of total dissolved solids in both surface and ground waters are approaching critical levels for municipal, industrial, and agricultural uses. At present, the major economic detriments occur to irrigated agriculture, which is by far the largest water user. Adverse effects to the three water uses will continue to increase unless effective measures for controlling salinity concentrations are implemented.

2. The maintenance of an acceptable level of water quality is particularly critical and complex because maximum water utilization must be obtained by recycling available supplies. New sources of good quality water for dilution are not available. These conditions will dictate the continuation of an exceptionally high water use efficiency with little or no possibility for transportation of salts or waste loads from the area.

3. A large percentage of the salt accretions contributing to salinity are from diffuse natural sources and irrigation return flows. These two sources must continue to receive emphasis in future studies and in the implementation of land management practices.

4. Further deterioration in the quality of ground water due to overdraft and pollution from surface drainage can be expected. This could be minimized through a well-enforced ground-water quality management program. Such a program is critically needed in the heavily irrigated areas of central Arizona.

5. Limitation of depletions is not a presently acceptable alternative to the Colorado River Basin States.

6. The Federal Government has a well-defined responsibility in the management and use of the waters of the Colorado River.

RECOMMENDATIONS

1. The Colorado River Water Quality Improvement Program (CRWQIP) studies should be completed and feasible solutions implemented.

2. Agricultural land and water management programs on a farm-by-farm basis for some of the presently irrigated lands in central Arizona that are programed for a change in water source due to the transfer of water from the Colorado River should be started. The primary objective of these programs should be to match crops and soil characteristics with the quality of water to avert or minimize potential crop losses or other problems.

3. A special study for central Arizona to define the future water quality problems of the underground water supplies should be made immediately. Studies should include what effect, if any, that deep percolation of irrigation flows has on salinity, pollution from nutrients, and pesticides, and other degradation aspects of the underground supplies.

4. The ongoing Department of Agriculture Type IV study of the Little Colorado subregion should be expanded to a State-led Level B study to determine the best alternative means to solving the water and related land resource problems of the basin and to improve the quality of the water leaving the basin.

5. Water salinity problems in the Upper Gila basin should be resolved by local initiative with State and Federal assistance under existing programs and responsibilities, such as the irrigation scheduling and management program and onfarm irrigation systems improvement programs. A Level B study to assess the severity of the problem and to collect factual data should be started immediately to provide information for possible alternatives in water management to alleviate existing and impending problems. The first part of the study should assess the magnitude of past changes in ground-water quality and the rate of change. Present methods of water management should be assessed to determine the cause-effect relationship between water quality and water management. The final phase should evaluate all possible alternatives for alleviating the problem and how much each alternative would cost.

NO. 6–CONFLICT OF WATER ALLOCATION BETWEEN WILDLIFE RIPARIAN HABITAT AND OTHER USES

SUMMARY

The removal of riparian vegetation along Arizona stream courses has resulted in a drastic loss of this critical wildlife habitat. Much of this loss can be attributed to the removal of wildlife vegetation in an attempt to increase water supply primarily for irrigated agriculture. As an index of the problem, the loss of desert riparian vegetation suitable for white-winged dove nesting is estimated to have been in the range of 90 percent between 1960 and 1970.

DISCUSSION

In Arizona there is a minimal amount of riparian habitat due to the arid characteristics of the climate. This habitat occurs as a ribbon of desert shrubs along the streams forming an oasis for wildlife. Their use of this riparian vegetation is extremely high, especially for birdlife. As water resource developments utilize greater percentages of natural supplies and as stream systems are dewatered, there is increasing pressure for the conversion of the water used by the remaining areas of this critical habitat to other uses. Unless plans are made for the preservation of the remaining critical habitat areas, very little will remain of riparian ecosystems and their contribution to hunting, nature study, aesthetics, and the many recreational, cultural, and scientific uses man can make of these resources. The streams of major concern are the Lower Colorado, Gila, Salt, and Verde Rivers.

PROBLEM RESOLUTION

While the removal of riparian habitat on private lands would be difficult to halt, a State-Federal agreement for the preservation of riparian habitat on State and Federal lands could preserve a sufficient amount of the habitat to provide for the maintenance of a viable wildlife program.

CONCLUSIONS

1. Significant losses of wildlife habitat have occurred along Arizona stream courses due to removal of riparian vegetation. The continuing destruction of this habitat will drastically affect the wildlife of the area and will eliminate the nesting habitat of the white-winged dove.

2. Information is needed on the critical remaining riparian habitat for future water development planning purposes.

RECOMMENDATION

1. An immediate cooperative State-Federal special study to inventory and evaluate the riparian habitat in Arizona should be undertaken so that a system of significant riparian habitat could be set up which would be protected and managed for the enhancement of wildlife.

NO. 7 – INSUFFICIENT WATER SUPPLIES FOR ANTICIPATED OUTLYING URBAN GROWTH

SUMMARY

The local water supplies of several Arizona cities, such as Flagstaff, Prescott, and Kingman, are nearly fully developed and no margin of supply exists for years of low precipitation. Many small rural communities have no existing water service systems. Development is accelerated through national promotion by land developers offering land in "Sun Country." Development in many of these areas would overtax local water supplies and cause an immediate crisis to the local community.

DISCUSSION

Flagstaff is the principal trade center of northern Arizona. It is experiencing population growth and economic expansion caused by an annual increase in tourism and enrollment at Northern Arizona University. The local water supplies on which the city is dependent for municipal and industrial uses are nearly fully developed and there is no margin on which to rely in critical years of precipitation and runoff. In the Prescott area, large-scale land development promotions if developed would outstrip the water resource potential as well as having detrimental effects on other natural resources of the area. The towns of Williams and Ashfork have always had deficient water supplies. Williams requires the hauling of water by tank car on the average of once every 4 years to meet its needs and Ashfork must meet all its needs by hauling water from outside the area.

There are many other smaller communities with water supplies of inadequate quantity and quality. Blocks of land promoted nationally by land developers offering land in "Sun Country" are often adjacent to these small communities.

In some areas, irrigated lands can be converted, but in these rural areas the meager water supply is in most cases already insufficient so that additional water surface supplies must be obtained at distant locations through expensive physical works. If available surface supplies are overappropriated, growth can be supplied only if ground water is available and then ground-water mining is usually necessary.

PROBLEM RESOLUTION

Past uncontrolled land speculation schemes led to passage of an Arizona Groundwater Law in 1973 which requires a determination for such land developments of the available water supply, or lack thereof, by the Arizona Water Commission. Completion of the State Water and Land-Use Plan should provide direction in control and indications of State policies and programs to remedy present and future situations.

CONCLUSIONS

1. Application of Arizona's new water supply certification law will provide forewarning to all parties and could avoid further aggravation of the situations.

2. Land-use guidance will soon be provided through Arizona's State Water Plan.

RECOMMENDATION

1. Strict application of the State's water supply certification law should be made.

CALIFORNIA

California is the most populous State in the Nation as a result of one of the fastest growth periods ever experienced, moving from less than 7 million in 1940 to nearly 20 million in 1970. From 1960 to 1970, the State's population increased 27 percent, compared with a 13 percent increase for the Nation.

Although the rate of population increase is slowing, recent growth trends suggest a population in the state of 29 million in 1990 and 34 million in 2000 which is slightly less than the U.S. Census Series E projections shown in Chapter III, table III-2. California is also one of the most urbanized States in the Union with more than 90 percent of its population living in the large coastal urban areas. More than half of all Californians (55 percent) live in the South Coastal subregion which includes Los Angeles, Orange, San Diego, and adjacent counties. The next largest subregion is the San Francisco Bay with 22 percent.

California is the Nation's third and the West's largest State with more than 156,000 square miles of land area. There are more than 2,000 square miles of inland surface water area. The topography varies from mountains and valleys to coastlands and desert areas, from water-rich to water-scarce in character.

Since World War II, the economic basis of the State has shifted from rural-agrarian to industrial with emphasis on the agribusiness and aerospace industries. California, wity 1970 production valued at $4 billion, has been the Nation's leading agricultural State for more than 20 years. The total civilian employment in 1970 was over 8 million. This work force was employed as follows:

Industrial Sector	Employees (in thousands)
Manufacturing	1,600
Trade	1,500
Government	1,400
Services	1,300
Transportation and utilities	460
Finance, insurance, and real estate	370
Construction	300
Mineral extraction	30
Other nonagricultural	800
Subtotal nonagricultural	7,760
Agricultural	290
Total	8,050

During the past two decades, 30,000 to 40,000 acres of land a year have been required to accommodate California's growth in urban developments, with about half of the accommodation occurring on highly productive agricultural lands.

In Los Angeles, Orange, Riverside, and Santa Clara Counties, over 90 percent of the urban expansion, or 14,000 acres annually, has taken place on agricultural lands. It is predicted that in the highly urbanized regions of the San Francisco Bay and South Coast, agriculture will be virtually eliminated by urban encroachment by year 2000.

WATER SUPPLY

Two characteristics of climate have a major influence on water resources in California:

1. Precipitation and, thus, streamflow differ so widely between summer and winter that farmers in most areas have had to irrigate even their pasturelands and major cities have had to build reservoirs and aqueducts to insure an adequate water supply throughout the year.

2. Prevalence of both flood and drought years requires that planners design water systems capable of handling both extremes.

The Central Valley, a geomorphic province which dominates the center of the State of California, is a vast plain approximately 400 miles long, trending roughly north and south, and 50 miles wide. The southward-flowing Sacramento River system drains the northern half of this valley; the northward-flowing San Joaquin River system drains the southern half. These two river systems join at their terminuses, forming a large delta on the east side of San Francisco Bay. It is in this delta area that large water transfers occur from northern to southern California while, simultaneously, saline waste waters are discharged to the bay and the Pacific Ocean.

Water transfer systems are the dominant characteristics of the water scene in California. The metropolitan areas of southern California and San Francisco Bay, after developing nearby water supplies, have had to develop additional supplies through important and distant areas. Los Angeles built the 300-mile-long Owens Valley Aqueduct from the Sierra Nevada Mountains along the Nevada border, and the Metropolitan Water District of Southern California built the Colorado River Aqueduct from the Colorado River Basin. To the north, San Francisco brings water from the Hetch-Hetchy Valley, also in the Sierras and other bay-area cities to the east bring water from the Mokelumne River. The Federal Central Valley project and the California State Water project move water hundreds of miles from surplus water areas in the north to cities and farms in the south. About 86 percent of the water diverted from streams and pumped from the ground serves to irrigate farmland, about 12 percent to satisfy municipal and industrial needs, and about 2 percent to satisfy other needs.

Surface Water

Water development has been progressing through three stages: (1) local diversions from a particular river, (2) storage of water from a river for use within the river basin, and (3) storage and transport of water from river basins abundant in water to those deficient in water. In areas such as the San Joaquin Valley, the development of electrically-powered pumps made possible the exploitation of ground water as early as 1900 and postponed for many years the need to store or import surface water. Public utility systems have developed extensive hydroelectric power on mountain streams such as the Pit, San Joaquin, Feather, Kings, Tuolumne, and Kern Rivers. In the Central Valley, storage in mountain reservoirs now supplements irrigation systems which began as local valley canals.

Compared to other noncoastal Western States, California's surface supply of over 70 million acre-feet is very large. Although, in proportion, inflow and imports from Oregon and the Colorado River Basin are not large (about 10 percent), they are nevertheless significant in absolute terms, being over 2 and 5 million acre-feet, respectively. The great water-producing areas are the two northernmost: the North Coastal Areas and the Sacramento, where 50 million acre-feet a year originate. Either area alone produces more water than the entire consumption within the State of 21.4 million acre-feet/year. Tables VI-5 and VI-6 summarize California's estimated 1975 depletions and water supply situation.

Ground Water

Ground-water operations are both large and essential to the economy of California, and provide 40 to 50 percent of the total water supply consumed. A major portion of the ground-water development is in the Tulare Basin subregion of the Central Valley, which provides over 50 percent of the 8 million acre-feet used in that closed basin. Relative statewide data are shown in table VI-7.

Mining of ground water (which is included in the above data) is concentrated primarily in the Tulare Basin where approximately 1 million acre-feet of the estimated 2 million acre-feet statewide total is mined annually.

Water Quality

The large water supply within California and its intensive regulation by storage facilities provides a generally superior quality of water. The exceptions lie with that which is imported from the Colorado River Basin; the Delta Bay area, which receives large volumes of waste waters from cities, industries, and upstream agriculture; and zones of salt-water intrusion along the Southern Pacific Coast where the use of ground water has reversed the hydraulic gradient. Each of these problem areas is being investigated and solutions proposed. Respectively, they are the Colorado River Water Quality Improvement Program, Peripheral Canal, and Wastewater Injection; further discussion of each is presented later in this portion of the chapter.

CRITICAL PROBLEMS

The Westwide problems, dimensioned in this portion of the California presentation, provide State specific information not contained in the Westwide problem discussions in Chapter IV. The Regional problems of direct interest to the State are also listed. This portion concludes with detailed presentations of State specific problems.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – Californians spent over 20 million angler-days fishing during 1970, of which stream fishing accounted for 9.4 million days. The demand for stream fishing is expected to reach 12 million angler-days by 1980. Many streams also contribute significantly to commercial and ocean sport harvests along the Pacific Coast. Few streams remain that have not been altered by man, and in a number of cases, water developments have resulted in the loss and/or degradation of valuable stream habitat.

Wetlands are one of the most important habitat types for fish and wildlife resources in California. At the turn of the century, there were an estimated 3.5 million acres of wetlands. A survey conducted by the Fish and Wildlife Service and the California

Table VI-5.—*Estimated 1975 total depletions*[1] *for California*

(1,000 acre-feet)

Region and subregion	Function								Total depletions
	Irrigation	M&I including rural	Minerals	Thermal electric	Recreation[2] F&WL	Other	Reservoir evaporation	Consumptive conveyance losses	
California									
North Coastal	490	80	2	–	270	–	38	55	935
San Francisco	230	1,020	30	–	24	–	35	63	1,402
Central Coastal	750	130	8	–	5	–	32	15	940
South Coastal	790	2,010	46	–	8	–	120	200	3,174
Sacramento Basin	4,610	180	9	–	120	–	370	260	5,549
Tulare Basin	7,570	200	11	–	46	–	90	180	8,097
San Joaquin Basin	3,740	60	1	–	100	–	250	170	4,321
Delta-Central Sierra	1,820	80	1	–	15	–	60	97	2,073
North Lahontan	-300	13	1	–	14	–	29	20	377
South Lahontan	290	50	11	–	4	–	26	4	385
Colorado Desert	3,610	80	3	–	29	–	0	770	4,492
Total Region	24,200	3,903	123	–	635	–	1,050	1,834	31,745
State summary	24,200	3,903	123	–	635	–	1,050	1,834	[3]31,745

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] Exclusive of instream flow use.
[3] Surface-water depletions—21,359,000; ground-water depletions—10,386,000.

Table VI-6.—*Estimated 1975 surface water-related situation in California*

(1,000 acre-feet)

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within sub-region or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
California Region									
North Coastal	2,110	27,120	–	29,230	950	940	27,340	17,100	10,240
San Francisco	–	3,500	960	4,460	–	1,390	3,070	120	2,950
Central Coastal	–	1,810	–	1,810	–	760	1,050	20	1,030
South Coastal	–	1,620	1,930	3,550	–	3,170	380	0	380
Sacramento Basin	140	22,830	810	23,780	2,280	5,440	16,060	5,300	10,760
Tulare Basin	–	4,260	2,810	7,070	–	7,040	30	110	–80
San Joaquin Basin	30	6,360	1,600	7,990	1,410	4,170	2,410	220	2,190
Delta Central Sierra	18,270	2,140	120	20,530	1,960	1,920	16,650	0	16,650
North Lahonton	–	1,640	11	1,651	9	370	1,272	1,120	152
South Lahonton	–	1,300	30	1,330	420	250	660	50	610
Colorado Desert	–	310	4,140	4,450	–	4,310	90	0	90
Total Region	[5]2,250	72,890	[5]5,320	80,460	[6]0	29,810	50,650	24,140	[7]26,510
State Summary	2,250	72,890	5,320	80,460	–	29,810	50,650	24,140	[8]26,510

[1] Modified inflow reflects the effects of depleting upstream of State lines. Subregions therefore do not necessarily add to Regional values.

[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply. Modified supply total checked as sum of modified supply in Subregion 1, 2, 3, 4, 6, 9, 10, 11. (Supply in Subregion 6 includes 5, 7, 8.)

[3] Available for future instream uses such as, for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.

[4] Depletions related to ground-water mining removed from totals presented in Depletions table areas follows:

San Francisco Bay	10,000
Central Coastal	180,000
Sacramento Basin	110,000
Delta-Central Sierra	150,000
San Joaquin	150,000
Tulare	1,060,000
North Lahonton	10,000
South Lahonton	140,000
Colorado Desert	130,000
California Total	1,940,000

[5] Modified inflow from Oregon to North Coastal and Sacramento Basin, Subregions, and import from Lower Colorado Region. The other inflows shown by Subregions are from Subregion to Subregion within the State.

[6] No exports from State. Amounts are intraregional.

[7] Not additive due to interconnection between Subregions.

[8] It's estimated that due to present physical and economical constraints of the 26,400,000 acre-feet of water available, 20,200,000 acre-feet could be developed.

Table VI-7.—*Ground water use in California*

Function	Percent	Total acre-feet ground water depleted annually	Percent of total water supply
Irrigation	88	9,130,000	38
M&I	10	1,047,000	27
Minerals		38,000	31
Recreation, fish, and wildlife	2	171,000	27
Total depletion	100	10,386,000	

Department of Fish and Game indicated that only 560,000 acres remained in 1954. However, this survey did not include wetlands along the southern coast. Since then, wetlands have continued to disappear at an alarming rate, particularly along coastal areas, due to residential and commercial developments.

Studies are needed to provide instream flow needs for fish and wildlife, water quality, and related environmental data for use in total water planning. The State is currently preparing a comprehensive water quality plan and has selected for study those streams listed by area in table VI-8. Technical Federal assistance should be provided for those streams where there is an opportunity for research or for those where there are Federal interests in development.

California is the principal wintering ground for waterfowl of the Pacific Flyway. Each year, 10-12 million ducks, 1 million geese, and several million shorebirds migrate into or through the State. Wetlands are not only critical to the survival of migratory birds but resident species as well. Wetlands provide a variety of recreational opportunities such as hunting, fishing, and nature study. Waterfowl hunters spent about 1.7 million hunter days in 1970 and this use is expected to rise to 2.2 million days by 1980. While natural resource values of some wetlands have been documented, information on most areas is limited and based on preliminary data. In addition, studies to determine water requirements needed to maintain these areas have not kept pace with studies of water and related land resource needs for other purposes. This information is needed to insure proper consideration of preservation of wetlands and associated fish and wildlife values in any plans which may affect this habitat.

Studies are needed to collect data on acreage and type of wetlands, fish and wildlife species, sport and commercial harvests, nonappropriative uses, water quality problems, and water supplies needed to preserve and restore wetlands.

NO. 6 – NEED FOR ADDITIONAL FLAT WATER RECREATION OPPORTUNITIES. – In Westwide Issue No. 6 California was highlighted as an area of extensive Federal reservoir development and large populations. Because of limitations in project authorizations in earlier days, many Federal water projects in California have never been permitted to realize their full recreation potentials. Reservoirs built for a variety of other water management purposes have, over the years, become vastly important recreation resources. The Central Valley project represents a huge Federal investment in California amounting to some $2.6 billion for constructed and authorized project features.

The high-priority reservoirs recommended for early study in California include: Contra Loma, Woollomes, Folsom, Millerton, and San Luis. Factors which impede the maximizing of recreation at Central Valley project features would include the following items: rapid reservoir drawdown during the peak recreation season; inadequate recreation facilities; inadequate recreation management and staff; and poor access or underutilization at remote areas of a reservoir. These factors usually can be traced to either conflicting water uses at multiple-purpose projects, lack of funding to provide recreation facilities, or inadequate authority to provide proper management.

The first requirement is to identify those project features which are being underutilized from a recreation standpoint.

Table VI-8.—*California streams selected for instream flow studies*

North Coastal			
Alder Creek	Eel River	Klamath River	Navarro River
Albion River	Elk Creek	Little River	Noyo River
Bear River	Elk River	Mad River	Salmon Creek
Big River	Gualala River	Maple Creek	Redwood Creek
Brush Creek	Garcia River	Mattole River	Smith River
			Ten-Mile Creek

San Francisco Bay			
Gazos Creek	Napa River	Petaluma River	San Gregorio Creek
Lagunitas Creek	Pescadero Creek	Russian River	Sonoma Creek

Central Coastal		
Arroyo de la Cruz River	Naciemento River	Santa Rosa Creek
Arroyo Seco River	Pajaro River	Santa Ynez River
Big Sur	San Lorenzo River	Scott Creek
Carmel River	San Luis Obispo Creek	Sisquoc River
Little Sur	San Simeon Creek	Soquel Creek
		Waddel Creek

South Coastal		
San Gabriel River	Santa Clara River	Malibu Creek
Santa Ana River	Santa Margarita River	Ventura River

Sacramento Basin			
American River	Big Chico Creek	Cow Creek	McCould River
Antelope Creek	Burney Creek	Feather River	Mill Creek
Battle Creek	Cottonwood Creek	Hat Creek	Sacramento River
			Yuba River

Delta-Central Sierra		
Mokelumne River	Cosumnes River	Calaveras River

San Joaquin Basin			
San Joaquin River	Merced River	Stanislaus River	Tuolumne River

Tulare Basin			
Kaweah River	Kern River	Kings River	Tule River

North Lahontan				
Carson River	Pine Creek	Truckee River	Walker River	Willow Creek

South Lahontan			
Bishop Creek	Lee Vining Creek	Parker Creek	Rush Creek
Deep Creek	Mill Creek	Robinson Creek	Walker Creek
Hot Creek	Owens River	Rock Creek	

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. The Feather River in northern California was an initial component of the National Wild and Scenic Rivers System, while portions of the Kern, Klamath, Russian, Sacramento, Smith, and Toulumne Rivers were among a number of "5(c)" rivers (formerly Section 5(d) of P.L. 90-542, The Wild and Scenic Rivers Act). These rivers, named for inclusion by the Secretaries of Agriculture and Interior in 1970, must be evaluated for their wild and scenic river values in any Federal planning or developmental or control uses.

Bills have been introduced to the 93rd Congress that would add portions of the American and Tuolumne to the list of "study rivers" as potential additions to the System National Wild and Scenic Rivers. More recently, the Secretary of the Interior, acting on findings of a Federal interdepartmental study group, recommended passage of a comprehensive "Administration bill" that calls for study of a number of high priority rivers across the country in lieu of individual proposals for wild and scenic river studies. Included in the new bill are two California rivers. The Westwide study has identified two other rivers which, because of developing conflicts and probable degradation of the rivers' free-flowing values, should be studied as soon as possible. Table VI-9 summarizes information on the latter four rivers.

On December 20, 1972, California enacted Senate bill No. 107. This bill established a Wild and Scenic Rivers System which initially included portions of the following: Klamath River, Trinity River, Smith River, Eel River, and American River.

Table VI-9.—*California rivers recommended for study as potential National System additions*

River	River segment
Kern	The main stem from its source to Isabella Reservoir.
American (North Fork)	The North Fork from Mountain Meadow Lake to Auburn Reservoir and the lower 7.5 miles of the North Fork of the North Fork.
Sacramento	Sources to Shasta Lake and Keswick Dam to Chico Landing.
Russian	Ukiah to mouth (Pacific Ocean).

The California act states that "* * * no dam, reservoir, or other water impoundment facility, other than temporary flood storage facilities * * * shall be constructed on or directly affecting any river designed * * * nor shall any water diversion facility be constructed on any such river unless and until the Secretary (Secretary of the Resources Agency of California) determines that such facility is needed to supply domestic water to residents of the county, and unless the Secretary determines that it will not adversely affect the free-flowing condition or natural character."

Special provisions are made for the Eel River. However, the act states that any measures for flood protection, structural or nonstructural, necessary for the protection of lives and property along the Eel, except for (permanent) water impoundment structures, are specifically not prohibited. In effect, a moratorium is placed on development of the Eel because the act calls for a report in 12 years from the Department of Water Resources on the need for water supply and flood control projects on the Eel and its tributaries. This report is to be followed by public hearings to determine whether segments of the river should be deleted from the system.

Following are the specific river segments included in the initial California system:

1. *Klamath River:* Main stem from Iron Gate Dam to Pacific Ocean; Scott River from mouth of Shackleford Creek west of Fort Jones to river mouth near Hamburg; Salmon River from Cecilville Bridge to river mouth near Somesbar, North Fork of Salmon River from south boundary of Marble Mountain Wilderness to river mouth; Wooley Creek from western boundary of Marble Mountain Wilderness to its confluence with Salmon River.

2. *Trinity River:* Main stem from Lewiston Dam to river mouth at Weitchpec; North Fork of the Trinity from the southern boundary of the Salmon-Trinity Primitive Area downstream to river mouth at Helena; New River from the southern boundary of the Salmon-Trinity Primitive Area downstream to river mouth near Burnt Ranch; South Fork of the Trinity from State Highway No. 36 to river mouth near Salver.

3. *Smith River:* Smith River and all its tributaries from Oregon-California State line to Pacific Ocean.

4. *Eel River:* Main stem from Van Arsdale Dam to Pacific Ocean; South Fork of Eel from mouth of Section 4 Creek near Branscomb to river mouth near Weott; Middle Fork Eel from southern boundary of Middle Eel-Yolla Bolly Wilderness to river mouth at Dos Rios; North Fork of Eel from Old Gilman Ranch downstream to river mouth near Ramsey; Van Duzen River from Dinsmores Bridge downstream to river mouth near Fortuna.

5. *American River:* North Fork from its source to Iowa Hill Bridge; Lower American from Nimbus Dam to junction with Sacramento River.

Other California rivers identified by the State Study Team as having significant free-flowing values include the Kern, Gualala, Mad, San Lorenzo, Feather, Yuba, Truckee and Carson.

NO. 15 – COORDINATING LAND USE AND WATER PLANNING. – Many planners, conservationists, and concerned environmentalist groups have pointed with alarm to the present land use practices which lack consistency and understanding of interrelated aspects of land management, development, and economic growth.

Problems arise because there is no statewide land use policy to guide future resource management in California. Presently, each agency of State government makes its own assumptions toward supplying "its product" for State growth within a narrow sphere without assessing other major developments and the total ensuing impacts. Thus, there is not adequate assurance that such developments are not working at cross-purposes in terms of objectives, timing, and location.

Local government has, so far, been relegated to the task of deciding on land use principally through zoning. This has been inadequate because of political boundary limitation, financial limitation or enticements, extreme pressure from special interest groups, and lack of proper overview of issues to encourage sound actions.

There is a critical need for the development of statewide land use policy and plans if the State is to determine its own destiny and shape its own growth patterns. The lack of a deliberate, comprehensive policy commits California to reacting to growth patterns it does not consciously control. As an example, California's supply of "prime" agricultural land is being committed to irreversible urban development at the rate of about 20,000 acres per year. This resource, on which a large share of California's agricultural wealth depends, should be preserved for future demands through State and regional land use policies. Agricultural areas surrounding metropolitan areas generally represent a large share of the land available for retention as open space. In some counties, all additional development has taken place on cropland. The areas of prime agricultural land surrounding major metropolitan areas (40-mile radius) are currently being identified by the California Office of Planning and Research through the State Department of Water Resources. Once the areas needing protection from urbanization have been identified, several alternatives must be developed which will provide the necessary shield from development pressure. These alternatives might include (1) purchase of development rights, (2) purchase and leaseback for agriculture, (3) tax incentives to remain in agriculture, and (4) zoning for agriculture only with no incentive.

Regional Problems

Three regional problems discussed in detail in Chapter V have a direct bearing on California. They are:

NO. 1 – INCREASING SALINITY IN THE COLORADO RIVER

NO. 2 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

NO. 4 – MANAGING WATER AND RELATED LAND OF THE LOWER COLORADO RIVER MAIN STEM

State Specific Problems

Largely due to the success of Federal-State activities in the California State Water Plan and the State water project, the water supply situation appears generally adequate to meet the midterm projected needs for both major urban and agricultural uses. Some exceptions to this general statement exist, especially regarding the dependability of supplies. Some needs exist for conveyance facilities to address this issue. Flooding presents increasing problems in some areas. Water quality problems exist primarily in the areas served by supplies from the Colorado River and in the San Joaquin Valley and San Francisco Bay-Delta area. The water development facilities presently existing and under construction by Federal, State, and local agencies throughout California have the physical potential and flexibility to accommodate a wide range of alternative future patterns of population growth and dispersal. Technological advancement in such areas as desalting and water reclamation may further increase this potential and flexibility. A range of environmental issues exists within the State along with increasing demands for water-based recreation near urban areas. The generally favorable status of the water situation within the State provides the opportunity for such problems to be addressed.

California shares the headwaters of the Carson-Truckee-Walker River (or Central Lahontan) watersheds with Nevada. These waters are of concern to both States, though specific management problems occur in Nevada rather than in California. During the past two decades, a compact which divides these surface supplies has been negotiated and ratified by both States but has not yet been ratified by the U.S. Congress. The salient hydrographic feature is Lake Tahoe, astride the State's borders. Although accelerating recreation based growth on both sides of the lake has endangered the natural attractiveness, cooperative actions are resolving the pollution problem. However, the present controversy over Pyramid Lake in Nevada is expected to involve water releases and lake levels at Lake Tahoe; this latter condition being of great interest to lakeshore property owners. Additional discussion is presented in the Nevada portion of this chapter.

The State specific problems in California are listed below and are located in figure VI-3:

NO. 1 – NEED FOR WATER DEVELOPMENT, REGULATION, AND MANAGEMENT IN THE SACRAMENTO-SAN JOAQUIN RIVER BASIN AND DELTA

NO. 2 – NEED TO DETERMINE FACTORS AFFECTING THE DECLINE OF THE ANADROMOUS FISHERIES AND WILDLIFE IN THE EEL AND TRINITY RIVERS

NO. 3 – NEED TO EVALUATE POTENTIAL OF OF WASTE-WATER RECOVERY PROJECTS FOR WATER-SHORT AREAS

NO. 4 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 5 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

NO. 6 – RESOLUTION OF SALTON SEA FISHERY AND SALINITY CONFLICT

NO. 7 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS.

NO. 1 – NEED FOR WATER DEVELOPMENT, REGULATION, AND MANAGEMENT IN THE SACRAMENTO-SAN JOAQUIN RIVER BASIN AND DELTA

SUMMARY

The Central Valley of California is probably the largest intensively developed, irrigated, and productive agricultural area in the world. This massive, contiguous, and oblong landform has four general areas: (1) The surplus water area in northern California where the Feather, American, Pit, and Yuba Rivers, falling from the Sierra Nevada, join the Sacramento as it drains southward; (2) the delta area where the outflowing Sacramento is joined by the northward outflow from the San Joaquin and where, at this hub of river confluences, the surplus waters are transferred to the fertile southern fields; (3) the lower San Joaquin Stockton-Fresno area irrigated by Sierra snowpacks on the east side and Delta-Mendota Canal on the west side, and (4) the upper San Joaquin Tulare Lake-Bakersfield area at the southern end of the valley which has the least natural water supply. Water service problems of each area are directly related and inseperable due to the extensive interconnections of the State Water project, the Federal Central Valley project, and private developments. A summary of each of the salient problems follows.

Sacramento-American Riverflows

Flow regulation provided by Federal projects – existing Folsom Dam and pending Auburn Dam – has been ordered by an agency of the State. Hence, a Federal vs. State jurisdiction issue has arisen, the outcome of which may affect the Auburn-Folsom south service area.

M&I water demands in the Stockton vicinity, whose supply was to have been provided by the authorized Folsom South Canal, will exceed available local supplies in the near-term time frame. The local water conservancy district may consider, as an interim solution, building a pipeline to the completed portion of the Auburn-Folsom system. Supplemental near-term needs through 1980 amount to about 130,000 acre-feet.

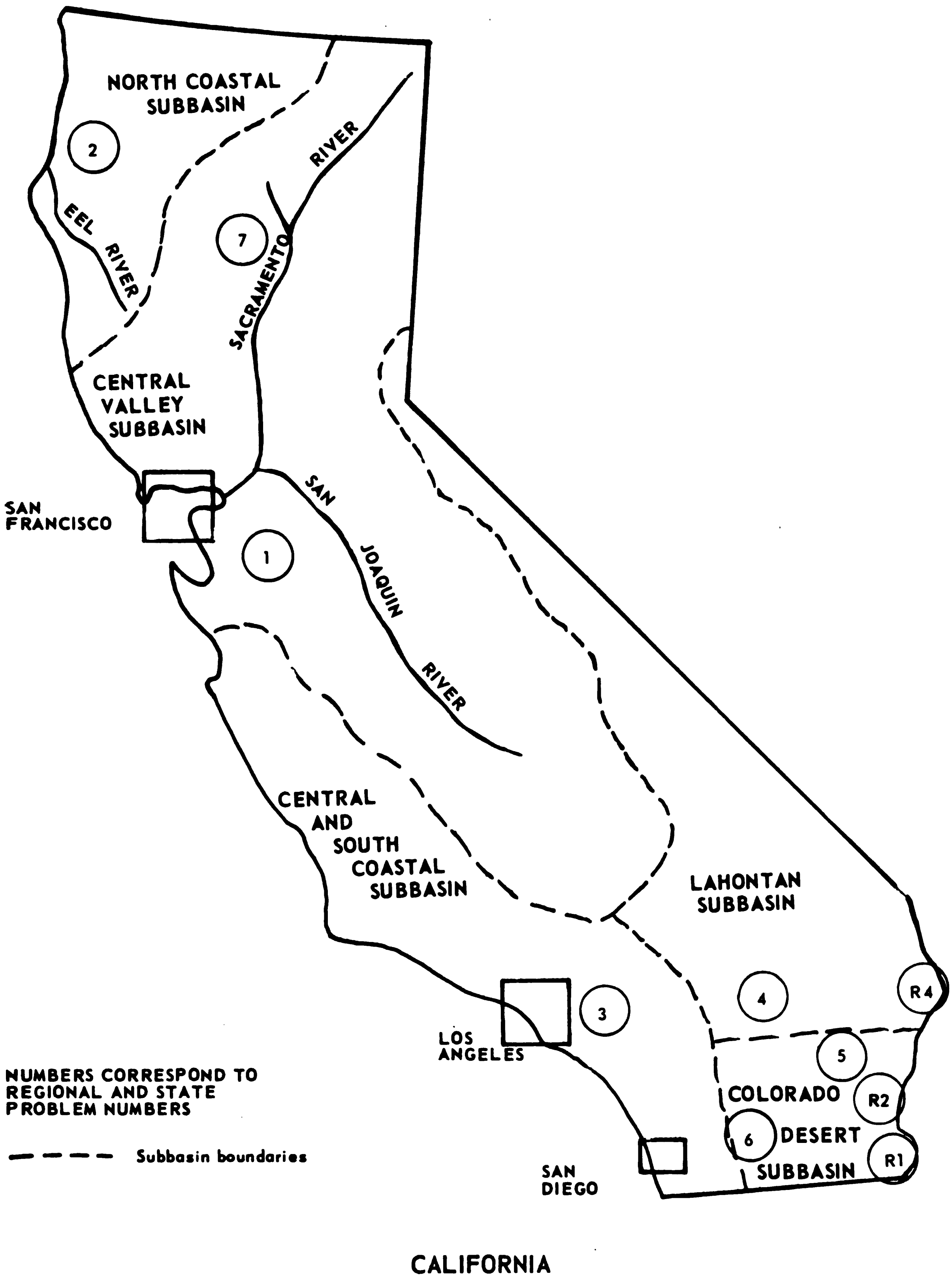


Figure VI-3. Critical water problems in California.

Delta Environmental Quality

The increased diversion of the Sacramento-San Joaquin river flows from delta to southern areas of the State will result in increased duration of present salinity levels occurring during summer months. This may cause increased physiological stress to fish and to fishfood organisms resulting in their displacement upriver or reduced survival. The existing level of diversion results in flow reversal within the delta channels which may displace fish eggs and larvae and young fish to areas where the environment may be more hostile to their survival.

A near-term solution is needed for the establishment of adequate levels and location of outflow from the two stream systems to stabilize the ecological system of the delta and maintain the valuable delta fishery.

Water Supply, Drainage, and Water Quality Problems in the San Joaquin Basin

Annual and seasonal shortages due to the natural variations in runoff are experienced along the east side in the Upper San Joaquin Basin. These shortages are presently being offset by the mining of groundwater supplies during periods of short supply. This is causing land subsidence problems. This ground- water supply in certain areas is expected to be at critical levels by the mid-1980's. Present legal and institutional constraints do not permit the optimum coordinated conjunctive use of the surface- and ground-water systems.

Waste water and irrigation return flows with high concentration of nitrates and salts contribute to the salinity levels of the San Joaquin River and the delta. There are areas in the river system and delta with high levels of nutrient pollution, low dissolved oxygen levels, and high levels of total dissolved solids. Original State and Federal plans included the collection of return drainage and disposition in the delta, but this could result in adverse environmental effects in the delta. To date, no widely accepted, well-defined plan has been developed. Ponding of saline return flow is being practiced as a temporary measure and has resulted in the establishment of a substantial wildlife habitat.

DISCUSSION

Sacramento-American River Flows

Since the completion in 1955 of Folsom and Nimbus Dams, substantial regulation of the American River has resulted in flood protection, power production, and water supplies for irrigation and municipal and industrial uses. This development has created a greater awareness of the importance of the lower American River, including aesthetic, recreational, and fishery values. The interim operation of the reservoirs has provided increased riverflows as compared to the low-flow periods that existed prior to their construction. These flow conditions will continue for the next 10 to 15 years until the demands increase and the authorized Auburn-Folsom South Unit is completed and diverts water to the Folsom South service area and other areas to be served from the American River.

The Folsom South Canal (see figure VI-4) will divert water from the American River at Nimbus and will extend about 70 miles to provide municipal and industrial water service to Sacramento and San Joaquin Counties. The first two reaches of the canal, about 27 miles, are completed. Construction of the remaining reaches of the canal is scheduled for fiscal years 1975-81.

At the time the Auburn-Folsom South unit was authorized, it was contemplated that the amount of water to be released downstream to the American River would be governed by the 1957 agreement with the California State Department of Fish and Game and the Bureau of Reclamation. In addition, releases would be made for downstream water users including the city of Sacramento. In the future, minimum flows, in accordance with these agreements, would range from about 300 to 600 cubic feet per second (ft^3/s) at the mouth of the American River.

With increased emphasis of local concerns on the recreation and fishery aspects associated with the lower American River, the State Water Resources Control Board issued Decision 1400 in April 1972. This decision ordered, among other things, that flows of not less than 1,250 ft^3/s be maintained in the river from Nimbus Dam to the confluence with the Sacramento River from October 15 through May 14 and 1,500 ft^3/s from May 15-October 14 for fishery and recreation purposes. Annual flow releases for normal years would require quantities about three to four times greater than was contemplated with existing agreements and authorizations. Decision 1400 is currently in litigation and has been removed to the Federal District Court. A contention is that conditions cannot be imposed by a State agency which would interfere with or affect the operation of Federal projects for the purpose for which such projects were authorized. The decision, if implemented, would require the releases of stored water and there would not be sufficient supply of water available for the Folsom South Canal in some years to meet future needs.

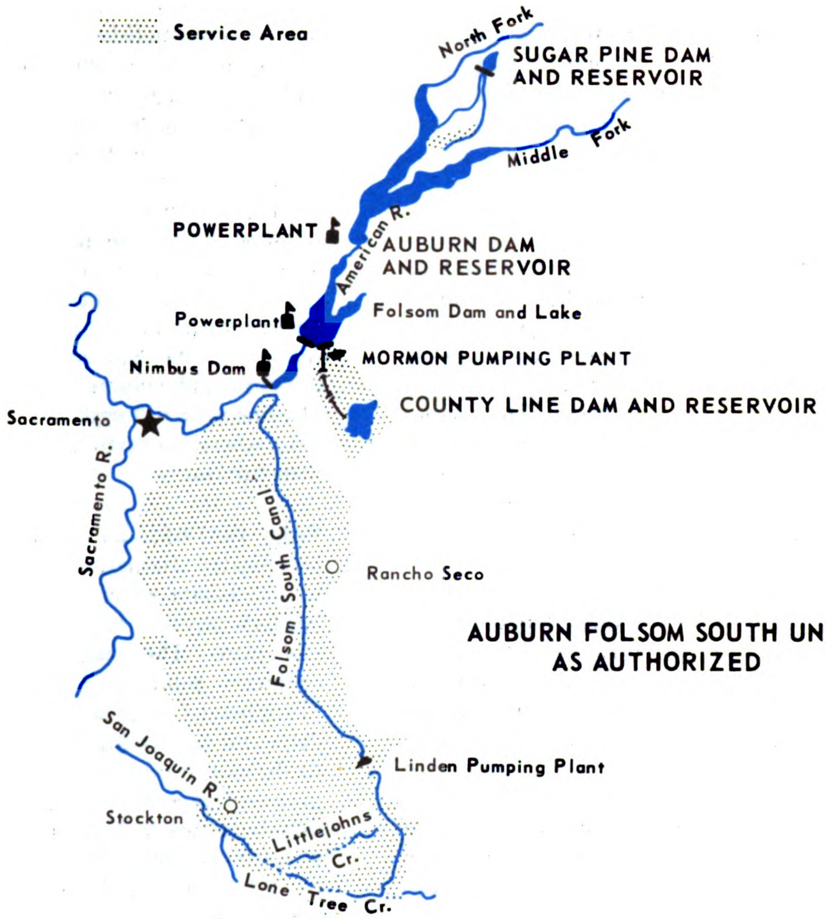


*Figure VI-4. **Auburn Folsom South unit.***

The need for maintaining increased flows of water down the American River for recreation and fishery purposes has necessitated reevaluation to determine means whereby this could be accomplished along with meeting the needs in the Folsom south service area. A number of possible alternatives, including both structural and nonstructural measures, have been evaluated.

One structural alternative is the completion of the authorized Folsom South Canal along with a connecting recovery facility from the Sacramento River to the Folsom South Canal for conditions both with and without additional offstream regulatory storage. This would require additional authorization and would provide either all or most of the recreation and fishery needs for increased releases in the American River along with the municipal and industrial and agricultural water supplies in the Folsom south service area.

Several other possible water supply sources and alternative facilities are being studied. The alternative sources of water to be considered include the American, Stanislaus, and Calaveras Rivers, and the Sacramento-San Joaquin delta. These studies will include analysis of service from such alternative facilities as Folsom South Canal, New Melones Reservoir, the Peripheral Canal, a Hood-Clay pump connection, additional storage in Calaveras River and possibly others. To assist in coordinating and carrying out the objectives of this study, a policy advisory group has been formed which includes representatives of the Department of Water Resources of the State of California, representatives of the counties and concerned water districts, and other interested agencies and organizations.

A status report published in December 1973 discusses costs involved with the several alternative actions, the accomplishments, the project impacts, and the possible local financial participation that could be required. Some alternatives were based on sketchy data and assumptions and were considered of appraisal degree only. Subsequently, additional studies have been funded with findings expected by 1976. Construction of Auburn Dam has been resumed. Without additional facilities or actions, it will only be possible to provide the Decision 1400 flows and meet the demands in the foothills and the Folsom south service area for 10 to 15 years.

Delta Environmental Quality

The Sacramento-San Joaquin Delta in Central California east of San Francisco and the Adjacent Suisun Bay and marsh areas is a roughly triangular area of more than 1,100 square miles. It receives waters of the Sacramento-San Joaquin River system and empties them into the San Francisco Bay system. The present delta, interlaced with 700 miles of tidal channels, is essentially manmade, with some 50 leveed islands (tracts) containing 700,000 acres of intensively farmed, rich organic, peaty soil. Most of the islands are at sea level or down to 20 feet below sea level.

The major problems related to water supply in the delta today are water quality control for fisheries and other aquatic life and recreation. Future increases in exports and upstream uses of water, the growing recreation uses in delta channels, and the continued subsidence of islands could increase the magnitude of these problems for both fishery and agriculture. Flooding of the many manmade islands which are below sea level is also a major problem which will not be treated in detail in this report since solutions are not related to water supply.

Water Quality and Fishery. – At the present time, about 4 million acre-feet of water are diverted annually from the delta for export by the Federal Central Valley and State water projects. The diversion is projected to build up to 6 million acre-feet by 1980 and ultimately to 8.5 million acre-feet annually by year 2020. These export diversions combined with other upstream diversions will reduce the delta's average annual outflow from the present 18 million acre-feet to about 10 million acre-feet by year 2020. Present operations involve the use of the natural and manmade waterways to convey water from the Sacramento River south through the delta to the State and Federal export pumps. This mode of operation benefits local delta agricultural, municipal, and recreational users through salinity control and dilution of waste discharges. The benefits provide presently, at no cost, a better quality water in dry summer months than would be available without project conditions. However, this conveyance through delta channels is believed to have a damaging impact on the fish food chain, the anadromous fishes (striped bass, salmon, shad, steelhead, and sturgeon), and to some extent on the resident fishes which use the delta channels as a spawning, residence, nursery, and feeding area and as a migration route. Given the restricted cross-delta transfer capacity of the present channels the projected increased pumping will likely draw more saline waters into the interior delta from San Francisco Bay or increase the amount of outflow required to repulse the ocean intrusion. A higher level of salinity could complicate and intensify the fishery problems and cause degradation of the water quality at the various points of diversion. The flow reversal in the San Joaquin River will increase in duration and volume which may increase the displacement of fish eggs and larvae and young fish to areas where the environment may be more hostile to their survival.

From 1961-65, an Interagency Delta Committee investigated alternative solutions to problems caused by cross-delta water conveyance such as hydraulic barriers, physical barriers, and delta waterway control plans. The team, in 1965, selected as the optimum solution a 43-mile-long, 21,800 ft^3/s "Peripheral Canal" around the eastern edge of the delta and connecting the Sacramento River directly to the export pumps in the southern delta and to 12 proposed release facilities where the canal crosses delta waterways. This plan is strongly endorsed by water development agencies; conditionally endorsed by fish and wildlife management agencies, some environmental groups, and some local counties pending operational criteria for the unit; and unconditionally opposed by other environmentalists and one local county.

In addition to satisfying water quality requirements at the south end of the delta, the Peripheral Canal would provide an improved delta recreation capability if coupled with acquisition of sufficient land. By establishing positive net downstream flow in most delta channels, the canal also would redistribute the basic delta freshwater supply and salinity repulsion flows to solve fishery problems now attributed to poor quality water and flow reversals.

In 1971 the State Water Resources Control Board issued Decision 1379 which established conditions of the Federal and State water rights permits. The purpose was to protect municipal, industrial, agricultural, fishery, wildlife, and recreational uses in the delta. Decision 1379 establishes water quality standards above those which were anticipated during planning for the Central Valley and State Water projects. It would alter the operation of the Central Valley project from that approved when Congress authorized and appropriated funds for project features. Thus, it raises the question of State jurisdiction over Federal projects. The Federal Department of Justice has advised the State of California that the Bureau of Reclamation will not be bound by the provisions of Decision 1379. Water users of the Federal Central Valley and State water projects have obtained a court injunction which prohibits the use of the Decision 1379 water right provisions.

Prior to Decision 1379, the minimum annual delta outflow requirement was estimated as 1.3 million acre-feet. Water supply studies indicate that varying amounts of additional water would be needed under terms of the Decision, depending on assumptions as to what water conservation facilities might be constructed in the delta. Estimates of the additional outflows needed to meet the criteria are as follows:

	Millions of acre-feet
Present facilities	3.6
With Peripheral Canal	2.7
With Peripheral Canal and western delta facilities	1.8

These increases in outflow would reduce the supplies available for deliveries elsewhere in the State. Under present assumptions, about 60 percent of these additional outflows would be required from the Federal Central Valley project and 40 percent from the State water project. With the present service area commitments from the Central Valley project, and assuming that both Auburn and New Melones Dams will have been completed, the available water supply would be inadequate shortly after 1980. If both the Peripheral Canal and western delta facilities are in operation, the date would be extended to the mid-1990's. The same timing applies to the State water project.

There are various possible means which, if implemented, could help meet Decision 1379 requirements if after a 1978 reanalysis it is adopted as permanent delta quality criterion. Most of them require additional analysis, some would require Congressional authorization, or changes in policy, regulations, or statutes.

A logical way of meeting the buildup in water demands to the mid-1990's while satisfying requirements of Decision 1379, would be construction of the Peripheral Canal and the western delta facilities. The western delta facilities would consist of an overland pump and pipe conveyance system to irrigate agricultural lands in the western parts of the delta and the Kellogg or a similar project to serve the municipal and industrial demands of Contra Costa County. An alternative to building the irrigation service facilities might be to purchase the lands for recreation and wildlife management. Another alternative would be to modify the requirements of Decision 1379 for fishery criteria during critical dry years.

Additional possibilities for increasing the available water supply are weather modification, evaporation suppression, watershed management, and design improvements such as Trickle irrigation, pipe conduits vs. open canals, automation of conveyance and distribution operations, and reclamation of urban waste water.

Recreation. – The delta is extensively utilized for water-oriented recreation. The visitor-day use in 1973 was projected at over 5 million days with the 1980 projection estimated at over 7.5 million days. Approximately 4 million people live within a 1-hour drive, and in this same zone about 80,000 boats are registered.

Problems of the increasing use include: insufficient boat mooring space, limited land access to waterways, limited waterside recreational areas, littering, waste cleanup expense, boat accidents, boat wake damage to levees, damage to ecologically sensitive areas, boat waste discharge, trespass on private lands, and absence of controls on housing developments.

A master recreation plan was completed in February 1973 by a State Task Force with the participation of Federal and local representatives. Recommendations include measures for planning, coordinating, and implementing ways to both maintain the delta's uniqueness and provide for additional recreation.

Water Supply, Drainage, and Water Quality Problems in the San Joaquin Basin

The San Joaquin basin is composed of two hydrologic subregions. The San Joaquin in the north covers about 7 million acres, and the Tulare in the south, which is essentially a closed basin, covers about 11 million acres.

The water supply for the basin is chiefly derived from surface runoff from the Sierra Nevada Mountains, from water importation from the Sacramento Valley, and from ground water. Minor amounts are derived from the coast range streams and from rainfall on the valley floor.

Approximately 85 percent of the consumptive use of water in the basin is for the production of agriculture. The San Joaquin subregion normally has a sufficient supply of water, with surface water serving about two-thirds of the subregion and ground water the remaining third. However, there are areas in western Madera County and southern Merced County where 150,000 acre-feet ground water is being mined annually. The Tulare subregion is dependent upon runoff from the Sierra Nevadas, imports from basins to the north, and extracting of ground water to supply its water needs.

The three major water-related problems in the San Joaquin Valley are:

1. Inadequate water supply, ground-water overdraft, and land subsidence on the east side of the Tulare subregion.

2. Crop losses due to degradation of ground-water quality and soil salinity in the valley trough and on the west side of the valley.

3. Deterioration of surface water quality in the Lower San Joaquin River.

Inadequate Water Supply, Ground-water Overdraft, and Land Subsidence. – Estimates indicate that about 5 1/2 million acre-feet of ground water are presently utilized annually for irrigation in the San Joaquin and Tulare subregions. Over 50,000 wells are in operation, and some pumping lifts exceed 600 feet. Before completion of the California Aqueduct and the Joint Federal-State San Luis project on the west side, the basin had the largest overdraft in the Nation. Today the annual overdraft still exceeds 1 million acre-feet, with most of it on the east side of the valley. The most critical overdraft is in the Tulare subregion where damages are occurring from serious land subsidence caused by this overpumping. Local surface-water supplies in the Tulare subregion are almost completely developed. To prevent additional subsidence and thus to protect the existing social and economic values, even with no allowance for future growth, additional water importation will be necessary.

One alternative solution which could partially alleviate water problems on the east side of the valley would be expansion of a planned cross-valley canal to be built by the Kern County Water Agency. This canal will convey about 172,000 acre-feet annually from the State water project on the opposite side of the valley. Additional capacity is being considered for the canal which would permit conveyance of reserve supplies from the Federal Central Valley project. The larger sized canal could import up to approximately 300,000 acre-feet annually into the area.

Since only a small part of the existing overdraft of over 1 million acre-feet annually would be satisfied by the imported water, a joint State-Federal study is presently underway to evaluate methods for conveying additional Central Valley project reserve water to the eastside area. These alternative conveyance alinements extend from the vicinity of the San Joaquin River to the Bakersfield area.

The joint feasibility study is scheduled to conclude in June 1975. The results and findings will be presented in a report which would be suitable for further processing. Projects which may result from this study would only partially solve the east-side water problem. The long-term water needs for overdraft correction, arresting of subsidence, municipal needs, and environmental enhancement on the east side will require additional facilities and import water.

Crop Losses Due to Degradation of Ground-Water Quality and Soil Salinity. – In the Tulare subregion, incoming minerals in ground, surface, and imported waters are trapped in the soil profile or within the ground-water basin and have a detrimental effect on subsurface water supplies. Without drainage facilities to maintain the productivity of the San Joaquin basin, ground-water quality will continue to deteriorate. Problems of rising ground-water tables and increasing soil salinity will continue to be so severe as to necessitate changes in cropping patterns and markedly decreased agricultural production. A 1965 report of the Department of Water Resources identified approximately 1,600,000 acres which will ultimately require drainage if they are to continue to be agriculturally productive. Of this total, drainage for 1,100,000 acres would be required by 1990. The report recommended the construction of a 280-mile-long combined Federal-State San Joaquin master drain. In addition, tile drains or pumping would be required of the local landowners to convey the drainage water to the master drain. When the State was unable to get the necessary local participation, construction of agricultural drainage facilities was authorized for 300,000 acres as part of the San Luis unit of the Central Valley project, with disposal near Antioch in the Sacramento-San Joaquin Delta.

In 1969, local agricultural interests prompted the State of California to request the Department of Agriculture to conduct a river basin investigation to determine the needs for onfarm drainage facilities and solutions to other land and water-related problems.

To date, the Soil Conservation Service has studied 28 project areas in the San Joaquin subregion and has developed economically and environmentally viable solutions to the agricultural drainage problems in 9 of these, which would provide drainage for 325,000 acres.

Their investigations are continuing on the east side of the Tulare subregion where emphasis is placed on agricultural drainage and local flooding problems.

The completion date for the San Luis Drain is anticipated at some time after 1980. However, construction of the drain north of Kesterson Reservoir, a regulatory reservoir on the drain in Merced County, will not be completed until a safe disposal point and operating criteria can be agreed to by the Bureau of Reclamation, the Federal Environmental Protection Agency, the Department of Water Resources, and the State Water Resources Control Board. A four-agency (the Federal Bureaus of Reclamation and Sport Fisheries and Wildlife and the California Departments of Water Resources and Fish and Game) ecological study of the delta was initiated in 1970. The purpose of this study is to develop design and operating criteria for the existing and proposed Federal and State water development facilities. Fishery, waterfowl, and water quality are major study considerations.

Deterioration of Surface Water Quality. – The major water quality problems in the lower reaches of the San Joaquin River and its major tributaries result from streamflow withdrawals, saline return flows, and nutrients from municipal, industrial, and agricultural sources.

During some periods, diversions literally dry up the river and some tributaries, while under certain other conditions the entire streamflow is composed of return flow. The reduction of streamflow by diversion and by dam construction, as well as the pollution problems, have caused a drastic decline in the salmon resources of the San Joaquin River system.

At times, severe crop damage has been experienced in western Stanislaus County due to high salt loads from irrigation return flows. Another contributor is the saline water from the abandoned gas wells on the Tuolumne River.

Diurnal fluctuations of dissolved oxygen due to the presence of large algal concentrations and partially treated municipal and industrial wastes have contributed to fishkills in the lower San Joaquin River. Other water quality problems include excessive coliform levels and turbidity.

Unless corrective measures are taken, future water quality problems will be aggravated by the wastes produced by a growing urban population and increases in industrial activity and irrigated agriculture. A number of measures are available, or might be made available, to improve water quality and augment flows in the Lower San Joaquin River system. The principal measures include:

1. Treatment of point sources;

2. Reclamation of waste waters for use for irrigation and surface flow augmentation;

3. Removal of unreclaimable waste waters from the San Joaquin Valley via drainage systems such as San Luis drain, now under construction, and the proposed master drain; and

4. Flow augmentation from local existing reservoirs and New Melones, now under construction, from the existing west side import canals of the Federal Central Valley and State water projects and from future east side import supplies.

Presently under way is the development of a comprehensive basin water quality control plan for the San Joaquin Valley under the direction of the State Water Resources Control Board. The proposed plan will set forth a definitive program of actions designed to preserve and enhance water quality and to protect beneficial water uses. In 1971, an interim plan was completed to be used as a guide for providing grants to local agencies for construction over a 2-year period. The comprehensive plan is expected to be completed in late 1974.

CONCLUSIONS

Sacramento-American River Flows

1. Decision 1400 of the State Water Resources Control Board, now under litigation as to its enforceability, requires releases from Federal reservoirs on the American River sufficient to maintain flows below Nimbus Dam of from 1,250 to 1,500 ft^3/s in normal years.

2. It will be possible, under normal operation, to meet such releases for the next 10 to 15 years. After that, providing such releases, without additional facilities or actions, would prevent fulfillment of authorized purposes of the Folsom-South unit.

3. There are several alternative plans by which both the Decision 1400 flows or similar increased flow conditions and the authorized Folsom-South unit project purposes can be accommodated. Implementation of such plans, however, will require additional authorizations and additional expenditures.

Delta Water Quality

1. The delta is an important resource which should be managed to maintain and enhance its beneficial uses.

2. The Peripheral Canal is the most acceptable overall solution to preserving and enhancing the fishery and water quality in the delta.

3. The ongoing four-agency study is needed to provide design and operating criteria for existing and proposed facilities.

Water Supply, Drainage, and Water Quality Problems in the San Joaquin Basin

1. Pumping of ground water is causing an average annual overdraft of over 1 million acre-feet as well as causing damaging land subsidence on the east side of the valley.

2. An adverse salt balance condition is causing continued deterioration of the ground-water quality.

3. San Joaquin subregion streamflow diversions coupled with waste water return flows from agriculture, industry, and municipalities are causing water quality degradation in the Lower San Joaquin River and its tributaries, resulting in damages to fisheries and agriculture.

4. The ongoing four-agency study will provide design and operating criteria for facilities such as the San Luis and San Joaquin Master Drains.

RECOMMENDATIONS

Sacramento-American River Flows

1. Pending litigation should be settled as soon as practicable.

2. A decision should be made as to which, if any, of the alternative plans for meeting Decision 1400 flow or similar flow conditions are to be implemented.

Delta Water Quality

1. An immediate decision should be made regarding joint participation by the Federal Government and the State in construction of the Peripheral Canal.

2. Steps should be taken by all levels of government to implement the proposals made in the Delta Master Recreation Plan.

Water Supply, Drainage, and Water Quality Problems in the San Joaquin Basin

1. The State, with Federal assistance from the Bureau of Reclamation, Geological Survey, and others as needed, should develop a plan for the conjunctive use of surface and ground water in the Upper San Joaquin basin.

2. The Department of Agriculture's San Joaquin Valley Basin Study should continue to identify opportunities to solve drainage problems and the justifiable drainage should be installed. Such studies should be expanded to cover all portions of the Central Valley not currently included in the San Joaquin Basin Study.

3. The comprehensive water quality control plan presently being prepared should be considered for implementation as soon as possible.

4. To maintain the productivity of the San Joaquin Valley, the following actions should be considered:

a. Timely completion of San Luis drain.

b. Action to advance construction of a master drain to remove industrial, municipal, and agricultural waste waters beyond those which could be reclaimed. The facility would serve principally as an outlet drain for agriculture and would permit the protection of soils and ground-water basins of the San Joaquin Valley for continual salinization.

c. Onfarm drainage systems and project collector drains must be installed to convey drainage waters from the cropland to the master drains.

NO. 2 – NEED TO DETERMINE FACTORS AFFECTING THE DECLINE OF THE ANADROMOUS FISHERIES AND WILDLIFE IN THE EEL AND TRINITY RIVERS

SUMMARY

Anadromous fish runs of salmon and steelhead and wildlife populations have been declining in several North Coast rivers and streams, including the Eel and the Trinity. Since construction of the Trinity project and transbasin diversion of flows to the Sacramento River, there has been a drastic decline of steelhead runs in the Trinity River. An understanding of the causes of these declines and methods to restore anadromous fish runs and wildlife productivity is critical to any considerations of further development on the Eel River, including exportation to southern California.

DISCUSSION

Over the past two decades, anadromous fish (salmon and steelhead) runs have been declining in this area, and a reduction in wildlife has been noted within water-project zones of influence. A report on the Eel River will be submitted by the State Resources Agency to the State Legislature in 1984, regarding future use of the Eel for water supplies or as a wild river. Analysis of the present Trinity River fishery and wildlife problem will prove useful in evaluating alternative plans for the use of other north coast streams.

The North Coastal Subregion (see figure VI-5) is by far the most water-abundant area in California, producting about 40 percent of the State's total surface water runoff, or about 27 million acre-feet per year. Lumbering, recreation, and fishing industries are the mainstays of the economy. Total net water demand in 1972 was about 960,000 acre-feet, of which 660,000 acre-feet were for agriculture. In addition to the water used locally, an average 1,400,000 acre-feet is exported: 1,200,00 acre-feet to the Sacramento basin from the Trinity River and 200,000 acre-feet to the Russian basin from the Eel River.

The North Coastal streams support average annual runs of about 250,000 king salmon, 80,000 silver salmon, and perhaps 450,000 steelhead. Sports fishing and commercial catch support a significant share of the local economy. Commercial salmon catch in 1971 at ports north of San Francisco totaled 5.6 million pounds with a value of $3 million. Adequate volumes of water are required not only for transportation of adult and young fish to complete their life cycle, but

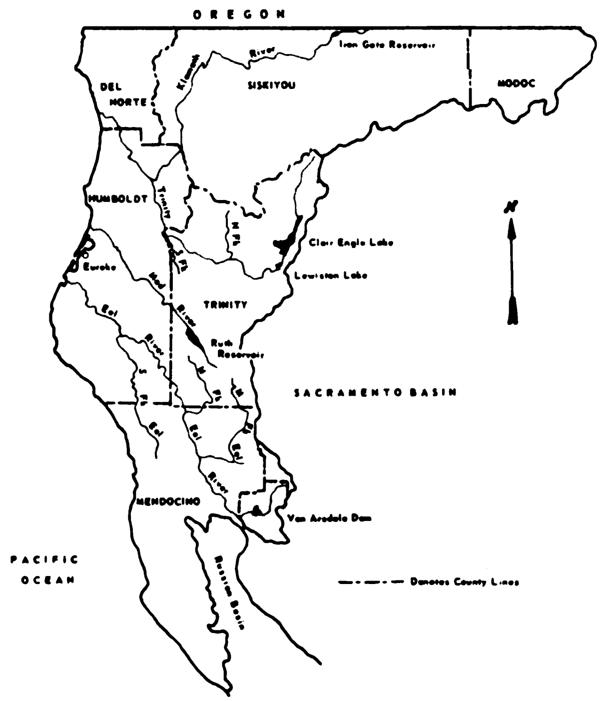


Figure VI-5. The North Coastal subregion of California.

also to keep water quality at a level compatible for fish. Contracts between local and Federal agencies and the California Department of Fish and Game are in effect on three north coastal rivers for releases aggregating almost 1 million acre-feet per year to maintain salmon and steelhead populations. These releases are made on the following rivers:

River	Location	Amount (1,000 acre-feet/ year)
Klamath	Iron Gate	833
Trinity	Lewiston	120
Mad	Ruth	46

Big game, upland game, fur animals, and waterfowl are abundant in the area. Common species include Columbian black-tailed deer, black bear, blue and ruffed grouse, California and mountain quail, band-tailed pigeons, mourning doves, gray squirrels, snowshoe hares, mink, river otters, coyotes, bobcats, black brants, and mallards. Critical winter habitat is essential for resident and migrating deer and a wide variety of other wildlife species. Usually this type of habitat is located in river valleys where it often comes in conflict with other land uses.

Since 1960 when Trinity Reservoir (Clair Engle Lake) began to fill, extensive habitat changes have occurred in the Trinity River downstream from Lewiston Dam, largely as a result of alterations in the river's historic flow patterns. Significant changes have occurred both before and since that time in various parts of the basin as a result of logging, road building, man's other activities, and floods.

In recent years the numbers of steelhead returning to the Trinity Hatchery at Lewiston Dam have dropped from several thousand to a few hundred. Biologists believe that the key to questions on the North Coast fisheries rests in understanding the Trinity River.

The number of deer in the herd around Clair Engle Lake has also declined by approximately 5,000. Inundation of the deer winter range by the reservoir may be a major factor in the immediate local area affecting the Weaverville deer herd. But other impacts mentioned earlier must be included in future studies and resulting recommendations for the remedial measures.

The problem of determining and evaluating preproject fishery resources presents a major difficulty in developing fish preservation measures in the north coastal area. The fish populations which might be affected by water developments in the North Coastal area need better definition. A comprehensive effort to determine fish populations in North Coastal streams was made about 15 years ago by the Department of the Interior, Pacific Southwest Field Committee. The California Department of Fish and Game has supplemented this information from time to time, but the reliability of the overall estimates now in use is open to question.

Turbidity is a major related fish problem in the North Coastal area. Persistent turbidity in a river reduces a stream's fishability and productivity. At this time, little is known about the impact that existing or proposed projects would have on turbidity or the extent to which poor land management practices may affect the overall problem. Additional work is required to define the causes and sources of turbidity and to develop alternative means of controlling its level in streams and reservoirs.

The Eel River has a particularly high sediment load and is rated as one of the five highest in the world in this respect. The problem manifests itself in channel aggradation and degradation. There is a lack of understanding of these changes and their effect on fish habitat and fish production.

The population of all wildlife species that might be affected by water development also should be better defined. Past studies have concentrated on the deer population where a measurable reduction in deer kills has been noted. Emphasis should be placed on ecological and population studies of the other game and nongame species as well. Riparian habitat for the various stream systems should be inventoried on a comprehensive basis.

PROBLEM RESOLUTION

There is need for a comprehensive investigation to evaluate the environmental impact of construction of the Trinity River division on the Trinity basin. This investigation, however, should not be confined only to fishery and wildlife biological aspects. but should include watershed management, geological, engineering, legal, social, economic, and other related considerations as well. Since the Trinity River division is not the sole cause of the changed conditions in the basin, the comprehensive investigation should include an evaluation of the environmental impact that other man-related activities have had on the area. A multidisciplinary approach to the evaluation and solution of the problems involved is needed.

Through the Trinity River Basin Fish and Wildlife Task Force, a proposed program was developed for fishery studies in the summer of 1973 and for wildlife studies in early 1974. The key to the public's acceptance of future water development in California is to determine how best the environment can be protected or enhanced. In order to insure that all significant factors will be considered, the membership of the Task Force was recently expanded to include the Forest Service, Bureau of Land Management, California Department of Water Resources, Trinity County Board of Supervisors, and Humboldt County Board of Supervisors. It is also planned to invite a representative of the Hoopa Valley Indians to become a member.

CONCLUSIONS

1. Significant declines of both fishery and wildlife resources have occurred in the north coastal area due to some combination of man's and nature's activities.

2. There is an immediate need to determine the causes of and possible solutions to the problems of fish and wildlife decline.

3. A data base to permit the findings on the Trinity River to be extended to the Eel River and possibly other streams on the north coast is essential.

4. Problem solutions should include consideration of basin watershed management practices which contribute to problems of fishery management in the Trinity River.

RECOMMENDATIONS

1. An early decision should be reached by the Trinity River Task Force on the magnitude of the studies to be made, the agencies' involvement, and the source of funding. Implementation of the Task Force's recommendations should begin in FY76.

2. Studies should include remedial action for solution of Trinity River fishery problems as well as elimination of factors precipitating these problems.

NO. 3 – NEED TO EVALUATE POTENTIAL OF WASTE-WATER RECOVERY PROJECTS FOR WATER-SHORT AREAS

SUMMARY

Southern California has been a pioneer area in utilizing waste water to provide recreation opportunities. The Santee project is one of the best known examples of water reuse in the country. Formerly an unattractive gravel pit, it was opened to the public in 1961 and now offers opportunity for picnicking, boating, fishing, and swimming. The State of California is continuing to include waste-water reclamation in all of its planning activities to provide "in lieu" sources in inland areas where incidental reclamation is practiced and new sources of water in areas where waste water is discharged to saline water bodies.

Waste-water reclamation must be considered an "alternative" supply. If other sources of better quality and cheaper water exist, little demand for reuse of reclaimed water would exist, unless regional water quality boards' allowable discharge requirements would dictate long-distance conveyance facilities to remove unacceptable effluent from an area. This removal cost alone could well make waste-water reuse attractive to a given area even if a cheaper alternative base water supply exists.

Much of the potential expansion for water reclamation is made possible by the availability of an initial supply of good quality water, such as is provided by import projects to certain areas, which consequently provide a better quality waste water than that derived from local supplies. Thus, in most areas an imported water supply is and will be necessary to make possible the development and use of reclaimed water.

DISCUSSION

With the concern today for the environment and with the ever-increasing demand for both instream and out-of-stream use of the limited undeveloped freshwater resource in California, any plan for efficient management must consider reuse of available supplies. Reclamation of waste water thus merits special attention.

Waste-water reclamation is the planned treatment of wastes with the intent of producing water for beneficial purposes. The treatment may be the minimum process required for waste disposal, or it may include further treatment to remove or neutralize specific pollutants. Reclaimed water can be used to meet some of the increasing water demands. For reclaimed water to be credited as a "new" source to supplement and augment other water supplies, the planned reclamation must be made on that waste water discharging to either inland salt or sinks or coastal waters and, hence, otherwise lost to the freshwater cycle.

Waste-water reclamation and reuse are more favorable and advantageous where some combination of the following conditions prevails: (1) wastes would otherwise be lost to freshwater beneficial uses through disposal to a marine environment; (2) water is costly or scarce; (3) the original water supply is of good quality or good quality water is available for blending; (4) waste water discharge requirements are restrictive and, consequently, the highly treated wastes may be of such good quality or so valuable that reclamation potential is enhanced. In addition, it is essential that user response and public opinion are favorable toward the use of reclaimed water.

About 2.4 million acre-feet of municipal and industrial waste water were discharged in California during 1970. Only about 175,000 acre-feet of that amount were reclaimed and put to use, primarily for agriculture and recreation. An additional 440,000 acre-feet were discharged, after treatment, onto land or into freshwaters. Of this, 340,000 acre-feet were mingled with and became part of the surface water supply. The remaining 1,770,000 acre-feet were discharged to the ocean. That part of the quantity discharged to the ocean containing fewer than about 1,500 p/m of dissolved solids provides the greatest opportunity for further water reclamation and reuse, since it now is lost to the freshwater supply system. Current information suggests that by 1990 about a million acre-feet of new water may reasonably be reclaimed in certain areas where conditions are favorable. This compares with new demands of about 6 million acre-feet and an expected total net water use approaching 35 million acre-feet in California in 1990. Reclaimed water could then meet about 17 percent of California's new demand. These estimates depend on a number of factors, including population growth and efforts devoted to upgrading the level of waste-water treatment to minimize the effects of waste discharges on the environment, such as implementation of the basin water quality plans required by the Federal Water Pollution Control Act and under development by the State Water Resources Control Board.

The areas of the State where the greatest potential exists for future increased sources of and/or uses of reclaimed waste water are:

1. The nine county San Francisco Bay area;

2. The Central Coastal basin in the Monterey Bay area in the north and the Santa Barbara-Ventura area in the south;

3. The South Coastal basin covering the metropolitan areas of Los Angeles, Orange County, and San Diego;

4. The San Joaquin basin which includes the entire drainage area of the San Joaquin River in the counties of Madera, Merced, Mariposa, Stanislaus, Tuolumne, and the southern portion of San Joaquin County; and

5. The Tulare basin, including Fresno, Kings, and Tulare Counties and those portions of Kern and San Benito Counties lying in the Central Valley.

Projected supplemental water demands in 1970 (demands in excess of the capabilities of existing and authorized facilities) expected to develop in each of these five basins by the year 2020 are as follows:

	Projected supplemental demands (1,000 acre-feet)
San Francisco Bay	470
Central Coast	360
South Coastal	650
San Joaquin	610
Tulare	2,090

PROBLEM RESOLUTION

Use of reclaimed waste water is considered by some to be a panacea for California's water problems. Others deplore more general use of waste water. Reclaimed water can extend the utility or upgrade the quality of the water supply, but it is not a substitute for the basic system.

Reclaimed water is a "different" water supply which requires special handling. The direct use of reclaimed water for domestic purposes is not permitted in California by public health authorities because of possible health hazards, particularly viruses and the long-term effects associated with the stable organic materials which remain after treatment. Consequently, reclaimed water must be kept separated from domestic supplies. Public health criteria are also enforced for agricultural and recreational use of reclaimed water, including disinfection or restrictions on use for certain crops, and timing of reclaimed water application for specific edible crops. Requirements for the use of reclaimed water are set by the Regional Water Quality Control Board in conformance with these criteria.

Irrigated agriculture appears to have the greatest potential for use of reclaimed water. Since the irrigation demand pattern is seasonal, there is a need for interim storage of the reclaimed water which is produced on a regular basis. Ground-water recharge could provide most of the needed storage. There is also an increasing potential and use of reclaimed water for recreational purposes.

Agricultural use would require the recharge of substantial quantities of reclaimed waste-water. However, the present policy of the California Department of Health is to recommend against the near-term recharge of a substantial volume of reclaimed water into a small basin but to consider the possibility of permitting a small percentage of reclaimed water in the underground storage capacity. In the latter case, the location of the recharge area relative to community wells would be considered.

If the full potential use of reclaimed waste water is to be achieved, two major undertakings should be accomplished; namely, intrastate regional application of large quantities of reclaimed water in those categories now acceptable, and continued research into and development in those categories now restricted.

Intrastate Regional Application

At present, reclaimed water is used chiefly for agricultural, landscape irrigation, recreational, and industrial activities.

Agricultural use represented 90 percent of the reclaimed water. Uses include the irrigation of: (1) pasture; (2) fodder, fiber, and seed crops; (3) crops that are grown well above the ground, such as fruits, nuts, and grapes, provided they are not harvested after they have fallen; and (4) crops that are processed so that prior to human consumption pathogenic organisms are destroyed.

The direct use of reclaimed water for landscape irrigation and recreational pursuits represented 8 percent of the reclaimed water. Uses include (1) irrigation of parks, freeway landscapes, golf courses, and athletic fields; (2) creation of scenic and ornamental lakes and ponds; (3) the maintenance of recreational lakes – for picnicking, boating, fishing, etc.; and (4) fire protection.

Industrial uses of reclaimed water represented 2 percent of the reclaimed water. Uses include cooling water, process washwater, boiler feed water, quenching spray water, fire protection, and secondary product recovery. These are carried out chiefly at metallurgical manufacturing and fabrication plants, electric power generation plants, oil refineries and petrochemical plants, and in mining and quarrying.

Presently under way are the following three studies to identify the potential for intrastate regional reclamation and use of large quantities of waste water in those categories acceptable: (1) San Francisco Bay Area Interagency Wastewater Reclamation Study, (2) Land Application Alternatives for Wastewater Management; and (3) the Ventura County Water Management project.

San Francisco Bay Area Interagency Wastewater Reclamation Study

A multiagency reconnaissance-level study initiated by the Department of Water Resources and the State Water Resources Control Board (SWRCB), but involving various other State, Federal, and local government agencies, was concluded in February 1974. The results of this reconnaissance-level study were anticipated for their possible inclusion in the SWRCB's basin plan for the San Francisco Bay region.

The interagency study was made to examine the potential of intercepting and reclaiming bay area waste water to augment delta outflows either directly or indirectly by substituting reclaimed water for irrigation and ground water recharge demands in the bay area or adjacent area.

Among other findings, the study identified the following:

1. The average dry weather discharge of waste water in the San Francisco Bay area will increase from 700,000 acre-feet in 1980 to 1,000,000 acre-feet in year 2000. Of this, about 500,000 acre-feet increasing to 700,000 acre-feet, will be available for reuse at convenient locations during the same time frame.

2. Within the next 20 to 30 years, a supplemental demand for water will develop to maintain the yield of the Sacramento-San Joaquin Delta "pool." This quantity will be greater than the quantity of waste water in the bay area available for reclamation.

3. This reclaimed waste water can be introduced for salinity repulsion outflows in the delta, or for a portion of the water now being exported for irrigation in the San Joaquin Valley. The alternative project unit costs would range from $90 to $130 per acre-foot, based upon the presumption that all waste-water sources will have received the equivalent of secondary (biologic) treatment and made available by the discharger at no cost.

4. There is an annual demand for 80,000 acre-feet of freshwater for irrigation in the Santa Clara-Hollister Valleys. This could be supplied by 100,000 to 120,000 acre-feet (depending on the total dissolved solids) of reclaimed waste water in lieu of the authorized San Felipe project drawing from delta exports.

The high cost of reclaimed water would severely limit its use for irrigation unless subsidies are provided. However, these costs for reclaimed waste water are not considered excessive or limiting for many industrial uses or for cooling large thermoelectric powerplants.

Land Application Alternatives for Waste-water Management

The U.S. Army Engineer District, San Francisco, is assisting the SWRCB in developing "Comprehensive Water Quality Control Plans" for basins within the San Francisco Bay and Delta and Central Sierra subregions. The Corps is providing the State with an evaluation of alternative land applications or "land disposal" components of the integrated regional waste-water ment systems.

The Corps' major effort has been directed toward developing alternative systems for managing the area's waste waters and residual solids from waste-water treatment by suing the land and crops growing on the land as an integral part of the treatment process. The land application portions of the alternatives incorporate reusing the waste water for irrigation and reclaiming a part of the water after land treatment for further beneficial uses. Land sites in nine counties were evaluated, with the largest in Yolo County. Six alternatives have been developed. Quantities of waste water to be applied to land ranged from 560,000 to 1,050,000 acre-feet per year. Quantities expected to be re-collected in underdrains for further limited reuse at the year 2000 level of development ranged from 126,000 to 281,000 acre-feet per year.

Ventura County Water Management Project

The Bureau of Reclamation initiated the Ventura County Water management feasibility study in October 1973. Its purpose is to develop a plan for the beneficial use of all waste waters in Ventura County (South Coastal subregion), with an emphasis on reuse of municipal waste water. Elements of the study will include waste water aggregation, advanced treatment, potential areas of reuse, distribution of beneficial use, and residual waste disposal. The study will include all of the area lying within Ventura County, with emphasis on the Calleguas-Conejo drainage basin, the area with the most available waste water and highest water need. It is estimated that as much as 100,000 acre-feet of waste water could be reclaimed annually by the year 2000. The study is scheduled for completion in FY 1977.

Research and Development

In addition to the identification of the potential for large-scale reclamation of waste water in those categories now acceptable, there is a need for continued research into and development of the public health aspects of reuse to determine if domestic purposes can be included. Particular emphasis should be on the use of reclaimed water that enters ground-water basins. Research and development should be carried on to:

1. Define, detect, and identify stable organics and viruses in waste waters and their effects upon the public health;

2. Determine levels of the stable organics and viruses at which they adversely effect the public health;

3. Develop methods, processes, and means of removing or neutralizing the harmful stable organics and viruses from wastewater for all beneficial uses, especially domestic and municipal purposes;

With past diversions of natural streamflows, there are estuarine and wetland areas in California which now depend to a very significant extent on waste water to maintain critical salinity gradients and ground-water levels. Any diversion and reuse of these particular wastewater flows could have disastrous effects on these surviving habitat areas.

CONCLUSIONS

1. There is a potential for regional level reclamation and use in acceptable categories of large quantities of wate water in California.

2. The areas of the greatest potential are along the coast from San Francisco to San Diego and in the San Joaquin Valley.

3. Studies under way for intrastate regional level applications in acceptable categories should be completed and considered for early implementation.

4. Current scientific knowledge and technology in the field of wastewater treatment are not sufficiently advanced to permit direct reuse of treated waste waters as a source of domestic water supply.

5. Immediate steps should be taken, through intensive research and development, to advance technological capability in order to reclaim waste waters for all beneficial uses and identify the risk involved.

6. Such research and development are considered to be a national need that should continue to be supported by the Federal Environmental Protection Agency.

7. Any studies of the reclamation and reuse of specific waste-water flows should cover the impact of such reuse on aquatic, wetlands, and estuarine habitat downstream.

RECOMMENDATIONS

1. On going studies, such as the Ventura County Water Management Project and Land Application Appraisals, should be continued.

2. A feasibility level investigation should be undertaken to develop a plan to reuse San Francisco Bay

area waste water. Special attention should be given to the effects of this reuse on the ecology of the bay. This investigation would be a followup to the recently completed interagency study. The investigation could be initiated in FY 1978 and could be completed in approximately 3 years.

NO. 4 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

California's large population and extensive industrial and agricultural bases are creating high levels of energy demand. As these demands double, then triple, in the next 20 years, fossil and hydroelectric sources, which have until recently been the major power suppliers, will have reached their production limits and extensive reliance on nuclear plants is expected. However, location of generating facilities near faultlines and populated load centers poses problems of safety, pollution, land use, and especially water supplies. As the high demand areas are also those where water is not plentiful, use of good quality water for powerplant cooling could be at the expense of other uses. Since low quality water can be used and/or once-through cooling by water already in transit through aqueducts could be adapted to meet high priority energy needs, these and other potential solutions should be studied as soon as possible.

Of the 20 million people living in California, over 80 percent live relatively close to the Pacific Ocean, with 11 million in the South Coastal subregion and 4.5 million in the San Francisco Bay subregion.

Most of the electricity, therefore, is generated and used in the coastal areas. Since World War II, the majority of the new powerplants have been fueled by gas and oil and located near large bodies of water, such as bays, estuaries, and the Pacific Ocean, which provide the large quantities of once-through cooling water required.

The 1972 level of installed capacity was approximately 30,000 megawatts (MW). Electric power requirements in California can be expected to continue to increase due to a gradual rise in population, more commercial activity, expansion of industry and agriculture, and greater water deliveries by the State Water project. Other factors which may also affect future power requirements are the development of rapid transit systems and the conversion from other forms of energy to the use of electric power. The California Public Utilities Commission estimates that about 70,000 MW of new generating capacity should be built in the next 20 years. This projection is founded on historical use and does not anticipate restraints by governmental agencies or other bodies nor the effect that energy limitations might have upon demand.

Because of environmental, fuel, safety, siting, cooling water, and aesthetic considerations, electric utilities in California will find it increasingly difficult to meet electric power requirements in the future.

Of the 70,000 MW of new generating capacity required, about 7,000 MW may be imported from outside of California. Of that remaining capacity, hydroelectric generation is expected to account for 8,000 MW, geothermal for 7,200 MW, and fossil fuels (oil and gas) for 10,600 MW. The balance of some 37,200 MW is expected to be supplied by nuclear powerplants.

In the siting of a major nuclear powerplant, the method of cooling to be used is an important consideration. The most abundant source of water is, of course, the Pacific Ocean. However, coastal sites are limited because of seismicity and population density and are also subject to great competition from other uses. The competition for land use resulted in the California Coastal Zone Conservation Act of 1972, which established a commission to prepare a management plan for proposed coastal developments.

Sites for inland plants are much more plentiful and less seismically active. Most of the favorable areas for nuclear powerplant sites are in the Central Valley (Sacramento, Delta-Central Sierra, San Joaquin basin, and Tulare basin subregions) and the southeastern desert area (Colorado Desert subregion). Siting in these areas would usually require evaporative cooling because the State Water Quality Control Plan has greatly restricted the use of inland waters for once-through cooling. Evaporative cooling consumes about 25,000 acre-feet per year of freshwater for each 1,000-MW generating capacity. If all new nuclear powerplants were located inland and used freshwater for evaporative cooling, approximately 1 million acre-feet of water annually would be needed. This quantity has not previously been included in most State water resources planning projections.

PROBLEM RESOLUTION

Presently, the major electric utilities in the State are actively investigating for powerplant sites the areas between Chico and Bakersfield in the Central Valley and in the Rice and Palo Verde Valleys near the

Colorado River. These areas, except for the northern part of the Central Valley, are water deficient.

Alternative sources of water supply for use as powerplant cooling in these water-deficient areas are imported freshwater, agricultural and municipal waste water, poor quality ground water, purchase of existing water rights, exchange of contracted water, and once-through conveyed water destined for other use.

Since imported water supply will be needed in the San Joaquin Valley (see California No. 1) to meet the existing ground-water overdraft and future growth needs, an additional supply could also be provided through a common conveyance system for powerplant cooling.

In the Colorado Desert subregion, the Metropolitan Water District of Southern California has announced a policy to make available up to 100,000 acre-feet anually of Colorado River water for powerplants in the Rice and Palo Verde Valleys.

Waste-water return flows from agricultural and municipal uses are also possible sources of cooling water. Two areas with large amounts of agricultural drain water are the San Joaquin and Imperial Valleys. In 1972, the California Department of Water Resources completed a preliminary study in the Tulare basin subregion which listed the agricultural waste water expected to be produced in Kern, Kings, and Tulare Counties and compared these quantities with those required to cool a nuclear powerplant. The study concluded that from three to five 1,100 MW nuclear units could be cooled with available agricultural waste water by 1991, the exact number depending on the efficiency of the units and the allowable salt concentration of the cooling water. However, use of waste water for thermal cooling would not eliminate the saline brine disposal problem associated with irrigation return flows.

A similar opportunity might exist in the Salton Sea area as part of the solution for the problem of controlling the increasing salinity which is discussed later in this chapter. However, one limitation of this area with respect to nuclear powerplant siting is the high seismicity.

Municipal waste water has potential for use as cooling water for nuclear powerplants. However, this will involve conveyance of water from the coastal areas to inland nuclear sites.

Poor quality ground water would have a potential similar to waste water. Such valleys as Soda and Silver Lakes in the south Lahontan subregion and Dale Valley in the Colorado Desert subregion should be evaluated as potential sites for nuclear powerplants. Other valleys in more actively seismic areas, for example, the Carrizo Plain in the Central Coastal subregion and Panamint Valley in the south Lahontan subregion, should be considered for possible fossil fuel generation powerplant sites. All of these valleys are located in sparsely populated areas.

With respect to purchase of existing water rights, the cost of cooling water for an inland plant is not a major factor in the total cost of power production. For example, if water were as expensive as \$100 per acre-foot, the generating cost would be increased by only 5 percent over that of a seawater system. Therefore, there may be some opportunities to purchase land and existing water rights now being used for marginal agricultural production.

Exchange of contracted water would involve either a change in the place of use or the substitution for water from a particular source. For example, a southern California utility could locate powerplants in the San Joaquin Valley and use water contracted from the State Water project instead of using it in the service area in the south as originally planned.

Similarly, water presently being imported into the South Coastal subregion from the Colorado River could be used at powerplants in the desert. State Water project yield from northern California could then substitute for the Colorado River water in the South Coastal area. This substitution has been proposed with respect to the planned plants in Rice and Palo Verde Valleys.

Once-through conveyed water would involve locating a powerplant at or near a water supply canal used for other purposes. The generation of 1,000 MW requires about 1,500 ft^3/s of once-through cooling water.

Each of these alternative sources for cooling water for inland siting of powerplants will require more detailed analysis.

Many of the major electric utilities are conducting studies within or near their service boundaries to identify "candidate areas" for the general location of future powerplants. Additional evaluations of these "candidate areas" will be needed to identify specific potential plantsites. Because of the limited area of coverage of the studies by the individual utilities, there has been a need for a statewide summary of the water requirements for future power generation. Therefore, commencing in FY 1973, the California Department of Water Resources initiated a Statewide Planning Program on "Water for Power."

The program will be completed in FY 1975. The objectives of the program are:

1. Preparation of estimates of power requirements for the next 20 to 30 years;

2. Evaluation of alternative generating methods, including conventional and pumped-storage hydroelectric generation, fossil fuel plants, geothermal plants, nuclear plants, and other sources;

3. Determination of generating plant site requirements and criteria to satisfy environmental considerations; and

4. Estimation of cooling water requirements for generating plants and effect on the State Water project of supplying a portion of such requirements.

A particularly significant water-related aspect of the investigation of peak powerloads should include a study of the impact that might result from establishing a large-scale coordination of pumping schedules within and between the many water districts in the State.

Certain of the utilities which are conducting the candidate area studies have indicated the possibility for the use of water from Central Valley project reservoirs, canals, and drains. A major element would be analysis of heat dissipation resulting from the use of water from once-through cooling.

CONCLUSIONS

1. Future power needs in California are expected to require an increase in generating capacity of 70,000 MW in the next 20 years. The impact of energy conservation programs on this requirement has not been determined.

2. The major part of the increase in capacity will be nuclear, because air quality standards limit the use of fossil fuel. The nuclear plants, due to siting restrictions, will be located inland, primarily.

3. Approximately 1 million acre-feet of water annually would be required for condenser cooling by evaporation at the inland sites. Alternative sources of cooling water that should be considered are: imported water, agricultural and municipal waste water, poor quality ground water, purchase of existing water rights, exchange of contracted water, and once-through conveyed water.

4. In addition to the ongoing studies by the electric utilities to identify powerplant sites, there is a need for a detailed statewide summary of water requirements and sources for future power generation. A program entitled "Water for Power" underway by the California Department of Water Resources will provide much of the needed data.

RECOMMENDATIONS

1. A joint State-Federal evaluation of the possibility of providing cooling water from the features of the Central Valley project should be initiated in FY 1977. This study should include the effects of thermal heat on instream uses. It would be a part of the solutions sought through the recommendations to Westwide No. 1, WATER REQUIREMENTS FOR ENERGY, and would be coordinated with the ongoing Central Valley Project Study.

2. A special study is needed for determining groundwater supplies available at remote desert locations to supply cooling requirements for thermal plants.

NO. 5 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

SUMMARY

There are two major salinity problem areas in the State: (1) the San Joaquin-Sacramento River systems and delta and (2) the Colorado River. The first has been addressed previously; the second is a part of the total Colorado River salinity problem described on a basinwide basis in Regional No. 2. The major effect of California's water use on Colorado River downstream salinity is not due to large contributions of salt but rather from the concentration effects caused by large withdrawals of water supply mainly in the Palo Verde Valley.

In California, the impact of salinity from the Colorado River Basin is primarily through the All-American Canal and Metropolitan Water District of Southern California aqueduct systems. This salinity is adversely affecting both irrigated agriculture production and cost of treatment from M&I water users. Plans have been developed for blending the Colorado River M&I supplies with better water to alleviate the problem.

The following discussion relates only to the California portion of the Regional Problem pertaining to the increasing salinity in the Colorado River system.

DISCUSSION

The Colorado river is the major source of water supply for Southern California. Except for some minor uses, California's water users obtain Colorado River water through three major projects on the river. The Metropolitan Water District of southern California pumps from Lake Havasu, formed by Parker Dam. The Palo Verde Irrigation District diverts into its canal at the Palo Verde Diversion Dam, about 10 miles north of the city of Blythe. The Imperial Irrigation District, Coachella Valley County Water District, Bard Irrigation District, and Yuma Indian Reservation all receive river water through the All-American Canal, heading at Imperial Dam. California's Colorado River diversions minus return flows amount to 5.2 million acre-feet per year.

The Metropolitan Water District of Southern California

During the period 1942-69, total dissolved solids varied at the district's intake pumping plant at Parker Dam from a low of 495 p/m to a high of 840 p/m. Total water hardness has varied between 295 p/m and 400 p/m, a range which is in the "excessive hardness" category. For a 1973 level of development, the historical range would have been higher.

A moderately hard water is sometimes defined as having hardness between 60 p/m to 120 p/m. The district has softened a large part of its water supply for many years. The constituents primarily responsible for the hardness, calcium and magnesium, were reduced in the softening process. However, in that process, the amount of sodium ions increased. Because of adverse effects of high sodium ion concentrations on plant growth, unsoftened water is preferable for irrigation use.

Problems associated with the use of Colorado River water for municipal and industrial purposes have been high soap consumption, formation of objectionable scale in heating vessels, and damage through corrosive attack on distribution pipelines and user plumbing systems and applicances. These have resulted in economic impacts on urban water users. In addition, the problem of water taste is another consideration. The United States Public Health Service drinking water standards recommend that "waters containing more than 500 p/m of dissolved solids not be used if other less-mineralized supplies are available."

With completion in 1972 of the initial facilities of the State Water project, the district has available, to it supplies of northern California, water with about one-third the salinity of Colorado River water. In order to reduce the salinity of water delivered to its service area, the district is proceeding with a plan involving a significant expenditure of funds which would allow delivery of a blend of Colorado River and State project water to 75 percent of its service area. Eventually, this program will result in the bulk of the service area receiving water with a salinity ranging from around 350 p/m to slightly over 400 p/m. However, in this range, the detriments due to salinity are generally proportional to the salts in the water. Thus, one of the major objectives of the district is to reduce the salinity of its Colorado River supply.

Palo Verde Irrigation District

Water diverted for the Palo Verde Irrigation District at Palo Verde Dam, approximately halfway between Parker and Imperial Dams, has a slightly higher salinity than the water at Lake Havasu. The principal salinity problem in this area in the past has been caused by salts in the water in conjunction with a high water table. Open-ditch drains have been constructed and have recently been enlarged to lower the water table to a safe depth; when the impaired flow conditions at the drain outlets are fully corrected, these measures should overcome most salinity problems in the valley.

Most of the valley's soils have good drainage, thus enabling salts to be leached out without the necessity of installing tile drains. However, it is important that the infiltration capacity of the soil profile be maintained and the district's drainage facilities be expanded as necessary to stabilize the ground-water levels at sufficient depth below the surface to permit free draining of the soil root zone.

Bard Irrigation District and Yuma Indian Reservation

Even though the salinity of the water obtained from the All-American Canal for use within Bard Irrigation District and Yuma Indian Reservation is higher than the water available to Palo Verde Valley, the situations are similar. The main drain serving these areas was improved during 1969, which should result in a general lowering of the water table over much of the area. At the projected salinity levels, soil drainage and accompanying drainage channels will require continued attention for these areas to maintain their productivity.

Imperial Irrigation and Coachella Valley County Water Districts

Water users in Imperial and Coachella Valleys have experienced an increase in the salinity of their Colorado River supplies in recent years. For example, during the period 1943-47, after completion of the All-American Canal, the river's salinity at Imperial Dam averaged about 700 p/m, but for the period 1965-69, salinity averaged 875 p/m.

Not only have total dissolved solids been increasing, but also the more harmful constituents, namely sodium and chloride ions, have markedly increased. An additional problem presently causing much difficulty in Imperial and Coachella Valleys is related to seasonal variations in salinity that occurs each year. The salinity of the water arriving at Imperial Dam is lowest during summer months and reaches its highest values in November and December of each year. Salinity levels in recent years have adversely affected germination of seeds and early growth and development of plants, with the salinity peaks that occur during winter months being particularly adverse.

Because of the predominance of clay and heavy loam soils in Imperial and Coachella Valleys, most farmers have installed tile pipe drainage systems and use irrigation water in excess of plant needs to leach out the salt and maintain a favorable salt balance in the root zone. These drainage systems cost from $150 to $400 or more per acre, depending upon the required depth and spacing of the pipes. Any increase in salinity of irrigation water results in an economic loss, since a greater quantity of water is required for the equivalent crop output. To overcome the effects of saline irrigation water by leaching requires that the soil be able to accept an increase in the amount of applied water.

For some crops and soil conditions, a change in the manner of irrigation, such as from the furrow to the sprinkler method, may both save water and permit operations with higher salinities. Additional research on this possibility is needed.

Increasing salinity of Colorado River water would also have an effect on the salinity of the Salton Sea. The sea is primarily a repository for storage of agricultural drainage waters from the Imperial and Coachella Valleys but has also become a valuable habitat for fish and wildlife and a center for water-associated recreational activities. Presently, the water level is relatively stable, with evaporation approximately equal to the inflow. Salinity, however, is increasing at a rate of about 550 p/m per year because there is no surface outflow. As the salinity of the Colorado River water supply used by farmers in the Imperial and Coachella Valleys has increased in the past, and the amount of irrigation water needed for leaching has increased, additional drainage waters at a higher salinity have been discharged to the Salton Sea. However, due to the limitation on water supplies, increased quantities of water for leaching will not be available in the future. Accordingly, increasing levels of Colorado River salinity will be reflected only in accelerating the present increase of salinity of the sea.

PROBLEM RESOLUTION

The most promising approach to reducing salinity is through a basinwide program of construction of salinity control projects and implementation of measures which would prevent large quantities of salt from entering the river. The Bureau of Reclamation has proposed a comprehensive water quality improvement program which is presented in its report entitled "Colorado River Water Quality Improvement Program." The Bureau's plan has the objective of maintaining salinity at or below present levels at Imperial Dam while orderly development of Upper Basin apportioned water continues to full utilization. The seven Colorado River Basin States are united in support of such a program to control the river's salinity.

Most alternatives to the salinity control program involve augmentation of the river to achieve a degree of dilution, hence lower salinity concentrations. Numerous augmentation programs have been proposed, including large-scale diversions from other river basin systems, weather modification, and geothermal desalting.

The Bureau of Reclamation is studying potential geothermal developments in Imperial Valley as a possible augmentation source for the Colorado River. If the geothermal water resource in the Imperial Valley should prove to be a practicable water supply, it is strategically located to be of assistance in solving the water quantity and quality problems relating to the Colorado River. Development of 2.5 million acre-feet of demineralized water (about 50 p/m) would improve the water quality of the Lower Colorado River and would help the United States in meeting its Mexican Treaty obligations. Delivery as far upstream on the Colorado River as possible, such as to Lake Havasu or Lake Mead, would provide the greatest benefits to the entire basin, including improved quality of water diverted for use in the South Coastal and Colorado Desert subregions in California.

The Bureau is also studying augmentation by weather modification in its Colorado River Basin Pilot project now ongoing in the San Juan Mountains of Colorado. (See Westwide No. 17 and Regional No. 1.)

Part of any program to mitigate the increasing salinity of the Colorado River will be the continuation of measures being taken within the respective service areas. These would include the treatment or dilution of water within municipal and industrial service areas to the extent practical and economical. In agricultural service areas, drainage tiling, where necessary because of soil conditions, and revision of irrigation practices to permit continued economic crop production should be accomplished insofar as practicable.

Limitations of further depletions of the basin water supply have been suggested as a solution to the salinity problem. This would entail halting of projects now under construction and restricting full utilization of projects already completed. However, this is not a viable alternative since, under the Colorado River Compact approved by Congress, the States have a right to use water within their apportionments.

CONCLUSIONS

1. Salinity of the waters of the Colorado River basin is increasing and is expected to increase further unless substantial salinity control measures are taken.

2. There are two basic alternatives for salinity control: salt-load reduction and augmentation of the riverflows. Of the two, a basin-wide salt-load reduction program is the most feasible solution for the next several years.

3. Augmentation programs may offer additional relief in achieving the goal of maintaining salinity levels at or below current levels.

4. As an adjunct to any program for controlling salinity of the river, it will be desirable to continue implementation of programs for water treatment and dilution in urban areas and drainage and irrigation improvement in agricultural areas insofar as practicable and economical.

5. Limitation of depletions is not a presently acceptable alternative to the Colorado River Basin States.

RECOMMENDATIONS

1. Feasibility studies under the 10-year comprehensive program (CRWQIP) proposed by the Bureau of Reclamation for water quality improvement should be adequately funded and those features found feasible should be implemented. Cooperative studies by the U.S. Department of Agriculture on onfarm irrigation improvements should also be funded.

2. The Bureau of Reclamation should undertake a demonstration weather modification program in the Upper Colorado Basin, one important benefit of which could be improved water quality in the Lower Colorado Basin. See Regionals No. 1 and 2.

3. Research and development or the technology of desalting geothermal brines and saline waste waters should be carried out.

NO. 6 – RESOLUTION OF SALTON SEA FISHERY AND SALINITY CONFLICT

SUMMARY

The primary use of the Salton Sea by law is as a repository of agricultural drainage and seepage waters. Irrigation in California's Imperial and Coachella Valleys is dependent upon drainage into the sea, and irrigation return flows maintain the Sea as a perennial lake. The Salton Sea has become a habitat for saltwater fish and wildlife and a valuable center of recreational activity.

From 1925 to 1964 when the sea was expanding, the intermittent rise in surface elevation was the most serious threat to shoreline developments. Since 1964, however, resources have effectively stabilized the sea's surface level. But now that the sea is no longer increasing in volume its salinity is increasing.

The salinity of the Salton Sea, 38,000 mg/l is increasing at an average of about 550 mg/l per year, caused by about 4.5 million tons of salt entering the sea with drainage waters. When the salinity reaches 40,000 mg/l, severe adverse effects on the sea's vuluable sport fishery are expected. Above 115 percent of seawater salinity, it is likely that reproduction of corvina, sargo, and other sport fishes will cease. Then, as the salinity continues to increase further, the fish will gradually or suddenly die out as the mature fish eventually succumb to the rising salinity. Other forms of water-oriented recreation and wildlife uses provided by the sea will also dimish as the salinity increases.

DISCUSSION

The Salton Sea in the Colorado Desert subregion of southeastern California is a unique inland saltwater lake, 36 miles long and 9 to 15 miles wide. It is the State's largest lake, with 360 square miles of water surface and 110 miles of shoreline. The surface of the sea lies approximately 232 feet below sea level. The California Legislature enacted a statute (Ch. 392, Acts of 1968), which declares that the primary use of the Salton Sea is to serve as a repository for storage of agricultural drainage and seepage waters. Irrigation in California's Imperial and Coachella Valleys is dependent upon drainage into the Sea and irrigation return flows maintain the Sea as a perennial lake. The Salton Sea has also become a habitat for fish and wildlife and a valuable center of recreational activity. Although its recreation potential has been only partially developed, fishing, boating, water sports, camping, and hunting have in the past attracted up to a million recreation use-days per year.

Continued use of the Sea for multiple purposes is being threatened by three conditions: increasing salinity, unstable water levels, and nutrient inflow. Inflow to the Sea transports dissolved salts with a salinity less than one-tenth that of the Sea; however, because there is no surface outflow, the Sea's salinity is increasing. Continuation of this rise in salinity will eventually eliminate fish life and create unfavorable conditions for recreation and seashore development.

An imbalance between historic inflows and evaporation has caused unstable water levels which have adversely affected public and private property. Future rising levels could affect drainage from surrounding farmlands and could also inundate shoreline developments. Falling levels could necessitate abandonment, relocation, or modification of existing shoreline facilities.

Inflow to the Sea also transports large quantities of mineral nutrients which produce abundant growths of algae. Algal blooms discolor the water and, upon death and decomposition, often cause temporary anoxic conditions locally. These conditions occasionally prove fatal to fish and produce unpleasant odors.

As agricultural acreage in the Salton Sea basin expanded during the period 1925 to 1960, the level of the sea was gradually increasing. Although the salt load in the Sea was also increasing, there was generally an excess of inflow over evaporation to dilute the annual addition of salt. Thus evaporation drainage inflow, and salt load remained sufficiently balanced so that the Sea's salinity remained close to that of ocean water for more than 50 years. Ocean fishes introduced from the Gulf of California in the 1950's have thrived.

The total Salton Sea basin has become an increasingly popular recreation area, serving the populous southern California coastal cities and winter visitors from the Northern States and Canada. Warm winters, a picturesque setting, and ample opportunities for outdoor recreation within the basin attract millions of recreationists annually. The Salton Sea is potentially capable of accommodating several times its present recreational use. Fishing, mostly from small powerboats, currently averages about 360,000 angler-days per year. Other boating, water skiing, swimming, camping, and picnicking average about 200,000 recreation days, and hunting and nature study contribute an additional 177,000 recreation days per year.

The loss of these valued resources would be particularly unfortunate in view of the ever-increasing unmet demand for water-based recreation in the southern California area which, if present trends continue, is projected to reach about 30 million recreation days by the year 2000. The Salton Sea could conservatively meet 1.5 million recreation days of this demand by then and ultimately about 4 million recreation days.

Without the fishing and recreation opportunities afforded by the Sea, a State recreation area along 20 miles of shoreline and more than a dozen commercial or county recreational developments would be virtually unused. As the Sea's salinity increases without a definite plan for its control, several well-planned recreational-residential communities in various stages of development around the Sea, representing a present investment of $380 million, are now declining economically and socially. The decline of these resort communities creates hardships for the remaining residential dwellers and commercial interests and a loss of tax base to local governments. Other valuable uses of the Sea endangered by the increasing salinity include national and State wildlife refuges created to provide migrant waterfowl resting and feeding areas and to alleviate agricultural crop depredations, and a Navy base for testing equipment and operational techniques for naval and space programs.

PROBLEM RESOLUTION

Department of the Interior and Resources Agency of California Joint Study Teams recently completed an investigation to seek means to preserve the threatened sport fishery and recreational use of the Salton Sea, consistent with its primary purpose as a drainage repository. The joint report of their findings, conclusions, and recommendations, which is currently being reviewed by both agencies, presents four plans providing the maximum practicable range of effectiveness in reducing salinity, within the limitations of presently available resources that could contribute to the project. One of the more promising of the alternatives calls for the construction of a 40- to 50-square-mile diked impoundment in the southeastern end of the Salton Sea. The dike would be a continuous earth "dam" built on the sea floor, with its shoreward side generally 0.5 to 1 mile from shore. The dike would be accessible during construction by means of causeways which would subsequently be retained for recreation uses – such as fishing and sightseeing.

The salinity of the Sea would be controlled by the impoundment, with evaporation of saltwater, and storage of residual salt. Drainage water, with a salinity of about 3,000 mg/l, would continue to add an average of 4.44 million tons of salt to the sea each year. A portion of the sea's water, containing an amount of salt equal to or exceeding the 4.44 million tons entering the sea, would be removed annually through inlet structures into the impoundment. There the water would evaporate with the salt accumulating over a period of 100 years or more until it eventually fills the impoundment.

This alternative has a high degree of public acceptance. Citizen groups of many types actively support a salinity control project. With adequate guarantees that project operation would not affect operation of the irrigation systems adjacent to the Sea or the Sea's role as a repository of agricultural drainage water and that project costs would not be distributed to agricultural lands or areas not directly benefited, no substantial opposition to the project is expected.

All of the alternative plans formulated have a degree of incompleteness, however, because unforeseeable changes in conditions affecting inflow to the Salton Sea may require future additions to or modifications of the project works.

Time is of the essence in initiating salinity control measures that would accompoish the objectives of the project. About the earliest that a salinity control plan could be authorized, constructed, and placed in operation is 1979, when the salinity is expected to be approximately 42,000 mg/l. In general, the longer the initiation of control measures is delayed, the more saline the Sea will be, and the larger and more costly will be the project works required to reduce its salinity to acceptable levels.

CONCLUSIONS

1. The Salton Sea is a unique and valuable resource imminently endangered by its increasing salinity, currently about 38,000 mg/l. As the salinity increases about 40,000 mg/l, the Sea's valuable sport fishery will be destroyed and other water-oriented recreation and wildlife uses of the Sea greatly diminished.

2. The alternative plans presently formulated cover the range of practicable solutions currently available to control the salinity of Salton Sea.

3. Until a decision is made as to what steps, if any, should be taken to preserve the recreation and fish and wildlife uses of Salton Sea, no additional Federal studies are required.

RECOMMENDATION

1. Decisions should be made promptly by the Federal Government and the State as to whether a program to preserve the recreation and fish and wildlife uses of Salton Sea is feasible and justified and, if so, to what extent the Federal Government should participate.

NO. 7 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

The water requirements for the development of the Indian land-based resources have in most instances never been quantified. In California, a critical situation is the establishment of many small reservations without adequate natural water supplies. Potentially more than 70,000 acres of land could be brought into immediate agricultural production if irrigation water supplies were made available. In addition, Indian water needs for M&I, fish and wildlife, power, recreation, etc., have not been identified or quantified.

California has over 60 rancherias and reservations located within its borders. In 1968, the respective tribes were owners of some 504,000 acres in the State. Approximately 230,000 acres of these lands were in cropland and pasture of which nearly 10,000 acres were under irrigation. The State of California experienced the sharpest gains of the 11 Western States in Indian population numbers. In 1970, the population was 91,000 – a gain of 133 percent over the previous census estimates of 1960. California has the second largest resident Indian population among the Westwide States.

The California Indian problems can for the most part be traced to methods employed in setting up the

reservation systems. Much of the land which makes up the system came into existence well after the State had been settled, for all practical purposes, and the best lands had been taken for non-Indian development.

The composition of the Indian land base was built on the remaining lands – lands which were of little value, comprised of small tracts and, in some instances, inaccessible for normal Tribal use. E.g., a number of holdings can only be reached by walking through lands which are controlled by others. The lone exceptions to the general case were the well-defined and relatively large reservations set aside for the tribes in northern California.

The restrictive capabilities of the land base has severely curtained the opportunities for developing viable economies on most of the reservations. As a consequence, the tribes have not been able to achieve the standards of living so enjoyed by non-Indian State residents. The bleak economic picture (rate of unemployment – 48 percent in 1970 – and low family incomes – roughly 25 percent of those for non-Indian) has forced many Indians to leave the reservations and seek employment in the urban areas.

Working in the cities has, on the whole, proved to be unsatisfactory to most Indians. California Indians, like others elsewhere, are neither culturally or socially prepared to cope with the internal pressures of metropolitan living. Thus, many return to become a part of the growing force of unemployables living on the respective tribal lands.

All the State reservations including the smallest are in need of some type of resource development. Preliminary investigations indicate that presently domestic water consumption requirements are in the neighborhood of 42,000 acre-feet per year. In addition, there are approximately 70,000 acres which could be irrigated if adequate water supplies were made available. Bringing these lands into production could conceivably resolve in a large part the employment and income problems of a number of the tribes. Future water and related land-resource requirements must also be accommodated – particularly if the Indian population continues to grow at its present rate of 13.3 percent per year.

CONCLUSIONS

1. The size and geographical location of the reservations basically sets the tone and character of the Indian resource problem. In the South, the restrictive size of the land base and inadequate amounts of good surface water together accentuate the difficulties of upgrading the population's standard of living. Here the plans of development must not only reflect the physical limitations of the reservations but also the economics of drilling and utilizing ground-water supplies.

2. The search for dependable ground-water sources will be expensive and time consuming if surveys of the resource potentials have not been undertaken. The knowledge of the amounts of water and the depths of occurrence, however, is an essential function of the planning process. Without such information, planners will not be able to properly evaluate resource responses relative to needs and consequently will not be in a position to determine what must be done or what can be done in terms of programs to satisfy these needs.

3. Water supplies appear to be adequate to satisfy present and future resource requirements on the northern reservations. The economic growth among the tribes during the past has been slow principally because of the lack of development of available water supplies and other Indian resources. Studies are needed to determine the optimum approaches in which these resources can be employed in stimulating new job opportunities and raising family income.

4. Water resource development, coupled with other types of investments – private and Federal – in roads, businesses, manufacturing, etc., would assist in correcting and improving current economic problems. The tribes recognize the inherent advantages of intensifying the economic use of their resource base but also recognize that such development could threaten their living environments unless adequate safeguards to the environment are implemented. Planning proposals must therefore take into account these concerns and present the tribes with a wide range of viable options for consideration ranging from maximum protection of the environment to fullblown development schemes. Indian leaders will need to know the consequences of choosing one plan over another in order to ascertain which choice is compatible with individual goals and aspirations for the tribe.

RECOMMENDATION

1. Water and related land-resource investigations for purposes of identifying and dimensioning resource capabilities, needs, and problems, as have been requested by the tribes, should be undertaken and coordinated by the Bureau of Indian Affairs with technical assistance from other agencies as required.

The general impact of these studies should be directed towards:

A. Locating and quantifying available ground and surface supplies of water – to be used for any purpose by the respective tribes.

B. Determining present and future Indian land and water requirements relative to economic development proposals.

C. Devising procedures and methods necessary for protecting and enhancing all environmental concerns – air and water quality, recreation, religious and archeological areas, fish and wildlife resources – which directly or indirectly have a significant bearing on the cultural and social well-being of the California Indians.

COLORADO

Colorado, one of the 4 States lying astride the Continental Divide within the 11-State Westwide Study area, covers more than 104,200 square miles and is the sixth largest of the Westwide States and eighth in the United States. It has a wide variety of landscapes with mountains the dominating topographic feature. With more than 2,200,000 people, it is the 3rd most populous Westwide State and 20th in the Nation. The population is concentrated primarily in the 13 counties along the east slope, or Front Range, of the Rocky Mountains from Fort Collins on the north to Pueblo on the south. Population density for the entire State is slightly more than 21 persons per square mile; however, more than 80 percent of the total population lives along the Front Range.

Early settlers were attracted to Colorado by the legendary mineral riches. Then agriculture became the leading basic industry. In recent years and in terms of gross state product, manufacturing has become the foremost economic activity in an economy that is generally very healthy. Agriculture is still the second ranking industry and tourism is third.

In terms of personal income, Government, wholesale and retail trade, and manufacturing are the major contributors with agriculture ranking eighth. Colorado is the world's leader in the production of molybdenum. Oil, gas, and coal are produced in quantity and the State holds a key in the Nation's future energy scene with its huge deposits of oil shale.

The Denver metropolitan area attracts the bulk of the new economic and population inflow from out of State, and also attracts enterprises and population from the rural areas within the State. This trend represents a process which tends to feed on itself and becomes self-generating; newcomers are attracted to the opportunities in the complex; industry is attracted to the labor pool and services; finance and services are attracted to the source of industry and people; rural Coloradans are attracted to the job opportunities; developers are attracted to the opportunities for land value appreciation; new governmental jurisdictions come into being alongside existing ones; new schools, roads, services, and natural resources – land and water – are required to provide for the needs of increased population and industry base. Once started, the process tends to become irreversible.

Contrasted with this rapidly urbanizing area, the State's vast rural areas – the Eastern Plains, San Luis Valley, and most of the western slope counties are not growing.

In many ways, the rural area of Colorado is becoming a land of limited opportunity. In fact, the economic and social problems that drive citizens to the cities prevent rural governments from significantly improving the situation. Population declined in 32 of Colorado's 63 counties between 1950 and 1970. Most of the counties with declining employment opportunities had specialized economies, highly dependent on either agriculture or coal mining or a combination of both.

Thus, Colorado is faced with a dichotomy: rapid urbanization along the Front Range contrasting with a lack of growth in neighboring rural regions.

Colorado, with about 58 percent of its land in private ownership, ranks second among the Westwide States in this category. Another 35 percent of its land is in Federal ownership. As with most of the Westwide States, the majority of Colorado's land is used for agricultural purposes. In that respect, Colorado ranks 2nd among the Westwide States with about 18 percent of the land used for growing agricultural products. Another 34 percent is classified as range or grass land.

WATER SUPPLY

Colorado is the origin for four major river systems: Arkansas, Rio Grande, Colorado, and the Missouri Rivers. Only a limited amount of surface drainage flows into Colorado; consequently, the surface water resources available for us in Colorado are derived almost exclusively from waters originating in Colorado.

Colorado has a continental type of climate due to its inland location, being characterized by wide ranges in temperatures and irregular annual and seasonal precipitation. The climate is temperate and is semiarid except in the high mountain areas where the precipitation averages more than 40 inches per year.

The prevailing westerly winds dominate Colorado's weather, especially during the cool and cold seasons.

Precipitation west of the Continental Divide is more evenly spread over the year than is the case in the eastern plains. For much of western Colorado, the greatest monthly amounts of precipitation occur in the winter months, with June the driest month. Runoff is mainly a function of the amount of snow that falls during the winter months.

Surface Water

The State's watersheds yield on the average about 15.4 million acre-feet per year and another 0.2 million acre-feet per year flows into the State from Wyoming. The Colorado River region is the most productive water yielding region. Interstate compacts control the development and use of all the major river systems.

It is estimated that by 1975 the State's water supply will be depleted by about 5.6 million acre-feet per year and that about 4.6 million acre-feet of these demands will be met from surface supplies and the other 1.0 million acre-feet will rely on ground water as its source of supply. The majority of this water will be used in the agricultural sector.

Tables VI-10 and VI-11 summarize Colorado's estimated 1975 depletions and water supply situation.

Table VI-10.—*Estimated 1975 total depletions for Colorado*[1]
(1,000 acre-feet)

Region and subregion	Function								Total deple-tions
	Irriga-tion	M&I including rural	Min-erals	Thermal electric	Recre-ation F&WL	Other	Reser-voir evap-oration	Consump-tive con-veyance losses	
Arkansas-White-Red									
Arkansas	628	63	0	6	1	22	68	53	841
Total region	628	63	0	6	1	22	68	53	841
Upper Colorado									
Green River	89	2	4	10	3	5	2	22	137
Upper main stem	779	14	8	4	8	11	37[3]	175	1,036
San Juan-Colorado	173	3	2	0	20	5	10	12	225
Total region	1,041	19	14	14	31	21	299[4]	209	1,648[4]
Missouri									
Platte	1,182	191	3	10	2	40	152	56	1,636
Kansas	215	3	0	0	2	6	4	1	231
Total region	1,397	194	3	10	4	46	156	57	1,867
Rio Grande									
Upper Rio Grande	564	6	0	0	19	2	621	53	1,265
Total region	564	6	0	0	19	2	621[5]	53	1,265
State summary	3,630	282	17	30	55	91	1,144	372	5,621[6]

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] Exclusive of instream flow use.
[3] Includes 19,000 acre-feet of main stem reservoir evaporation from Curecanti project.
[4] Includes Colorado's remaining share of main stem reservoir evaporation, and therefore subregions will not add to region total. Average annual main stem reservoir evaporation assumed to be 520,000 acre-feet. Colorado's share, 269,000 acre-feet. However, Curecanti project evaporation of 19,000 acre-feet is included in the upper main stem subregion total.
[5] Includes ground water evaporation.
[6] Surface-water depletions — 4,641,000; ground-water depletions — 980,000.

Table VI-11.—*Estimated 1975 surface water-related situation in Colorado (1,000 acre-feet)*

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within subregion or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Arkansas-White-Red									
Arkansas	0	875	163	1,038	0	841	197	50	147
Total region	0	875	163	1,038	0	841	197	50	147
Upper Colorado									
Green River	237	1,776	0	2,013	0	137	1,876	[8]	0
Upper main stem	0	6,738	0	6,738	614[5]	1,036	5,088	0	0
San Juan-Colorado	0	1,987	130[5]	2,117	113[6]	225	1,779	[8]	0
Total region	237	10,501	0	10,738[7]	597[7]	1,648[9]	8,493[9]	7,748	745[10]
Missouri									
Platte	0	2,041	342[11]	2,383	22[11]	1,636	725	520	205
Kansas	0	353	0	353	0	231	122	122	0
Total region	0	2,394	320[12]	2,714	0	1,867	847	642	205
Rio Grande									
Upper Rio Grande	0	1,576	4	1,580	0	1,265	315	315	0
Total region	0	1,576	4	1,580	0	1,265	315	315	0
State summary	237	15,346	0[13]	15,583	110[14]	5,621	9,852	8,755	1,097

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] Intersubregion transfer of 130,000 acre-feet from Dolores River, upper main stem to San Juan River in San Juan subregion.
[6] Includes San Juan-Chama export of 110,000 acre-feet.
[7] Intersubregion transfer referred to in footnote 5 excluded from region totals.
[8] Yampa, Little Snake, San Juan and La Plata Rivers are also covered by Compacts.
[9] Includes Colorado's share of Colorado River main stem reservoir evaporation and therefore subregions will not add to Region total.
[10] Represents the remaining amount of water the State of Colorado can develop from the waters of the Colorado River system. Assumes 5.8 million acre-feet availability to Upper Colorado Region States adjusted for 1975 Colroado depletions and Fryingpan-Arkansas and Homestake exports at full development (96,000 acre-feet). 110,000 acre-feet export to New Mexico is not chargeable to Colorado's Colorado River apportionment and therefore Colorado's net exports for developing net supply are 487,000 acre-feet.
[11] Intersubregion transfer of 22,000 acre-feet from North Platte River to South Platte River.
[12] Intersubregion transfer referred to in footnote 11 excluded from region total.
[13] No imports into state. All of above imports are intersubregional.
[14] Exports to New Mexico through San Juan-Chama project. This export is chargeable to New Mexico's Colorado River apportionment. Remaining exports are all intersubregional.

Ground Water

Ground water is an important source of supply in many parts of Colorado. Abundant supplies occur in the valley alluvium of the Rio Grande, South Platte, and Arkansas Rivers. Other geologic formations in which vast quantities of ground water have accumulated are the Ogallala and the Dakota sandstones that underlie the plains of eastern Colorado.

In western Colorado, ground water has also accumulated in the valley alluvial and other geologic formations of sedimentary origin, but in much lesser quantities than in the eastern part of the State. In the Colorado mountains, neither the geology nor the topography is favorable for the accumulation of significant amounts of ground water. Usually, the igneous bedrocks in the mountains are poor aquifers and the unconsolidated soil mantle is too shallow to permit significant accumulations of ground water.

Water Quality

The melting snows and rainfall in the mountains supply high-quality water to the headwaters of the four major river basins in Colorado. However, through natural phenomena and many activities of man, the water ultimately picks up various types of impurities which in many instances alters the quality so as to reduce the suitability of the affected supplies for beneficial use. Major sources of manmade polution are salinity, sediment, municipal discharges, and some mine drainage.

While some specific and some general problem areas are known, much study remains to be done to get an accurate picture of water quality statewide. To this end, several studies are already in progress, and other programs will be developed to fully implement the policy enunciated by the Federal Water Pollution Control Act. Implementation of this Act by Colorado was authorized by the recently adopted Colorado Water Quality Control Act of 1973.

With regard to ground-water quality, the northern two-thirds of the eastern one-half of the State is underlain by aquifers to depths of over 1,000 feet containing water of 3,000-10,000 p/m dissolved solids. The remainder of the eastern one-half and the western one-third of the State are underlain to depths of less than 500 feet by aquifers containing water of 1,000-3,000 p/m dissolved solids. The high intermontane valleys contain mineralized water at considerable depth.

Of primary importance in the State are the shallow alluvial aquifers of the stream valleys which are readily largely recharged by surface water and which are parts of integrated ground- and surface-water systems. The quality of the water in these aquifers is a reflection of the quality of the surface water with which they are recharged.

CRITICAL PROBLEMS

The major interfaces of the Westwide problems directly affecting the State of Colorado are discussed in this section. Also discussed in detail are the State specific problems. The regional problems directly affecting the State are listed. On figure VI-6 are shown the approximate locations of regional and State specific problems that were found to be critical in Colorado.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANING. Coal and oil shale development in eastern Colorado will have a significant impact on the water resources of that area. The area also has significant environmental attributes in the form of fisheries, white-water canoeing, etc. Studies are needed to determine instream flow needs and impacts of restricted flows on these functions.

The humpback chub and Colorado squawfish are two endangered species which reside in the Colorado and Green Rivers. Specific habitat requirements to ensure the survival of these species must be determined so that provision for their survival can be made in water resource development planning.

NO. 6 – NEED FOR ADDITIONAL FLAT-WATER RECREATION OPPORTUNITIES. – The majority of Colorado's population is located along the Front Range from Fort Collins to the north to Pueblo to the south. Demand for additional flat-water recreation is increasing in these areas. Several Federal reservoirs, located near these population centers, would help to satisfy these needs, if they were operated differently.

Westwide No. 6 identifies Green Mountain, Willow Creek, Granby, Taylor Park, and Twin Lakes Reservoirs as those recommended for high priority study to determine their potential for meeting recreation demands.

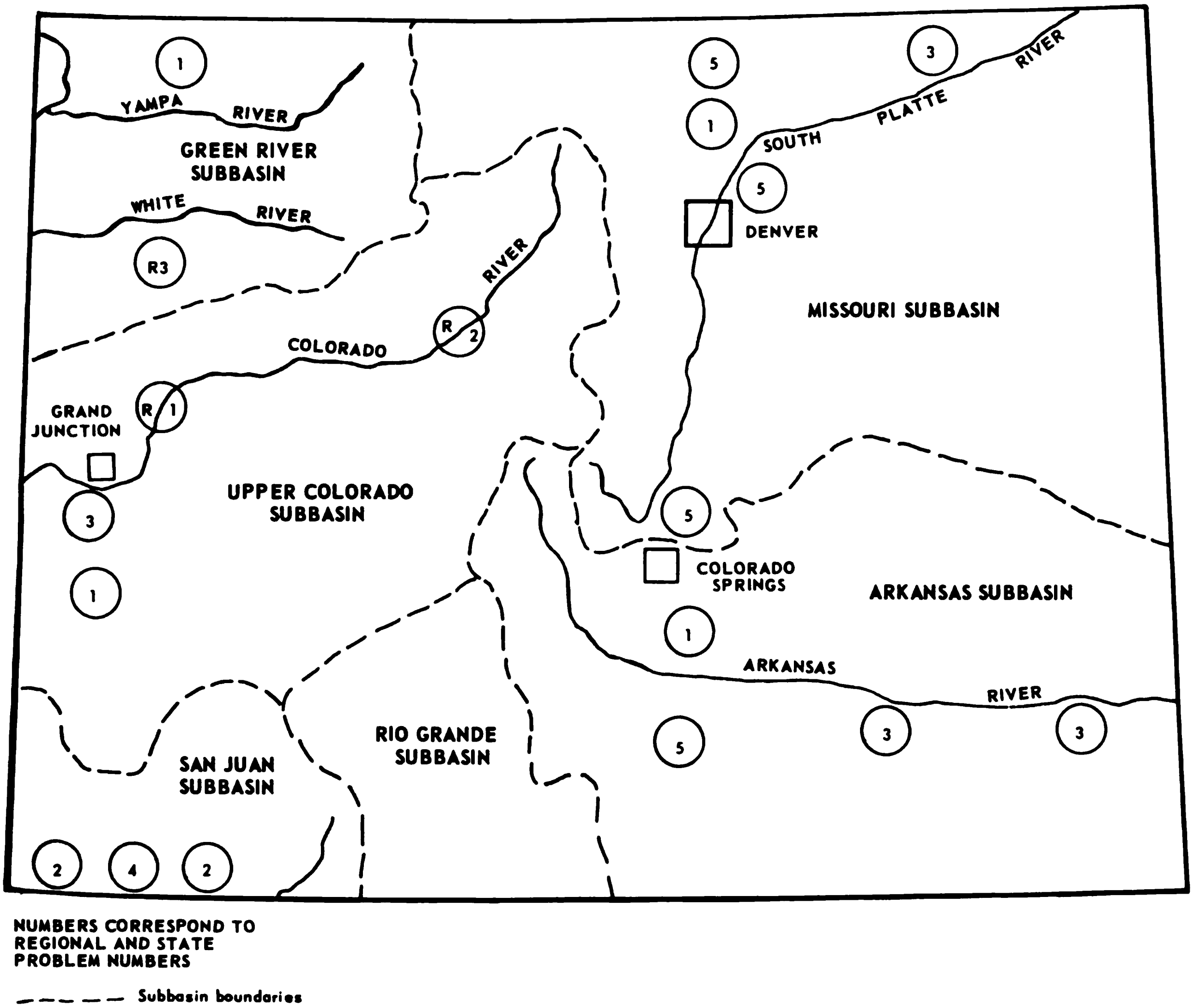


Figure VI-6. Critical water problems in Colorado.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. – A number of Colorado rivers have been identified as having significant free-flowing values. Proposed Federal legislation has included 15 Colorado rivers that would be studied as potential additions to the National Wild and Scenic Rivers System. Included are segments of the Colorado, Dolores, North Platte, Encampment, Green, Yampa, Gunnison, Big Thompson, Cache La Poudre, Los Pinos, Elk, Conejos, Laramie, Michigan, and Piedra Rivers. More recently, the Secretary of the Interior recommended passage of a comprehensive "Administration bill" that calls for study of a number of high priority rivers across the country in lieu of individual proposals for wild and scenic river studies. Included in the new bill are several rivers given the highest study priority due to probable involvement in energy-related development. One of these, the White, is in Colorado (and Utah). Table VI-12 summarizes information on Colorado rivers included in the new bill.

Other Colorado rivers identified by the State Study Team as having significant free-flowing values include the South Platte, Taylor, Cache La Poudre, Animas, Lake Fork, Piedra, Los Pinos, and Conejos.

NO. 8 – IMPACT OF WILDERNESS AREA ON WATER PLANNING. – Colorado with the large amounts of forest lands with wilderness potential is

Table VI-12.—*Colorado rivers identified for free-flowing values*

River	River segment
White	Entire river, including North and South Forks.
Green	Entire river in Colorado.
Colorado/Dolores	The main stem from the confluence of the Gunnison River to the Utah State line, including the Dolores River below the proposed McPhee Dam but excluding the segment from 1 mile above Highway No. 90 to the confluence of the San Miguel River.

keenly interested in this Westwide issue. There is an increasing trend toward large blocks of land being proposed for inclusion into the wilderness system development of the water and land resources for other uses. Comprehensive studies by the Forest Service should be completed before determining how much of these proposed areas should be added to the wilderness system.

NO. 16 – THE CHANGING FEDERAL ROLE IN DEVELOPING IRRIGATION PROJECTS. – Colorado has water and large blocks of arable land which could meet some of the Nation's food requirements. However, use of the water for food production appears to conflict with its use for developing oil shale and coal resources to meet the current energy crisis. Public Law 90-537, the authorizing legislation for the Westwide Study and for the construction of the Central Arizona project also authorized the concurrent construction of five Colorado projects: Animas-La Plata, Dolores, San Miguel, West Divide, and Dallas Creek. A major authorized purpose of these projects was irrigation. Federal policies with respect to support of irrigation projects are currently under review. With the increasing pressure for energy development in the area, these projects may be reformulated to provide additional municipal and industrial water with corresponding reductions in irrigation water.

Regional Problems

Three regional problems have a direct impact on the State of Colorado. They are:

NO. 1 – INCREASING SALINITY IN THE COLORADO RIVER

NO. 2 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

NO. 3 – WATER REQUIREMENTS FOR SHALE DEVELOPMENT IN THE UPPER COLORADO

State Specific Problems

The critical problems which the Colorado State Study Team identified and in which the Federal establishment has a major interest are those involving: (1) a certain amount of public trust, such as in the Colorado River region where most of the storage facilities are in public ownership, where most of the energy resources are located on public lands, and where Colorado's two Indian Reservations are located; and (2) a concern for resource problems created by rapid and concentrated growth. The problems that fall into this category are listed below in random order and are located by number on figure VI-6.

NO. 1 – WATER SUPPLY FOR POPULATION AND ECONOMIC GROWTH ALONG THE FRONT RANGE

NO. 2 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 3 – LAND AND WATER RESOURCE PROBLEMS OF THE ARKANSAS RIVER BASIN

NO. 4 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 5 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

The challenge in all the above problems is the wise use of the remaining water supplies, especially those of the Upper Colorado Region.

NO. 1 – WATER SUPPLY FOR POPULATION AND ECONOMIC GROWTH ALONG THE FRONT RANGE

SUMMARY

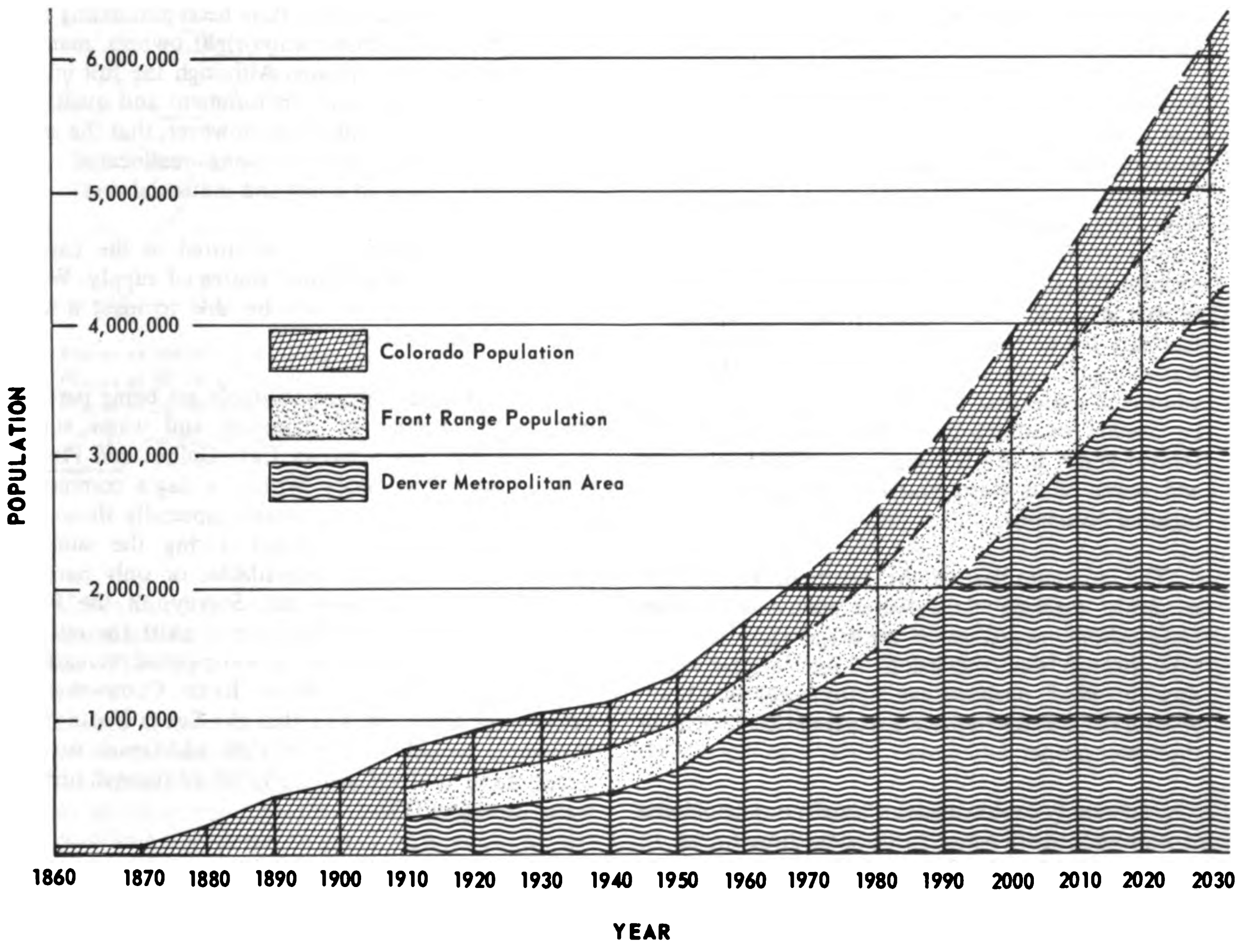
Population increases are creating water supply, recreation, and flood damage problems along Colorado's Front Range. Area water needs could be satisfied through 1990 if planned storage projects are constructed. However, segments of the public are contesting the validity and need of these programs. Flooding, especially on the smaller urban drainage is a major problem. Water-oriented recreation facilities around the major metropolitan areas are overcrowded and demands for this type of recreation are increasing.

DISCUSSION

Colorado's population increased in the 1960's from 1,754,000 to 2,207,300. The State's 25.8 percent increase in the 1960-1970 decade corresponds to an annual growth rate of 2.3 percent, or a population doubling every 30 years.

Based on current trends, it is expected that by the year 2000 about 90 percent of the State's increased population would be located in the Front Range corridor from Wyoming to New Mexico. The Denver metropolitan area alone could have a population of 2.5 million or about 60 percent of Colorado's citizens. Figure VI-7 shows Colorado State Planning Commission projections of growth for the State, Front Range, and Denver. As this growth continues, land use problems will become more severe, and additional sources of water supply will need to be developed. Recreational needs and the other social-cultural needs will also have to be met.

Water demands are currently being met from local surface and ground-water resources, conversion of agricultural water rights to municipal and industrial (M&I) needs, and transregional diversions. Future demands are expected to meet through expansion of the above sources and some waste-water reclamation.



Source: Based on figures supplied by the Colorado State Planning Office.

*Figure VI-7. **Projections of growth in Colorado.***

Following is a summary of how the Pueblo and Colorado Springs Standard Metropolitan Statistical Areas (SMSA) (figure VI-8), Douglas County, Denver SMSA, and communities north of Denver – Boulder, Fort Collins, Greeley, etc., are currently meeting water demands and how they expect to meet future demands.

1. Water demands in the Pueblo-Colorado Springs area are currently being met from local sources or through transregional diversions. Needs through 1990 can be met through expansion of existing transregional diversion facilities and the Fryingpan-Arkansas project, presently nearing completion.

2. In Douglas County, water requirements are currently being met through ground-water development. It is estimated that this source of supply will be exhausted in the next 10 to 15 years. Future water supplies will have to be developed through the efforts of the Denver Water Board or other regional authorities.

3. Current Denver SMSA water demands are being met from local sources and from the Denver Water Board's extensive transregional diversion facilities. Presently, the Denver Water Board has rights to West Slope water to meet about 60 percent of the Denver SMSA water requirements through 2010. Considering all of the water rights available to this service area and assuming the necessary regulation facilities are in place, there would be an adequate water supply through the year 2010. However, additional collection and distribution facilities will be needed to utilize these rights. In addition, the Denver Water Board is investigating the reclamation and reuse of its waste water resulting from transregional diversions.

4. The communities to the north of Denver are currently meeting their water demands through local developments, some transregional diversions, and through the conversion of agricultural water uses to M&I purposes as agricultural lands are urbanized. Future needs are expected to be met in the same manner.

The water supply problem at this time is not associated with running out of water in the near time frame. In fact, except for Douglas County, the other three areas have programs or plans either under way or proposed which could meet most of the Front Range water demands through 1990. The water supply problem centers around the implementation of the proposed programs and plans including their impacts on West Slope economic development and environment. Much concern is being expressed about increasing transregional diversions, pumping ground water, and converting agricultural water rights and uses to M&I purposes. With regard to the Denver Water Board's proposed expansion of transregional diversion facilities, considerable opposition has been voiced. Diversion of additional West Slope water will be complex and costly from both a monetary and environmental viewpoint. Naturally these diversion proposals are highly controversial and environmental groups and West Slope interests are expected to challenge any further West Slope diversions.

The agricultural water conversion alternative poses other problems. Urbanization of the Front Range is changing the character of the State's economy from agricultural to industrial. Agriculture is the second ranking industry in the State. Most conversion is taking place in the Front Range area where much of the State's prime irrigated agricultural land is located. Eastern slope municipalities have been purchasing their water rights from current water-right owners, many of whom are irrigation farmers. Although the full impact of this trend on land use, environment and quality of life is uncertain, it seems clear, however, that the area's limited water supplies are being reallocated from irrigated agriculture to urban and industrial uses.

Ground-water development, as noted in the case of Douglas County, is a limited source of supply. Wastewater reclamation will only be able to meet a small part of future demands.

Current flat-water recreation needs are being partially met by a number of irrigation and water supply reservoirs situated between Fort Collins and Pueblo, and on the West Slope within a day's commuting distance. Some of the reservoirs, especially those near the SMSA's are overcrowded during the summer; others are undesirable, unavailable, or only partially available for recreational use. Surveys of the Front Range area reveal that deficiencies exist for resident populations in all categories of water-based recreational demand. The Missouri River Basin Comprehensive Framework Study showed that the South Platte River subregion would require 13,000 additional surface-water acres by 1980 and 135,000 additional surface-water acres by 2000.

Flood control and urban drainage problems can be divided into two categories:

1. Floods occurring on major tributaries to the South Platte River. These tributaries flow mainly through commercial areas and, to a lesser extent, residential areas.

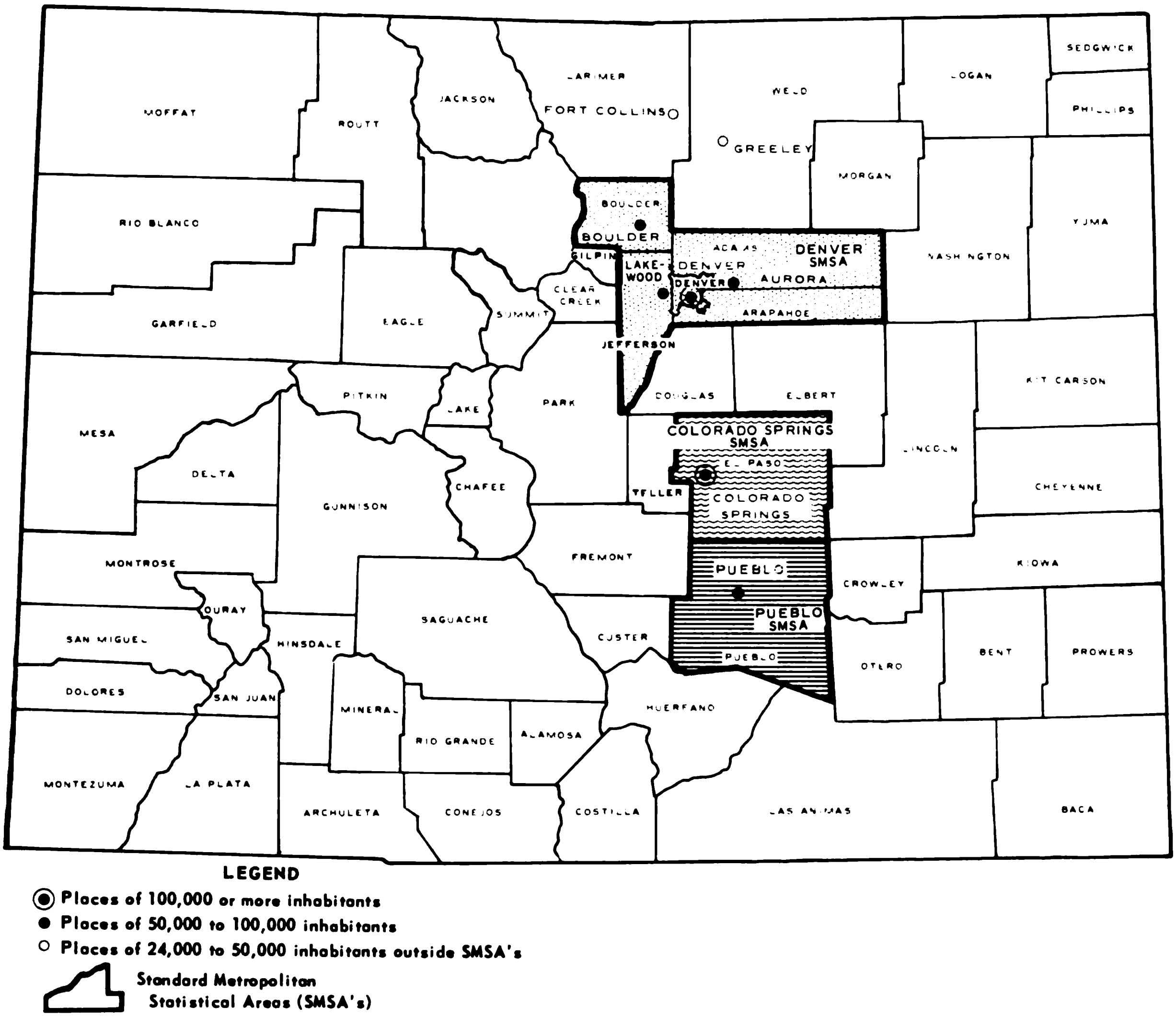


Figure VI-8. Standard metropolitan statistical areas – Colorado.

2. Urban flooding which occurs along small washes or drainages in urban areas and is generally the result of inadequate land use planning and control.

Several large flood-control structures have been constructed on the major Front Range river systems and their tributaries. These structures have reduced flood damages on these major stream systems; however, local flood problems that occur on small drainages in urban areas cause considerable damage.

PROBLEM RESOLUTION

There are no major M&I water supply problems at this time. Most areas, except for Douglas County have programs and plans in the planning stage to take care of water needs through 1990. The problems are with the probable impacts of solutions and current institutional arrangements. If the planned solutions are not accepted and implemented, water supply problems could occur in 1980-85 time frame.

Providing water-based recreation opportunities will be a continuous and increasing problem. All bodies of water, both public and private, in the vicinity of the Front Range should, to the extent practicable, be made available for recreational use. Investigations should be made for Federal reservoirs to examine changing operating criteria to meet recreation and fish and wildlife demands and possibilities for structural changes in association with operating changes. The

State and local entities should arrange with the owners of non-Federal reservoirs for appropriate recreation use.

Urban flooding is a major problem at this time. However, through such organizations as the Urban Drainage and Flood Control District which covers most of the Denver SMSA, solutions are being worked out. In general, assuming land use planning legislation is enacted and a continuing program to solve present flood problems, urban flood control and drainage problems should be less of a problem in the future.

CONCLUSIONS

1. The Colorado Front Range area will continue to grow in population and industrial activity in the near-term time frame.

2. Water planning must be tied to land use planning and, conversely, land use planning should consider water availability.

3. In general, land use planning could affect the location of population growth and, to a lesser extent, the growth rate.

4. Current programs either under construction or in the planning stages will meet most water needs through the 1985-1990 time frame if implemented. However, concern is being expressed about some solutions such as regional diversions and conversion of agricultural water users and rights to M&I purposes.

5. Present legal and institutional arrangements are not fully responsive nor representative of the communities and citizens affected.

6. Many local, State, and Federal studies are under way seeking solutions to these problems. These efforts need to be fully coordinated.

RECOMMENDATIONS

1. The following programs should be continued or implemented:

a. Corps of Engineers' "An Urban Regional Study. Water and Related Land Resources" for metropolitan Denver, the South Platte and tributaries, Colorado, Wyoming, and Nebraska.

b. Bureau of Reclamation's "Front Range Unit, Longs Peak Division, Pick-Sloan Missouri Basin Program".

c. Department of Agriculture's authorized Type IV studies on the Front Range basins.

2. State water planning should continue with Federal assistance as required.

3. The State should take the lead in coordinating water planning programs with land use planning and determine those programs to be implemented.

4. Consideration should be given to establishing Regional Water Resource Authorities to meet future M&I needs for all Front Range areas.

NO. 2 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

In Colorado, exclusive of oil shale development which is covered in Regional Problem No. 3, there are three areas facing different and distinct environmental, land use, and water supply problems with respect to energy development. The three areas are: Northwest Colorado near Craig; west-central and southwest Colorado; and the Front Range area.

A coal-fired plant of 1,400-MW capacity is currently under development in northwest Colorado. Expected additional development of coal will require more water resulting in additional impacts on the land and environmental resources of the area. The west-central and southwest Colorado area also contains significant coal resources. Current development is insignificant; however, the area has potential and, if development takes place, similar problems could be experienced.

The Front Range energy-related problem is mainly one of thermal plant-siting and obtaining and developing a water supply. Since presently the fuel is usually transported to this area from an outside source, the water-based environmental problems stem from thermal pollution.

DISCUSSION

Presently, Colorado has a total installed capacity of about 2,900 MW (all types of plants) using about 18,000 acre-feet of water per year.

Many projections have been made on future load requirements and how these loads should or could be satisfied. The latest projection comes from the Western

Systems Coordinating Council (WSCC) which is made up of private and public utilities in the West.

The WSCC estimates that for the area covered by the Rocky Mountain Power Pool, which includes Colorado, peak demand will increase from 2,900 MW today to 9,200 MW in 1985 and 25,100 MW by 2000. Total water requirements for this magnitude of development are estimated to be about 133,000 acre-feet.

Colorado's share is estimated to be 18,000 acre-feet at present, 22,000 acre-feet by 1985, and 62,000 acre-feet by 2000.

For the near term, it appears that coal will be the dominant fuel source; however, as indicated in the above table, nuclear development is expected to claim a larger share of future generation.

Colorado has coal reserves scattered throughout the State. However, the best coal reserves are located in the western portion of the State. Currently, the coal deposits in northwest Colorado near Craig are being developed. It is anticipated that coal reserves in the west-central and southwest portions of the State will be developed at a later date.

It is estimated that there are about 32 billion tons of bituminous coal located in northwest Colorado. The Type I studies projected a 5,000-MW to 10,000-MW range of powerplant development in this area. An electric power complex is under active development by a public power combine. Its plans include four 350-MW generating plants, two of which it proposes to build within the next 5 years. Cooling water requirements for 1,400 MW of power capacity would be about 21,000 acre-feet per year.

The electric power combine has bought land along the Yampa River for a pumping plant to take water in accordance with its direct flow right. In addition, it has entered into agreement with the Colorado Division of Wildlife for storage on Elkhead Creek of almost 14,000 acre-feet of which 8,300 acre-feet will be specifically for power purposes.

In addition, due to energy-development-related growth, the city of Craig must develop and expand its municipal water system. It has requested Federal help in developing a 5,000 acre-foot supply. The problems of the area are centered around future energy development through thermal powerplants. If the 5,000-MW to 10,000-MW range of development occurs, then considerably more water storage facilities and more extensive land treatment measures to reclaim the stripped areas will be required.

Another factor which could affect this rate and magnitude of power development is the utilization of oil shale. A significant amount of power may be required for developing the oil shale deposits. Recently it was stated that to produce 100,000 barrels per day of oil from test tract C-a, about 200,000 kW of power on the average would be required.

The Nucla-Naturita coal deposit in west-central and southwest Colorado is estimated to include about 100 million tons of coal, most of which is too deep for strip mining. It is estimated that 60,000 tons to 90,000 tons of coal per year could be mined from the Nucla-Naturita deposit. The area has significant environmental attributes which must be considered in any development proposal.

There is a small (50 MW) powerplant in operation now which is served by the Nucla-Naturita coal deposit. Initial planning toward increased utilization of this deposit has been undertaken by several private companies. The Upper Colorado Region Framework Study projects 1,500 MW of development between 1980 and 2000. Presently, development is not expected to take place before 1980.

Powerplant development is projected to continue along the Front Range. Most of these developments will rely on coal as the source of fuel; however, an increase in nuclear development is expected in the latter time frame. The source of coal is expected to be Wyoming, as in the case of the Commanche Plant at Pueblo.

In May 1974, a coal gasification development was proposed for an area 17 miles east of Denver. The development would use lignite-type coal which is abundant in this area and Denver waste water for plant operation and land reclamation purposes. Expansion of this plant or new plants could have major impacts with respect to water supply and land use plans in the area.

The problems associated with projected Front Range energy developments include water supply, land use, environment, and air and water quality. Water supply could be a very serious problem since Front Range supplies are limited.

PROBLEM RESOLUTION

Table VI-13 summarizes the time frame and the most significant problems facing the three areas previously discussed.

As can be seen, water supply is only one element of the total problem. Water supply will be needed in all of the

Table VI-13.—*Most significant study requirements for energy developments in Colorado*

Area	Decision needed	Study start	Most significant problems
Northwest	1978-82	1976	Land use, water supply and environment
West-central and southwest	1980-90	—	Environment
Front Range	1980-90	—	Water supply and quality and land use

above cases and water supply facilities will need to be developed. In addition, the impacts on the natural environment, land resources, and the economy of the area will have to be evaluated. Following is a brief discussion of potential water supply solutions and some of their impacts.

Water is available in northwest Colorado; however, additional storage facilities and possibly distribution systems will have to be constructed if the 5,000-10,000-MW development takes place. Development of these additional storage facilities will have considerable impact on the environmental resources of the area including potential wilderness areas, endangered species, and instream flows which would affect fish and wildlife resources. Air and water quality would also be affected.

In west-central and southwest Colorado, water for thermoelectric cooling, coal gasification, or other potential uses of the coal could be provided by the authorized San Miguel project. The recent project plan includes 5,000 acre-feet of M&I water, which would be available for coal development or other M&I uses. The area has significant environmental resources which would be affected by this development.

Water for Front Range development can be obtained from three sources: transregional diversion of West Slope water, conversion of Agricultural water use and rights or waste water. If West Slope water is developed, additional diversion facilities and collection systems, with their associated environmental impacts, will have to be constructed on the West Slope. Conversion of agricultural water use and rights will have significant land use, economic, and social impacts, which will need to be evaluated. If major technological breakthroughs occur to make dry-cooling towers economically competitive, water requirements for power development could be significantly reduced. Waste water appears to be a good, although limited, source of supply.

CONCLUSIONS

1. The rate of coal development for thermal powerplant purposes is expected to increase for some time.

2. Powerplant development, both nuclear and coal, will accelerate along the Front Range.

3. Coal gasification plants are being proposed for the Front Range area.

4. Currently planned powerplant developments in the Craig, Colorado, area are requiring storage facilities to meet water requirements, and if the projected development of 5,000 MW to 10,00 MW takes place, additional water supplies requiring storage will be needed before 1985. Oil shale development could accelerate powerplant development in this area.

5. The west-central and southwest areas of Colorado are being considered for fossil fuel powerplant development beyond 1980.

6. Because of the environmental attributes of the impacted areas, the public lands that will be affected, and the Federal responsibilities with regard to the water of the Colorado River, there is a strong public interest in any future storage facilities constructed in northwest Colorado.

7. Obtaining water supplies for powerplants and coal gasification plants to be located along the Front Range could become a major problem in the 1980-1990 time frame.

RECOMMENDATIONS

1. Because of environmental concerns, State and Federal agencies should review and monitor the plans currently being developed by the public utilities in the Craig area.

2. Because of the public interest in northwest Colorado, the Bureau of Reclamation's Yampa River basin studies should be revised to reflect possible future powerplant development as well as other uses in the area.

3. In those other Colorado areas where coal development is projected to take place and where there is a strong public interest, Federal resource studies should be initiated in the 1985 to 2000 time frame.

4. Collection of environmental data should be initiated in 1976 in northwest and west-central and southwest Colorado so that better planning and decisions on improvement programs can be made considering the environmental impacts.

5. The State and the public utilities, in cooperation with Federal agencies, should begin studies to identify potential energy plantsites and site limitations, taking into consideration water and land availability and social, economic, and enviornmental impacts.

NO. 3 – LAND AND WATER RESOURCE PROBLEMS OF THE ARKANSAS RIVER BASIN

SUMMARY

The Arkansas River basin is experiencing all the problems associated with increased growth occurring in an area of limited water supply. Its communities along the Front Range need additional water supply and flood protection. Communities in the valley must contend with high salinity levels, flooding, extreme erosion and sedimentation problems, and a decreasing water supply. It is also one of the few regions in the West that has not been studied under the Water Resources Council's Comprehensive Framework Study Program.

DISCUSSION

The Arkansas River basin is located in the southeastern quarter of Colorado. The main stem and its numerous tributaries drain an area of 28,300 square miles. From the headwaters on the eastern slope of the Rocky Mountains, the river flows south and east through mountainous terrain until it emerges near Canon City, Colorado, thence with decreasing gradient, it flows generally eastward across the High Plains.

The population of the Arkansas River basin in Colorado has increased steadily, except for the "dust bowl era" of the 1930's when severe drought and poor economic conditions prevailed. The urban population grew 22 percent and the rural population lost 11 percent for the 1960-1970 period. Two metropolitan areas, Colorado Springs, and Pueblo, have populations of 236,000 and 118,000, respectively. The basin's total population in 1970 in Colorado was 482,700.

Agriculture, manufacturing, mineral production, governmental and military activities, outdoor recreation (winter and summer), educational and health institutions, and mercantile business are all contributors to the present economy. The area has had predominantly an agricultural economy since its early settlement, but other economic developments have been gaining in importance since World War II.

The major farming areas are located along the main stem of the Arkansas River and some of its tributaries where a source of water supply is available and the soil is arable. In 1969, there was 487,900 acres of land under irrigation producing alfalfa, corn, sorghum, small grains, sugar beets, melons, and truck crops.

The water supply in the Arkansas River basin Region for the period 1950-1970 averaged about 969,000 acre-feet annually of which 94,000 acre-feet is imported. The depletion in the basin is 791,000 acre-feet; 89 percent of which is irrigation related. The surface water flowing across the Colorado-Kansas State line on an average annual basis is about 178,000 acre-feet and is controlled by the Arkansas River Compact among Kansas, Colorado, and the Federal Government.

There are nine existing transregional diversions which import water to the Arkansas basin. Ultimate transregional diversion capacity is 260,000 acre-feet. Two of the facilities, the Fryingpan-Arkansas project now under construction, and the Homestake project, will ultimately deliver 69,200 and 37,000 acre-feet annually, respectively.

Problems

The basic problem or critical issue facing the Arkansas basin is the lack of dependable, high-quality water to meet increasing M&I requirements without adversely affecting the agricultural economy of the region. However, the basin has many other significant water-related problems including water quality, flooding, erosion and sedimentation, and providing water-based recreation in the plains area. Most of the above and other related problems have been created principally due to the growing popularity of the area for development of new industries, homes, and businesses.

Water Supply. – The demand for domestic, municipal, and industrial water is growing rapidly. About 43,950 acre-feet of water have now been converted from agricultural use to municipal and industrial use. Since agriculture is still a major economic sector of the basin, especially in the rural areas, concern is being expressed about impact the conversion process will have on regional water supply, land use, economy, and social structure.

The most productive ground-water zone is the valley fill where there are about 1,500 large-capacity wells between Pueblo and the Kansas boundary. These wells pumped 230,000 acre-feet of water in 1969. There is about 1.9 million acre-feet of water within the Arkansas River Valley alluvium of which about 1 million acre-feet are usable.

Water Quality. – Coincident with growth has been the pollution of surface and ground-water supplies caused in part by the expanding urban population. The basin's supplies are detrimentally affected by urban and agricultural runoffs, return flows from irrigation use, and surface flows carrying naturally dissolved salts and suspended sediment. Inadequate sewage treatment and mining waste outflows further degrade the river.

Pollution by agricultural runoff varies with land use; dryland farming, irrigated farming, or grazing. Pollutants include not only sediments, but also dissolved chemicals, nutrients, herbicides, pesticides, and organic residue.

The runoff from urban areas contains many of the same pollutants as rural runoff and other items such as hydrocarbon residues and other contaminants generated by large concentrations of people, industries, and vehicles.

While there are other sources of salinity, a major reason for substantial increases in dissolved mineral concentrations is the leaching effect of water used and reused for irrigation.

Ground water quality in the basin varies widely, but downstream there is a progressive increase in salinity in the river and the aquifer as the result of irrigation return flows and salt pickup from soluble rock strata. Generally, the ground water is more mineralized than the surface water.

Table VI-14 shows the dissolved solids concentrations for water year 1970-71.

Mine Wastes. – Quite the opposite of most other forms of pollution in the basin, mining wastes affect the smaller headwater tributaries rather than the downstream main stem. This is because the quantities of pollutants involved are small, neutralized, and diluted during downstream travel. Their greatest impact is the destruction of reaches of otherwise fine mountain stream fisheries.

The upper basin waters above Buena Vista are affected by drainage from numerous abandoned mine workings which pollute the water with heavy metals in suspension and solution. Perhaps the most serious is California Gulch which enters the river just below Leadville. Manganese and zinc are of such concentrations as to be considered toxic to aquatic life which renders several miles of the main stem incapable of supporting a self-sustaining fishery.

Flooding. – Related to the pollutant problems discussed above is the ever present flood threat. The Arkansas basin has some particularly troublesome flood problems. Fountain Creek from Colorado Springs to Pueblo is noted for having multi-

Table VI-14.—*Dissolved solids concentrations, Arkansas River*

Stations[1]	Number of samples	Dissolved solids (mg/l)		
		Maximum	Minimum	Average of samples
Halfmoon Creek near Malta, Colorado	10	62	40	53
Arkansas River at Canon City, Colorado	12	190	86	150
Arkansas River near Portland, Colorado	12	389	138	288
Arkansas River below John Martin Res., Colorado	4	3,110	1,650	2,195
Arkansas River at Lamar, Colorado	12	4,320	2,870	3,794
Arkansas River near Coolidge, Kansas	12	4,060	2,520	3,592

Source: Water Resource Data for Colorado, Part 2, Water Quality Records, 1971, U.S. Geological Survey.
[1] Listed in downstream order.

dimensional problems of flood control and municipal and industrial water supply shortages.

Local flood protection works are needed at Florence, Portland, Pueblo, La Junta, and Lamar, and channel improvements are needed on the Arkansas River from Pueblo to Las Animas.

Much of the flood damage could be avoided or severely limited if the flood plains were zoned or controlled to prevent intensive development. There is a need to pursue a program of integrated flood control, using nonstructural measures as well as structural means. Such a program would provide for an increase in the water supply by reducing nonbeneficial use, prevent loss of lives and property, and provide much greater recreational use.

Phreatophytes. – The Arkansas Valley is an area of limited water supply and phreatophytes present a major supply problem. They grow where the water table is high and eventually occupy large areas along tributaries and main river channels, irrigation channels and laterals, flood plains and the deltas of reservoirs. These plants use from 50 to 100 percent more water than most agricultural crops on equivalent acres. They cause accumulation of sediment, reduce channel capacity, and increase the number of river meanders. Very little other vegetation can coexist with some varieties of phreatophytes, particularly saltcedars. Lands which have become infested deteriorate to the lowest quality of grazing land for livestock.

Phreatophytes began to appear in the Arkansas River basin as early as 1913 and have spread throughout the area, primarily along stream channels, canals, and reservoirs. A 1968 survey showed that 23,000 acres of phreatophytes were found along the Arkansas River between Pueblo and the Kansas State line, 4,500 acres along Fountain Creek between Colorado Springs and Pueblo, and 11,220 acres along the Purgatoire River between its headwaters and confluence with the Arkansas River.

Erosion and Sediment. – Closely related to flooding issues, but treated separately, is the problem of erosion and sedimentation. Erosion is closely related to peak flows and the formation of gullies are accelerated during high-flow conditions. However, serious erosion affecting gullies, streambanks, roadsides, and valuable topsoil can occur without damaging floodflows.

Deposition of sediment in irrigation water distribution systems is a continual problem reducing canal capacities and increasing operation and maintenance costs. Aggradation of the river channel in the vicinity of irrigation diversion dams requires yearly maintenance to keep the structures operative.

Serious sediment problems, which are associated mainly with floods, occur in the Arkansas River basin downstream from Pueblo. Based on recent surveys, sediment reduces the capacity of John Martin Reservoir about 3,000 acre-feet annually.

Recreation. – The 1948 Arkansas River Compact among the States of Colorado and Kansas and the United States, provides operating criteria for John Martin Reservoir which limits that reservoir's usefulness in meeting recreational needs. The result is that each State must use its water simultaneously with the use of the other State. The rapid release of this storage water provides a very inefficient usage.

PROBLEM RESOLUTION

Each of the above problems is unique in terms of when it will become a critical problem, solutions available to solve the problem, and adverse impacts that the Nation, State, or region and its people might experience if the problem were not solved. The status of each problem in terms of time frame, solutions, and impacts is summarized below.

Transregional diversions will meet M&I water supply requirements through 1990. Conversion of agricultural water rights and uses to M&I purposes is always an additional alternative. Irrigated agriculture will continue to experience periodic shortages and conversion to other uses will probably continue. The impact of the conversion on the region's economy, especially the rural economy and social structure may be adverse and needs to be evaluated.

Except for waste water from mines, the quality of the Arkansas River above Pueblo is very good. With regard to mining wastes, some limited studies have been done and others are under way. The reconnaissance phase of a Geological Survey study, which identified over 1,000 mine drainage sites, has been completed and more detailed studies are now going forward at a limited number of sites.

Salinity in the lower reaches of the Arkansas is a major problem now and will continue to be a major problem. Solutions are limited. Short of desalting, better onfarm management practices and improvement of delivery systems are about the only two alternatives available.

The Corps of Engineers' survey report for flood control and related purposes from John Martin Reservoir to the headwaters of the Arkansas River was recently authorized by the "Water Resources Development Act of 1974." The Corps' recommendations include a reservoir on Fountain Creek just above Pueblo, a channelization test section of 7 miles above La Junta, Colorado, and several local protection projects. The Corps is also completing a survey study on the Arkansas River below John Martin Reservoir in which a multiple-purpose reservoir on Willow Creek near Lamar is recommended.

Eradication and control of selected areas of phreatophytes would provide additional water. Although there are some adverse wildlife habitat effects, the need for water may lead to this method of water salvage. Proper management plans can minimize these effects and in some instances enhance wildlife. A recent court decision in the State has allowed some salvage of water through removal of these plants.

Erosion and sedimentation is a serious problem from Pueblo Dam throughout the lower reaches of the region. Erosion caused by construction, agriculture, and man-influenced activities can be controlled to some degree. However, a considerable amount of natural erosion occurs in the region. This problem and its impacts need to be evaluated.

In the lower reach of the Arkansas region, John Martin Reservoir is the logical facility for meeting recreation needs. Congress, by the Flood Control Act of 1965, authorized the Corps of Engineers to provide 10,000 acre-feet of reservoir flood space for fish and wildlife and recreation purposes. The State of Colorado is negotiating for the necessary water rights to establish this pool of 10,000 acre-feet. However, the 1948 Arkansas River Compact needs to be revised to take full advantage of John Martin Reservoir and the purchased water rights.

CONCLUSIONS

1. The Arkansas River basin is currently experiencing severe water and land use problems.

2. Because of continuing growth, these problems will continue to grow.

3. Although many studies have been made of the Arkansas problems, the objectives have been agency oriented, generally, single purpose in scope, limited geographically, and not sufficiently coordinated with other agency programs.

RECOMMENDATION

1. A Water Resources Council Level B Study should be initiated in 1979 or sooner under State leadership with technical assistance from Federal agencies.

NO. 4 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

Colorado's two Indian tribes want to use their existing water rights and establish additional rights to waters within their jurisdictions. There are many problems associated with improvement of reservation economic and social conditions. Developing a viable economy and improving the economic status of tribal members are the main problems which both reservations are trying to resolve. Intertwined with this problem are those faced by people everywhere such as flooding, obtaining M&I water, and protecting the environment. In the process of solving reservation economic problems, other conflicts will arise and decisions and trade offs between economics, environment, and land use will have to be made. The economic problem exists today; the environmental, water supply, and land use problems will occur in the future as the tribes resolve their economic problems.

DISCUSSION

There are two Indian reservations within the State of Colorado; they are the Southern Ute Indian Reservation and the Ute Mountain Ute Indian Reservation. The Southern Ute Indian Reservation contains about 300,000 acres and supports approximately 800 tribal members. It is bordered on the south by the New Mexico State line, on the west by the Ute Mountain Ute Indian Reservation, and on the north and east by various non-Indian lands. The Ute Mountain Ute Reservation contains 569,060 acres. Of this amount 448,030 acres are in Colorado, 107,520 acres in New Mexico, and 13,510 acres in Utah. The total population is about 1,225 with 1,000 living at Towaoc, Colorado, and 225 living at White Mesa in Utah, south of the community of Blanding.

Southern Utes

Municipal. – The town of Ignacio, which is centrally located on the Southern Ute Reservation, has a population of 710, including tribal members. It is the primary user of municipal water along with the tribal motel complex and related facilities such as a shopping center, golf course, and industrial park. Ignacio is forecasted to have a population of 1,100 by the year 1990 and may grow to between 2,000 to 3,000 individuals by the year 2000. The existing water delivery system is 40 years old and is inadequate and cannot accommodate increasing municipal demands. Municipal water is presently diverted out of the Pine River, which flows through Ignacio.

Domestic. – Tribal members not residing in or around Ignacio are classified as rural; their water needs are of a domestic nature and are served chiefly by water wells. Studies are needed to determine the quantity and quality of ground water.

Industrial. – Industrial use of water does not presently exist; however, two sites have been located near Ignacio for industrial site development.

Environmental Quality. – Aesthetic water-related values at present are generally unaffected by population densities or riparian development; the main rivers that traverse the reservation do so under natural conditions, and most support fish and wildlife habitat. Tribal fish and game permits are sold annually so a need exists to preserve and enhance critical habitat. The situation becomes more critical as water resources development becomes imminent.

Recreation. – One lake and several rivers have limited recreational facilities which need to be expanded. Potential picnic and camping sites are abundant near or adjacent to the river systems. Several sites for potential reservoirs exist on reservation lands. These reservoirs possibly could be developed for multiple uses which would include recreation.

Water Quality – Pollution Control. – All of the rivers on the Southern Ute Reservation are subject to pollution; primary contributors are silt, sediment, sewage, and return flow from irrigation. There is also a presence of selenium and mercury. Water quality studies are continually needed for various purposes; the consideration of quality is relevant to practically every conceivable use of water on the reservation.

Energy Development – Mineral. Coal, of an average grade, is abundant at various depths throughout the reservation. Significant amounts of water may be needed if this resource is developed to its full potential. Evaluation of the coal resource and its potential for development is needed.

Food and Fiber. – The Pine River Indian Irrigation project and the Florida project include Indian lands. Irrigation water for these projects is diverted from the Pine and Florida Rivers, respectively. The Pine River project, involving approximately 17,000 acres, will have to be totally rehabilitated in the period between now and the year 2000 in order to continue to serve the needs of the water users. It has been rehabilitated once before. The proposed Animas-La Plata project would supply irrigation water for additional area.

Livestock and wildlife ponds and reservoirs must be built and restored to effectively manage both livestock and game herds. This is a continual requirement up to year 2000.

Flood Control. – The Florida and Pine Rivers are the only rivers that have reservoirs on them large enough to serve as flood control structures; the other rivers are subject to flooding, which in the past has caused damage to Indian lands. Studies to assess potential flood damages are needed.

Other. – The forested areas of the reservation need water for fire control purposes. Dams, reservoirs, supply points in rivers, or any other means of providing water for fire control need to be developed.

Ute Mountain Utes

Municipal. – Towaoc's 1,000 permanent residents have experienced extreme water shortages for many years. Drinking water is currently being hauled in and for a time during the drier months of the year, it is necessary to haul water to keep the sewage system operating properly. By the year 1980, the population is projected to increase to 1,500 and by the year 2000 to 2,200. With the increase in population and increase in water usage, some 1,500 acre-feet of water will be required. The planned Ute Mountain Ute Tribal Park will create an additional demand for water. Also based on expected increases in reservation visitations, it is estimated that 180 acre-feet of water will be needed for this purpose by year 2000.

Industrial. – A commercial and industrial park is currently being laid out along Highway No. 160 east of Towaoc. One industry is already starting to build. By 1980, it is anticipated that 100 acre-feet will be required annually to satisfy the demand.

Environmental Quality. – With the advent of the Four-Corners Powerplant, the quality of air in the reservation area has deteriorated. The San Juan generating unit will further result in a deterioration of the air quality. The use of water in the development of the tribes' coal resources will be governed by the ability of the companies to assure that there is no further deteriorating effect.

The Mancos River as it passes through the Mesa Verde and the planned Ute Mountain Ute Tribal Park enhances the quality of the scenery and environment in the area. Further enhancement of the environmental quality can be obtained by stabilization of streamflows on the Mancos River and by erosion control.

Recreation. – There is a need to develop recreation reservoirs throughout the reservation, particularly adjacent to the Ute Tribal Park. Studies are needed to determine possible ways of maintaining a constant streamflow in the Mancos River as it crosses the Ute Mountain Homelands. By maintaining the flow, it could provide fishery waters through the Ute Mountain Ute Tribal Park to the confluence with the San Juan River.

Water Quality. – The quality of water on the reservation, both surface and ground, is of extremely poor quality. The water quality of the Mancos River has deteriorated over the years due to upstream uses and return flows from the Mancos Irrigation project. At the present time, the water in the Mancos River as it enters the reservation is of such poor quality that it cannot be used for irrigation or domestic purposes. Ground water on the reservation is inadequate and of such poor quality that it cannot be used for municipal or industrial purposes.

Control of erosion on the Mancos River would improve the quality of water from a scenic standpoint as well as for the fishery.

Energy Development – Minerals. – Large coal deposits are located throughout the reservation. Most of these deposits are of a deep nature; however, there are some shallow deposits which could be strip mined.

Mineral resources other than coal are of an unknown quality and quantity. Studies are essential to determine if occurrences are such as to make commercial development feasible.

Food and Fiber. – The reservation has a considerable amount of land which is suitable for irrigation. The Dolores and the Animas-La Plata projects would utilize some of these lands and contribute to the economy of the reservation.

Livestock production and its attendant use of water provides much of the income derived by the Ute Mountain Ute Reservation. Additional stock ponds will have to be constructed to meet increased needs for livestock water. The development of a feedlot on the reservation is a distinct possibility.

Flood Control. – Mancos River floods have destroyed bridges and numerous archeological sites.

Other. – The use of helicopters for fire control purposes requires that tanker refill and dip ponds be developed in strategically located areas. A water supply will have to be developed in conjunction with these ponds.

CONCLUSIONS

1. There is a definite need to improve the economic position of each tribe and its members.

2. The reservations have resources which could be developed to the benefit of the tribes and their members.

3. The reservations currently are experiencing M&I shortages, environmental, water quality, land use, erosion, sedimentation, and flooding problems.

RECOMMENDATIONS

1. The Federal Government, through the Bureau of Indian Affairs, should initiate level B resource studies in 1976. The primary purposes of these studies would be to assess the resources available and their potential for development.

2. Preconstruction planning of the authorized Dolores and Animas-La Plata projects should recognize to the maximum extent possible opportunities to assist Indians in achieving their economic and social development goals.

NO. 5 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

SUMMARY

Salinity in varying degrees is a problem along the South Platte and Arkansas Rivers and in the Upper Colorado Region. From north of Denver to the Nebraska-Colorado State line, the South Platte River salinity increases from 516 p/m to 1,330 p/m. The Arkansas River increases from 365 p/m near Pueblo to 2,200 p/m below John Martin Reservoir and to about 3,600 p/m near the Colorado-Kansas State line. Upper Colorado region salinity is not a problem in Colorado; however, salts added by natural sources and return flows from irrigated areas contribute significantly to the salinity problems of the Lower Colorado region and Mexico.

DISCUSSION

The melting snows of the Rockies supply high-quality water to the headwaters of four major river basins within Colorado. However, as noted in the following list, arranged by decreasing magnitude, quality is affected in a variety of ways, both natural and manmade, which degrades the quality of the water as the water travels through the system.

Surface water

Surface runoff
Depletion by irrigation, transmountain diversions and other uses
Sediment
Salt pickup from irrigation and other sources
Municipal wastes
Industrial wastes
Mining wastes

Ground water

Percolation of poor quality water into shallow aquifers
Irrigation deep percolation
Seepage from land fill disposal operations
Poorly sealed wells
Deep well disposal

Table VI-15 is a summary of the salinity conditions for the South Platte and Arkansas Rivers and Upper Colorado region, the major salinity problem areas in the State.

Water quality in terms of dissolved solids in the South Platte River from Denver downstream is largely the result of irrigation return flows. The tabulation in table VI-15 for water years 1969-1970 clearly shows the increase.

Table VI-15.–*Dissolved solids, South Platte River below Denver, water years 1969-1970*

Stations progressing downstream	Dissolved solids, mg/l		
	Maxi-mum	Mini-mum	Average of 12 samples
South Platte River at Henderson, Colorado (north of Denver)	783	181	516
Near Kersey, Colorado	1,450	373	965
At Balzac, Colorado	1,530	605	1,159
At Julesburg, Colorado	1,590	672	1,330

Impacts are limited mostly to irrigation users in Colorado. Nebraska uses only minor amounts of South Platte water and mainly for irrigation and power purposes.

Dissolved solids concentrations for water year 1970-71 for the Arkansas River and some of its tributaries are presented in table VI-14. These concentrations increase from about 50 p/m at the headwaters to about 3,600 p/m at the Colorado-Kansas border.

Salinity has also affected to a similar degree the shallower groundwater aquifer along the Arkansas River. In fact, towns below John Martin Reservoir have gone to deep wells or water softening to obtain potable supplies.

Irrigation users, as well as M&I users in both Colorado and Kansas, are affected by these high salinities.

Upper Colorado region salinity is generally not a problem in Colorado; however, Colorado sources do contribute significantly to Lower Colorado region salinity problems.

Table VI-16 shows the salinity of the Colorado main stem progressing downstream to Cisco, Utah, the closest station to the Colorado-Utah border. Only at the last station shown does salinity exceed the Public Health Service recommended drinking water standard of 500 mg/l.

Table VI-16.—*Salinity of Colorado River*

Station	Dissolved solids (mg/l)	
	1968	28-year average
Colorado River		
Near Glenwood Springs, CO	312	272
Near Cameo, CO	439	406
Near Cisco, UT	680	613

The Lower Gunnison area, Grand Valley area, Glenwood-Dotsero Springs, Paradox Valley, and McElmo Creek areas are the main sources of salinity. It is estimated that the Lower Gunnison area contributes about 1,100,000 tons of salt annually to the Colorado River. About 160,000 acres of land are irrigated in this area. The total quantity of salt contributed by the Grand Valley area is about 600,000 tons annually. Flows from McElmo Creek near the Colorado-Utah State line averages about 31,000 acre-feet per year and contributes an estimated 115,000 tons of dissolved solids. Some of this salt is from natural sources and some from return flows. Within the State, natural source salinity is considered to be a serious problem only in the Colorado River Region. Diffuse sources are the greatest contributors. Two point sources – Paradox Valley and Glenwood-Dotsero Springs – are heavy contributors. Paradox Valley is estimated to contribute 200,000 tons of salt per year to the Dolores River, while the Glenwood-Dotsero Springs discharges an estimated 500,000 tons annually to the Colorado River.

PROBLEM RESOLUTION

South Platte and Arkansas Rivers

The salinity problems of the South Platte and Arkansas Rivers are much more serious today than those of the Upper Colorado region. Increased salinity levels are affecting small communities' M&I supplies in the Arkansas River Valley below Pueblo and along the South Platte River from Henderson, Colorado, to the east. Irrigation continues to these areas even though salinity levels are increasing. At some point, production will be seriously affected.

No simple solutions exist. Better onfarm management practices and better distribution systems will reduce salinity but not completely solve the problem.

Upper Colorado Region

Presently Upper Colorado region salinity levels are not affecting Colorado users; however, activities including transregional diversion, irrigation depletions, M&I use, and natural saline sources are contributing to the overall Colorado River salinity problem. From the Lower Colorado region's and Mexico's viewpoint, any future development may intensify the existing problem.

The Colorado River Water Quality Improvement Program (CRWQIP) is investigating ways to reduce salinity. Studies are under way in Grand Valley and Paradox Valley and are programed for the Lower Gunnison, Glenwood-Dotsero Springs, and McElmo Creek areas. Following is a brief summary of the Grand Valley and Paradox Valley studies:

Grand Valley. – The investigation is oriented toward determining the best methods of increasing water delivery efficiency. Major items that will be pursued are alternate methods of delivery, system water requirements based upon projected land use patterns, a complete hydrogeologic study of the valley, and evaluation of proposed improvements for economic benefit to the local area and downstream salinity impacts. The combination of water systems improvement and irrigation management services could result in a reduction of about 200,000 tons of total dissolved solids to the Colorado River and a salinity concentration reduction of about 19 mg/l at Imperial Dam. Cooperative State of Colorado-Department of Agriculture investigations are scheduled regarding the contributions which improved onfarm system measures can make in salinity reductions.

Paradox Valley. – Based on data developed at this time, the control plan is to lower the freshwater/brine interface by pumping wells along the Dolores River to prevent the brine from entering the river. The estimated pump discharge of 5 ft^3/s to 8 ft^3/s would be transmitted via pipeline to an evaporation and salt storage reservoir on the West Fork of Dry Creek about 20 miles to the southeast. The control project would reduce salt contribution by about 180,000 tons per year. This would result in a reduction of salinity at Imperial Dam of about 16 mg/l.

Regional Problem No. 2 discusses the Colorado River salinity situation in more detail.

CONCLUSIONS

1. South Platte salinity will continue to affect Colorado and Nebraska water users. Measures other than improvements in irrigation systems and water management would probably not be justified at this time.

2. Arkansas River salinity significantly affects both irrigation and M&I users. Several small communities are considering alternative supplies or desalting of present supplies. Basinwide improvements in irrigation systems and water management should be considered.

3. Because of international implications, the salinity sources in the Upper Colorado region of Colorado are of sufficient magnitude to warrant corrective measures.

4. Onfarm management and control measures can be an important means of salinity control.

5. Limitation of depletions is not a presently acceptable alternative to the Colorado River basin States.

RECOMMENDATIONS

1. The Bureau of Reclamation's Colorado River Quality Improvement Program and allied Department of Agriculture programs should be continued. From these programs, recommended level C studies should be initiated and justifiable programs implemented.

2. As a part of the level B study recommended for the Arkansas River Basin, in Colorado Problem No. 3 salinity problems should receive further study and evaluation.

3. The State should monitor salinity levels throughout the State and support corrective measures where required.

Idaho, like several of the Westwide States, is a land of extreme contrast – Idaho's natural attractions include rugged mountain ranges with wild rivers and peaceful streams and valleys. The State also contains vast stretches of forested, primitive wilderness and sagebrush-covered desert. Its area of more than 83,000 square miles ranks 10th among the Westwide States and 12th nationally. Within its vast area, Idaho has slightly less than 800,000 people – a population density of less than 10 per square mile. Many areas of the State are virtually unpopulated; other, much smaller areas have high and rapidly growing concentrations of population and economic developments. Although past trends are changing as manufacturing assumes a larger role in the economy, overall the State has not experienced as much economic growth and development of its natural resources as has occurred in most other States. This is related to the fact that the Federal Government manages and administers nearly two-thirds of the State's lands, which has tended to preserve them in their natural state.

Current patterns of growth are resulting in increasingly uneven spatial distributions of populations: the more densely populated counties continue to gain residents, while many sparsely populated areas are experiencing continued low growth rates or population losses.

Between 1960 and 1970, only 10 Idaho counties experienced net immigration population gains. The remaining 34 counties experienced varying degrees of population outmigration. In all, 41,000 people left the State during the decade. Except for the 1920's the 1960's was the decade of slowest recorded population growth, with an increase of 6.9 percent or 46,000 persons. Since 1970, population trends have changed dramatically in Idaho. The Bureau of Census in a report released in January, 1974, estimated migration increases of 30,000 for the period 1970-1973. Population growth amounted to 57,000 or an increase of 7.9 percent during this period. More recent estimates show Idaho with a mid-year 1974 total of 790,000. Consolidation of small farms is occurring. Population statistics indicate a definite trend toward migration of Idaho's young adults from rural areas to larger cities and better employment opportunities. Further development of agricultural and recreational potentials would alleviate some of these problems and provide expanded economic bases in some thinly settled areas.

Idaho's economy has traditionally been centered on industries which were dependent on natural resources and raw materials. For many years, agriculture, lumber, and mining were the primary producers of wealth. Today, agriculture is first in cash receipts, followed by forest products, manufacturing, tourism, and mining.

The irrigated farm segment is important as a basic support for the State's growing industrialization. The bulk of the present industrial effort is associated with the processing of food and livestock products.

Although agriculture is still Idaho's largest employer, manufacturing and services are capturing an increasingly significant share of the labor market. Agricultural employment decreased 24.1 percent between 1960 and 1970, largely because of consolidation into larger farm units, increased mechanization, and better opportunities in other industries.

WATER SUPPLY

Idaho has significant quantities of both surface and ground water. The State has more than 16,000 miles of streams, more than 2,000 natural lakes, and one of the largest ground-water reservoirs in the world – the Snake Plain aquifer.

Surface Water

The Snake River is the principal supplier of consumptive water uses in Idaho. With the exception of the Bear River basin, all runoff in Idaho flows generally from east to west and drains into the Columbia River.

The works of man have significantly altered streamflows, especially in some areas such as southern Idaho where a high level of development has occurred. The magnitude and seasonal distribution of flows of the Snake River and many of its tributary streams are affected greatly by storage facilities, diversions, and return flows from irrigation, and consumptive use of water by plants. In dry years, flows of the Snake River above Milner Dam are almost entirely regulated. Flows generally are higher in the summer as releases are made for downstream irrigation but become low in the late fall as flows are stored for the next year.

Table VI-17 shows estimated 1975 surface water depletions for Idaho by subregions while table VI-18 shows estimated, net water supplies available in 1975. The supplies available could be used for either instream use for environmental, hydropower, or navigation purposes, or could be developed for consumptive use. Physical and/or economic constraints would preclude practical development of much of the supply. Figure VI-9 shows the major river systems in Idaho and the

Table VI-17.—*Estimated 1975 total depletion for Idaho (1,000 acre-feet)*[1]

Region and subregion	Irrigation	M&I including rural	Minerals	Other[2]	Reservoir evaporation	Total depletions
	Purpose or cause of depletion					
Columbia-North Pacific						
Clark Fork, Kootenai, Spokane	69	10	1	0	480	560
Upper Snake	5,710	48	0	22	640	6,420
Central Snake	1,735	36	0	9	350	2,130
Lower Snake	288	12	0	11	77	388
Total region	7,802	106	1	42	1,547	9,498
Great Basin						
Bear River	391	12	0	1	130	534
Total region	391	12	0	1	130	534
State summary	8,193	118	1	43	1,677	10,032[3]

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] No depletions are attributed to thermal electric, recreation and consumptive conveyance losses.
[3] Surface-water depletions — 7,760,000; ground-water depletions — 2,272,000.

type I regional and subregion boundaries. The sum of the modified flows to the subregions are determined as follows:

From	Acre-feet
Montana	25,960,000
Wyoming	4,630,000
Utah	20,000
Nevada	130,000
Oregon	800,000
Oregon	2,590,000
Wyoming	330,000
Total modified inflow	34,870,000

Idaho has about 50 reservoirs with a usable capacity of 5,000 acre-feet or more. The total usable storage represented by these reservoirs is 10.5 million acre-feet, and the total surface area is about 500,000 acres. These reservoirs have inundated about 600 miles of the 16,000 miles of Idaho streams.

Ground Water

Ground water is one of the principal resources of Idaho. In recent years, the development of ground-water supplies for irrigation has been increasing at such a rate that serious overpumping has occurred in some areas in south-central Idaho such as the Raft River Valley, part of the Goose Creek drainage south of Burley, and the Blue Gulch area west of Twin Falls. New wells in these areas are restricted. However, in spite of the fact that ground-water development must be restricted in localized areas, the State's overall ground-water potential has barely been tapped.

The principal aquifers occur in the Snake River Plain of southern Idaho, Rathdrum Prairie of northern Idaho, and along the western side of the State. The mountains in the central portion are composed largely of consolidated rocks with resultant low permeability. Intermontane valleys and basins which are partially filled with alluvial sand and gravel are important as seasonal ground-water reservoirs, storing water during periods of high rainfall or snowmelt. Ground water from these areas is not utilized to any great extent as a source of of water supply.

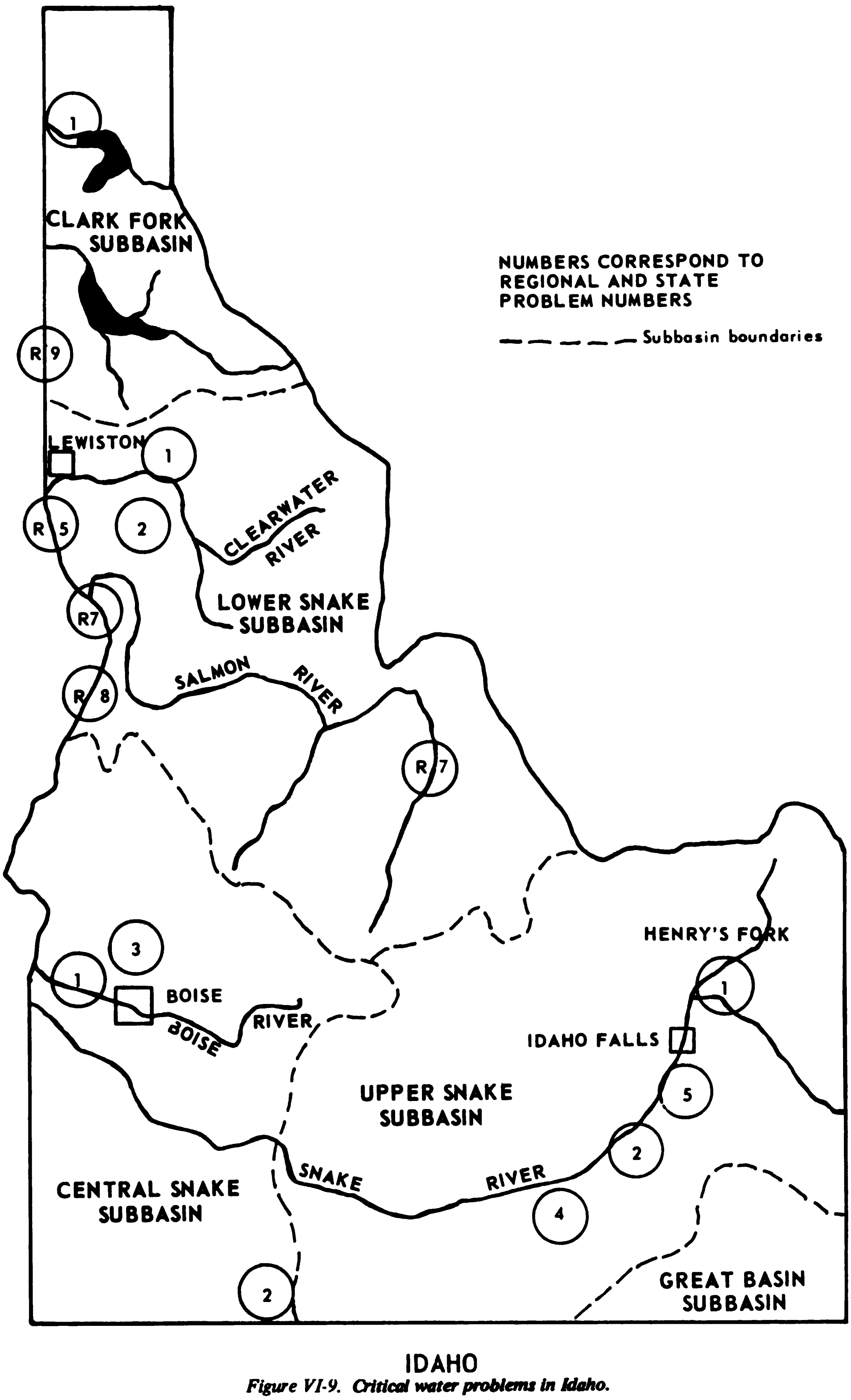
Water Quality

In general, the waters of the State of Idaho are of excellent quality in spite of the intense uses and a high degree of river regulation. There are, however, many instances of violation of existing water quality criteria

Table VI-18.—*Estimated 1975 surface water-related situation in Idaho (1,000 acre-feet)*

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within sub-region or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Columbia North-Pacific									
Clark Fork, Kootenai, Spokane	26,040	8,960	0	35,000	0	560	34,440	2,620	31,820
Upper Snake	4,770	8,510	0	13,280	0	6,420	6,860	3,920	2,940
Central Snake	8,070[5]	6,020	0	14,090	0	2,130	11,960	1,760	10,200
Lower Snake	14,550[6]	20,000	0	34,550	0	388	34,162	7,230	26,932
Total region	34,610	43,490	0	78,100	0	9,498	68,602	15,530	53,072
Great Basin									
Bear River	330	890	0	1,220	0	534	686	300	386
Total region	330	890	0	1,220	0	534	686	300	386
State summary	34,940	44,380	0	79,320	0	10,032	69,288	15,830	53,458

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] Modified inflow from Upper Snake subregion plus modified inflow of 800,000 acre-feet from Oregon and 410,000 acre-feet from Nevada.
[6] Modified inflow from Central Snake subregion plus modified inflow of 2,590,000 acre-feet from Oregon.



IDAHO

Figure VI-9. Critical water problems in Idaho.

and many opportunities exist for water quality improvement.

Return irrigation flows, municipal and industrial wastes, and runoff from dry cropland areas and associated channel erosion in the Snake, Bear, Palouse, and Spokane River basins and runoff from mining areas in the panhandle are the most significant examples of water pollution in Idaho.

CRITICAL PROBLEMS

The major interfaces of the Westwide problems directly affecting the State of Idaho are discussed first in this section; regional problems, details of which appear in chapter V, are then listed by number; State specific problems are discussed in detail.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – Even though environmental data needs are discussed subsequently as parts of specific State issues, and Idaho-related regional issues, it is emphasized here that this is a priority need in Idaho due to the relatively unspoiled character of many of Idaho's rivers and water-related lands.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. – The Middle Fork of the Clearwater River and the Middle Fork of the Salmon River are already in the National Wild and Scenic River System. The following Idaho streams are being studied under Section 5(a) of the Wild and Scenic Rivers Act: the main stem of the Bruneau, the Moyie River from the Canadian Border to the Kootenai River, the entire main stem of the St. Joe River, the Salmon River from the town of North Fork to the Snake River, and the entire Priest River main stem.

The Henrys Fork, from Big Springs to its confluence with the Warm River, and the Snake, from Hells Canyon Dam to Lewiston, Idaho, were among a number of "5(c)" rivers (formerly section 5(d) of P.L. 90-542, the Wild and Scenic Rivers Act) named by the Secretaries of Agriculture and Interior in 1970, whose wild and scenic river values must be evaluated in any Federal planning for other (developmental or control) uses of these rivers.

No new Idaho river studies are being proposed at this time.

NO. 12 – MEETING WATER DEMANDS THROUGH CONSERVATION AND REUSE. – In many areas of the State, water management of surface supplies could be improved and in turn make water available for other uses that benefit man. Major area of concern is the Upper Snake River basin. Delivery schedules maintained by some irrigation districts sometimes results in excess diversions of water. Annual diversion rates for some land companies in the Upper Snake River subbasin exceed 10 acre-feet per acre-foot.

Where diversion rates are high, studies are needed to determine the relationship to ground-water recharge and surface runoff, the economic feasibility of system rehabilitation, ownership of water made available by increased use efficiency, the possibility of changing delivery schedules, and the amount of water which might be available for other uses.

NO. 16 – THE CHANGING FEDERAL ROLE IN DEVELOPING IRRIGATION PROJECTS. – Idaho has abundant land and water resources that could support a greatly expanded irrigation acreage and contribute to the economic stability of the State. Out of Idaho's 12 million acres, 3.1 million acres of irrigated area received water in 1969. The irrigable lands are primarily in the Upper Snake River subbasin (1973 irrigated area of 2.4 million acres) and the Central Snake River subbasin (1973 irrigated area of 0.85 million acres). The Columbia-North Pacific Framework Study listed 4.2 million acres and 2.6 million acres of potentially irrigable lands in Idaho in the Upper Snake and Central Snake subbasins, respectively. Some additional water could be made available through surface diversions, ground-water development, and better management practices and modernized irrigation systems. However, the preponderance of unappropriated State waters are in the Salmon and Clearwater Rivers to the north where irrigable land is scarce. Costly transbasin diversions would be needed to develop major new irrigated areas. This would disrupt the existing high-quality environment in the areas of water export.

Using 1972 OBERS series C information on projections as a base, historical projections of Idaho irrigated area have been made showing a potential increase of 1.17 million acres by year 2000 and a total increase of 1.58 million acres by year 2020. Using 1974 OBERS series E information on projections as a base, projections of irrigable area would be an added 0.85 million acres by 2000 and a total of 1.05 million acres by 2020. These projections were derived by extending historical trends of irrigated cropland harvested to irrigated land. These are not targets or goals, but rather extrapolations of historic trends and could vary in either direction depending on such factors as world demand for food, loss of irrigated land to urbanization, and local, State, and Federal policies toward the use of fertilizer, pesticides, herbicides, and water.

Both private and federally-assisted irrigation have contributed to development in Idaho. It is likely that private interests will continue to develop lands especially by ground water and small developments adjacent to major streams. Development of large blocks of new acreages can be accomplished as Federal programs. However, such development likely will involve high-cost facilities and environmental conflicts.

Regional Problems

Four problems regional in scope directly affect Idaho. These problems, discussed in chapter V, are:

NO.5 – OPERATION AND MANAGEMENT OF THE COLUMBIA RIVER MAIN STEM SYSTEM TO MEET TOTAL WATER USES

NO.7 – MAINTAINING AND IMPROVING ANADROMOUS FISHERIES IN THE NORTHWEST

NO.8 – CONFLICTS OF WATER USE IN THE HELLS CANYON REACH OF THE MIDDLE SNAKE RIVER

NO.9 – EROSION AND SEDIMENTATION IN PALOUSE REGION OF THE NORTHWEST

State Specific Problems

There are several major water and related land resource problems within the State of Idaho. Stream resource maintenance flows (instream needs) for fish, wildlife, water quality, recreation and other aesthetic considerations are needed for certain streams or stream stretches. The State of Idaho has adopted an objective of electrical energy self-sufficiency through reduced reliance on imported electric energy.

There are also problems of competing uses which encompass the water requirements and social problems of the Indian reservations, and the many needs of the Snake River basin areas. The basin is a tremendous user of both surface- and ground-water resources usage, both directly and indirectly. Future economic growth, orderly development, and aesthetic concerns must be balanced to meet local, State and Federal objectives.

The State specific problems in Idaho are listed below and are approximately located on figure VI-9.

NO.1 – THE NEED TO DETERMINE INSTREAM FLOWS FOR WATER QUALITY, FISH, WILDLIFE, RECREATION, AND OTHER ENVIRONMENTAL PURPOSES.

NO.2 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS.

NO.3 – COMPETING USES OF LAND AND WATER RESOURCES AND NEED FOR COORDINATED STUDIES IN THE BOISE AND PAYETTE RIVER BASINS.

NO.4 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS.

NO.5 – COMPETING USES AND NEED FOR CLOSELY COORDINATED STUDIES OF WATER AND LAND RESOURCES OF THE UPPER SNAKE RIVER BASIN.

NO. 1 – THE NEED TO DETERMINE INSTREAM FLOWS FOR WATER QUALITY, FISH, WILDLIFE, RECREATION, AND OTHER ENVIRONMENTAL PURPOSES.

SUMMARY

Federal Water Pollution Control Act Ammendments of 1972 and State of Idaho legislation set standards for water quality on Idaho streams and lakes which will require the treatment and control of wastes from point sources as well as control of pollutants from nonpoint sources. Even assuming that existing legislation, regulations, and Federal and State programs will be effective in controlling or eliminating point source pollution, a balanced approach to meeting water quality standards in streams, lakes, and ground water must be made. This approach must consider the value of minimum streamflows for the assimilation of residual wastes and the dilution of salt, other minerals, sediment, and nutrients which arise primarily from nonpoint sources.

Due to diversions and consumptive uses, the flow of water in many of Idaho's streams is not now sufficient or at some time in the future will not be sufficient to meet the needs of instream uses. Decisions are needed regarding reserving adequate quantities of water for these uses. However, before instream flow standards can be established, more information needs to be compiled on the amount of water necessary to support various instream uses. There exists a question as to whether these instream flows can be legally established without diversion.

DISCUSSION

Effective control of nonpoint source pollution to meet established State standards is a highly complex problem with major technological, institutional, and financial obstacles to be overcome; for instance, adequate control of salt and nutrients added to streams and groundwater systems from irrigation return flows may involve sophisticated management techniques, including automated delivery systems, sprinkler irrigation, lined canals, closed pipe systems, and consolidated distribution systems, to minimize the diversion of water. The technology and performance of such systems in terms of their impact on return flow water quality is not fully known. The assignment of costs for such systems where the benefits accrue largely away from the point of installation is difficult to analyze.

Primary responsibility for meeting Federal and State water quality standards rests with the State of Idaho although it would be appropriate for relevant Federal agencies to provide technical assistance in a supporting role.

At present there is a lack of data and information on which sound decisions can be made on establishing flows for water quality. The Idaho Department of Water Resources has requested funds to increase its comprehensive planning effort which includes consideration of water quality and is proposing that minimum flows be determined for key stations. These stations are:

a. Snake River at Heise, at Blackfood, below the Milner Reservoir, at the mouth of Rock Creek, at King Hill, at Weiser, and at Lewiston;

b. South Fork Teton at Rexburg;

c. Henrys Fork below South Fork Teton;

d. Payette River at Emmett; and

e. Boise River at Boise and Caldwell.

In Idaho the critical environmental data gap is the determination of instream water requirements for recreation, fish, and other aquatic organisms and stream-related wildlife so that these resources can serve man's needs in recreational, aesthetic, scientific, and cultural areas.

Since numerous streams are already fully allocated and some stream reaches are actually dried up during parts of the year, such determinations are critical in any planning for water development in the State if environmental interests are to be given adequate consideration.

Any legislation to deal with the allocation of instream flows for environmental purposes will require a sound basis for such allocations. The major areas of the State where recreation use of a free-flowing river is in conflict with use for all purposes are as follows:

a. Boise River (Barber Dam, above Boise, to Fairview Bridge) – A water quality problem due to discharge of waste into the water by municipal and industrial users is aggravated in winter months during periods when Lucky Peak outlet works are shut down for maintenance purposes. Boise River flows are usually good during the summer months except in lower reaches of the river.

b. Snake River (Twin Falls and Shoshone Falls) – The diversion of water from the Snake River flow which has significant adverse effects upon the aesthetic attractiveness of these falls.

c. Snake River (Hells Canyon Reach) – The operation of the Brownlee-Oxbow-Hells Canyon Dam complex for electric power production and upstream uses during extremely dry years could have a detrimental effect on river boating, upon those recreational activities largely dependent upon boating, and on fish.

PROBLEM RESOLUTION

The following stream reaches have been identified as having a high study priority for determination of instream needs:

a. Main Stem Snake River (Palisades Dam to Brownlee Reservoir)

b. Henrys Fork River (Island Park Dam to confluence with Snake River)

c. Teton River (Below Teton Dam)

d. Willow Creek and Grays Lake Outlet (entire system)

e. Blackfoot River (Blackfoot Dam to confluence with Snake River)

f. Portneuf River (Downey Canal to confluence wtih Snake River)

g. Rock Creek (entire drainage)

h. Big Wood River (below Magic Reservoir)

i. Boise River (below Lucky Peak Reservoir)

j. Payette River (entire drainage)

k. Weiser River (entire drainage)

l. Clearwater River (below Dworshak Dam)

m. Kootenai River (below Libby Dam)

n. Snake River – Hells Canyon Reach – (see Regional No. 8)

Other streams in need of study to determine stream resource maintenance flows for recreation and aesthetics are Bear River, Clark Fork River (Bonner County), Lembi River, Priest River (Priest Lake to confluence with Pend Oreille River), 270 streams in Forest Service Region 1 (northern Idaho) in National Forests and 250 streams in Forest Service Region 4 (southern Idaho) in National Forests.

CONCLUSIONS

1. Early action is needed to determine minimum flows at critical points and reaches of rivers of Idaho or else instream values will be ended and lost.

2. The State of Idaho should reach an early decision as to whether instream flows for fish, wildlife, water quality, and recreation are to be granted a State water right.

3. In addition to State agencies, Federal participation in instream flow studies is also needed because: Federal agencies have technical expertise in most specialized fields of resource planning; Federal agencies manage many of the dams involved in regulating flow release relating to these study purposes; and stretches of streams to be studied are within land areas administered and managed by Federal agencies.

RECOMMENDATIONS

1. The State, in cooperation with Federal agencies as required, should complete special studies to establish recommended optimum flows for the following 12 priority points:

a. Snake River at Heise, at Blackfoot, below Milner Reservoir, at the mouth of Rock Creek, at King Hill, at Weiser, and at Lewiston,
b. South Fork Teton at Rexburg,
c. Henrys Fork below South Fork Teton,
d. Payette River at Emmett, and
e. Boise River at Boise and at Caldwell.

2. Special studies on the reaches of streams listed under Problem Resolution for this problem should be carried out to develop plans for stream resource maintenance flows for recreation, water quality, fish and aquatic wildlife. The 12 priority points listed above would fall within these study stream reaches.

3. The studies should be multidisciplinary with major involvement of the State of Idaho and appropriate Federal agencies. The studies should be coordinated with the level B studies undertaken as part of the Pacific Northwest River Basins Commission Comprehensive Joint Plan. Most of these studies would be part of study proposals discussed in the following State or Regional Problems.

NO. 2 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

A variety of problems, needs, and land and water resource potentials exists on Idaho Indian reservations. The spectrum of opportunities for development ranges from intensive agricultural production via irrigation in the south for the Fort Hall Reservation and Duck Valley Reservation to prospects of developing hydropower, recreation, agriculture, forests, and fish and wildlife resources in the more northerly reservations. These development potentials could take significant quantities of water which are, as yet, undetermined. Since these water requirements are not fully established, there is a critical need to determine water needs on the reservations so that water planning can go forward on the reservations according to Indian goals and aspirations to support future Indian community development.

DISCUSSION

The Indian reservation population for the State of Idaho is approximately 4,900 people. The reservations, Coeur d'Alene and Kootenai in northern Idaho, Nez Perce in central Idaho, and Duck Valley and Fort Hall in southern Idaho have communities ranging from 52 to 2,800 people. About 56 percent of the Indian population resides in the southeastern portion of the State, with the remainder in the northern and southwestern sections. A major portion of the age distribution is in the younger people – 55 percent of the resident population is under 25 years of age. Population increase in recent years is substantial and the high percentage of younger people is an indication that population will continue to increase, bringing all the accompanying concerns such as community health, economic needs, housing, and others which must be adequately resolved.

In a rural setting, the economic base has been directly related to the natural resources existing on or near the reservations. Agricultural land, range, timber, and minerals are the primary resource categories which support the Idaho communities. In 1970, per capita annual income of the reservation communities was $1,376 as compared to the statewide per capita income of $2,649. The unemployment rate varies in the different Indian communities, but is substantially higher than the State as a whole – an average of 18 percent compared to a statewide rate of 5.2 percent.

A basic objective of all Indian communities is to raise their standard of living to equal the levels of the surrounding non-Indian communities. To accomplish this, much more benefit must be realized from the utilization of resources and from more highly developed community services.

Trust land acreage amounts to 682,558 acres including 145,545 acres in the Duck Valley Indian Reservation – approximately 277,706 acres of tribally owned, with 363,496 acres in allotted status, and 41,355 acres of Government land which is reserved for Indian concerns. Irrigated acreage totals 77,554, dry farm 98,870 acres, and there are 378,000 acres of rangeland. Forest land is in excess of 121,000; however, of this, commercial forest land amounts to 65,000 acres.

It is estimated that an additional 20,000 acres could be placed under irrigation in the near future, and an additional 88,000 could be under production by the year 2000. In addition, substantial potential exists for expansion of irrigation after the year 2000.

Timber production on trust lands in the State are nominal. Estimated annual production of phosphate is over 1,500,000 tons.

Future development potentials exist in:

1. Expansion of irrigable land in reservation areas;

2. Initiation of commercial recreational development;

3. Development of industrial capability to process agricultural products, minerals, and other resources related to the trust land areas;

4. Diversification of reservation economy to the extent possible to provide more services to reservation communities and surrounding non-Indian communities; and

5. Improvement of community environment through improved housing and community facilities.

The general level of development and consequently the use of water has been generally at a lower level than surrounding communities. However, it is anticipated that the increasing capability, and development of reservation areas will result in a much higher per capita use of water in the future.

Irrigation occurs primarily on the Fort Hall Indian Reservation where the Shoshone-Bannock Tribes are well adapted to an irrigated agriculture economy and want to develop an additional 100,000 acres of irrigable land so they can realize increased social and economic benefits.

The Bureau of Indian Affairs is currently funding an $85,000 water resources inventory by a private consultant that will include a water resources development plan for the reservation. There is also a need for a land capability study to determine the potential irrigable acres on the reservation. Information from the aforementioned two studies could then be used as a basis for more detailed comprehensive water and land resources studies.

CONCLUSIONS

1. Water needs for Indian trust lands should have a high priority in planning for water management and use.

2. Water and related land resource studies are needed to dimension the Indian water right and to ascertain which resource programs and projects are best suited for improving economic and social conditions as well as enhancing and protecting the natural environment on Idaho Indian reservations.

3. Indians of the Fort Hall Reservation have planning studies underway to develop their land and water resources for economic and social objectives.

RECOMMENDATIONS

1. Expedite special studies for water resource investigations and development of water management plans for trust land areas. In water deficit areas or basins which contain trust lands, pursue special planning studies for water management and storage projects which will result in more efficient use and reuse of the total water resource.

2. Level B studies including water and land resources inventories should be carried out on Indian reservations in Idaho, working closely with the Indian Tribal Councils. Responsibility for conducting water and related land studies should rest with the tribes and the Bureau of Indian Affairs with technical assistance from the Idaho Department of Water Resources and Federal agencies as requested.

NO. 3 – COMPETING USES OF LAND AND WATER RESOURCES AND NEED FOR COORDINATED STUDIES IN THE BOISE AND PAYETTE RIVER BASINS

SUMMARY

A variety of studies by State and Federal agencies indicate a number of problems such as municipal water supply, land use, water-based recreation, water quality, drainage, power, supplemental water for irrigation, fish and wildlife enhancement, and flood damage. If more detailed studies are conducted on a piecemeal basis, they would merely perpetuate the conflicts in resource use in the basins. Many of the problems and their solutions are interrelated and a comprehensive systems approach is needed. Following is a brief discussion of the specific problems existing in the basins.

DISCUSSION

Municipal Water Supply

Boise's M&I water supply, now obtained from ground water, needs modernization. Presently, it consists of 30 separate water supply systems and many suburban tracts have their own well and distribution systems and septic tanks. Mountain Home and Payette also have water supply problems. The initiative in these instances rests with the local entities. State water resource agencies are capable of providing leadership and technical assistance in solving these municipal water supply problems. Federal agencies, because they operate large Federal water supply facilities in and around these towns, could provide technical assistance and integrate solutions with other developments in the area.

Land Use

Because of the concentrated population in some parts of the Boise River basin, improved land use planning and zoning are needed. Agriculture land which provides open and green space is being encroached upon by expanding urban areas.

Recreation

The Columbia-North Pacific Framework Study identified water-related recreation needs in the vicinity of the area's population centers and emphasized the need to preserve the scenic mountainous areas for their natural values. The area's reservoirs including Lucky Peak, Lake Lowell, Arrowrock, Cascade, and Deadwood do not have adequate facilities to support recreation demands.

Water Quality

The lower Boise River has serious water quality problems where streamflows sometimes consist almost entirely of irrigation return flows and municipal waste water which create slime and algae growth during low-flow periods. Flow stoppages in the Boise River below Lucky Peak Dam every 2 or 3 years because of maintenance work at the dam just upstream from Boise aggravate the water quality problems.

Even with recommended levels of waste treatment, minimum water quality flow requirements in the Boise River at Boise are estimated to increase from the current 113 ft^3/s to 330 ft^3/s by year 2020. Boise area water quality needs are being further defined by the current studies of the Ada Council of Governments, Corps of Engineers, and other agencies. The Columbia-North Pacific Framework Study recommended further studies on minimum flows in the lower Boise River at Caldwell; these studies are currently underway in a cooperative joint State-Federal effort.

Community water and sewage treatment facilities are needed throughout the basin. A few communities still utilize wells to dispose of wastes, but this practice is being discouraged. Some modern dairies and feedlots are installing collection and distribution facilities to handle animal wastes.

If State of Idaho and Environmental Protection Agency standards for water quality, particularly as pertains to nonpoint discharge control, are to be met, major technical, financial, and institutional obstacles will need to be overcome.

Drainage

High ground-water tables from Boise to Caldwell and in the Emmett Valley along the lower Payette River cause localized drainage problems. Over the years irrigation has caused a buildup and concentration of ground water resulting in loss of production of basin lands due to seepage problems and salinity in the Emmett Valley.

Electric Power

The Northwest faces a growing demand for power much of which will be met by thermal additions to the system which will have an impact on Idaho's water resources. However, additional hydropower development potentials in Idaho should also be carefully evaluated. One such potential exists at Anderson Ranch powerplant on the South Fork of the Boise River where a 17,000-kW unit could be added economically. Without special protective measures, power production and peaking at Anderson Ranch Powerplant could adversely affect the high-quality trout fishing of the South Fork below the dam. Another possibility of constructing a dam and powerplant exists at the Twin Springs site on the Boise River and a powerplant with pump-back capability at the existing Lucky Peak Dam. This combined project would enhance recreation on Lucky Peak Reservoir, provide power for the Pacific Northwest System, and provide a minimum flow of 113 ft^3/s in the Boise reach of the river for water quality improvement.

Food and Fiber

Urbanization of agricultural land in the Boise Valley has resulted in the loss of high producing farmland which has a negative effect upon the agricultural economy. The major areas of water shortage for agriculture include Round Valley, Long Valley, and Willow Creek in the Payette basin.

Improved water management on irrigated lands is needed in the area, including conversion to sprinkler systems and construction of drains.

Ground-water pumping in selected areas could provide both needed drainage and water supplies for other purposes. In addition, there is growing pressure to permit the transfer to new uses of irrigation water formerly associated with areas such as new suburban developments where irrigation facilities have not been developed. These transfers could free water supplies for new uses.

Fish and Wildlife

Many of the fish and wildlife problems can be resolved through proper planning. Studies are needed to determine instream flow needs for fish, water quality, and recreation in the Boise and Payette River drainages. Game habitat should be maintained and improved throughout the basin.

Flood Damage Reduction

Additional storage, zoning, and other measures could eliminate flood damages along the lower Boise River. Damages in this area average $100,000 per year and without proper land use controls are expected to triple by year 2020. Flooding is also a serious problem in the lower Payette River basin where damages caused by December 1964 and January 1965 floods alone totaled more than $700,000. New Payette River storage could prevent much of the flooding in the lower Payette River basin.

PROBLEM RESOLUTION

One possible method of resolving these problems is to continue to solve them through local, county, State, and Federal agency implementation of proposed study solutions. The agency studies of one or more of the basins issues may solve some of the problems but will continue to create conflicts and will not achieve the most beneficial overall management and use of the basins resources.

Another means of resolving the problems is to consider the problems in the area on a comprehensive basis and formulate plans considering all uses of the water resource before making specific recommendations. The Pacific Northwest River Basins Commission through the Commission's Coordinated Comprehensive Joint Plan (CCJP) level B study of C-NP subregion 5 will consider water and related land problems in the area. The CCJP joint State-Federal study effort was rescoped in fiscal year 1974, due to budget priorities, and work accomplishments will be limited due to manpower and funding restraints. This study effort must be supplemented in order to develop viable plans in accordance with the principles and standards for water and related land resource planning. The CCJP study will rely upon ongoing agency programs, such as the Department of Agriculture type IV study of the Snake River basin and the Bureau of Reclamation's Southwest Idaho Water Management Study, the Corps of Engineers – Ada Council of Governments urban water study and Idaho State studies for study input.

CONCLUSIONS

1. Because of the high level of use, particularly in the Boise River, the conflicts between existing and proposed consumptive use developments and emerging environmental values, and the many other water needs in the basins, there is a need for integrated studies to determine the adequacy and optimum use of water resources and control facilities.

2. Because the Boise and Payette Rivers are closely integrated in the operation of the existing Boise project, the Payette River basin should be included as an essential part of the study.

RECOMMENDATIONS

1. Present studies underway by local, State, and Federal agencies should be closely coordinated through the Idaho State Study Team, which is under the chairmanship of the State and is the coordinating body for accomplishing the Commission's CCJP study. The Department of Agriculture type IV study of the Snake River basin and the Bureau of Reclamation Southwest Idaho Water Management Study are special studies that are concentrating on taking an indepth look at some of the specific problems cited above. Whatever study information that is developed through ongoing studies will be made available for use in the Commissioner's CCJP study.

2. The Commission's level B study of CNP subregion 5 should be implemented to the extent required to develop adequate detailed plans in compliance with current Federal planning procedures. This is expected to include new study authority and continued adequate funding of all participating Federal agencies such as the Fish and Wildlife Service and the Bureau of Outdoor Recreation to participate in programed special studies such as the Department of Agriculture's type IV study of the Snake River basin, Corps of Engineer's Water Quality-Pollution Control Study of the Boise Valley, and the Bureau of Reclamation's Southwest Idaho Water Management Study.

NO. 4 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

Idaho's present and expected future demands for water related to energy development stem from hydroelectric generation and water for cooling of thermal electric plants. At the present time, there are no known demands for water for development of coal, oil, gas, oil shale, or other basic energy resources because they do not exist in significant amounts in Idaho. The most pressing need is for a multiple objective evaluation of those hydrosites having the greatest potential for near-term development. Private power interests are considering construction of about 5,000 MW of thermal-electric capacity at four new plants in Idaho prior to 1990. Pumped-storage projects may be needed in Idaho after year 1990. Geothermal potential in Idaho is significant and should be examined.

DISCUSSION

At the present time Idaho has an installed capacity of about 1.8 million kW, including Oxbow and Hells Canyon developments with powerplants on the Oregon side of Snake River. Virtually all of Idaho's electric power is hydroelectric. Per capita energy consumption increased much more rapidly in Idaho than it did throughout the Nation in recent years because of two factors – the increasing use of electroprocessing and agricultural expansion through irrigation pumping. Peak demand for power in Idaho now occurs in the summer due to irrigation pumping.

Seasonal variations in power loads in the Pacific Northwest are minimized through operation of the entire regional system as an interconnected unit and through major ties to adjacent areas. Idaho's electric power needs, therefore, must be considered in the context of power production in the Pacific Northwest.

Future Power Requirements

Actual energy use in Idaho in 1970 amounted to slightly over 9 percent of that for the total Pacific

Northwest. Idaho generated about 7 percent of the energy generated in the Pacific Northwest. That same year Idaho's maximum peak generating capacity totaled nearly 1,456 megawatts. Idaho was power deficient and had to import power to meet requirements.

According to preliminary estimates (1970 estimates reported in the Idaho Department of Water Resource's 1972, *Interim State Water Plan*), Idaho's electric energy loads are projected to increase about three times by 2000. The upper Snake River basin will continue to be the region of heaviest use in the State. The projected energy loads are:

	1967	1980	2000
	(average MW)		
State electric energy load	940	1,780	4,070

Future Power Resources

In the time frame from the present to the year 2000, electric energy will be produced in the Northwest at power generating plants of a diverse nature. New types of generating facilities may augment the choices

For the near term (to the late 1980's) with known technology and available energy sources, the most likely type of additional electric power generation for baseload will be by nuclear and coal-fired thermal plants. Some additional electric power may be developed through geothermal development. Additions to existing hydroplants and reoperation of existing plants are expected to provide some of the immediate peaking requirements.

Hydropower. – Many opportunities for additional hydropower development still exist in Idaho, particularly in the Clearwater-Salmon basins and southwestern Idaho. Concern over effects of hydropower development on anadromous fish and conflicts with the national wild and scenic river systems make the possibility of developing much of this potential unlikely.

It is possible to install additional capacity at Dworshak Dam; however, this would require that a reregulating dam be built downstream. The reregulating dam would adversely affect steelhead trout.

There is also potential for hydropower development at the Asotin and China Garden sites on the Middle Snake River below the confluence with the Salmon River. These developments have been opposed because of the adverse impact on anadromous fish runs into the Salmon River. The hydropotential is discussed more fully in Regional No. 8 on Hells Canyon of the Middle Snake River.

Recent unpublished studies by the Corps of Engineers and the Federal Power Commission indicate that the numerous potential hydropower sites on the Salmon River are economical and have a combined dependable capacity in excess of 3.5 million kilowatts. However, these sites have conflicts in use with free-flowing river values.

Most of the remaining hydropower potential is in southwestern Idaho basins with two notable exceptions. The potential Lynn Crandall site on the South Fork of the Snake River could include about 200 megawatts; it is possible to install about 100 megawatts at American Falls Dam, as proposed by the Idaho Power Company; enlargement of Palisades Dam and Reservoir could increase power capacity significantly.

Because of the conflicts, as noted, a substantial portion of the potential hydrosites in Idaho probably will not be developed. An increasing share of Idaho's future electric power requirements, therefore, will probably be supplied by thermal generation, by the northwest power system, and by interregional power imports via interties. It is the State of Idaho's objective to become self-sufficient in electrical energy production through reduced reliance on imported energy.

Thermal Power. – Thermal powerplants, unlike hydropower plants, consume resources and produce a certain amount of air and water pollutants. New thermal units, both fossil fuel and nuclear, will probably be large (500 to 1,000 megawatts) in order to achieve economies of size. Since these units may produce more than the load requirements of any single utility, output could be shared by utilities within the region with construction timed to meet area requirements. Plants could be located at optimal sites, and high-voltage transmission lines could be built to coordinate with existing facilities to transmit power to load centers at minimum cost.

Although Idaho has no known reserves of fossil fuels large enough to supply the requirements of economically sized generating units, the economics of plant siting could result in some thermal plants in Idaho in the future. Some studies have indicated advantages of minemouth construction of coal-fired thermal plants to minimize the combined cost of coal transport and energy transmission. However, recent indications are that the cost and availability of water for cooling may be an overriding determinant in plant location. Idaho, with relatively abundant supplies of water, particularly the Snake River, and low licensing fees for thermal plants could become a major center for thermal electric generation with coal hauled in from Montana and Wyoming or by use of nuclear-fired thermal plants.

It is possible that Idaho would become a major exporter of power to adjacent States rather than an importer as at present. For instance, the private sector is considering construction of 5,000 MW of thermal power at six new powerplants in Idaho, one in the Bear Valley, three in southern Idaho, and two in northern Idaho to meet future regional demands. Present planning indicates some plants will be coal fired and others nuclear fired.

Although no water is now used consumptively in the production of electric power, water needs for thermal power production to meet Idaho's internal needs are estimated to be 17,000 acre-feet annually in 1980, and 77,000 acre-feet by 2000. However, if the aforementioned 5,000 MW of thermal capacity to meet regional needs are included and establish a trend of locating thermal plants close to available water supply, these estimates could change dramatically.

Geothermal. – The U. S. Geological Survey classified 21,000 acres of Federal land in Idaho as known geothermal resource areas (KGRA). An application has been filed with the Idaho Department of Water Resources to develop a water and stream supply in the Raft River area. The project would involve drilling as many as 32 wells with the hope of producing 250 megawatts at the plant. The proposed plant would be within the Raft River critical ground-water area where no permits for drilling have been issued since 1963. In all, nearly 15 million acres in Idaho are believed to have some value as a potential geothermal resource. In terms of total needs and other factors, the possibilities for large-scale development are unknown, but are under investigation.

Pumped Storage. – Studies have indicated that the peaking requirements of the region could be met until about 1990 by adding generating units at existing hydroelectric projects. When the addition of these units is completed, other sources of peaking power must be developed. The assumption that all peaking requirements could be met by conventional hydroelectric plant expansion by 1990 was based upon scheduled development of thermal plants. Thermal plant construction has been delayed and peak energy shortages have occurred.

A map survey of potential sites was made for the Columbia-North Pacific study to evaluate the pumped-storage potential of the region. Only the portion of the region west of the Cascade Divide was surveyed although it was recognized that a very large potential exists in the eastern portion of the region, chiefly Idaho.

Pumped storage has an inherent disadvantage in that it is a net energy consumer, using approximately three units of energy for every two that it produces. The effect of a pumped-storage unit is to convert low-value offpeak energy to high-value onpeak energy, and has the net effect of using more fuel. On the other hand, when integrated into a total system, some overall efficiencies in fuel consumption could occur if the integration of pumped storage displaced low-efficiency thermal peaking plants.

CONCLUSIONS

1. Development of the few remaining large potential hydrosites in Idaho would be in competition with use of the streams for free-flowing environmental values and will require multiobjective studies.

2. Idaho's power demands will increasingly be met by large thermal plants, either coal fired or nuclear within the State. It is likely that the State's adopted goal of self sufficiency in energy can be met.

3. Idaho could become an exporter of electric power if the relative water availability in Idaho makes it economical to transport coal and other energy resources to Idaho for conversion and transmission to other Western load centers.

4. Water supply for cooling thermal plants and water quality may place increasing pressure on available water resources.

RECOMMENDATIONS

1. Site selection, timing, and sizing studies for large thermal generating plants and transmission facilities should involve close coordination between private and public power interests and State and Federal agencies on a regional basis as presented in Westwide No. 1.

2. The remaining new hydroelectric power potential and additions to existing powerplants in Idaho should be reevaluated in light of the energy crisis and new values of power at sites where there are no major conflicts with unique environmental values such as on wild and scenic rivers and in wilderness areas. Potential multipurpose projects should be reexamined for inclusion in plans for added hydroenergy resources. In the 1990 period, pump-storage projects should be considered to meet peaking capacity requirements.

NO. 5 – COMPETING USES AND NEED FOR CLOSELY COORDINATED STUDIES OF WATER AND LAND RESOURCES OF THE UPPER SNAKE RIVER BASIN

SUMMARY

A series of problems exist in the Upper Snake basin including persistent or recurring surface water quality problems specifically in Milner Reservoir and the lower Portneuf River, flood damage, unaesthetic conditions at Jackson Lake, deteriorating conditions at American Falls Dam, inadequate water supply for irrigation, need for land use planning, erosion and sedimentation, Indian water development potentials, fish and wildlife enhancement, and Grays Lake restoration. Operation and management of the existing storage reservoirs to provide conjunctive use of surface water-ground water (Snake Plain aquifer) supplies are important in solving many of the basin's problems. The variety of problems and their geographic extent call for a greater and more comprehensive basin analysis than is presently being undertaken.

DISCUSSION

Much of the surface water supply of the upper Snake River basin has been committed for beneficial uses. During dry years flows at Milner Dam are fully committed, and there is little or no water in the river channel from this diversion point downstream to where the river is reestablished by the Thousand Springs, irrigation return flows, and other tributary inflows.

In contrast with surface water supplies, the Snake Plain groundwater aquifer is a vast resource that has potential for providing a water supply for a variety of needs. The actual storage capacity of the aquifer has not yet been determined accurately. Based on storage coefficients of 5 to 10 percent, the storage capacity has been estimated to be between 400,000 and 800,000 acre-feet per vertical foot of aquifer.

The following is a summary of problems that exist in the basin.

Snake Plain Aquifer Potential

Many complex water-supply considerations are fundamental to any further substantial expansion of water usage in the upper Snake River basin. Use of available ground and surface waters will have to be flexibly coordinated, particularly in dry years. It is in this companion use of ground and surface supplies that the potential artificial recharge of the Snake Plain aquifer has its most important application. In years of abundant runoff, excess surface water could be artificially introduced underground to augment and stabilize ground-water supplies. In dry years when surface supplies are inadequate for existing and future uses, ground water would be pumped and used to supplement the water supply. In order for the ground water to be an effective dry-year water supply for new uses, some exchanges between the ground water and existing surface supplies may be necessary.

The potential of the aquifer to meet future demands could be substantial. The problem is that there isn't enough specific knowledge of the aquifer to make reliable water supply planning decisions to meet future needs. Many of the plans that propose artificial recharge pumping to supplement water supply are subject to some speculation. The need to further develop the aquifer has arrived, along with the need to know what can be expected from aquifer development. The aquifer is a major factor in future Upper Snake conservation and development proposals, and without knowledge of its actual potential, large-scale benefits to local, State, regional, and national interests could be forfeited.

Over the past 50 years, considerable information has been gathered on the characteristics of the water resources, present uses of water, and geology of the Snake Plain aquifer. However, the investigations are not complete and additional detailed study is needed to determine specific ways the aquifer could be managed. For instance, artificial recharge studies were of a very general reconnaissance nature. It was not possible to arrive at specific projections of the effects of large-scale artificial recharge over many years.

Water Quality

There have been some instances of persistent or recurring surface water quality problems in recent years, including acquatic growths and sedimentation. Milner Reservoir and the lower Portneuf River have consistently exhibited undesirable water quality conditions for at least a portion of each year. Low flows are a problem in a number of areas. A limited water quality sampling program of the Snake Plain aquifer has been carried out in areas of major pumping. However, additional sampling and study is needed to determine overall aquifer water quality. A sampling and monitoring program for non-point pollution sources and irrigation return flows should be a continuing program.

Flood Damage

Flood problems exist in the Sand Creek drainages near Idaho Falls; the lower Willow Creek area; on the Portneuf River in the Bancroft area, the Lava Hot Springs area, and around Inkom and Pocatello; along portions of the Snake River near Blackfoot and other areas; and on agricultural lands along the Big Lost River and tributaries to Mud Lake. A flood damage potential is also developing along the Big Wood River, where a rapid buildup of recreation facilities and homes is being experienced.

Safety of American Falls Dam

Since this Federal dam does not meet current safety standards, the reservoir is being filled to only two-thirds of capacity. Recent Federal legislation permits non-Federal reconstruction of the dam with participation by the Federal Government in the recreation aspects. If the dam is reconstructed as is now presently planned, this problem will be solved.

Stabilization of Jackson Lake

Drawdown of Jackson Lake during the recreation season presents a major problem in dry years. The lake is a key attraction of Wyoming's Grand Teton National Park and is visited by millions of people each year. Although the lake is located in Wyoming, part of the storage capacity is owned by irrigators in Idaho. Any solution to the problem will therefore involve Idaho interests. Recent studies, however, have shown that the maximum fluctuation comes at infrequent intervals, and that the benefits of stabilization may not support a high priority for this problem at this time. However, the problems at Jackson Lake will become more serious as existing storage is used more intensively.

Supplemental Water

Ground-water levels in the Raft River and Oakley Fan (Goose Creek) areas south of the Snake River are receding, and supplemental water is needed by present users. Because of the critical ground-water situation, some wells have failed and others have had to be deepened.

Water supplies for the Salmon Falls area south of Twin Falls are inadequate, and supplemental water is required. Water shortages in this area are serious and longstanding. Congress recently authorized construction of a major project to eliminate the water shortages of the Salmon Falls area, but construction funds are not yet available.

Recreation Planning

Recreation planning is needed to develop measures to protect recreational values and water quality in prime recreational areas such as Henrys Lake, Island Park Reservoir, the Big Springs area, Palisades Reservoir, and the Wood River basin. More planned facilities will be needed to meet the ever-increasing need for water-based outdoor recreation.

Water contact recreation in the Snake River is increasing and developments to handle this increased use and protection for the natural values will require a well-conceived management plan for the riparian lands of the Snake River and its major tributaries.

Because the land along the Snake River is owned and controlled by a multitude of Federal, State, and local Government agencies as well as the private sector, a unified approach to managing these riparian lands to protect and enhance the public values of the river is difficult.

If nothing is done continued degradation and exploitation of much of the Snake River will occur. An alternative would be to establish a Snake River Greenway Plan to serve as a guide to all entities managing land along the river. It should encompass all lands within the flood plain or canyon with a suitable buffer strip to preserve and improve the environmental quality of the Snake River and the lower reaches of its major tributaries.

A greenway is defined as a riparian land management concept or policy for the protection of the riverine values from degradation, and enhancement of degraded areas along the river. When dealing with private lands, the greenway concept would not require purchase of the lands, but simply put restrictions on certain adverse uses which threaten public values. The greenway concept would not preclude dams, reservoirs, and diversion structures. It would preclude flood damageable real property from being built in flood prone areas.

Implementation of a greenway concept would require close coordination and cooperation between State, local, and Federal agencies responsible for land and water management along the river. Ideally, the plan should cover the entire Snake River from the headwaters to the Columbia River. However, as a first step the concept could be tested in the Upper Snake subbasin.

Erosion and Sedimentation

The Twin Falls-Rupert area erosion problems on both irrigated and dry cropland loess soils result in high sediment yields. East of Lake Walcott, the lowlands are subject to erosion from wind as well as from irrigation and precipitation; the uplands south of the Snake and Teton Rivers to the Idaho-Wyoming-Utah boundaries are subject to high-intensity summer storms as well as moderately heavy snows which produce runoff and severe cropland erosion on partially frozen ground. The most severe erosion in eastern Idaho is in the Rockland and Arbon Valleys on dry cropland.

Preservation and Enhancement of Thousand Springs, Shoshone Falls, and Twin Falls

Excessive pumping from the Snake Plain aquifer could affect the spring flows at Thousand Springs. Any programs or projects significantly altering the quality or quantity of water available at that point would have important effects on the trout farming industry. A small private hydropower plant constructed in 1912 taps water flowing from Thousand Springs. Its continued operation could conflict with proposals to develop the Springs for recreation and parkland.

Shoshone Falls and Twin Falls are outstanding sites when water is cascading over them. However, upstream diversions for power and irrigation all but dry up the falls in summer except for extremely wet years. Opportunities exist for reoperation of the river system to increase the flows over these falls during the peak recreation season.

Fish and Wildlife

Wildlife management programs are needed to improve winter range in the foothill areas for both big and upland game. Nesting facilities and feeding areas should be developed from the protection of waterfowl.

Indian Water Requirements

The problems and needs of the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation are described as a part of Idaho No. 2

Restoration of Grays Lake

Grays Lake historically was a waterfowl and fur animal paradise. Today its central portion is a National wildlife refuge. The Fish and Wildlife Service has developed a plan for management of Wildlife resources of the lake area. However, water diverted from the lake to supply irrigation water to the Fort Hall Indian Reservation has damaged Grays Lake wildlife productivity. Opportunities exist to replace the existing water via ground-water pumping or other surface diversion. However, there are significant legal, jurisdictional, economic, and ecological problems involved.

PROBLEM RESOLUTION

The conjunctive use of surface and ground-water resources in the upper Snake River basin presents many possible solutions to the problems and needs of the area plus consideration in the problems and solutions of downstream uses. Some possible solutions are listed below, but the list is not meant to be all inclusive. Since many of the solutions are interrelated, they cannot be studied or considered in isolation.

Ground-water pumping from the Henrys Fork-Teton River area. – Pumping from the aquifer in this upstream area could provide a water supply to meet water quality and fish and wildlife needs in both the Idaho Falls-American Falls reach and the Milner-Thousand Springs reach.

Exchange pumping in developed areas now irrigated from surface water. – This alternative would pump water from the Snake Plain aquifer and put it into the canals serving the existing development. The surface water which would have been diverted to that area could then be released to meet water quality, fish and wildlife, or other needs.

Ground-water recharge in the Idaho Falls area. – Surplus flows in the upper part of the basin of up to 200,000 acre-feet could be diverted into the open basalts overlying the plain where they would recharge the regional aquifer. Diverting these floodflows would result in substantial flood benefits. In diverting the floodflows out into the plain, there are excellent opportunities to establish waterfowl refuges in connection with the infiltration ponds, although the recharge sites in some areas could result in the loss of sage grouse or other wildlife habitat. Adequate information on water needs for maintenance and improvement of aquatic wetlands and riparian habitat is critical to multiple-objective planning for the area.

Recharge and channel improvements for flood control in the Wood River basins. – There are opportunities to divert floodflows from both the Big and Little Wood Rivers onto the Snake Plain for recharge. Reductions in diversions through rehabilitation of canal and lateral systems and lining of large canals would make surface water available for use in the basin.

The Columbia-North Pacific Framework Study recommended broad-scaled basin and special studies in the upper Snake River basin to analyze the complex and difficult water management and environmental resource problems.

The Pacific Northwest River Basins Commission is conducting a coordinated Comprehensive Joint Plan Study of the Pacific Northwest. – A level B study of the C-NP subregion 4, upper Snake River basin, is a part of the CCJP study. Rescoping of the Westwide Study and the CCJP in fiscal year 1974 created funding problems and work activities on the level B study was limited.

CONCLUSIONS

1. The conjunctive use of surface and ground water presents several alternative opportunities to meet the water needs of the upper Snake River basin. Conjunctive use is only one of several measures which would have to be studied simultaneously to find the best mix of alternatives.

2. The basin also has major environmental resources and values which need to be protected. The scarcity of water and competition for its use require that plans, objectives, and alternatives for the upper Snake River basin be closely related to the management of flows in the Snake River. The River provides the major source of surface water and is, in combination with the use of ground water, the key to resolving conflicts and assuring the best use of available resources to meet needs.

RECOMMENDATIONS

1. Present studies underway by local, State, and Federal agencies should be closely coordinated through the Idaho State Study Team, which is under the chairmanship of the State and is the coordinating body for accomplishing the Commission's CCKP Study. The Department of Agriculture type IV study of the Snake River Basin and the Bureau of Reclamation Upper Snake River Water Management study are special studies taking an in-depth look at some of the specific problems cited above.

2. The Pacific Northwest River Basin Commission's level B study of CNP subregion 4 should be implemented to the extent required to develop adequate plans in compliance with current Federal planning procedures. This is expected to include new study authority and continued adequate funding by all participating Federal agencies such as the Fish and Wildlife Service and the Bureau of Outdoor Recreation to participate in programed special studies such as the Department of Agriculture's type IV study of the Snake River basin and the Bureau of Reclamation's Upper Snake River Total Water Management Study.

Vast areas suited to agriculture and fine native grasses with an abundance of scenery, water, minerals, and timber are Montana's most valuable resources. It is a large State, ranking second, in size among the 11 Westwide States and fourth nationally, encompassing more than 147,000 square miles. Many areas of the State have little or no population; the major concentrations of people are at Billings, Helena, Great Falls, Butte, and Missoula. Montana has some of the most beautiful scenery, some of the most concentrated mineral-rich areas, and one of the most interesting political and social histories to be found in America. It has an incredible varied landscape – from the expansive level plains of the east to the rugged crest of the Rockies in the West. Copper and silver lie in the hills of the Western half of the State, and it is here that several principal cities are clustered.

On a proportionate basis, Montana has less federally-owned land than any other Westwide State. Slightly less than 29 percent of Montana is federally owned; most of this is timbered and in the mountainous western portion of the State. Indian lands comprise an additional 5.5 percent of the land base. Opportunities for outdoor recreation are among the Nation's finest.

In 1970, Montana had a population of 694,400 persons of which 372,300 (54 percent) were classed as urban and 322,100 (46 percent) were rural. Of the rural, only 82,100 lived on farms. The remaining 239,900 were nonfarm rural dwellers. Minority races totaled 39,100 persons of which 7,800 were Spanish; 27,100 were Indian; 2,000 were Negro; and other minority races combined, 2,200 persons.

Per capita income in the State averaged $3,130 in 1970 in comparison with a National average of $3,698. There are 13.6 percent of Montana's people with incomes less than the poverty level, ranking Montana fourth in poverty among the 11 Western States and twenty-second nationally. Median family income is $8,512 which compares with $9,590 nationally. The Montana civilian labor force totals 260,600 or 37.5 percent of the population with an unemployment rate of about 6 percent. The employment by industry is as follows: Agriculture, Forestry, and Fishery – 32,726; Mining – 5,877; Construction – 15,674; Manufacturing – 23,626; and Other – 166,705.

WATER SUPPLY

The State has abundant amounts of water. Its stream systems include the Missouri River System which drains the State east of the Continental Divide and two major tributaries of the Columbia River System – the Kootenai and the Clark Fork which drain the more mountainous western portion.

Surface Water

Inflow to the State totals approximately 15,512,000 acre-feet annually of which 8,751,500 enter from Canada and the remaining 6,760,500 from eight tributary systems of the Upper Missouri and Yellowstone Rivers in Wyoming. An additional 135,000 acre-feet are imported into the Milk River basin from the St. Mary River.

Montana's yield from precipitation as reflected in runoff equals 32,103,900 acre-feet in an average year. Of this amount, 4,813,000 acre-feet are consumed for irrigation, M&I, thermal electric power generation, reservoir evaporation, and other uses. The remaining water, 43,949,400 acre-feet, passes out of the State and is available for downstream use.

Figure VI-10 shows the major river systems in Montana and their associated subregions. Table VI-19 shows the estimated 1975 surface water depletions for Montana by subregions, and table VI-20 shows the estimated net water supplies available in 1975. The supplies available should not be considered surplus to expected future needs. Rather they represent water that could be used for either instream use such as for fish, wildlife, recreation, hydropower, or navigation; or could be developed by diversion for consumptive use. Because of physical, environmental, and/or economic constraints, much of the water shown as available could not actually be diverted and used.

Ground Water

Ground water is an important source of supply in eastern Montana for municipal and industrial and domestic use. Supplies are limited due to limited recharge in the area, and quality ranges from adequate to poor due to excessive mineralization.

Water Quality

Overall, the quality of Montana water is good. Enforcement of State water quality standards and the National Pollutant Discharge Elimination System, a component of P.L. 92-500, the Federal Water Pollution Control Act Amendments of 1972, will upgrade water quality and lessen the impact of most existing problems and prevent potential future sources of pollution from

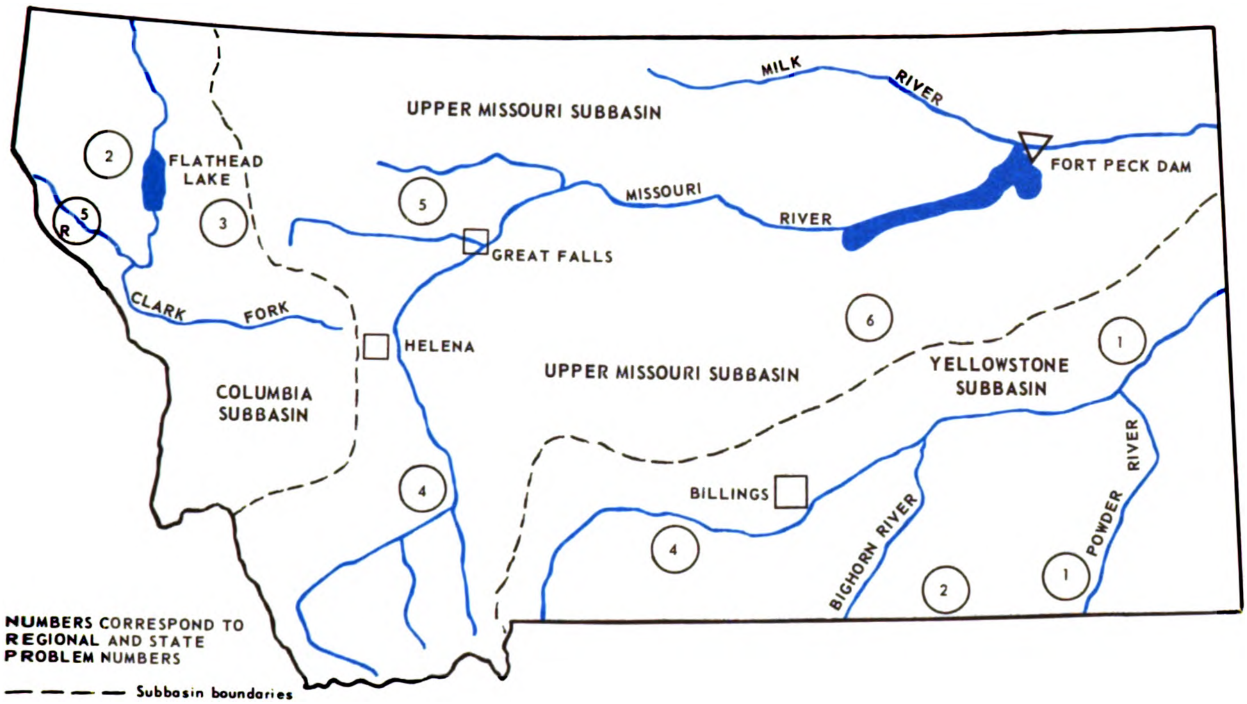


Figure VI-10. Critical water problems in Montana.

Table VI-19.—*Estimated 1975 total depletions*[1] *for Montana (1,000 acre-feet)*

Region and subregion	Purpose of cause of depletion						
	Irriga-tion	M&I including rural	Min-erals	Thermal electric	Other[2]	Reservoir evaporation	Total depletions
Columbia-North Pacific							
Clark Fork, Kootenai, Spokane	985	163	0	0	3	509	1,660
Total region	985	163	0	0	3	509	1,660
Missouri							
Upper Missouri	1,480	56	0	0	155	369	2,060
Yellowstone	776	43	10	1	49	234	1,113
Western Dakota	24	0	0	0	0	0	24
Total region	2,280	99	10	1	204	603	3,197
State summary	3,265	262	10	1	207	1,112	4,857[3]

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] No depletions are attributed to thermal electric, recreation and consumptive conveyance losses.
[3] Surface-water depletions — 4,810,000; ground-water depletions — 47,000.

Table VI-20.—*Estimated 1975 surface water-related situation in Montana (1,000 acre-feet)*

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within sub-region or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Columbia North-Pacific									
Clark Fork, Kootenai Spokane	8,304	19,396	0	27,700	0	1,660	26,040	5,640	20,400
Total region	8,304	19,396	0	27,700	0	1,770	26,040	5,640	20,400
Missouri									
Upper Missouri	847	8,398	140	9,385	0	2,060	7,325	0	7,325
Yellowstone	6,305	4,239	0	10,544	0	1,113	9,431	0	9,431
Western Dakota	56	156	0	212	0	24	188	0	188
Total region	7,208	12,793	140	20,141	0	3,197	16,944	0	16,944
State summary	15,512	32,189	140	47,841	0	4,857	42,984	5,640	37,344

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.

becoming a problem. Although some local acid mine waste in the Sand Coulee area near Great Falls will continue, the problems are not of adequate seriousness to establish corrective measures. One area where problems exist now and will continue in the future is that related to irrigation wastes and erosion leading to stream sediment problems.

CRITICAL PROBLEMS

The major Westwide problems that have specific aspects in Montana are discussed in this section. Only the major interfaces are covered as they specifically relate to the State of Montana and that are not covered in detail later as a State specific problem. On figure VI-10 are shown the approximate locations of regional and State specific problems in Montana.

Westwide Problems

NO. 2 – MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS FOR SMALL COMMUNITIES. – The City of Billings has a water-supply system that is inadequate to meet the present water needs of the city. Population is expected to grow from its current level of 75,000 to 186,000 in the year 2020, largely in response to an expected influx of people related to coal development. The city needs to develop a long-term solution to its water problem rather than continue year-to-year expansions of the system.

Other smaller communities in the coal area will experience proportionately greater population increases. Municipal water supplies for these smaller communities may or may not be a problem depending upon how the coal is to be developed.

The best approximation of coal development indicates there will be approximately 43,000 persons in the Montana portion of the coal region as a direct result of coal development. As a minimum, there could be about 22,000 persons in the area if all the coal were mined for shipment to other locations for further processing. Should this lesser development take place, suitable ground-water supplies would have to be located.

There are a number of small communities in eastern Montana which have an inadequate water-supply quantity, quality, or both. These communities are generally declining in population. Solutions to the problem have been determined for several of these communities, but the costs of developing more adequate supplies have been prohibitive.

NO. 4 – MANAGING FLOOD PLAINS. – The State of Montana has adopted a Statewide flood plain management program to regulate new construction in the flood plain which could be inundated more frequently than once in 100 years. This is an ongoing program being accomplished by the State with assistance from Federal agencies. The work on the 100-year flood plain delineation will take several years to accomplish. Some assistance may be forthcoming from Federal programs to determine flood hazard areas for the 115 communities in Montana which are subject to periodic flooding.

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – Montana has been blessed with an abundance of natural resources. These resources include: fauna and flora, wilderness areas, wild and scenic rivers, wetlands, recreation and flatwater resources, and open space.

Wetlands contribute to the diversity of the environmental features and landscapes in Montana and are valued for their waterfowl production and use. During the 1950's and 1960's, wetlands in Minnesota and the Dakotas were being drained. The loss of wetland habitat and its future impact on waterfowl led to a wetlands acquisition program in these States. The program was expanded to Montana during the 1960's. To date, approximately 10,000 acres of Montana wetlands have been purchased and an additional 3,000 acres are under easement. Originally, the program was to terminate in 1968 but has been extended to June 1976. About $500,000 is made available annually for the program. It is planned that 47,000 acres of wetlands be purchased and additional easements obtained before the program terminates.

Montana has abundant open space with a low population density and extensive public land areas. Neither the quantity nor quality of open and green space is a problem in Montana. Public access to the lands, however, is a serious problem and getting worse year by year.

Most Montana streams are overappropriated. In the high-demand months, existing water users effectively dewater many miles of tributary streams. Other streams face the possibility of dewatering in the future. An analysis of alternative uses is needed. The first step in the analysis would be to determine instream flow needs for maintenance of the existing aquatic ecosystems.

Montana recently modified its water law to recognize the need for minimum instream flows for recreation and aesthetics and to eliminate the requirement of actual diversion of the water if combined with storage facilities in order to perfect such an appropriation in a stream for wild and scenic river purposes. The "Montana Water Use Act" provides a system for the appropriation and use of surface and ground waters, provides a procedure for the determination and confirmation of existing water rights, and establishes a system of centralized records of all water rights.

In particular, the Act relates to recreation and the environment by redefining the term "beneficial use" to include fish and wildlife and recreation. Further, it extends the meaning of the term "appropriate" to include an instream reservation of water for existing or future beneficial uses or to maintain a minimum flow, level, or quality of water throughout the year or at such periods or for such length of time as the Board of Natural Resources and Conservation designates.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC AND RECREATION RIVERS. – More than 2,000 miles of Montana streams have been identified as having free-flowing values. Most of these streams face growing competitive pressures for water for industrial, municipal, or agricultural uses. Before irreversible decisions are made of the competitive uses, the streams should be evaluated for merit for inclusion in the wild and scenic rivers system. Only then can the tradeoffs be determined. The specific reaches of nine rivers which are recommended here for inclusion under Section 5(a) of the Wild and Scenic Rivers Act evaluation in the near term are listed in table VI-21.

Table VI-21.–*Montana rivers recommended for study as potential National System additions*

River	Length in miles	Segment
Rock Creek	51	Origin to Clarks Fork River
Madison River	90	Earthquake Lake to Missouri River
Gallatin River	90	Yellowstone Park to Missouri River
Bitterroot River	72	East & West Fork Junction to Clark Fork River
Bighole River	140	Entire River
Clark Fork River	260	Drummond to Mellonin; Bitterroot River to Plains
Swan River	47	Origin to Swan Lake
Smith River	60	T Logan to Hound Creek
Sun River	28	Origin to Gibson River

NO. 16 – THE CHANGING FEDERAL ROLE IN DEVELOPING IRRIGATION PROJECTS. – Agriculture was Montana's leading industry until 1960 when both the service and retail trade employment exceeded farm and ranch employment. Employment trends in Montana follow generally the employment trends of the Nation with declining employment in agriculture and rapidly increasing employment levels in the noncommodity-producing sector. Income from agriculture in Montana contributed only 10 to 13 percent of personal income in the 5 years, 1964-1968, in comparison to a high in the 1940's of 33 percent. Nevertheless, agriculture remains the most important basic industry in Montana, and the decline of employment opportunities and related social services could be of major significance.

To determine the need for social or regional development in Montana, it is useful to measure (1) percent of persons with incomes less than poverty level; (2) population density; and (3) percent of population increase. Nine counties in the State appear to be critical. Five of the nine critical counties contain Indian populations which range from 23 percent to 41 percent of the population. Six of the critical counties are 100 percent rural. Eleven counties were judged moderately critical in their social and regional needs. None of the 11 counties contained appreciable Indian populations, but 9 had 100 percent rural populations.

Three of the nine counties are located in the coal region. These three counties, plus the remaining six counties, could also rely on new irrigated agricultural developments for social and regional development.

The need for continued emphasis on agricultural production in Montana can be also addressed from the point of view of meeting the Nation's food and fiber requirements. The Water Resources Council sponsored the preparation of the 1972 OBERS projections to assist in water planning. These nationally consistent projections for future agricultural needs are broken down by State into crops and livestock. If the livestock production needs are converted to feed units and compared with the feed units grown at the various time frames as projected by OBERS, for Montana there could be a sizable shortage of feed units grown. It is estimated that in Montana about 220,000 acres would have to be irrigated by year 2000 and 1,033,000 acres by year 2020 to meet the projected demand. This would be influenced by the assumptions concerning the continuation of ths historical export-import relationships of feed and livestock in adjoining States. Private irrigation development has played an important role in developing Montana's irrigation base and is expected to grow in the future. However, it would be difficult if not impossible to develop significant amounts of new irrigation in Montana without Federal assistance. As suggested in Westwide No. 16, additional study is needed to determine the Federal role in assisting irrigation development. The outcome of such a study may indicate that:

1. Future demands for red meat production in Montana should be reduced if too high;

2. Agricultural projections should be reallocated among States and regions;

3. Greater reliance should be placed on private development of irrigated land;

4. Federal irrigation policy should be developed to give impetus and national direction to irrigation as it affects agricultural production.

State Specific Problems

The most critical issue to the people of Montana is the maintenance of an adequate future environment in the coal regions of Montana. Coal is Montana's major energy resource, with about 12.5 billion tons of strippable coal reserves inventoried. With present energy resources in short supply and declining reserves projected into the future, the questions of the development of Montana's coal are when and how and to what extent. The people of the State are, therefore, quite concerned that development shall be accomplished in a way that creates as little disturbance as possible to the people and the environment of the area. There are, however, other critical issues relating to municipal water supplies, maintenance of environmental quality, water quality needs, requirements for social and regional development, food and fiber needs, and land management.

Indian water requirements to support Indian economic and social goals are important. In terms of site specific problems, comprehensive planning in the Flathead basin should be carried forward because of hydroelectric potentials which conflict with federally administered National parks, wilderness areas, and potential wild and scenic rivers.

The State specific problems shown on figure VI-10 are:

NO. 1 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 2 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 3 – CONFLICTS IN PROPOSED USES OF THE FLATHEAD RIVER BASIN RESOURCES

NO. 4 – IMPROVEMENT IN WATER QUALITY IN THE YELLOWSTONE AND MISSOURI RIVER BASINS THROUGH TOTAL WATER MANAGEMENT

NO. 5 – POOR WATER QUALITY DUE TO EROSION SEDIMENTATION ON MUDDY CREEK AND SUN RIVERS

NO. 6 – SALINE SEEP DEVELOPMENT AND ITS IMPACT ON LAND USE AND WATER QUALITY

NO. 1 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

Montana has an abundance and variety of mineral and hydroelectric energy resources, enough to meet its own internal needs into the foreseeable future. Historically, Montana's power supply has been over 90 percent from hydroelectric generation. However, the dominant feature of the future energy development in Montana is the vast coal deposits that underlay Eastern Montana. The Nation faces a long-term energy shortage and this coal can be used to meet future energy demands in other regions of the country, either through coal export or conversion of coal to electricity or liquid gas for transmission to distant markets. Uncertainty as to the future amount and character of coal development makes estimates for future water requirements difficult. However, there is expected to be a major emphasis on the use of the coal resources of Montana resulting in a need for additional water supplies. Plans for meeting long-term water needs for energy should be pursued on a systematic basis with full consideration

being given to protecting the long-term environmental values in the affected areas such as instream flows, wildlife habitat, and overall aesthetic and social values.

DISCUSSION

Following is a component-by-component analysis of the major energy resources of Montana as they would influence the demand for water and water management.

Coal Development

Coal production in Montana in 1971 was about 7 million tons; whereas, 1980 production has been estimated as 41 to 64 million tons and year 2000 production at from 133 to 392 million tons. It is obvious that relying on historic trends to establish future levels of coal production in the region is not appropriate since major, but imperfectly defined, factors associated with the Nation's total future energy needs will have the major impact on demand for Montana coal.

Montana has an estimated 158 billion tons of coal reserves of which 32 billion tons are mineable by surface mining techniques. Environmental and economic constraints limit these coal reserves to about 25 billion recoverable tons using current technology.

Ninety percent of the State's coal is in the Fort Union region of southeast Montana where thick beds lying close to the surface make strip mining economically feasible.

The critical unknown is to what extent Montana will assist in meeting known national energy demands through export of raw coal or through at-site conversion to electric energy, gas, or oil.

Montana coal is part of large deposits extending into northeastern Wyoming, and problems and uncertainties concerning the physical development are somewhat similar in both States. However, the rate of development between the two states may differ because of viewpoints toward development and associated impacts on environmental values.

If the coal is primarily mined and shipped out of the region, water demands will be much lower than if mine-mouth plants and coal liquefaction or gasification plants are constructed in the State. With at-site power generation, the use of dry cooling towers could also significantly reduce the demand for water. There are many unanswered questions concerning projections of the level of coal development and its impact on the demand for water.

If coal is developed primarily for export, the relatively modest water demands for mining activities might be met locally by developing ground water. Municipal and domestic water associated with the mining economy would also have to come from ground water. This could be a problem because of the limited ground water in the coal regions and because existing communities which would likely form the basis of any new population do not have the financial resources to develop ground water or surface water supplies.

If the coal is used within the mined area for generating electric power in thermal plants using wet cooling towers for conversion to liquid or gas for export out of the region, then water requirements will be substantial and beyond the capability of local ground-water resources. A regional water-supply system would be needed to carry available water from the Yellowstone-Missouri River systems to the coal fields. Such a system could also meet the expanded needs for municipal water resulting from this increased industrialization. Any regional water system should consider the needs of northeastern Montana, southeastern Montana, and northeastern Wyoming for most efficient development of water supplies.

Unused water supplies are available in storage reservoirs on the Bighorn River, a major tributary of the Yellowstone River. However, instream flow requirements, which have not yet been established, alternative uses such as irrigation, downstream water rights, evaporation rates at new reservoirs, and maintenance of downstream river and reservoir ecosystems, may preclude full use of this water for energy development. Moreover, recent State legislation has imposed a moratorium on diversions of water from the Yellowstone River for purposes of energy production in order to permit more time to evaluate environmental impacts and to develop more comprehensive plans for Montana coal development.

The Northern Great Plains Resources Program, an interdepartmental Federal-State study group, has recently completed a draft report on the energy resource potential of the five-state area of Wyoming, Montana, North Dakota, South Dakota, and Nebraska to assess environmental, economic, and social consequences of various alternative levels of resource development. The data prepared on social and environmental impacts will be very useful. However, more information is needed to fully and accurately assess environmental, social and economic consequences of alternative development options. The objective of this effort has been to provide a data base for future decisionmaking and planning. It did not propose an actual plan for development in the five-state region.

Production of coal for meeting the demands for energy will require various amounts of water, depending upon the purpose of which the coal is to be used. The Northern Great Plains Resource Program projected a range of production of coal in Montana and its use for electric power generation, production of synthetic natural gas, and for export. The conversion of coal to synthetic pipeline gas and export are expected to be the principal use of Montana coal.

Water requirements for the Northern Great Plains Program projected levels and uses of coal were estimated by the Bureau of Mines using the following unit water requirements: (1) a synthetic natural gas plant producing 250 MCFD annually would consume about 8 million tons of coal and 10,000 acre-feet of water, or 1,250 acre-feet of water for each million tons of coal; (2) fifty percent of the coal exported from the Northern Great Plains Area will be transported via slurry pipeline, requiring 600 acre-feet of water per 1 million tons of coal transported; the balance of coal exported would be by unit train; (3) coal-fired electric powerplants will require 15,000 acre-feet of water annually per 1,000 MW of capacity (a 1,000-MW plant would require about 4 million tons of coal, approximately 3,750 acre-feet of water per million tons of coal consumed); and, (4) coal mining will consume about 100 acre-feet of water per 1 million tons of coal mined.

Table VI-22 summarizes projected coal production and water requirements for Montana. Most of the coal production and associated conversion activity is expected to take place in the Powder River basin. However, a significant part of the production is projected for the Upper Missouri subbasin, south of Fort Peck Reservoir.

The extensive level of development represents a probable maximum level of coal use and is due to increased use of coal for conversion to natural gas and for export. Under either future circumstance use of coal for thermal electric power generation in Montana is not expected to be large.

Municipal water requirements related to coal development are expected to be modest. With the most probable level of coal development, depletion requirements would be about 10,000 acre-feet by 2000. With an extensive level of development, depletions would be about 20,000 acre-feet by 2000.

Water Requirements for Revegetation after Strip Mining

In the Northern Great Plains areas of Montana, when and where natural precipitation is adequate to restore strip-mined areas to their present rangeland conditions, supplemental water would not be required. However, when land is being revegetated to restore suitable habitat for wildlife, it is possible that larger volumes of water over a longer period of time may be required.

During periods when natural precipitation is inadequate estimates have been made on the most probable plan. By year 2000, the most probable level of coal development would require an estimated revegetation of 4,900 acres every year. Assuming that at least two consecutive years are needed for establishment of grasses, in a drought year, 9,800 acres would require irrigation. Therefore, 8 inches (12 inches minus 4 inches) of irrigation over this land area could require, annually, 6,600 acre-feet. Table VI-23 summarizes this water requirement for the two levels.

Environmental Concerns

These estimates are little more than guesses at this time, assuming no restraints to development. Any development of this scope, however, can have a tremendous impact on the environment if not properly controlled. For this reason, the Montana State Legislature has recently passed both a powerplant siting and strong strip mining reclamation bills.

These bills, in conjunction with air and water quality standards, the Environmental Policy Act, and the Water Pollution Act may act in concert to prevent or retard development but certainly to lessen environmental consequences of future coal development.

Development of coal resources in Montana could result in controls related to the environmental destruction and degradation of land and water resources. A number of threatened species of fish and wildlife will be affected. Ancillary development will include powerlines, pipelines, roads, urban development, and water impoundment and/or diversion projects.

Major, but ill-defined, disruptions of both on- and off-site ecosystems pose an imminent threat. Proper environmental baseline inventories of habitat and fish and wildlife populations in the areas to be affected and long-term impacts of development are lacking. The art of revegetating reclaimed strip mines with suitable wildlife vegetation and cover in semiarid areas is only

Table VI-22.—*Estimates of consumption of coal by three major uses and water requirements in Montana – 1971-2000*

Coal and water needs	1971	1980	1985	2000
		(millions of tons)		
Probable level of development				
Amount of coal used for:				
Electric power	.8*	9.0	11.0	26.6
Synthetic natural gas	–	–	22.2	46.3
Export	6.1*	32.0	41.0	60.0
Total	6.9*	41.0	74.2	132.9
		(thousands of acre-feet)		
Water requirements for:				
Electric power	.3	33.8	41.2	99.8
Synthetic natural gas	–	–	27.8	57.9
Export	1.8	9.6	12.3	18.0
Mining	.7	4.1	7.4	13.0
Total	2.8	47.5	88.7	189.0
Extensive level of development				
		(millions of tons)		
Amount of coal used for:				
Electric power	.8	9.0	11.0	26.6
Synthetic natural gas	–	23.2	62.9	118.3
Export	6.1	32.0	77.0	247.0
Total	6.9	64.2	150.9	391.9
		(thousands of acre-feet)		
Water requirements for:				
Electric power	.3	33.8	41.2	99.8
Synthetic natural gas	–	29.0	78.6	148.1
Export	1.8	9.6	23.1	74.1
Mining	.75	6.4	15.1	39.2
Total	2.8	78.8	158.0	361.2

now beginning to be fully understood with new varieties being developed in laboratories. Scarcity of high-quality water will require the ultimate in technology for conservation and treatment plus long-range planning priorities for uses that include revegetation and maintenance of fish and wildlife. Studies will be needed to accurately assess the impact of proposed developments on the environment to permit the formulation of recommendations for alternative project designs that will lessen the impact of development on the ecosystem and to make recommendations for restoration of the disrupted areas.

The three major areas of water-related environmental data which are needed for planning purposes for Montana are: (1) instream flow needs for fish and wildlife, general environmental, and recreational uses, (2) inventory data on critical wetlands and riparian

Table VI-23.—*Estimated water requirements for revegetation in Montana, year 2000*

Range of coal development	Acres being mined acres/year	Area under-going reveg-etation acres/year	Supple-mental irrigation require-ment acre-feet/year
Most probable	4,900	9,800	6,600
Extensive	12,000	24,000	16,000

habitat, and (3) specific range and habitat requirements of rare and endangered species.

An immediate intensive study effort is needed in these three areas to provide necessary information and tradeoffs in developing adequate energy sources for the Nation.

Because Montana coalbeds are thick and near the surface, it is expected that strip mining will be the predominant mining method. Reclamation and restoration of strip-mined areas will present major problems in relation to coal development. Much of the coal is either on public lands or owned by the Federal Government even though the surface is owned privately. It will be necessary to restore strip-mined areas; however, there is a critical need for more information on the techniques of restoration. In the arid climate, typical of Montana, the native fragile ecosystems need detailed research on drainage, ground water, soil types, and vegetation studies to determine the best way to restore mined areas to have a minimum adverse long-range impact on the environment. Restoration to premining conditions would be one alternative. However, other uses of the land should be considered, including establishment of irrigated agriculture which would require substantial amounts of water.

Oil and Gas

Montana oil and gas reserves make up only 0.6 percent and less than 0.5 percent respectively of National reserves. However, they have been and will continue to be an important economic factor for the State, comprising about 40 percent of the total value of Montana's mineral production over the past decade. Water needs will be minimal, and no problems are foreseen at this time.

Hydropower

Although there are sites and plenty of head for hydropower generation in eastern Montana, they lie too far from the major energy load centers to provide peaking energy. No further study will be required in the near future.

The potentials for power development on the Western Slope are more favorable. It is expected that Montana will contribute 1,285 megawatts of capacity and generation of 64,300 million kilowatt-hours to meet Pacific Northwest needs by year 2020. Montana's potential is about 2,000 megawatts of capacity. The majority of this potential is located in the Flathead Divide basin and is described in more detail in Montana No. 3. All hydrosites in western Montana would conflict with use of the rivers for environmental purposes. Some are located in designated National parks, wild rivers, or wilderness areas and it is unlikely that they will receive serious consideration as viable hydrosites. The remainder could be studied under the Flathead basin level B studies.

Geothermal

Montana has several areas with the potential for geothermal development. However, with the State's potential for coal-fired thermal-electric generation, the geothermal resources should not be needed on any large scale in the near future. It is suggested, however, that an inventory study of geothermal potential be continued and expanded.

CONCLUSIONS

1. There is a vast potential in eastern Montana coal fields to meet a large share of the Nation's future energy demands. Economic and environmental constraints, combined with local preferences on the desirability of having Montana export energy to the rest of the Nation, lead to uncertainty concerning the level and character of future coal development.

2. Many of the richest coal deposits are on Indian lands, and any regional plan for water supplies to meet coal development requirements should recognize and be coordinated with Indian requirements.

3. Coal development and conversion to energy at site will require the conveyance of large amounts of water involving major water planning and investment. Major environmental and social impacts will be involved.

4. Water for northeastern Montana coal development can probably be provided from the Missouri River system without major storage facilities. However, conveyance facilities will be needed.

5. Water for southeastern Montana coal developments is available from the Yellowstone-Missouri River system. However, new storage facilities may be needed depending upon the magnitude of instream flow requirements which have not yet been established. Movement of water to the coal developments will require major conveyance systems which should be planned in conjunction with the development of northeastern Wyoming coal.

6. The Northern Great Plains Resources Program is expected to provide an extensive data base on alternative scenarios of future development conditions and levels, including water supply requirements and supply sources.

7. There are inadequate environmental baseline inventories of habitat and fish and wildlife populations in the affected areas.

8. Reclamation and restoration of the arid, strip-mined area will present major problems in relation to coal development. With a water supply and proper land use controls, there is some potential for enhancing future recreation, wildlife, and agricultural activities.

RECOMMENDATIONS

1. A special study on alternative plans to meet a range of water demands is needed in the coal areas of Montana and Wyoming. This study is needed now because of the urgency of the need to develop energy resources within the United States boundaries. Such studies should be multiple objective, provide for maximum protection to the environment, and such studies should be coordinated with the proposed Missouri River Basin Commission's level B study of the Yellowstone River basin.

2. Special studies on the reclamation of strip-mined areas should be undertaken by the involved land-managing agencies including the Forest Service and Bureau of Land Management, with technical assistance from other Federal agencies as required.

3. An intensive special study effort should be undertaken to develop water-related environmental data including (1) instream flow needs for fish and wildlife, general environmental and recreational uses; (2) inventory data on critical wetlands and riparian habitat; and (3) specific range and habitat requirements of rare and endangered animal and plant species. The study should be led by the Fish and Wildlife Service with participation by the Bureau of Reclamation, Forest Service, and the Montana Department of Fish and Game.

NO. 2 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

A variety of problems and needs and land and water resource potentials exist within the Montana Indian reservations ranging from a hydroelectric and irrigation potential on the Flathead Reservation in western Montana to the opportunities for coal development on the Crow and Northern Cheyenne Reservations in southeastern Montana. These development potentials could take significant quantities of water which are, as yet, undetermined.

DISCUSSION

General Conditions

Depressed economic conditions are being experienced on all the reservations in Montana. In terms of severity, the situation can be best described by comparing economic achievements of the tribes with the State citizenry. Unemployment among eligible workers, for example, averaged approximately 47 percent on the reservations in 1970. This was about eight times as great as the annual rate among non-Indians. Concurrently, Indians were also not as equally well off income wise as others – family income on the reservation was reported to be less than one-half of the State average.

The need, accordingly, is to provide ways and means to offset this adverse economic situation. The tribes, in general, believe that effective solutions to these problems may be obtainable if water and land resource development takes place on their reservations.

Water Quality

While irrigation return flows, livestock operations, and other activities contributing to water pollution have not become a major issue on the reservations; the tribes are cognizant of the disadvantages resulting in such pollution and have been alerted to the standards now required by law. Reservation occupants, both rural and urban, should be made aware of the ever-increasing intensity of pollution and of programs to offset such conditions.

Energy Resources – Fuel

Bureau of Mines and others indicate extensive coal fields on some of the reservations which the tribes are desirous of mining, either on their own initiative or as a joint-venture project with the various energy companies interested in local gasification or mine-mouth thermal electric plants. Studies are needed to determine the capability of reservation watersheds to provide water for processing Indian-owned coal deposits.

Hydrological determinations precedent to development of fuel and energy reserves are being made by consulting firms. Total watershed yields are also being prepared as a basis for total multipurpose users on the reservations. Residual supplies can then be earmarked for possible joint-venture projects with other agencies and firms.

Energy Resources – Hydroelectric

The existing power project on the Flathead Reservation, being operated in conjunction with the irrigation project, provides a major source of revenue for Indian participants. Increasing demands for power, both on and off the reservation, are taxing existing sources of supply. Additional hydro potential exists and should be evaluated for the benefit of Indians and non-Indians alike. A "Completion Report" previously submitted for the Flathead Power project includes plans for serving additional subscribers but does not foresee fulfillment of demands beyond the year 2000. New water resource inventories are needed to investigate the hydropower potential for providing services beyond that date.

Irrigated Agriculture Potential

The water resources inventories being conducted on some of the reservations in Montana have progressed to the point where, in most instances, it is evident that there are more areas susceptible to irrigation development than there are adequate water supplies to serve all such potentials without regulatory facilities or development. The existing irrigation projects appear to be using most of the available supplies already, or are designed, through extension of existing facilities, to serve whatever additional acreages can be adequately supplied. This does not rule out proposals for reaching additional lands through pumping, sprinkling, or other methods of application that may prove economical in the future. The need, insofar as irrigation pursuits are concerned, is to continue services to the lands already provided with facilities and to select new areas for development where water supplies are adequate or can be supplied through offstream diversion. Plans for completion of essentially all of the existing projects have been submitted to the Secretary of the Interior. Subsequent rehabilitation and construction programs have been initiated to the extent funds have been made available for that purpose.

CONCLUSIONS

1. Indian trust lands should have high priority in Federal and regional planning for water management and use.

2. Water and related land resource development could stimulate increased economic activity on the reservations. Studies are needed to evaluate the potentials of these resources and to determine the character of the programs and projects required to meet specific economic and social goals of Montana Indians.

RECOMMENDATIONS

1. Expedite level B studies for water resource investigations and development of water management plans for trust land uses.

2. Special water and land resources inventories should be carried out on Indian reservations in Montana. Responsibility should be with the Bureau of Indian Affairs with technical assistance from other Federal agencies as required.

3. Regional planning for water supply to support coal development should include Indian requirements where appropriate.

NO. 3 – CONFLICTS IN PROPOSED USES OF THE FLATHEAD RIVER BASIN RESOURCES

SUMMARY

The Flathead River and its tributaries drain an area of scenic mountains and valleys on the western slope of the Continental Divide. Development of the resources of the basin would contribute significantly to the supply of valuable goods and services needed by the Northwest region. Conflicts in proposed uses of the land and water resources include development for sites for hydroelectric power versus uses as a national park, wild and scenic river, fishery resource, or big game habitat. The Flathead Indian Reservation has pressing economic and social problems. A large irrigation potential exists in the basin. The two broadly based studies of the basin currently under way are not designed to resolve all of the specific issues necessary. Figure VI-11 presents a sketch of the Flathead River basin.

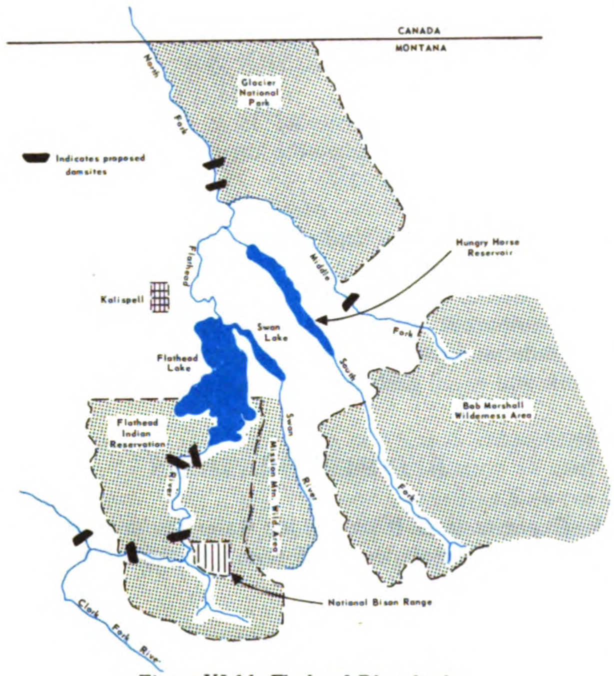


Figure VI-11. Flathead River basin.

DISCUSSION

According to the Columbia-North Pacific Framework Study, annual peaking power requirements in the Pacific Northwest Region are projected to increase from 21.5 thousand megawatts in 1970 to 102.3 thousand megawatts by 2000. A portion of the future power demands could be met by power developments in the Flathead River basin. The peaking capability that might be developed is estimated to be approximately 5 percent of the region's year 2000 peaking energy requirements. For instance, Glacier View or its alternative Smokey Range on the North Fork Flathead River could develop about 330 megawatts, and various alternatives on the Lower Flathead could develop 500 to 1,000 megawatts. However, development of these sites would impinge on Glacier National Park.

Development of the proposed power facilities could assist in resolution of some of the needs and problems of the basin but would conflict with other existing and proposed uses of the water resources. Facilities necessary for power production could be used to assist in resolution of several problems. Major flooding occurs along the Flathead River above Flathead Lake, causing extensive flood damages. The last major flooding occurred in June 1964. At that time, the upper basin sustained $24 million damage and the lower basin sustained $8.5 million (damage figures are in 1972 values). About 6,000 people had to be evacuated because of this flood. A combination of flood plain regulation, improved watershed management upstream, and provision of storage upstream, could alleviate the problem. In addition, flood control storage could help alleviate flood peaks at other locations within the Columbia basin. Although flooding in the vicinity of Kalispell, Montana, would be reduced with additional upstream storage, levees and improved outlets at Flathead and Swan Lakes would solve the flood problem more effectively but would create environmental problems at the lakes.

Without regard to economic infeasibility and constraints on irrigating National Park and National Forest land, about 458,000 acres of land in the basin could be placed under irrigation to produce food and fiber. Supplemental water could be provided to 127,000 acres of the 159,000 acres of land now irrigated with an inadequate water supply.

The Flathead Indian Reservation occupies about 617,000 acres of land, most of which lies within the Flathead River basin. The Flathead Irrigation Project contains 102,338 irrigated acres on the reservation. Optimum development of resource potentials of the reservation may include additional irrigation and power projects.

Portions of the facilities necessary for full development of the power capabilities involve conflicts in use. A total of 210 stream miles within the Flathead River basin upstream from Flathead Lake, including all of the North and Middle Forks, has been designated for study under Section 5a of Public Law 90-542. Studies are under way by the Forest Service and are expected to be completed by FY 1974. This use designation would virtually prohibit construction of major facilties upstream from Flathead Lake. This includes the potential Spruce Park, Glacier View, and Smoky Range Dams. No water developments can proceed until the issue is resolved by Congressional action. The wild and scenic river designation would, however, essentially preserve the existing environmental resources and values in their natural state and maintain existing revenues from tourism, recreation, and other water-related activities.

Fish and wildlife resources of the area are extensive and play an important role in meeting man's needs for hunting, fishing, and other recreational activities. The North Fork, Middle Fork, and main stem of the Flathead River above Flathead Lake are fishing streams of National importance, and the Flathead River downstream from Flathead Lake is of importance to large districts of the State of Montana. Power developments would not only inundate fish habitat at reservoir sites, but would impede fish passage to important spawning areas.

Big game resources, especially deer and elk, are important to the area, providing an estimated 100,000 man-days of hunting annually. Hunter success is good, and the harvest is relatively high. During most winters, both elk and deer winter at lower elevations along the stream valleys. Critical wintering habitat occurs along the North, South, and Middle Forks of the Flathead River. A significant amount of wintering habitat would be inundated and could result in a significant decrease in deer and elk populations, if reservoirs were constructed in the upper basin.

Both the North and Middle Forks of the Flathead River form portions of the western boundary of Glacier National Park. The South Fork arises within the Bob Marshall Wilderness area located within the Flathead National Forest. The Mission Mountain wild area lies between the lower Flathead River and the Swan River drainages, and the National Bison Range is near the Flathead River downstream from Flathead Lake. At many locations, power developments would detract from the environmental quality of adjacent areas through altered streamflows, construction activities, and other impacts.

Other basin problems not associated with power development alternatives include:

(1) Municipal wastes from the city of Kalispell.

(2) Potential water quality problems of the 197-square-mile Flathead Lake from the effects of recreation activities, homes, and other sources are already evident.

(3) Lack of adequate facilities for picnicing, camping, hiking, and swimming.

(4) Inadequate fish passage facilities at the diversion dam below Swan Lake.

(5) The Flathead Lake area is very active seismically, and there seems to be some correlation between lake level and seismic activity. This phenomenon would require intensive study before additional impoundment of water in the area.

PROBLEM RESOLUTION

Alternatives range from full structural development for power, irrigation, flood control, and watershed protection to nondevelopment with preservation of streams, lakes, and natural areas in their present state for cultural and aesthetic reasons and control of water pollution. Under full development, hydroelectric power could be developed at the Smokey Range site on the North Fork of the Flathead River; at the Spruce Park site on the Middle Fork; and, at the Buffalo Rapids 2 and 4 sites downstream from Flathead Lake. Irrigation development could be met by direct diversion from the Flathead River and tributary streams, from existing storage at Hungry Horse Reservoir and Flathead Lake, and from various potential storage site locations. Flood protection for Kalispell and vicinity could be met from new upstream storage, levees, and channelization at specific locations between the South Fork and Flathead Lake. Water quality would be improved by control of wastes. There are adequate land and water resources in the basin to satisfy recreation, municipal, and industrial water supply requirements, as well as fish and wildlife habitat development to the year 2000.

The Corps of Engineers has an active study covering the Flathead and Clark Fork River basins. The planned date of completion is 1975. The principal purpose of the study is to recommend adequate additional flood control measures, but other water resource development objectives are also being considered. To date, it appears as if additional storage in these basins is not economically justified if measured by the traditional means of evaluating water resource development projects, although construction of levees may be justified. Appropriate flood plain zoning is indicated.

The Department of Agriculture has initiated a type IV survey of the Clark Fork River basin, including the Flathead River basin, which is scheduled to be completed by 1976. The purpose of the survey is to gather information which will provide a basis for multiobjective planning and effective coordination of Department of Agriculture programs for flood prevention, watershed management, erosion control, water quality improvement, agricultural water management, other water management, recreational development, fish and wildlife development, socioeconomic development, and upstream water management, with related activities of local, State, and other Federal agencies.

The Pacific Northwest River Basins Commission has recommended, in the Columbia-North Pacific Framework Study, additional studies of the Flathead River subarea to evolve alternative plans which retain the high environmental values of the basin and still provide for power, irrigation flood control, water quality control, and industrial waste treatment needs.

CONCLUSION

1. Because both the problems and their solutions are complex, existing and any future studies should be fully coordinated to insure that planning efforts are efficiently accomplished.

RECOMMENDATION

1. The ongoing type IV survey of the Clark Fork River basin, including the Flathead River basin, led by the Department of Agriculture; the multipurpose flood control study of the Flathead and Clark Fork basins led by the Corps of Engineers; authorized multipurpose studies of the irrigation potentials of the Basin by the Bureau of Reclamation; and other specific studies being conducted by the Forest Service and the Geological Survey should continue to be coordinated through the Pacific Northwest River Basins Commission. The ongoing level B study of the Flathead River basin being conducted by the Pacific Northwest River Basin's Commission as an integral part of the Commission's Coordinated Comprehensive Joint Plan should serve as the vehicle for proposing further study or implementation actions. Recommended level C studies could be initiated on those features of the plan needing immediate implementation. The Montana State Study Team should continue to play an active leadership role in this effort.

NO. 4 – IMPROVEMENT IN WATER QUALITY IN THE YELLOWSTONE AND MISSOURI RIVER BASINS THROUGH TOTAL WATER MANAGEMENT

SUMMARY

After the Yellowstone and Missouri Tributary Rivers emerge from the mountainous areas east of the Divide, they flow through an area of badlands and plains. The waters become warmer and accumulate greater quantities of suspended and dissolved solids. In the lower precipitation areas, erosion is active because there is only a sparse vegetative cover for the soils. Because the soils are derived from soft sedimentary rock, they contain appreciable amounts of the more soluble mineral salts, particularly sulfates of calcium, magnesium, potassium, and sodium.

DISCUSSION

The water pollution problems that do exist involve the physiological and aesthetic degradation resulting from turbidity, improperly treated municipal wastes, agricultural wastes, industrial wastes, and some mining problems. Turbidity problems in most streams are temporary. Pollution problems resulting from inadequately treated municipal wastes have existed in all major river systems in the State of Montana. Increased sediment and mineral concentrations from irrigation return flows have been a problem in the Lower Gallatin, Sun, Milk, Musselshell, and Clarks Fork of the Yellowstone. Wastes from sugar beet processing, oil refining, and meat packing have adversely affected the Yellowstone River between Livingston, Billings, and Sidney.

The State of Montana has had State water quality standards since 1956 when they adopted, with some modifications, the guidelines developed by the Northwest Area Pollution Control Council. In 1964, the Pollution Control Council began studying the necessity of revising the guidelines. Before the job was finished, however, the Water Quality Act of 1965 was passed requiring all States to adopt water quality standards satisfactory to the Federal Water Pollution Control Administration. The State of Montana updated its standards and received approval from the Federal Water Pollution Control Administration in 1968.

The National Pollution Discharge Elimination System requires that each person discharging pollutants to a waterway from a point source obtain a permit issued by the Environmental Protection Agency or by an approved State agency. The State of Montana expects to administer the permit system within the State, which it may do providing the Governor develops a full and complete program for the administration of the system satisfactory to the Environmental Protection Agency.

With the State water quality standards in force, overall stream quality will be maintained. The permit system provides an enforcement measure to see that all waste sources, those that have been in existence for some time as well as proposed new developments, will receive adequate treatment.

Although the State water quality standards were written to stabilize or enhance the water quality from all sources of pollution, point source municipal wastes received most of the emphasis. This is true also of the National Pollution Discharge Elimination System.

In spite of the emphasis on cleaning up these sources, there are still a number of municipal and industrial waste problems existing today. The following communities and industries with wastes in excess of 100,000 gallons per day, in the Yellowstone and Missouri basins, are not in compliance with State water quality standards:

Missouri River Basin Municipalities

Big Sandy	East Helena	Harlowton	Malta
Boulder	Glasgow	Have	Manhattan
Bozeman	Great Falls-	Helena	Sheridan
Dillon	Black Eagle	Lewiston	Three Forks
			Townsend

Yellowstone River Basin

Absarokee	Glendive	Laurel	Miles City
Billings	Hardin	Livingston	

Municipal and Industrial

Boulder River School
Boulder, Montana

Great Falls Meat Company
Great Falls, Montana

Great Western Sugar
Billings, Montana

Farmers Union Central Exchange
Laurel, Montana

Noncompliance does not necessarily mean that the municipality or the industry is at fault, for in a number of instances Federal and State cost-sharing funds have not been made available. When money is available, most of the municipal and industrial waste problems will be completed satisfactorily.

One area that will be difficult to handle is that of agricultural pollution and particularly irrigation wastes. Most of the State's irrigation systems, both federally and privately developed, are inefficient. Through the years, they have become more and more inefficient in their use of water. This has been caused by increasing labor costs without corresponding increases in the selling prices of farm produce. Until recently, the price-cost squeeze left the farmer with inadequate funds to properly operate his farm. Historically, one way the farmer has economized in the short run is to cut down on farm labor costs by leaving an irrigation set longer than necessary and letting the excess water waste back to the farm drain. Irrigation companies also cut back on costs and capture the good will of the farmer by keeping the canals full of water at all times. Excess water is then wasted at the tail end of the system. If the waste is captured in a natural drain without the hydraulic characteristics to carry the flow, erosion can take place.

CONCLUSIONS

1. The Yellowstone and Upper Missouri basins have a critical water quality problem due to erosion, sedimentation, agricultural wastes, mining, and municipal and industrial discharges.

2. Existing programs and authorizations at the State and Federal level will take care of most of the point source pollution problems. However, there is a critical need to use a total water management approach to reduce pollution from irrigation systems and from poor agricultural practices in the basins.

RECOMMENDATIONS

1. A level C Total Water Management Study of the Yellowstone basin should be undertaken by appropriate Federal and State Water Management agencies.

2. At the completion of the Yellowstone Total Water Management Study, a similar study should be initiated in the upper Missouri basin drainage.

NO. 5 – POOR WATER QUALITY DUE TO EROSION AND SEDIMENTATION ON MUDDY CREEK AND SUN RIVERS

SUMMARY

Throughout Montana, streams are experiencing degraded water quality due to heavy sediment and salt loads that are caused by the activities of man, primarily agricultural wastes. A classic example of a severe erosion and sedimentation problem that could be improved by better water management practices is occurring on Muddy Creek, a tributary of the Sun River. Each year, Muddy Creek contributes 200,000 tons of sediment to the Sun River. The primary flow in Muddy Creek is composed of irrigation return flows and system wastes that have turned Muddy Creek into a high-volume drain. The drainage flows cause excessive erosion of the banks of Muddy Creek.

DISCUSSION

The major problem on Muddy Creek occurs on the lower reaches where both the Federal irrigation project (Sun River) and private irrigation companies waste water into the creek. Over the years, the average flow in this reach has increased as more land has been irrigated upstream. The low flow in 1936 was 44,000 acre-feet and the high flow in 1964, 130,000 acre-feet. The results of this excess flow are channel degradation which, in turn, greatly increases the turbidity of the Sun River.

Recent studies have shown a nearly five-fold increase in sediment yield in the lower 4.7-mile reach of Muddy Creek. The best solution to the Muddy Creek sedimentation problem would be to reduce or eliminate the waste discharge to the stream. This can be done by:

1. Better irrigation water management;

2. Construction of a concrete line interceptor canal to capture return flows before they enter Muddy Creek;

3. Construction of impoundments to collect flow for reuse or to level out waste flows.

PROBLEM RESOLUTION

Better water management can and will result from the National Pollution Discharge Elimination System. This will only be a partial solution, however, and will not substantially reduce the problem. Muddy Creek could be essentially dewatered by the construction of a 14-mile interceptor canal from a diversion structure on Muddy Creek, 2 miles south of the town of Power to the Sun River near Vaughn, intercepting all side channel waste from the west. This would provide the most inexpensive solution to the problem but would not permit additional beneficial use of the water.

Storage provides the most promising environmental improvement of Muddy Creek with reuse potential. A 25,000 acre-foot storage dam and reservoir could be constructed on Muddy Creek near Power. Water-surface area at that capacity would be approximately 1,400 acres. A 13-mile, lined collection canal would be constructed to pick up waste flows from five major wasteways south of Power which enter Muddy Creek from the west and convey the water northward to the storage reservoir. Beneficial uses of the water would be improved water deliveries to Bention Lake Wildlife Refuge, the use of water for irrigation on Greenfields Division in exchange for augmented minimum flows in the Sun River, and the development of new irrigation in the area.

Bank stabilization could be accomplished through the use of controls such as jacks, rock, facing, and other armament techniques.

CONCLUSIONS

1. A bad natural erosion problem on Muddy Creek has been made substantially worse by irrigation projects which drain waste water into the creek.

2. The effects are severe downstream where Muddy Creek joins the Sun River.

RECOMMENDATION

1. A level C study is proposed to find a workable solution to the Muddy Creek problem. The Bureau of Reclamation, Fish and Wildlife Service, and the Soil Conservation Service should be involved in the study.

NO. 6 – SALINE SEEP DEVELOPMENT AND ITS IMPACT ON LAND USE AND WATER QUALITY

SUMMARY

Areas commonly known as saline seeps are usually low lying on closed basin lands, mostly in dry cropland or grassland, which are salty and wet for part or all of the year. The seeped areas often have white salt crusts and crop or grass production is reduced or eliminated. The latest estimates of the area of cropland in Montana where production has either been eliminated or significantly reduced range from 150,000 to 250,000 acres. The annual increase in occurrence of these areas is about 10 percent. Extensive surface drainage systems to remove excess surface water and, where feasible, shallow ground water together with land leveling and more intensive cropping practices, could reclaim or improve many of the saline seeped areas.

DISCUSSION

The saline seep problem stems from geology of the region and has been occurring for centuries, but has become more apparent recently because of a greater use of the crop-fallow dryland farming system in Montana and associated areas in North Dakota, South Dakota, and Canada.

There is a total area of 228,000 square miles (16,500 in Montana) within which saline seeps may develop. The surface material is reworked glacial till, varying in thickness from 1 to 10 feet. This reworked till is underlain by a dense massive till which is impermeable to water. The massive till is in turn underlain by a marine shale formation. It appears that excess deep percolation (as a result of precipitation not utilized in plant growth) moves through the soil profile and builds up on top of the underlying impermeable dense till, forming a "perched" water table. This excess water gradually moves downslope, getting close to, or surfacing in the lower swales, where it evaporates, leaving dissolved salts behind. The ground water is strongly saline because of a large supply of natural soluble salts contained in the subsoil and glacial till. Surface runoff carrying salt picked up from the soil surface also collects in the lower swales, which normally have no outlets. This water also evaporates, leaving additional quantities of salt to aggravate the saline problem.

Saline seeps were first recognized as a serious problem in the 1940's in Montana, 15 years after summer fallow became a regular practice. Summer fallowing reduced crop failures and helped to stabilize farming in semiarid regions. Even though precipitation may be insufficient for annual cropping, it frequently is more than enough to refill the root zone during the fallow year. Any excess soil moisture becomes deep percolation and moves down to the top of the dense impermeable till where it builds up and also moves downslope as ground water. Variations in the dense till surface as well as surface topography cause the ground water to come close or break atop the land surface. On fallow areas, a water-table rise of 1 to 5 feet can be expected during years with average or above-average spring precipitation. These water-table highs gradually decline during the rest of the year, but normally do not reach the previous year's low indicating a continual buildup of excess water over the years. As a result, each succeeding wet cycle makes the saline seep problem worse.

Seeps are usually small – from a fraction of an acre to several acres in size – but are rapidly increasing in number and total area. Much land has been lost to production, land values have dropped, and field operations are more difficult. There are documented cases of deterioration of domestic wells and of livestock death and fishkills directly attributed to water from saline seep sources. These seeps are widely recognized as a serious threat to soil resources, to livestock and wildlife, to water quality, and to the environment in many respects. The size of each wet saline area (discharge area) is related directly to the size of the adjacent upland recharge area.

In many areas, the "perched" water table has built up to a point where coulees which were formerly dry most of the year are now starting to flow year around.At the present time, most of the saline water is evaporated before reaching the perennial streams, leaving the salts behind to be flushed away during spring runoff. Unless the growth and development of saline seeps are stopped soon, many coulees will start to flow appreciable quantities of highly saline water to all perennial streams throughout the region with the majority of the water coming during the low-flow season when it could rapidly impair the quality of the entire stream.

All available hydrogeological data indicate that the formation and development of saline seeps are a result of local, *not* regional, flow systems. Saline seep development is not just limited to high precipitation areas. During the past 2 years, large outbreaks of saline seeps have been observed in areas where average annual precipitation is less than 12 inches. At the present time, saline seep development is particularly pronounced in areas where the reworked glacial till is relatively thin (0 to 5 feet thick). Excess water is undoubtedly accumulating over large areas where the reworked glacial till is much thicker but as yet has not expressed itself at the surface. Water tables are now present under some of Montana's drylands. The water table is usually below the root zone of cereal crops. Most of this water is too salty for livestock or domestic use. Deep snow accumulation is believed to be responsible for certain saline seeps. Extensive surface drainage systems may be used to remove excess water in some areas; however, disposition of this very low-quality water is a serious problem.

Some saline seeps appear to be self-perpetuating. These areas support vigorous stands of Kochia during the growing season: when this weed growth stands over winter, it traps much snow which recharges the soil and adds excess water to the saline seep.

CONCLUSION

1. A better understanding of the saline seep problem in Montana will come from:

(a) Surveys to define the magnitude, extent, and character of the problem;

(b) Research to find workable soil, crop, land management and drainage practices;

(c) Education of farmers, ranchers, and landowners as to the nature and extent of the problem; and

(d) Technical assistance to farmers, ranchers, and landowners in applying different soil, crop, land use and drainage practices.

RECOMMENDATIONS

1. Federal agencies cooperate with the State of Montana to secure urgently needed action to investigate the development of saline seeps and to reclaim those lands which can feasibly be reclaimed.

2. Surveys should be undertaken to define the magnitude, extent, and character of the problem. A cooperative effort between the Montana Bureau of Mines and Geology and the Soil Conservation Service is recommended. Geologic investigations, soil surveys, hydrologic studies, and inventory of cultural practices would be involved.

3. Studies should be continued and expanded to find workable soil, crop, and land management practices to control seep development. These studies should include drainage, surface diversions, and snow management. This should be undertaken jointly between Montana State University, Agricultural Research Service, and Environmental Protection Agency.

4. A special demonstration program should be undertaken to field test and demonstrate effectiveness of currently known solutions. This effort should involve the research agencies as well as the Montana Cooperative Extension Service and the Soil Conservation Service.

5. A program of technical and financial assistance and supporting educational efforts should be initiated to accelerate the adoption of currently known improvement practices. The Soil Conservation Service and Agricultural Stabilization Conservation Service should utilize the Rural Environmental Conservation Program in this effort. If current program funds are inadequate, a special project should be considered.

Nevada's population of nearly one-half million people is centered in two principal metropolitan areas – Las Vegas and the Reno-Sparks-Lake Tahoe area. In terms of area, the State ranks fifth among the Westwide States and the seventh nationally. With its vast area and sparse population, there is an average of less than five people per square mile. Recreation and tourism are the leaders for economic growth in the major population centers. The Clark County (Las Vegas) area has become the recreational crossroads of the American Southwest and has become, through supporting service activities, the residence and livelihood of at least one out of every two Nevadans.

The livestock industry is a major support for the State's rural economy. Although a number of valley towns are prosperous due primarily to irrigated agriculture, ranching is Nevada's most important agricultural enterprise. Public rangelands, which comprise 80 percent of the State, play an important role in agriculture on a year-round basis. The higher elevations are grazed under controlled conditions in the summer: the low-lying lands are used in the spring, winter, and fall.

Most significant activities in Nevada are concentrated in either the Reno-Lake Tahoe or Las Vegas-Lake Mead regions at opposite borders of the State. These two areas account for 95 percent of Nevada's urban population and 70 percent of its rural population. Moreover, it is these two areas which are expected to share the growth and expansion in future years. These are also places which have a large influx of visiting tourists, gamblers, and travelers. They are significant contributors to impacts in municipal water use. Total water consumption projections include tourists; however, they are not included in statistical data of water consumption thus resulting in apparent high per capita use rates. In no other State is the proportional number of visitors so great and so consistent throughout the year.

WATER SUPPLY

A unique water resource characteristic of Nevada is that practically all of the precipitation and stream inflow ultimately is used, retained, or evaporated within the State. Only across the northeast, where some small streams leave the State and flow into the Columbia River system, and the southeast, where streams join the Colorado River, does Nevada have drainage to the oceans. The State's precipitation occurs primarily during the winter and on the average is less than any other State due principally to the mountain barriers. The Sierra Nevada on the western border of the State receives the greatest moisture and the low plateaus in Humboldt and Pershing Counties extending southward to the Amargosa and Ralston Deserts receive the least. With few exceptions Nevada's rivers find their way into terminal lakes, playas, or end in desert sinks. The largest rivers include the Humboldt River in northern Nevada; the Carson River and the Walker River in western Nevada; and the Truckee River which is fed by Lake Tahoe and empties into Nevada's largest natural body of water – Pyramid Lake. These interior draining streams are unique; at approximately their midpoint, the surface flows are at a maximum but decrease as they continue downstream until, at each stream's terminal sink, the flow is only a small portion of the midpoint flow. At Nevada's southern tip, water is pumped from the Colorado River to Las Vegas and surrounding communities. For the Truckee, Carson, Walker, Humboldt, or Colorado Rivers, the primary water source is the winter snowpack.

Tables VI-24 and 25 summarize Nevada's estimated 1975 depletions and water supply situation. Irrigation is the foremost water user, accounting for 70 percent surface- and ground-water withdrawals.

Ground Water

Under Nevada law, ground-water use can only be that which is perennially replaced. Hence, except where specific, temporary exceptions have been granted (e.g., Las Vegas), use has not been large. Current use is only about 10 percent of total depletions, but is a mjaor portion of municipal supplies statewide. (See table VI-26.)

Water Quality

Nevada's overall water quality is relatively good in streams and ground-water basins for most users. However, Nevada's unique characteristic of stream systems ending in terminal lakes creates a condition of gradual degradation. Nevada's only large river system is the Colorado. Quality declines in this river due to salinity increases; but Nevada's major concern is with the corollary problem of salinity levels in terminal lakes. Pyramid and Walker Lakes in Nevada and other lakes in the Western States are or will become critically saline. Resource planning would be aided if a national policy were provided regarding the preservation or abandonment of the terminal lake resources.

Table VI-24.—*Estimated 1975 total depletions[1] for Nevada (1,000 acre-feet)*

Region and subregion	Purpose or cause of depletion							Total[4] depletions
	Irrigation	M&I including rural	Minerals	Thermal electric	Recreation[2] F&WL	Other	Reservoir evaporation	
Great Basin								
Great Salt Lake	28						16	44
Humboldt	615	5				1	112	733
Central Lahontan	518	29		4		2	905	1,459
Tonopah	179	26				1	41	247
Total region	1,340	60		4		4	1,074	2,482
Columbia-North Pacific								
Upper Snake	26						4	30
Lower Snake	102						9	111
Total region	128						13	141
Lower Colorado								
Lower main stem	151	77	2	30	37	2	12	311
Total region	151	77	2	30	37	2	12	311
State summary	1,619	137	2	34	37	6	1,099	2,934[3]

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] Exclusive of instream flow use.
[3] Surface-water depletions — 2,598,000; ground-water depletions — 336,000.
[4] No depletions are attributed to consumptive conveyance losses.

The Virgin River, Meadow Valley Wash, and Muddy River are tributaries to Lake Mead but provide irrigation water to high-value cropland before entering the lake. Most of the time, these waters are very poor quality and have presented problems in their use for many years. These problems should be resolved if this resource is to adequately meet future needs.

CRITICAL PROBLEMS

The Westwide problems having a direct bearing on the State of Nevada are discussed in more detail in this section. The regional problems affecting Nevada are listed. This portion concludes with detailed presentations of State specific problems. Figure VI-12 presents the approximate location of regional and State specific problems found to be critical in Nevada.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – Fisherman in Nevada spent nearly 1.5 million angler-days fishing in 1970 of which stream fishing accounted for about 400,000 days. The demand for stream fishing in 1980 is expected to be 765,000 days and 1.3 million angler-days by the year 2000. The determination of water needs for fish, wildlife, and associated environment has not kept pace with studies of water needs for other purposes. In a number of cases, water and related land resource developments have resulted in the loss and degradation of stream habitat. Pollution is a problem in some streams. Of particular concern is the decline of water levels in Pyramid and Walker terminal lakes where maintenance of the valuable

Table VI-25.—*Estimated 1975 surface water-related situation in Nevada (1,000 acre-feet)*

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within subregion or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Great Basin									
Great Salt Lake	0	80	0	80	0	44	36	0	36
Humboldt	0	1,160	0	1,160	0	673	487	0	487
Central Lahontan	1,270[8]	270	0	1,540	0	1,458	82	82	0
Tonopah	0	900	0	900	0	227	673	0	673
Total region	1,270	2,410	0	3,680	0	2,402	1,278	82	1,058
Columbia-North Pacific									
Upper Snake	0	160	0	160	0	30	130	0	130
Central Snake	0	520	0	520	0	111	409	150	259
Total region	0	680	0	680	0	141	539	150	389
Lower Colorado									
Lower Colorado main stem	160[7]	160	107[5]	427	0	281	146	0	146[9]
Total region	160	160	107	427	0	281	146	0	146
Total summary	1,430	3,250	107	4,787	0	2,824[6]	1,963	232	1,741

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Estimated depletions associated with those projects, programs, or individual activities that will be in operation and depleting the water supply at the end of 1975. Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] Nevada's expected use of Colorado River main stem water in 1975.
[6] Sum of depletions in all regions. Surface water depletions = 2,598,000 ground-water depletions = 336,000 including 110,000 of ground-water overdraft.

Ground-water overdraft by subregion:

Lower main stem subregion	30,000
Humboldt	60,000
Tonopah	20,000
Total ground-water overdraft	110,000

[7] Virgin River inflow.
[8] Truckee, Carson, and Walker Rivers.
[9] Future supply from Lake Mead of 120,000 not included.

Table VI-26.—*Ground water use in Nevada (Est. 1975)*

Area	Ground-water depletions AF/YR	Percent of state	M&I use		
			Total	Ground water	Percent
Las Vegas	140,000	40	77	56	73
Humboldt	82,000	25	5	5	100
Tonopah	85,000	25	26	11	42
All others	29,000	10	29	16	55
Total	336,000	100	137	88	64

Lahontan cutthroat trout fishery is dependent upon sufficient inflow of freshwater.

Wetlands are one of the most important habitats for wildlife in Nevada. These areas provide seasonal and year-round habitat for waterfowl, shore birds, marsh birds, and mammals. The latest survey conducted by the Fish and Wildlife Service and Nevada Department of Fish and Game indicated that 192,000 acres of wetlands existed in 1954. This survey should be updated. Some wetlands are sustained by return flows of irrigation water, however, more efficient irrigation use of this water in the future could have serious effects on maintenance of wetlands and riparian vegetation.

Many species of waterfowl, shore birds and marsh birds nest in Nevada, including canvasback and redhead ducks whose numbers in the Pacific Flyway are low. In addition, several million waterfowl and shore birds are present during migrations. Wetlands provide a variety of recreational opportunities such as hunting, fishing, wildlife photography, and nature study. During 1970, waterfowl hunters spent 73,000 hunter-days and by 1980 this use is expected to be 123,000 days.

Studies of water requirements needed to maintain wetlands have not kept pace with studies of water and related land resource needs for other purposes. Information such as data on acreage and type of wetlands, fish and wildlife species, fishing hunting and nonappropriative uses and water quality problems is needed in order to insure that proper consideration is given to the preservation of wetlands and associated wildlife values in any plans which may affect wetlands.

Nevada has seven threatened fish species which are peculiarly adapted to this desert region. Lahontan cutthroat trout as a pure strain are found in Summit Lake and are protected. A Walker Lake strain has been stocked in Pyramid and Walker Lakes. Additional research on these species particularly as to lower Truckee River modifications to permit natural spawning is needed.

The cui-ui also depended on the lower Truckee River for spawning. Studies of habitat restoration in connection with water management in the Truckee-Carson basin is needed.

Relict species such as the Pahranagat bonytail, the Moapa dace, the Devil's Hole pupfish, the Warm Springs pupfish and the Pahrump killifish are restricted to small seeps, holes, and springs where ground-water pumping, diversions and other water development pressures have severely limited chances for their survival. Studies of the precise conditions needed to protect these species are vital. Research on these endangered species in Nevada, as related to methods and water resources needed to ensure their survival, will require a greatly increased scope and tempo of studies if the results of such research are to be pertinent to decisions on water development.

NO. 12 – MEETING WATER DEMANDS THROUGH CONSERVATION AND REUSE. – The primary opportunities for conservation are on the Newlands and Humboldt River Irrigation projects. Unresolved major factors revolve around identifying beneficiaries of conservation practices and working out equitable financing and repayment plans to share the costs. Acceleration of programs could result in as much as 560,000 acre-feet per year water savings. This water is now lost to phreatophytes, evaporation and deep percolation, but also supports a major natural wildlife refuge.

Present overall irrigation efficiency, including reuse-recycling, could be increased from the present 66 to 77 percent.

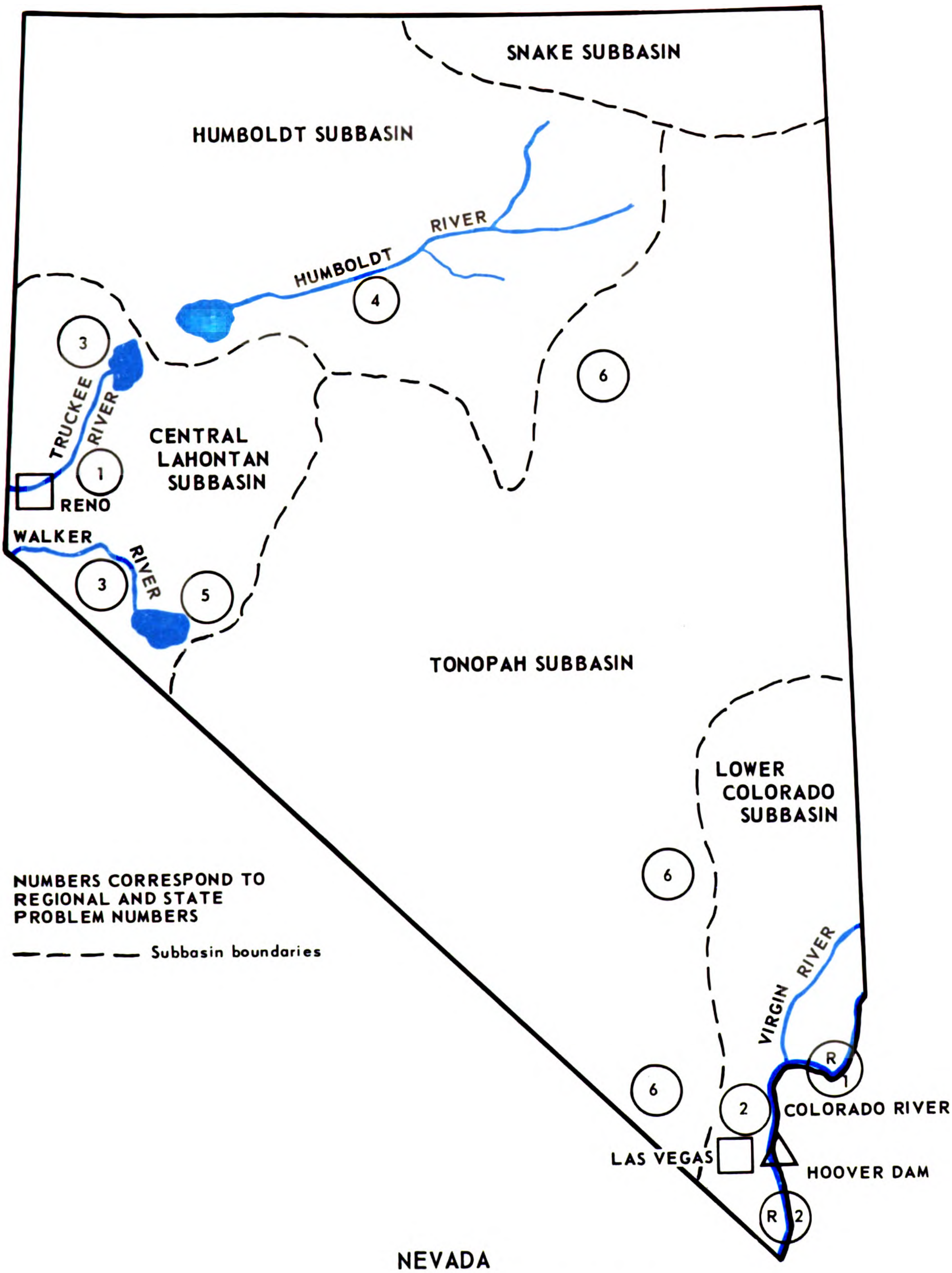


Figure VI-12. Critical water problems in Nevada.

Nevada has 2,100 farms consisting of more than 8 million acres, 11 percent of which are irrigated. Of these irrigated lands, over one-half (500,000 acres) are short of water by approximately 1 acre-foot per year. Irrigation water quality averages 250-300 p/m. Although off-farm conveyance seepage losses are 350,000 acre-feet per year, much of this is returned to streams and not totally lost. Irrigation scheduling could improve farm systems operations on almost three out of four farms.

The estimated potential statewide water savings that could accrue by 1985 under an accelerated program are presented in table VI-27. The Humboldt region leads all other regions combined in new storage, deepwell pumping, canal lining for seepage reduction, and gains from using better onfarm management. By such savings, large increases in irrigated acres in the Humboldt River system can be realized.

Regional Problems

Nevada is affected directly by the quality and quantity aspects of the Colorado River. These regional problems are:

NO. 1 – INCREASING SALINITY IN THE COLORADO RIVER

NO. 2 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

State Specific Problems

There are two major problem areas: the Truckee-Carson basins involving Pyramid Lake and the Las Vegas pollution problems. Other problems include Indian water requirements, Humboldt River water management, Walker basin management, and utilization of remote sites and ground waters in central Nevada for regional power installations. In the Lake Tahoe-Lake Pyramid situation, waters of the Truckee River have been diverted to the adjacent Carson River for development of irrigated lands whose productivity has historically been the backbone of the region's economy. As trustee for the Pyramid Lake Indian Nation, promoter and developer of the Carson basin irrigation economy, establisher and manager of numerous wildlife areas, and consenter to negotiations for interstate water compacts on the Truckee and Carson Rivers, the United States is deeply obligated to all parties of the current dispute regarding water allocations and water rights. Along the lower Colorado River border, meeting Federal water quality standards and growing municipal water supply requirements involves complex problems of water treatment, waste-water reclamation and salinity control. In this regard the State is anxious to initiate a study of the Virgin River basin which could lead to a compact among the States of Arizona, Nevada, and Utah regarding the flows of the Virgin River.

One of the most important issues pertaining to water resource development in Nevada, and one which overshadows the six specific problems that follow is the need for a California-Nevada Compact on the Carson, Truckee, and Walker Rivers. A draft compact was approved in 1971 by both the Nevada and California Legislatures after more than 12 years of negotiations. To date, the Compact has not been ratified. Until this issue is settled, water resource

Table VI-27.—*Potential water savings through conservation practices by 1985 (1,000 acre-feet)*

State planning areas	Number new improvements	Conservation storage	Off-farm seepage	On-farm systems
I Walker			42,000	45,000
II Carson-Truckee	1	600	38,000	183,000
III Humboldt	10	11,000	21,000	206,000
IV Central	9	3,200	5,200	–62,000[1]
V Colorado	2	200	5,300	41,400
VI Snake		-0-	-0-	19,000
Total	22	15,000	111,500	432,400

[1] Under a potential program, improved system operations and water conservation will permit new deliveries. These new blocks of land when added create additional losses and the net is shown between savings and new uses and losses. (Source: Nevada State SCS report, Oct. 1973.)

planning in these river basins is restricted by uncertainty.

Following are listed the six specific problems identified for Nevada. Figure VI-12 shows their approximate locations.

NO. 1 - CONFLICT OF WATER ALLOCATION AND USE IN THE CARSON-TRUCKEE RIVER BASINS

NO. 2 – POLLUTION OF THE LAS VEGAS ARM OF LAKE MEAD BY WASTE WATER AND SUBSURFACE INFLOWS

NO. 3 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 4 – NEED FOR REGULATION AND MANAGEMENT OF WATER SUPPLIES IN THE HUMBOLDT RIVER BASIN

NO. 5 – DECLINE IN SURFACE AREA AND QUALITY OF WALKER LAKE

NO. 6 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 1 – CONFLICT OF WATER ALLOCATION AND USE IN THE CARSON-TRUCKEE RIVER BASINS

SUMMARY

Truckee River, fed from pristine Lake Tahoe, is tapped for agriculture use in the lower Carson River basin through large-scale irrigation of valley floor lands. The success of this area centers on the Newlands project, the first Federal reclamation endeavor. For many years the competition for water from nonagricultural purposes has been alleviated by developing higher levels of annual supply through regulation control and upstream storage. However, with increasing upstream uses and a serious drought period, water supplies to Pyramid Lake were reduced and the lake declined over 40 feet between 1930 and 1960. Changing public values and desires for recreational, environmental and wildlife improvements have tended to bring traditional uses in confrontation with contemporary values. The problem is to maintain Pyramid Lake at a level acceptable to the Indians who own the lake and still meet other water demands in the basin. Because of the uniqueness of the situation, however, the issue of equitable allocations among users of the waters (Truckee-Carson Rivers) which flow into the lake must be first addressed and decided upon in the Federal courts. The Federal Government, recognizing the criticality of this issue, is presently seeking to have the question of water rights and legal entitlements of the Pyramid Lake Tribe and other residents of the area adjudicated in the Federal District Court of Nevada.

DISCUSSION

Within the Carson-Truckee River basins, the full spectrum of interrelated water problems exists from agricultural and municipal supply, stream pollution, flooding, terminal lake maintenance, recreation, fish and wildlife needs, Indian needs, State-Federal rights and interstate division of waters. Federal involvement has been significant throughout the history of the area as evidenced by Federal reclamation projects, flood control works, soil conservation programs. Lake Tahoe preservation efforts, and Indian reservations. Under present usage, there is insufficient runoff to satisfy current agricultural, municipal and industrial needs and also maintain Pyramid Lake at its present level. Climatic conditions vary from arid at the lower elevations to subhumid in the high mountains. In addition to consumptive use which relates to established water rights, approximately 175,500 acre feet of water per year are consumptively used by phreatophytes and 600,000 acre-feet from water surface evaporation.

Land ownership influences how the land is used which in turn is inseparably tied to the demands placed on the water system. About 60 percent of the land in the Nevada portion of the basin is in Federal ownership, about 10 percent in Indian reservation and the balance in private holdings.

About 5 percent of the area has been developed for cropland and urban uses; 69 percent is in woodland, range, and wildlife areas: 14 percent is in lakes and rivers: and about 12 percent is in playa or "salt flats." Included is important waterfowl habitat at the Federal Stillwater Wildlife Management Area.

The Carson and Truckee River basins have their origins in California where a significant part of their water supply is developed. The entire drainage area for both rivers forms a closed basin with no outlet to the sea.

The hydrology of this area is typical of that occurring in the eastern Sierra rain shadow. Most precipitation occurs in the winter in the form of snow. Streamflows are seasonal with peak flows occurring in late spring as a result of snowmelt. The wide ranges in flow create a variety of problems. Seasonal high flows often result in flood damage with serious erosion and sedimentation. Low flows limit agricultural production and tend to cause high water temperatures. Both sedimentation and high water temperatures impact adversely on fish life and general water quality. All of the water occurring during a given year is either consumed through upstream uses or ultimately evaporates from terminal sinks such as Pyramid Lake or Carson Sink.

The 1970 population of the Nevada portion of the Carson Truckee River basins was estimated to be 160,000; about one-third of the State total. The services industry is by far the largest employer with over 33,000 employees, because of the extensive outdoor recreational opportunites and the local gaming activities. These features draw many people from neighboring states to Nevada for recreation and relaxation. Trade is the second largest industry and employs about 17,400 workers. Population projections and M&I water requirements made by the Nevada Division of Water Resources for the Nevada portion of the area are shown in table VI-28.

The predominant use of water is for irrigation; however, substantial withdrawals are made for electric power. Table VI-29 presents a summary of water uses for the major function as of 1969.

Table VI-28.—*M&I water requirements.*

Year	Population	Acre-feet per year
1980	222,150	100,640
2000	340,550	161,520

In the Truckee River basin, Reno and Sparks use an average of 41,000 acre-feet of water per year for municipal and industrial purposes while irrigators use 73,000 acre-feet on about 41,000 acres. Maintenance of Pyramid Lake is dependent on seasonal flows from the Truckee River.

The Reno-Sparks-Truckee meadows area has historically been subject to severe flooding from the Truckee River which flows through the business district of Reno. Development in the flood plain has been taking place at an accelerated rate. Land use is rapidly being changed from agriculture to urban and industrial. Three reservoirs have been completed (Prosser Reservoir in 1962, Stampede Reservoir in 1970, and Martis Creek Reservoir in 1972) which provide flood control on tributaries of the Truckee River upstream from Reno. Completion of the three reservoirs has reduced the frequency of flooding in the Reno area and may account in part for the rapid development in the Truckee Meadows area. Although these reservoirs reduce the frequency of flooding in the Reno area they do not provide the degree of protection considered desirable for an urban area.

Storage on the numerous remaining uncontrolled tributaries would require expensively high dams for small drainage areas. A flood control plan for Truckee Meadows includes a reservoir on the Truckee River upstream from Reno together with an offstream reservoir on Steamboat Creek and various channel improvements. However, local residents have not supported this plan yet.

In recent years, interest in recreation fishery resources, in Indian resources and in conservation of the natural environment has increased the concern for preserving Pyramid Lake, the larger of the two main perennial terminal lakes in Nevada. Inasmuch as this lake is the

Table VI-29.—*Summary of water use, Truckee-Carson basins (acre-feet)*

Use	Withdrawals				Consumptive use
	Wells	Springs	Streams	Total	
Irrigation	8,800	2,200	875,700	886,700	388,000
Public supply	10,660	—	34,800	45,460	10,122
Self-supplied industrial	3,306	160	1,930	5,396	2,743
Electric power		—	1,004,000	1,004,000	0
Rural and domestic	3,051	210	810	4,071	2,060
Total	25,817	2,570	1,917,240	1,945,627	402,925

terminus of a perennial stream, climatic variations and upstream depletions cause inflow to vary widely from year to year. This in turn results in fluctuations in lake levels to maintain equilibrium between inflow and evaporation.

During the period 1931 to 1960, Pyramid Lake declined 1 to 2 feet per year. As an indication of its sensitivity to climatic conditions, the lake rose about 8 feet during 1969, a high runoff year. To maintain Pyramid Lake at 1965 levels would require increased inflows of about 130,000 acre-feet annually. Many studies have been made recently including the Great Basin Comprehensive Framework Study by the Water Resources Council (WRC) in 1971, The Central Lahontan River Basin Study by Nevada and the Department of Agriculture, and those of the Pyramid Lake Task Force. Table VI-30 lists the inflow rate which the WRC Framework Study estimated to be required to stabilize Pyramid Lake to certain levels by time frames.

Presently, the fishing is adequate in most portions of Pyramid Lake. Marble Bluff Dam and Pyramid Lake Fishway are being built to allow the lake fish, namely, the cutthroat trout and the cui-ui, to migrate up the Truckee River in the hopes of restoring natural spawning.

The Carson River basin has large irrigated acreages in the Gardnerville-Minden area, smaller acreages along the river near Dayton, and another large acreage in the Fallon area which is part of the Newlands project. The Fallon portion is the largest user, with about 360,000 acre-feet per year of Carson and Truckee river water diverted for this segment of the Newlands Project.

During the past several years, proceedings have been underway in which the Pyramid Lake Indians have sought to have the annual operating plan for Truckee diversions changed to lower diversion amounts. However, the crucial issue is the full adjudication of their rights. In December 1973 the Federal Government filed a suit in U.S. District Court in Reno on behalf of the Paiute Indian Tribe. Over 12,000 defendents were named including the Truckee-Carson Irrigation District (TCID) and the State of Nevada. This large number of defendants is indicative of the complexity of the problem which involves State, Federal and private rights acquired during the past 120 years through riparian, appropriative, and decree processes.

Carson City is rapidly outgrowing its existing water supply, and a shortage is predicted within 4 or 5 years. At the present time, this supply consists of surface runoff from Kings, Ash and Vicee Canyons on the east slope of the Sierra Nevada west of the city, and ground water from the Eagle Valley aquifer. Eagle Valley is the geographical location of urban Carson City.

An independent water system owned by the State furnishes water to the so-called State Complex and is what remains of the once famous water supply system for Virginia City. This system still furnishes water to Virginia City and most State buildings, and is a source of additional supply to Carson City during heavy demand periods. Although called the Marlette Lake system, or more accurately the Marlette-Hobart system because of Hobart Reservoir on the east slope of the divide, only during rare periods of peak demand in water-short years is water from Marlette Lake brought into the system. Marlette Lake, on the Lake Tahoe side of the divide, is presently used as a spawn-taking site for cutthroat trout. Since the original tunnel and

Table VI-30.—*Estimated water requirements to maintain Pyramid Terminal Lake at various levels*

Lake stage (MSL)	Decline from 1965 level (feet)	Required river inflow (1,000 af/yr)	Volume (million acre-feet)	Area (1,000 acres)	Dissolved solids content (mg/l)	Time[1] (years)
3,788.5	0	365	20.3	108	5,700	0
3,754.0	34.5	338	16.9	100	6,100	264
3,690	98	290	11.0	85	6,900	260
3,645	145	240.5[2]	7.4	71	7,900	259
3,583	205	170	3.7	51	10,000	171
3,551	237	140	2.2	42	12,000	163

[1] Time required to reach indicated lake stage from 1965 stage.
[2] Inflow value for 1931-60 reference period, modified to 1965 level of dev.

flumes from the lake to the Carson City side of the divide have long since deteriorated, the water, when needed, is pumped over the divide by a temporary pumping plant and surface pipeline.

The combined theoretical maximum yield of the Sierra Canyon's surface runoff, the ground-water pumping of the Eagle Valley aquifer, and the combined Marlette-Hobart system is 15,000 acre-feet annually. However, despite the fact that water from the Sierra canyons has been used for the past century to serve Carson City, very little is know about the runoff from these sources. Similarly, although the Marlette-Hobart system has been in operation for 100 years, no program was ever initiated to measure the yield of the watersheds. It is believed that the Marlette-Hobart system, if fully developed, could provide for the needs of Carson City for many years.

Various estimates of growth, demand, and supply indicate that should rapid growth occur, and yields be less than expected from Eagle Valley and the Marlette-Hobart system, water important will be necessary. Ground water from Carson Valley is considered to be the best source because of its proximity to Eagle Valley and its abundant supply. However, a well field in Carson Valley could impact on the Carson River basin supply, which in turn impacts on the Truckee River diversions and the Pyramid Lake controversy.

PROBLEM RESOLUTION

Essential to any solution of the water use conflict will be the consummation of a compact with California which adequately reflects the present and future needs of the two States and the affected Indian Nations. The effects of the compact should be evaluated and a determination made to see whether there will be a need to augment existing water supplies in the State from other sources.

Decisions on the maintenance of Pyramid Lake levels will set the direction and scope of all solutions. To compare the consequences, the State Water Plan Report outlines four alternative plans: a "without plan" situation which projects existing trends, a development oriented plan of projects to alleviate specific water problems (Watasheamu, Carson City protection works, Fallon Area irrigation improvements, four watershed projects), and two environmental quality plans: one which maintains Pyramid Lake at its present level and one ignoring lake levels but achieving other environmental objectives, such as the Stillwater Wildlife Management Area and other wetlands in the Lahontan Valley.

CONCLUSIONS

1. A significant Federal involvement exists in this interstate basin due to the many federally sponsored water-related programs and large Federal land holdings.

2. Past planning efforts have essentially exhausted the more feasible potentials for solution of the water allocation problems.

3. Most future allocations and developments are constrained until a decision is reached on water rights and allocation. Although the prospects of better water utilization and management seem apparent, as at least a partial solution, it does not get to the fundamental resolution of water rights. Until legal proceedings determine each claimant's rights, binding agreements and trade offs cannot be negotiated.

RECOMMENDATION

1. The State's Water Planning Studies should be expanded to provide for the completion of a State-Federal level B total water management study for the Truckee-Carson River basins under recently adopted and approved multiple objective planning procedures. In anticipation of court rulings, alternative action plans should be evaluated to permit initiation of level C studies or approved action programs in accordance with judicial or legislative decisions.

NO. 2 – POLLUTION OF THE LAS VEGAS ARM OF LAKE MEAD BY WASTE WATER AND SUBSURFACE INFLOWS

SUMMARY

For many years, municipal and industrial wastes from the Las Vegas Valley have been discharged into Las Vegas Wash, polluting Lake Mead and the Colorado River. The pollution problem is divisible into: (1) identifiable surface waste waters; and (2) subsurface saline ground-water movement towards Lake Mead. The former is readily resolvable by conventional methods, whereas solution of the latter may be more difficult. Several proposals have been developed, however.

DISCUSSION

Pollution results from a multitude of sources: secondary treated effluent from the city of Las Vegas; secondary effluent from the presently overloaded Clark

County Sanitation District plant; highly saline cooling water from two powerplants; highly saline industrial wastes from the Basic Management, Inc., complex at Henderson; secondary effluent from the city of Henderson; agricultural and domestic return flows; and septic tank effluents. Secondary treated sewage effluents are approximately 40 Mgal/d (40,000 acre-feet/year). When these wastes enter Lake Mead, algae feed on nutrients and form unsightly and odorous blooms in the Las Vegas Bay arm of the lake. The dissolved solids (salts) in the water (some 400 tons each day) mix in the lake and eventually flow downstream to water users in Arizona, California, and Mexico.

A significant factor to the situation and to solving the pollution problem is the operation of the Colorado River Compact which for Nevada limits the difference between withdrawals from Lake Mead and associated identifiable return flows to 300,000 acre-feet. Should Las Vegas and the surrounding area continue their rapid growth, this limit might be reached as soon as 1990.

On December 23, 1971, the Environmental Protection Agency instituted a 180-day enforcement action against the major polluting governmental agencies and industries. That agency presented evidence at a hearing on January 25, 1972, documenting the sources of the discharges and the violations of interstate water quality standards for Lake Mead and the Colorado River.

The Las Vegas metropolitan area has a resident population of approximately 300,000 people (1972 estimate). Gross water use is approximated at 150,000 acre-feet/year. Of this, something over 70,000 acre-feet/year is pumped from the aquifer of Las Vegas Valley and the remainder, 80,000 acre-feet, is pumped from Lake Mead.

The growth rate of the Las Vegas metropolitan area since the mid-1930's when the Hoover Dam was constructed has been as rapid as any area in the United States and State projections indicate a continued rapid growth. These projections, together with estimates of the amount of water needed and the sources from which it will be obtained, are presented below.

These water supply projects are based on the assumption that 30 percent of the total demand will be supplied indirectly through the use of reclaimed waste water. It is not proposed that the reclaimed waters be used directly, but rather the waste water would be used to recharge the local aquifer and to maintain water balance which would permit pumping from the aquifer at a distant location.

Table VI-31 indicates that full use of Nevada's Colorado River entitlement and extensive waste-water reclamation would be needed relatively soon. Although such a waste-water reclamation system may sufficiently resolve surface-related pollutants, the subsurface problem is not ameliorated and could be aggravated by injection of waste waters of poor quality.

Table VI-31.—*Estimates of population, water demand, and water sources for the Las Vegas, Nevada, metropolitan area, 1970 through 2020*

	Actual	High estimate			Low estimate		
Year	1970	1980	1990	2000	1980	1990	2000
Population	270	500	750	1,000	310	450	625
Water sources		(thousands of acre-feet per year)					
Wells	86	50	50	50	50	50	50
Lake Mead	37	260	258	266	260	258	265
Waste-water reclamation	10	81	118	170	49	75	106
Total supply	132	391	426	486	359	383	422
Demand	132	270	392	566	164	249	362
Surplus or (deficit) with waste-water reclamation	–	121	34	(80)	195	134	70
Surplus or (deficit) without waste-water reclamation	–	40	(84)	(250)	146	59	(46)

Source: "Water for Nevada": Special Report prepared by Montgomery Engineers for Nevada State Engineer's Office on "Water Supply for the Future in Southern Nevada," January 1971.

PROBLEM RESOLUTION

An initial plan was adopted by the Las Vegas Valley Water District and approved by the Environmental Protection Agency and other Federal agencies by which waste water would be collected and pumped a distance of 25 miles to a natural closed basin known as Dry Lake, where the waters could be allowed to evaporate, leaving the solids behind in the basin. Sufficient treated water would be allowed to flow down the wash and canyon to maintain the "greenbelt" which has already developed along its course, thus providing for continuation of cover, food, and water for wildlife and development as a recreation area. The initial plan also called for a pilot tertiary treatment plant and a pilot desalting plant, working together to explore the potential of reclaiming the major portion of the waste water for recharge into local aquifers and ultimate reuse.

However, in 1973 the Nevada Legislature rejected the proposed sewage effluent plan and directed the Clark County Commissioners to formulate other solutions. Accordingly, further studies identified the following objectives to be considered for any project selected for implementation:

1. Material reduction or elimination, if possible, of pollutants now entering Lake Mead from Las Vegas Wash.

2. Protection and best use of the water resources of the area.

3. Minimization, to the greatest extent possible, any adverse economic or environmental impact of any plan developed.

4. Development of an interim plan, if possible, for the immediate relief of the problems caused by Las Vegas Wash.

The studies further concluded that none of the alternatives as planned will completely meet the project goal of eliminating the pollution of Lake Mead. An unknown amount of highly saline ground water will continue to surface in Las Vegas Wash and flow into Lake Mead when direct discharges are stopped. Irrigation of existing and new greenbelt areas will raise the water table of the near surface aquifer, and decrease its quality. This water will flow downslope and surface in Las Vegas Wash, contributing to the pollution of Lake Mead. Construction of a dam or collection device near Lake Mead could intercept this water except during times when storm water flows in the wash.

Prevention of the salt loading to Lake Mead and the Colorado River system is closely related to the ongoing Federal Colorado River Water Quality Improvement Program. The effects of the saline ground water control portion of the Las Vegas Wash pollution abatement program are important in developing plans for dealing with salinity problems in the entire Colorado River basin. It would appear that the annual salt input to Lake Mead through the Las Vegas Wash of 200,000 tons could be prevented from entering the river system.

Recreation has been considered as a project purpose under the recommended project alternative but plans are still broad in scope. One proposal has called for a system of trails for hiking, bicycling, and horseback riding. Another proposal has been for the establishment of a wildlife refuge with associated self-guided instructional walkways.

On September 1, 1973, the Clark County Board of Commissioners submitted a report to the Governor and Legislature which recommended that an alternative plan be prepared to de-emphasize export of effluents as proposed by the Las Vegas Valley Water District and place primary emphasis on advanced waste treatment. A special Bureau of Reclamation report outlines possible approaches to a solution of the problem. One plan for reducing the salinity contribution of the ground-water component includes an underground interception facility, a delivery system, a reverse osmosis desalting plant, a brine discharge and evaporation system and a surface flow-bypass system. The product water from the desalting plant would be available for reuse in the valley or released to Lake Mead.

CONCLUSION

1. The local entities can satisfactorily treat the M&I surface wastes in order to meet Environmental Protection Agency enforcement action. However, treatment of saline ground-water outflows is more complex and should be considered as a part of the Colorado River salinity control program. Additional detailed studies under ongoing programs are needed to develop plans to treat saline ground-water inflows.

RECOMMENDATION

1. Existing authorities and programs should be continued with State and local interests completing their plans for control of surface water treatment. Treatment of underground waterflows should be made a

part of the Federal Colorado River Water Quality Improvement Program. No new or additional studies are recommended at this time.

NO. 3 – THE NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATION

SUMMARY

There are 21 Indian reservations covering about 1.3 million acres in the State of Nevada. About five-eighths of the State's Indian population of about 8,000 reside on reservation lands, the four largest being Pyramid Lake, Walker River, Duck Valley, and Goshute. Table VI-32 presents population and area of Nevada's Indian Reservations. The problem of declining lake levels, increases in salinity, and severe competition for available water supplies between Indian and non-Indian users is evidenced in widespread areas of the State. As in many states, there is a pressing need to determine the Indian water requirements and clarification of their water rights which affects efforts to improve Indian livelihoods in these areas where water is the prime factor of life.

DISCUSSION

Although Nevada's Indian population is small, it holds significant land and water resources. Statewide, almost 50,000 acres of Indian lands are irrigated, over 6,000 in the Walker River Reservation. The Pyramid Lake situation has already been presented and a subsequent item covers the Walker Lake area. There is a high concern for the present and future allocation and development of water resources as it affects the community environment; unemployment in 1970 was 35 percent whereas the median family income was little more than $2,000. Crucial to improvement of

Table VI-32.—*Nevada Indian population by reservation, 1969*

Reservation	Tribes	1969 Population	Area (acres)
Battle Mountain Colony	Shoshone	159	680
Carson Colony	Washoe	129	156
Dresslerville	Washoe	153	40
Duck Valley	Shoshone, Paiute	990	289,819
Duckwater	Shoshone	63	3,785
Elko Colony	Shoshone	140	195
Ely Colony	Shoshone	31	10
Fallon Colony and Reservation	Paiute, Shoshone	329	5,480
Fort McDermitt	Paiute, Shoshone	353	34,650
Goshute	Goshute	109	108,094
Las Vegas Colony	Paiute	85	10
Lovelock Colony	Paiute	136	20
Moapa	Paiute	73	1,174
Pyramid Lake	Paiute	900	475,086
Reno-Sparks Colony	Washoe-Paiute	553	29
South Fork	Shoshone	102	15,156
Summit Lake	Paiute	1	10,506
Walker River	Paiute	375	320,511
Winnemucca	Paiute	30	340
Yerington Reservation and Colony	Paiute	198	1,166
Yomba	Shoshone	61	4,682
	Totals	4,950	1,271,589

Source: EDA Handbook, February 1971.

Indian life will be the enforcement of final water resource decrees. Court proceedings are needed, such as those finally begun on the Truckee. However, without technical data to support these judicial determinations, they will be always subject to challenge.

CONCLUSIONS

1. The problem of declining lake levels, increases in salinity, and severe competition for available water supplies between Indian and non-Indian users is evidenced in widespread areas of the State.

2. The determination of Indian water requirements demands immediate attention so that Nevada can proceed with an orderly and confident program of water allocation and use which reflect adequate consideration to Indian development goals and objectives. The determination of Indian water rights to streamflows emptying into Pyramid Lake are presently under consideration in the courts.

RECOMMENDATION

1. Special studies should be conducted by the Bureau of Indian Affairs, with technical assistance from other Federal and State agencies, for each reservation so that Indian water requirements can be determined.

NO. 4 – NEED FOR REGULATION AND MANAGEMENT OF WATER SUPPLIES IN THE HUMBOLDT RIVER BASIN

SUMMARY

The Humboldt Valley comprising primarily the Humboldt River and tributaries, is a high, semiarid plateau crossed by numerous steep mountain ranges separated by broad, flat valleys. Practically the entire area along the Humboldt River (about 300 miles long) and lower reaches of its tributaries is subject to damage from flood overflow. Flooding causes damage to adjacent lands, public facilities and agricultural production. The flow of the Humboldt River, both in amount and distribution, generally results in ill-timed and deficient water supplies for irrigation. The latter is due to a lack of facilities to store late spring and early summer excess flows for later use. Existing authorized project currently in the preconstruction phase will be reevaluated under a total water management concept to include nonstructural measures and recognition of instream flow values and other environmental purposes.

DISCUSSION

The principal economic activity in the sparsely populated Humboldt basin is livestock raising and the basin's irrigated land is generally devoted to the production of hay and alfalfa for livestock. The area receives limited annual precipitation with the exception of occasional violent local thunderstorms. Precipitation on the upper one-third of the basin falls primarily as snow and accounts for approximately 80 percent of the runoff from the entire river system.

Irrigation for crop production is the major use of water in this area. Presently about 343,000 acres are being irrigated by waters from both underground and surface sources, but, irrigated agriculture is inhibited both by inadequacies in water supply and inefficiencies of existing structures. Many places could use additional storage to capture the spring floods, for later release during periods of low flow, now lost to the Humboldt sink and subsequent evaporation.

To enhance fishery there is a need for regulated streamflow to offset low summertime flows and corresponding high water temperatures.

PROBLEM RESOLUTION

The Nevada State Water Plan, being developed by the State of Nevada with Federal agency assistance considers three alternative plans:

(1) A "without plan" condition following existing trends,

(2) An economic efficiency plan, and

(3) An environmental quality plan.

The Upper Humboldt Storage project which includes three authorized (Corps of Engineers) reservoirs is an essential element of both economic development and the environmental quality plans. These reservoirs, Hylton on the South Fork of the Humboldt River, Devil's Gate on the North Fork of the Humboldt River, and Vista on the Marys River would prevent 85 percent of the total flood damages that are expected to occur in the basin. In addition, they would provide a new yield of about 18,000 acre-feet of stream runoff annually for more effective irrigation use. These reservoirs, including inactive pools, would provide additional outdoor recreational opportunities. The reservoirs will be used for boating, swimming, water skiing and fishing. During low water years and in winter seasons, the impoundments would provide fairly good holdover pools for maintenance of fisheries.

Presently under study are plans to raise the height of the existing Rye Patch Reservoir near Lovelock, Nevada. The three authorized upstream reservoirs would be operated in coordination with the operation of Rye Patch. A completed type IV Study in the upper Humboldt drainage area by the Department of Agriculture contains proposals in the upper watersheds which are not in competition with the authorized reservoirs.

Elko City and County, some local interests, and the State actively favor construction of the project. The Nevada State Legislature in April 1973 passed a bill endorsing the Upper Humboldt Storage project. The Upper Humboldt Water Users Association of Nevada opposed the project as originally planned and sought judicial relief unsuccessfully. However, strong pressures toward nonstructural solutions to water problems have resulted in a growing recognition that a total water management plan may provide the best long-range water plan. Improvement of delivery systems and operations may be practical through application of automated scheduling and irrigation management. The Humboldt River scope of development may be increased by a proper combination of structural and nonstructural measures.

The Upper Humboldt Storage project has now advanced to the reconstruction planning phase. The draft environmental statement is scheduled for submission to the Council on Environmental Quality in 1976 with the final statement scheduled for submission in 1977.

CONCLUSION

1. Completion of the State Water Plan and its subsequent public airing will insure that the desires of the public are known and subsequent plans evaluated in light of the public's wishes. Significant gains in water effectiveness could be achieved through implementing "total water management" concepts in conjunction with surface water control in the upper basin. Changing public attitudes towards recreation and environmental considerations should be accommodated in the final planning efforts.

RECOMMENDATION

1. **Previous or ongoing studies and projects adequately address the problems. No new studies beyond those now in progress are recommended.**

NO. 5 – DECLINE IN SURFACE AREA AND QUALITY OF WALKER LAKE

SUMMARY

Walker Lake is the terminus of Walker River in the Walker River basin. As its natural inflow becomes reduced, as upstream use increases, a compounding increase of lake salinity results. Without changes in the recent trend, survival of the freshwater fishery is threatened. However, recent studies indicate that costs to protect the freshwater fishery far exceed the present and foreseeable economic benefits as a fishery. In contrast, other economic benefits accrue today from development of rim lands as the lake recedes. Future economic returns could occur if extensive iron and other mineral resources are developed upstream. The average annual decline is 2 feet even though it rose 8 feet in 1969. Present water quality is poor with the salinity currently measuring 9,000 milligrams per liter.

DISCUSSION

Wells, springs, and streams in the basin yield 330,000 acre-feet/year of which 145,000 is consumed, 85 percent (133,000 acre-feet/year) by irrigation.

Much of the preceding discussion on the Carson-Truckee/Pyramid Lake area applies also to the Walker River basin and its terminal lake. Lake stabilization data similar to those presented for Pyramid Lake are listed in table VI-33.

Two major differences from the previously discussed Pyramid Lake are: the Walker River Indians are using the bed of the receding lake as a community livestock pasture, and the unpopulated nature of the area and the lake's present use do not create adequate justification for existensive programs.

According to 1967 data, 11 percent of the land area in the Walker River basin is privately owned, 1.1 percent is owned by the counties and the State, 11.9 percent comprises Indian reservations, 5.9 percent is owned by the Navy, and the remainder, 70 percent, is administered by the Forest Service and the Bureau of Land Management. The basin has 2.7 million acres: 38,000 are urban and industrial, 120,000 are irrigated cropland (private development) and 48,000 are water surface in lakes, reservoirs, and streams. Approximately 83,000 irrigated acres are in Nevada, with the remainder in California. Of the total basin irrigated acreage, 52,000 are cropland, and 68,000 are permanent pasture. There

Table VI-33.—*Walker Lake*

Lake stage (MSL)	Decline from 1965 level (feet)	Required river inflow (1000 ac-ft/yr)	Volume (10^6 ac-ft)	Area (1000 acres)	Dissolved solids content[1] (mg/l)	Time[2] (years)
3,972.7[3]	0	147	3.10	39	8,700	0
3,900	73	81[4]	.73	25	37,000	83
3,868	105	50	.11	14	100,000	64
3,862	111	37	.05	11	100,000	58

[1] Assumes that variations from the present-day dissolved solids tonnage (about 36½ million) will be minor. Actual dissolved solids contents may be greater than those indicated for lake stages below 3,972.7 feet because of apparently significant tonnage increases with time (similar situation does not apply at Pyramid Lake).
[2] Time required to reach indicated lake stage from 1965 stage.
[3] Lake stage in 1965.
[4] Inflow value for 1931-60 reference period, modified to 1965 level of development.

are also an estimated 88,000 acres of phreatophyte growth (pasture and wildlife uses) with a consumptive water use of about 100,000 acre-feet per year. The agricultural activity is heavily oriented toward livestock. A significant iron ore deposit is located in Mason Valley and Anaconda has a large open-pit copper mine which constitutes the present principal mineral activity at Weed Heights. A large Naval munitions depot is located at Hawthorne, near the southern tip of Walker Lake.

The population of the basin was 12,500 in 1970 and is projected to reach 19,500 by the year 2000. Of 6,000 workers, 2,600 are employed by Government (most at the Naval munitions depot) and 1,700 by the service industry (including lodging, restaurant, and casino workers). Approximatey 6,000 people live in the Hawthorne area and about 5,000 in the Mason Valley-Weed Heights area.

The Walker River Indian Reservation, through which the Walker River flows, comprises over 300,000 acres and is located immediately north of Walker Lake. Of the 6,300 acres irrigated by diversion from the river, 1,800 are intensive and 4,500 are by semicontrolled wild flooding. Full development of the reservation's potential has been limited due to lack of funds, and to the inadequacy of the 10-acre plots to support a livelihood. The Pyramid Lake Indians principally use their lake as a fishery. This is not the case with Walker Lake which lies adjacent to the reservation. The tribe has over the years used the receding lake bed for livestock grazing; however, the economy is principally dependent on the annual flows of the Walker River. The tribe uses these waters to support a multitude of needs ranging from agricultural production to sustaining the requirements for fish and wildlife habitat.

Antelope, Smith and Mason Valleys experience flood damage by winter rainstorms and spring snowmelt, and irrigation water deficiencies during the summer dry season. Leaky canals and ditches require large diversions in order to maintain the necessary supplies at lower points on the ditches. Additional regulation of streamflow could enhance fishery in both Antelope Valley and between Topaz Reservoir and Wilson Canyon. After leaving Smith Valley, the West Walker joins the East Walker and passes through the copper and potential iron ore mining area in Mason Valley, then into Walker Lake.

The large distances between storage facilities and use points such as between Topaz Reservoir and Mason Valley and between Bridgeport Reservoir (on the East Walker in California) and Mason Valley cause a significant time lag between release and delivery. The periodically required heavy releases cause erosion, sedimentation, and high turbidity which are harmful to stream fishery and cause high stream and ditch maintenance costs. This problem would seem to have a solution in improved scheduling practices.

The city of Hawthorne experiences water quality deficiencies and unreliable quantities. Municipal water-supply reservoirs on Corey Creek and Cat Creek are susceptible to heavy sedimentation.

PROBLEM RESOLUTION

The State Water Plan Report on the Walker River basin, presents five alternative plans for public review and consideration. These are:

1. A plan emphasizing nonstructural solutions.

2. An economic development plan oriented towards improving agriculture water supplies, upstream recreation, and the sport fishery. Major facilities include Pickel Meadows (California), Hudson, and Strosnider Reservoirs and the Bridgeport (California), and Pumpkin Hollow Irrigation Improvement projects but maintenance of Walker Lake is not included.

3. An economic efficiency plan emphasizing full development of mineral resources (the most promising are extensive iron ore bodies in Mason Valley which also has the most irrigated acres). The Pumpkin Hollow project is not included, and Strosnider's function upstream from Weed Heights is changed to service the mining industry.

4. An environmental quality plan maintaining Walker Lake at its present level, through decreases in upstream uses or improvements in upstream use to reduce consumptive losses.

5. An environmental quality plan consistent with existing development which would alleviate the Walker Lake situation by construction of a dam across the northern end of the lake to create a freshwater upper lake.

CONCLUSION

1. Available studies are not adequate to delineate alternative plans to facilitate local decisions. Of concern to lower river and lake users is that upstream development will impact on the incoming water quality under the economic efficiency alternative directed towards large scale mining. Should such a course be taken using the leaching method, quality of return flows to upper basin users would have adverse impacts on their lands.

RECOMMENDATION

1. A State-Federal level B study should be completed by 1980.

NO. 6 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

Nevada's future needs for a very small fraction of the region's total where a peak power demand for the Lower Colorado region (mostly Arizona) of 8,300 megawatts by 1980 and 174,700 megawatts by 2000. Southern Nevada is increasingly being viewed as a site for coal, oil, and nuclear-fueled powerplants due to its water supplies, proximity to the Utah-Arizona coal and oil fields and the Los Angeles load center, its sparse population, and the existing power circuits emanating from Hoover and Davis Dams. Close coordination is needed between the State of Nevada which must sanction these plants and permit water use and Federal agencies which have to grant sites and easements on Federal lands.

DISCUSSION

Several southern Nevada desert valleys appear to have potential as sites for either coal or nuclear-fuel powerplants since the ground-water resource and runoff from surrounding mountains could be used for cooling water. As high-voltage transmission lines in the region become loaded, new lines would be necessary for export of power to California. An alternative would be to use the power in mining and processing of Nevada copper reserves.

The nearest source of coal is Southern Utah. For 1,000 megawatts, a nuclear plant would have an estimated consumptive water use of 25,000 acre-feet/year versus 15,000 acre-feet/year for coal.

Although precipitation is only about 7 inches per year, runoff occurs in numerous intermittent streams which may infiltrate to the ground water in alluvial fans at the base of the mountains. Thus, the ground- and surface-water resources may not be distinct with regard to usable quantities.

Big Smoky Valley apparently has the most extensive ground-water resource in the subregion. Ralston Valley, Stone Cabin Valley, and Hot Creek Valley, which are east of Big Smoky Valley, have similar but smaller ground-water resources. Other significant valleys in the subregion are Monitor, Antelope, Little Fish Lake, Little Smoky, Reville, and Railroad. All appear to have potential for powerplant siting.

For example, in the Tonopah Desert and specifically Big Smoky Valley, west and north of the town of Tonopah, the ground-water budget (inflow and outflow) is estimated at 14,000 acre-feet per year in the Tonopah Flat portion of the basin and 65,000 acre-feet per year in the northern part. Ground-water storage volumes are 70,000 and 50,000 acre-feet per foot of saturated alluvium respectively, although the depth and thickness of the aquifer are unknown. Respective perennial water yields (amount that can be withdrawn without mining) are 6,000 acre feet per year and 65,000 acre-feet per year. Because Nevada water laws prohibit mining, legislative changes would be required to utilize the apparent large quantities of ground water now in storage.

The population of the area is slightly more than 2,000 mainly concentrated around the town of Tonopah (total subregion populatin is less than 20,000). The valley land is almost entirely federally owned, administered by the Bureau of Land Management, and is bordered by national forest; therefore, the Federal Government would have an interest in development of the groundwater resource. Agricultural activity in the subregion is minor. Mining, construction, and other industry are the major employers.

PROBLEM RESOLUTION

Siting of thermal powerplants would appear to have minimum environmental impact in a remote region such as this. However, possible impact on desert flora and fauna, particularly endangered species, should be evaluated including effects of ground-water drawdown on connected basins and the possibility of eliminating natural springs which might support fish and wildlife. Furthermore, adequate air pollution controls for fossil-fueled plants would be necessary to insure against degradation of air quality within and outside of the region.

CONCLUSION

1. Use of the ground-water resource in the central Nevada desert as cooling water for thermal generating plants with possible supplementation by surface-water storage, appears to be an attractive concept. In the Big Smoky Valley, the example used, perhaps 3,000 megawatts of nuclear capacity could be supported. Since large volumes of ground water might be useable if mining were permitted, a determination of the amount of water stored in the aquifer reservoir is needed for decisionmaking.

RECOMMENDATION

1. A special study be conducted to identify throughout the subregion the volume and yield of the resource, both surface and ground water. Once the ground-water resources are delineated, additional studies may be needed on air and water quality impacts of powerplant siting, fish and wildlife effects, availability of fuels, and requirements for transmission facilities.

NEW MEXICO

New Mexico has a total land area of more than 121,000 square miles placing it fifth in the United States and third among the 11 Westwide States. Space is its keynote – vast limitless stretches of plains, deserts, buttes and mesas. It is a land of contrasts – geographically, socially, and culturally. Slightly more than 1,000,000 people reside in the State, principally in the cities of Albuquerque, Santa Fe, Las Cruces, Roswell, and Clovis. Approximately one-third of the State's population resides in the Albuquerque metropolitan area. The population density is about eight people per square mile.

New Mexico is rich in natural resources. A sizable portion of the total land area is used for agricultural purposes (livestock grazing and farming) but a relatively small percentage of the populatin is engaged in agriculture. This enterprise is still of major importance but the picture is changing as the State becomes more industrialized.

In the per capita income category New Mexico ranks last among the Westwide States and 44th in the Nation. The major income producing sections are Government, services, and wholesale and retail trade. Of the nine income producing sectors identified, agriculture ranks fifth. It is the major economic activity in rural areas.

Minerals comprise one of the State's major economic attractions and resources and New Mexico is the second largest mineral producer among the Westwide States. The most valuable of its mineral products are petroleum, natural gas copper, uranium, and coal. The State produced 90 percent of the Nation's postassium salts and is the Nation's major uranium producer. It ranks third in the Nation in copper production.

Lumbering and the manufacturing of wood products also rank high. From a commercial and industrial viewpoint, the future of New Mexico is highly promising, especially when consideration is given to its vast coal deposits, but presently the State's most rapidly growing enterprise is tourism.

Thirty-four percent of the land is in Federal ownership, and another 44 percent is classified as private. With 9.4 percent of its land classified as Indian Trust lands, it ranks second among the Westwide States in this category. About 70 percent of the land is classified as range or grassland. Only 3 percent of the land is used for growing crops.

New Mexico is a water deficient area with respect to the availability of fresh-water to maintain present irrigated agriculture and to meet other projected needs. Except for small quantities of available undeveloped surface water supplies in the Lower Colorado and Canadian River regions and the committed but not yet used supplies of the Upper Colorado region, the surface supply is fully appropriated and is being used beneficially within the terms of international treaties, interstate compacts, court decrees, and State laws.

WATER SUPPLY

The majority of New Mexico's precipitation is from moist air-masses that periodically traverse the State from the Pacific Ocean and the Gulf of Mexico. However, snowmelt is the main source of runoff.

Reflecting its paramount importance in a semiarid state, water in New Mexico is a commodity owned by the people, and its use is closely governed by law. The institutions affecting water use range from the ancient community ditch association to Federal water importation projects involving interstate compacts, conservancy districts, etc. New Mexico has been a leader among the Western States in terms of ground-water management, extensive use of interstate stream compacts and water right transfers.

Surface Water

The State is a part of five Water Resource Regions – Upper Colorado, Lower Colorado, Texas-Gulf, Rio Grande, and Arkansas-White-Red. The State's major rivers include the Rio Grande, Canadian, Cimarron, Pecos, San Juan, and Gila. The two largest rivers, the San Juan and Rio Grande, enter from Colorado. The San Juan River crosses into New Mexico and back into Colorado in the northwest corner of the State and the Rio Grande bisects the State from north to south. The Gila River, largest in the southwestern part of the State, flows for about 100 miles southwesterly before entering Arizona. The largest stream heading in New Mexico is the Pecos River, which begins in the southern Sangre de Cristo Mountains, and flows southerly for more than 300 miles to the Texas border. The northeastern portion of New Mexico is drained to the east by the Canadian and Dry Cimarron Rivers and their tributaries. Commitments to downstream States under existing interstate compacts and court decrees require delivery of water to those States. When New Mexico has fully developed its surface-water resources within the allowances of interstate compacts and court decrees, river outflow will approximate river inflow and the State will be using about the amount of streamflow that it produces.

New Mexico watersheds contribute about 2.2 million acre-feet per year of surface water to the 2.1 million acre feet that flow into the State. Another 0.11 million acre-feet are imported from the San Juan River Basin in Colorado for a total average annual surface-water supply of 4.4 million acre-feet. However, compacts and international treaties limit the amount of water the State can utilize. Total 1975 water depletions are estimated to be about 2.4 million acre-feet. Further, it is estimated the 1.2 million acre-feet of these depletions (i.e., demands) will be satisfied using surface water and the other 1.2 million acre-feet of demands will be satisfied from ground water. Agriculture in the major water user.

Tables VI-34 and VI-35 summarize New Mexico's estimated 1975 water use and surface-water supply situation.

Ground Water

In addition to the surface-water supplies, New Mexico is fortuante to possess large quantities of water in underground storage. The United States Geological Survey has estimated the magnitude of this supply to be some 20 billion acre-feet, with about one-quarter being fresh or only slightly brackish. Much of the ground water is either of poor quality or would be too expensive to develop under the present techniques. In the areas of the State where the ground water is of good quality and can be economically obtained, development and use is already underway. The draft on the supply in many of these areas exceeds recharge and consequently ground-water levels are receding.

Water Quality

Generally, surface runoff and ground-water discharge in the high mountain areas is of an excellent quality due to the nonsoluble nature of the geologic formations. Water originating from lower areas frequently is of a lesser quality due to presence of more readily soluble materials. As good quality water flows downstream it is subjected to degradation by use and by comingling with other waters containing substantial quantities of dissolved solids acquired through natural processes.

CRITICAL PROBLEMS

The Westwide problems directly affecting New Mexico are discussed in this section in more State-specific detail. Regional problems concerning New Mexico are listed. This portion concludes with detailed presentations of State-specific problems.

Westwide Problems

NO. 2 – MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS FOR SMALL COMMUNITIES. – New Mexico has a number of small communities which need to improve their water supplies from the standpoint of either quality or quantity or both. Areas or major concern are eastern New Mexico; Tularosa Closed Basin, Catron, Grant, and Luna Counties, and communities of northwest New Mexico.

Presently eastern New Mexico communities are obtaining their supplies from the Ogallala groundwater aquifer. The aquifer is in the process of being dewatered due to overpumping. Also the quality of the water is poor with flouride concentrations above recommended limits.

Communities in the Tularosa Closed Basin are currently using highly saline ground water. In the case of Catron, Grant, and Luna Counties development of extensive mineral deposits, especially copper will increase the need for additional M&I supplies. The Indian communities of northwest New Mexico also have water quantity and quality problems. Water use in the development of the coal resource will introduce added competition for a limited water resource.

NO. 5 – NEED FOR ADEQUATE INFORMATION FOR ENVIRONMENTAL PLANNING. – In connection with the development of the coal resources of northwest New Mexico there is a need to determine instream flow needs for the San Juan River below Navajo Reservoir.

In attempting to recover water, a general problem is created through removal of riparian habitat. In the process, dove nesting habitat as well as habitat for other wildlife species can be destroyed. The major problem areas are the Rio Grande below Albuquerque and the Pecos River below Fort Sumner.

Water development projects in New Mexico have significant direct and indirect effects upon wildlife species, including many species that are rare and endangered. Reservoir waters inundate flowing streams and natural lakes which accommodate indigenous species. Removal of riparian vegetation alters streams and adjacent flood plains affecting both fish and wildlife habitat. Reservoirs inundate the habitat of a great variety terrestrial wildlife and intensive recreational uses of reservoirs result in inroads into habitat niches heretofore little trampled by man. Species of fish and wildlife of concern include: Rio Grande darter, Pecos gambusia, lesser prairie chicken, American peregrine falcon, blackfooted ferret, southern bald eagle, greater sandhill crane, Mexican duck and Gila trout, and others. Studies are needed to determine the type and extent of enivronment needed for the continued existence of these rare and endangered species.

Table VI-34.—*Estimated 1975 total depletions*[1] *for New Mexico (1,000 acre-feet)*

Region and subregion	Purpose or cause of depletion							Total depletions
	Irrigation	M&I including rural	Minerals	Thermal electric	Recreation[2] F&WL	Other[5]	Reservoir evaporation	
Rio Grande	634	72	26	7	19	16	110	884
Pecos River	392	16	9	1	7	13	61	499
Total region	1,026	88	35	8	26	29	171	1,383
Texas Gulf								
Brazos and Colorado (Texas)	390	11	4	5	0	3	12	425
Total region	390	11	4	5	0	3	12	425
Upper Colorado								
San Juan-Colorado	102	8	4	25	6	5	84[3]	234
Total region	102	8	4	25	6	5	84	234
Lower Colorado								
Little Colorado	9	2	2	0	1	2	5	21
Gila River	59	1	6	1	1	2	9	79
Total region	68	3	8	1	2	4	14	100
Arkansas-White-Red								
Canadian	203	3	1	0	22	15	55	299
Total region	203	3	1	0	22	15	55	299
State summary	1,789	113	52	39	56	56	336	2,441[4]

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] Exclusive of instream flow use.
[3] Includes New Mexico's share of Colorado River main stem reservoir evaporation. Average annual main stem reservoir evaporation assumed to be 520,000 acre-feet; New Mexico's share, 58,000 acre-feet.
[4] Surface-water depletions — 1,171,000 acre-feet; ground-water depletions — 1,270,000 acre-feet. The portion of the ground water that was mined is as follows: Rio Grande Region: Rio Grande Subregion, 116,000 acre-feet, Pecos River Subregion, 120,000 acre-feet; Texas-Gulf Region: Brazos-Colorado (Texas), 411,000 acre-feet; Lower Colorado Region: Gila Subregion, 40,000 acre-feet; Arkansas-White-Red Region: Canadian Subregion, 50,000 acrefeet.
[5] No depletions are attributed to consumptive conveyance losses.

Table VI-35.—*Estimated 1975 surface water-related situation in New Mexico (1,000 acre-feet)*

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within subregion or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Rio Grande									
Rio Grande	315	639	110	1,064	0	768	296	245	51
Pecos River	0	459	0	459	0	379	80	80	0
Total region	315	1,098	110	1,523	0	1,147	376	325	51
Texas-Gulf									
Brazos and Colorado (Texas)	0	14	0	14	0	14	0	0	0
Total region	0	14	0	14	0	14	0	0	0
Upper Colorado									
San Juan-Colorado	1,779	250	0	2,029	0	234	1,795	1,752	43[5]
Total region	1,779	250	0	2,029	0	234	1,795	1,752	43
Lower Colorado									
Little Colorado	0	56	0	56	0	21	35	19	16
Gila River	0	215	0	215	0	39	176	158	18[6]
Total region	0	271	0	271	0	60	211	177	34
Arkansas-White-Red									
Canadian	0	560	0	560	0	249	311	203	108
Total region	0	560	0	560	0	249	311	203	108
State summary	2,094	2,193	110	4,397	0	1,704	2,693	2,457	236

[1] Modified inflow reflects the effects of depletions upstream of Statelines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] Represents the remaining amount of water New Mexico can develop from the waters of the Colorado River System assuming 5.8 million acre-feet availability to the Upper Colorado River Region States adjusted for 1975 depletions; San Juan-Chama export 110,000 acre-feet; and Navajo Indian Irrigation project, 226,000 acre-feet; and Animas-La Plata project, 34,000 acre-feet.
[6] Additional development permitted by Colorado River Basin Project Act P.L. 90-537.

NO. 6 – NEED FOR ADDITIONAL FLAT WATER RECREATION OPPORTUNITIES' – In New Mexico, the Rio Grande Valley in the general vicinity of Albuquerque has been identified as one of the most critical areas of need for additional recreation surface water. Several Federal reservoirs in New Mexico have been identified for high-priority study to determine if greater economic and social benefits could be realized by reallocation of stored waters and/or modification of operations. They include: Alamogordo, Elephant Butte, El Vado, Abiquiu, and Jemez Canyon.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. – A portion of the Rio Grande and tributary Red River in northern New Mexico is already in the National Wild and Scenic Rivers System.

One New Mexico River, the Gila – specifically the segment upstream from the Arizona-New Mexico boundary line to the river's source including its principal tributaries but exclusive of the authorized Hooker Reservoir site – has been included in the new "Administration bill," which calls for study of 32 high-priority rivers, 16 of which are within the Westwide States, to determine their potential for addition to the Wild and Scenic Rivers System.

Other New Mexico rivers identified by the State Study Team as having significant free-flowing values include Cimarron Creek and the Canadian, Lucero, Pecos, Rio Penasco, Rio Pueblo, Rio Guadalupe, San Francisco, and San Juan Rivers.

Regional Problems

New Mexico is vitally interested in Regional Problems one and two relating to the quantity and quality aspects of the Colorado River. They are:

NO. 1 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

NO. 2 – INCREASING SALINITY IN THE COLORADO RIVER

State Specific Problems

Because of its arid southwest location, New Mexico's water supply is one of its most important and valuable assets and generally is considered the key factor affecting future economic growth and quality of life in New Mexico. The water supply in the State is critically limited when compared with the amount of water needed. The water-related problems facing the State emphasize the urgency; first, of properly using the remaining undeveloped waters of the State; and second, of planning for the most efficient use of existing water supplies.

Since the State is fast approaching full utilization and development of available water supplies, conversion of water use to higher economic uses will play an important role in the future. In addition, further development of the ground-water resources will be needed. This will involve desalting of the brackish waters for many uses. Mining of extensive ground-water deposits for short-term benefit may play a role in total water management of the water resource. However, as pointed out in New Mexico No. 3, excessive mining without regard to long-term recharge capabilities of the aquifer can result in serious economic dislocations.

The following problems are discussed in more detail in the remainder of New Mexico section. The location of these problems are shown in figure VI-13.

NO. 1 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 2 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 3 – ADVERSE EFFECTS OF DECLINING GROUND-WATER TABLES ON THE ECONOMY OF EASTERN NEW MEXICO

NO. 4 – LAND AND WATER RESOURCE PROBLEMS OF THE RIO GRANDE BASIN INCLUDING THE PECOS SUBBASIN

NO. 1 – WATER REQUIREMENT TO MEET ENERGY DEMANDS

SUMMARY

At this time New Mexico's water-related energy problems are concentrated in the northwest part of the State where electric power is being developed from coal to meet regional energy needs primarily in parts of the southwest outside of the State. More thermal power development is planned; however, recent information indicates that coal gasification may be the predominant method of development of the coal energy resource. A major roadblock to further development of the coal resources is water supply. Also, the area has many environmental attributes and there is

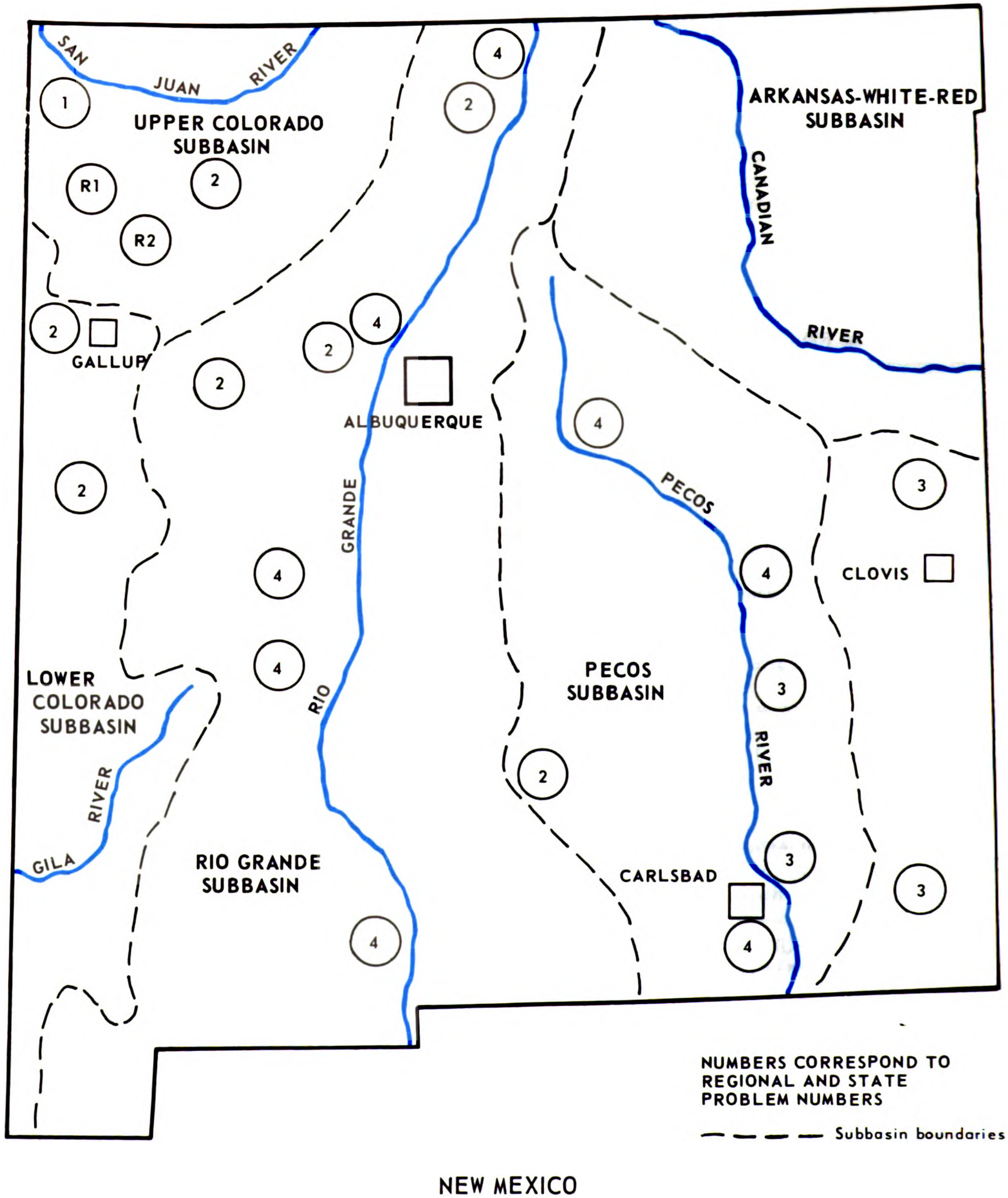


Figure VI-13. Critical water problems in New Mexico.

concern about the effects additional development will have on land and water environments. Problems and needs of Indian tribes in the area who are concerned about economic and social progress through coal development and also protection of the environment create increased pressure for resource evaluation in the area.

In the remainder of the State there are currently no major water supply problems associated with energy development. However, because of limited water supplies, finding suitable powerplant sites is expected to become a major problem in later time frames.

DISCUSSION

The coal industry in New Mexico has recently been revitalized with the development of power-producting facilities in the Four Corners area, to meet southwest regional electric power demands. In addition, coal gasification development is emerging as a major new industry. Private industry announcements, press releases, and the State-Federal study team estimates have indicated that gasification plants could be in operation before 1980.

Thermal Power

New Mexico, in 1970 had, an installed capacity of 3,500 MW, using about 28,600 acre-feet of water. The Western States Coordinating Council and the State-Federal study team have made projections of future powerplant developments and related water requirements.

These projections are shown in Table VI-36.

Table VI-36.—*New Mexico total projected plant capacity and related water requirements*

Year	Plant capacity MW	Water requirement acre-feet
1970	3,500	28,600
1985	4,650	33,000
2000	14,000	67,000

Source: Western System Coordinating Council.

The above projections for the year 2000 are based on the assumption of advanced cooling technology and extensive use of irrigation wastewater.

Coal Gasification

Coal gasification is an emerging industry. Its rate of growth and the degree to which gasification will replace thermal power as a mode of energy export from the region make projections of future water requirements uncertain. Coal gasification plants will likely use dry cooling towers, and thus water requirements for a given amount of energy development could be reduced as compared to conventional thermal-electric generation. Table VI-37 shows development with related water requirements expected to take place before 1990.

Table VI-37.—*New Mexico coal gasification water requirements*

Company	Ultimate plant capacity (million cubic feet per day)	Annual water requirements (acre-feet)
Utah International	1,000	33,000
El Paso Natural Gas	750	30,000

Coal-related energy development will take place in northwest New Mexico while nuclear development is expected in the remainder of the State. There are an estimated several billion tons of strippable coal reserves in the State, most of which are located in San Juan and McKinley Counties of northwestern New Mexico. These latter coal reserves, which are on Indian lands, usually contain less than 1 percent sulfur.

The majority of New Mexico's power development is currently concentrated in this area. Presently, 2,260 MW of installed capacity are located in this area using about 16,400 acre-feet per year of San Juan River water. Electrical energy development in this area of the State is projected to increase to 3,600 MW by the year 2000 with a corresponding water requirement of 58,000 acre-feet.

All coal gasification development is expected to take place in this area. The extent of coal development in the area will be controlled by water supply and environmental considerations. Critical water-related problems associated with the development of strippable low sulfur coal in the northwest portion of New Mexico are discussed in the following section. The primary problem is to obtain a water supply for coal subject to all legal commitments and to give full consideration to protection of the area's environmental attributes.

The San Juan River basin in New Mexico is the only portion of the State in the Upper Colorado River basin. Presently, some of the San Juan River surface water supply is not being used, but most of the unused supply has been allocated to the San Juan-Chama, Navajo Indian Irrigation, and Animas-La Plata projects, and 7,500 acre-feet have been reserved for municipal and industrial use at Gallup. In addition, companies (mostly electric power producing concerns) have contracted with the Secretary of the Interior for over 64,000 acre-feet of water.

Under terms of the Colorado River Compact and the Upper Colorado River Basin Compact, New Mexico's entitlement to Upper Colorado River Basin water, based on 7.5 million acre-feet availability, is estimated to be 838,000 acre-feet of consumptive use annually. Recent water supply records suggest that the average flow of the Colorado River may be less than previously estimated. These most recent estimates indicate that at site depletions would be limited to 770,000 acre-feet. Main stem reservoir evaporation would reduce this to a usable supply of only 665,000 acre-feet.

New Mexico's share of Colorado River water is from the San Juan River. Under present flow conditions, enough water is physically available to New Mexico in the San Juan River to permit depletion of over 1 million acre-feet. However, because of the statements made in the above paragraph, the amount of water available for use in New Mexico is 770,000 acre-feet. The Secretary of the Interior has determined that 100,000 acre-feet of water is conditionally available for a limited period of time from Navajo Reservoir for M&I purposes. The 100,000 acre-feet was determined to be available through the year 2005 in Report No. 1106, 90th Congress, Second Session, dated February 27, 1968, on S.J. Res. 123, which provided for Congressional approval of certain water delivery contracts from Navajo Reservoir. Review and reevaluation of all existing contracts, permits, or reservations of water rights, etc., is to be made by the year 2005 prior to reissue of contracts and permits for use of the water supply. Presently 64,000 acre-feet of this 100,000 acre-feet is under contract to energy companies. In addition, the State has approved additional allocations of water to the energy industry which if implemented, would bring total water use for energy purposes to 132,000 acre-feet annually.

It is expected that strip mining will be the predominant mining methods in coal production. It will be necessary to restore strip-mined areas; however, there is a critical need for more information on the techniques of restoration. In the arid West, typical of New Mexico, the native fragile ecosystems need detailed research on drainage, ground water, soil types, and vegetation studies to determine the best way to restore mined areas to have a minimum adverse long-range impact on the environment.

The area also has many environmental attributes. Tributaries to the San Juan River have been mentioned for inclusion in the National Wild and Scenic Rivers System. There are opportunities for realization of instream flow values below Navajo Reservoir.

In other areas of the State there are no significant energy-related problems at this time. As indicated in the projections, nuclear fueled powerplants are expected to assume a larger share of the generation after 1985. Consideration should be given to joint Federal-State analysis of powerplant sites with respect to land, water, and environmental requirements well before the sites are needed.

PROBLEM RESOLUTION

In northwest New Mexico, existing problems can be expected to become more acute with time. In the remainder of the State, no significant problems are expected to occur before 1985.

The main problems of the northwest related to obtaining adequate water supplies for continued coal development and limiting and correcting the land use impacts associated with strip mining. There are several solutions to the water supply problem. These include:

1. Provision of new water through augmentation by weather modification or other means.

2. Limitation on development of the coal resource.

3. Mining and transport of coal to load centers.

In the case of the weather modification alternative, it has been estimated that a weather modification program could increase present streamflows to Navajo Reservoir by 63,000 to 115,000 acre-feet on an average annual basis. This could increase in whole or in part the available water supply to New Mexico. Tributaries to the San Juan River below Navajo Reservoir would also experience increases in runoff. Presently the Bureau of Reclamation has a pilot weather modification program under way in the San Juan subregion to test operating procedures and evaluate weather modification potential.

From the land use and strip-mine reclamation standpoint, studies are needed to determine what is the best solution for this area. Restoration to premining conditions would be one alternative. However, other uses of the land should be considered, including establishment of irrigated agriculture, wildlife habitat, and parks.

CONCLUSIONS

1. There is an extensive and economically developable coal resource located on Indian lands in northwest New Mexico.

2. New Mexico entitlement to Colorado River water is completely committed to projects constructed, under construction, or in authorized plans.

3. Any coal development beyond existing and actively proposed developments will require water over and above New Mexico's Colorado River entitlement or a conversion of water from other uses. This water limitation is expected to occur between 1985 and 1990.

4. There are many environmental resources in northwestern New Mexico which need to be quantified and on which basic data are needed for planning purposes.

5. Electrical energy development outside the northwestern portion of the State is projected to be mostly nuclear oriented and will take place after 1985.

RECOMMENDATIONS

1. The proposed level B study of Indian needs and development should include alternative ways of using northwest New Mexico's extensive low-sulfur coal resource. The study objectives should be to (1) determine the use of the coal resource in conjunction with the other resources of the area and (2) develop a comprehensive water and land use plan for the area. This study should start in 1976.

2. The Bureau of Reclamation's weather modification program should be continued in the San Juan Basin.

3. Special studies are needed to collect basic environmental data with respect to:

a. Instream flow needs for fish and wildlife and general environmental and recreational uses.

b. Wilderness and wild and scenic rivers potential.

4. A joint public utilities, State, Federal study should be made to identify potential plantsites and site limitations, throughout the State taking into consideration water and land availability and social, economic, and environmental impacts.

NO. 2 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

In the arid climate of New Mexico, economic and social progress of Indians is closely related to the availability of water. A critical need exists to establish the water requirements to support Indian social and economic objectives.

DISCUSSION

New Mexico has 26 Indian reservations and pueblos located mainly along the Rio Grande above Elephant Butte Reservoir and in the northwest portion of the State. They occupy a total of 7,348,600 acres or approximately 9.4 percent of the total land in New Mexico. About 6,492,000 acres are used as rangeland, of which about 1,254,000 acres are forest and wood land. Currently, about 24,700 acres are irrigated. As of 1970, total population was estimated to be 72,800, an increase of 29.4 percent over 1960 levels.

The water-related problems of the Indian Nation are similar to those of the State, but may be more serious since development of Indian lands has been neglected for a long period of time. With the Indian population growing much faster than the national average, pressures for development and social and economic progress can be expected to intensify.

In varying degrees, all tribal groups are experiencing economic development problems. Unemployment is very high; for some groups it is greater than 60 percent. The median family income is the lowest among all the Westwide States.

Since most Indians prefer to live on or near their reservation, irrigated agriculture has been recognized as a potential for meeting some of their economic and social demands. However, development has been slow and there are competing water supply needs which require evaluation on a continuing basis. Also in many of the reservation lands, water supply for irrigation is nonexistent.

Water supplies for domestic use are also generally inadequate from both quantity and quality standpoint.

Present supplies utilize nearly every available source of water; springs, wells (shallow and deep), infiltration bays, and streams. Per capita consumptive use is extremely low with most Indian communities using less than 50 gallons per person per day. Reserves for fire control and other emergencies are low or nil. With the high-growth rate, coupled with improved housing, indoor plumbing, and needs for economic developments, it is expected that domestic water supplies on Indian reservations could easily triple by 1985. At present, small communities have difficulty in attracting industrial development because they cannot provide sufficient water supplies.

Domestic supplies for isolated rural families are often a community well or a stock water development. Drinking water is at a premium in these situations and the supply is inadequate for personal needs, laundry, and other domestic uses. Poor water quality is also a problem. The Public Health Service has authority for providing domestic water and disposing of waste water. Funds have been insufficient to meet the needs.

Erosion, sedimentation, flooding, and lack of adequate livestock water are other problems common to most reservations. Instream flows for fish and wildlife resources need determination. Definition of ground-water resources is needed to help solve critical supply problems at homes, schools, and communities, and for recreational and industrial developments.

CONCLUSIONS

1. Water will play a major role in facilitating economic and social development for Indians in New Mexico.

2. Identification of the impact of water resource development and the scale of programs and projects required to stimulate needed growth is presently unknown. The determination of the effects – beneficial and adverse – can only be realized by a thorough examination of the resource potentials.

RECOMMENDATIONS

1. Expedite level B studies for water resource investigations and development of water management plans for Indian land uses.

2. The Federal Government, through the leadership of the Bureau of Indian Affairs in coordination with the Indian tribes and with technical assistance from other Federal and State agencies, should implement level B studies for each reservation and pueblo so that Indian water requirements can be determined and incorporated into State water planning activities.

NO. 3 – ADVERSE EFFECTS OF DECLINING GROUND-WATER TABLES ON THE ECONOMY OF EASTERN NEW MEXICO

SUMMARY

The thriving economy of the eastern New Mexico-west Texas area, which is presently based on irrigated agriculture is threatened by a rapidly declining ground-water supply. Some of the fringe areas overlying shallow ground-water aquifers and areas with major depths to water are already experiencing declines in irrigation activity. It is projected that due to the depletion of the economically developable ground-water supply, irrigation activity will start to decline about 1980. Nationally, significant social and economic dislocations will occur with this decline in irrigation activity.

DISCUSSION

Texas and New Mexico are currently irrigating about 7.7 and 1.0 million acres of land, respectively. The eastern New Mexico-west Texas area (figure VI-14) accounts for about 70 percent of Texas' and 50 percent of New Mexico's irrigated land. Principal crops grown in the area are sorghums 42 percent, cotton 44 percent, soybeans 6 percent, wheat 3 percent, and field corn 2 percent. It is also the center of an important cattle industry. The area relies on ground water as its source of irrigation water and, as a result, almost the entire area is presently in a ground-water overdraft situation.

The main areas of ground-water overdraft are in the Pecos and High Plains areas. Presently, the Pecos area within New Mexico is experiencing a 100,000 to 125,000 acre-feet per year overdraft. Within the High Plains area natural recharge to the ground-water source is estimated to be about 50,000 to 75,000 acre-feet per year, which is insignificant when compared to the annual pumpage.

Table VI-38 summarizes the present water and land situation within the area.

As of 1972, it was estimated that from 100 to 130 million acre-feet of physically pumpable water remain within the Ogallala aquifer. Assuming an average pumpage rate of 5 million acre-feet per year, the aquifer would be depleted sometime between the years 1990 and 2000. The projected decline in irrigated

Table VI-38.—*Water and land, eastern New Mexico*

Hydrological unit	Surface water (thousand acre-feet)		Sources of supply (thousand acre-feet)		Irrigated land (thousand acres)
	Natural (virgin)	Historic	Ground water	Surface water	
Arkansas (NM)	583[1]	196[2]	11	243	100
Pecos					
New Mexico	529[3]	181[3]	256	392[7]	130
Texas	NA[4]	284[5]	949	20	246
High Plains	M[6]	M			
North Plains			900	–	700
South Plains (TX)			6,850	–	4,300
New Mexico portion			376	23[8]	288
Red (TX)	NA	1,160[9]	123	51	110
Brazos and Colorado (TX)	NA	904[9]	243	89	200
Total			9,708	818	6,074

[1] Total consists of 471,000 acre-feet from the Canadian River and 112,000 acre-feet from other rivers within the unit.
[2] Measured near Logan, New Mexico.
[3] Estimated or measured at or near New Mexico-Texas state line.
[4] NA – not available.
[5] Near confluence with Rio Grande.
[6] M – minor.
[7] Includes 68,000 acre-feet, mainly in form of reservoir evaporation which cannot be assigned to ground water or surface water.
[8] Includes 22,000 acre-feet of reservoir evaporation which cannot be assigned to ground water or surface water.
[9] Estimated near eastern boundary of the study area.

acreage for the entire study area is shown on figure IV-15.

The current and projected population for the area using the Water Resources Council's subareas (figure VI-16) and the OBERS 1972 projections are presented in table VI-39.

Using 1972 OBERS data and the subareas, table VI-40 shows that agriculture is a significant contributor to the economy of the area.

Even in areas 1112, 1205, and 1208 which contain the cities of Amarillo, Lubbock, and Midland-Odessa, Texas, it plays an important role. In all areas the agricultural activity is significantly higher than the State average.

It should be noted that generally the OBERS projections of population and economic activity were based on local trends of historical activity with adjustments to gradually achieve more uniform national levels over time. However, the High Plains area was the only major

Table VI-39.—*1972 OBERS population projections (thousands)*

Subarea	Year 1970	1980	1990	2000
1108	29.1	27.8	27.0	27.0
1109	107.6	98.5	92.5	93.3
1112	174.4	175.7	178.4	192.2
1205	367.4	326.7	307.7	297.9
1208	315.7	323.4	338.5	361.0
1306	114.0	121.8	132.3	143.5
1307	71.1	67.3	65.5	65.7
Total	1,179.3	1,141.2	1,141.9	1,180.6

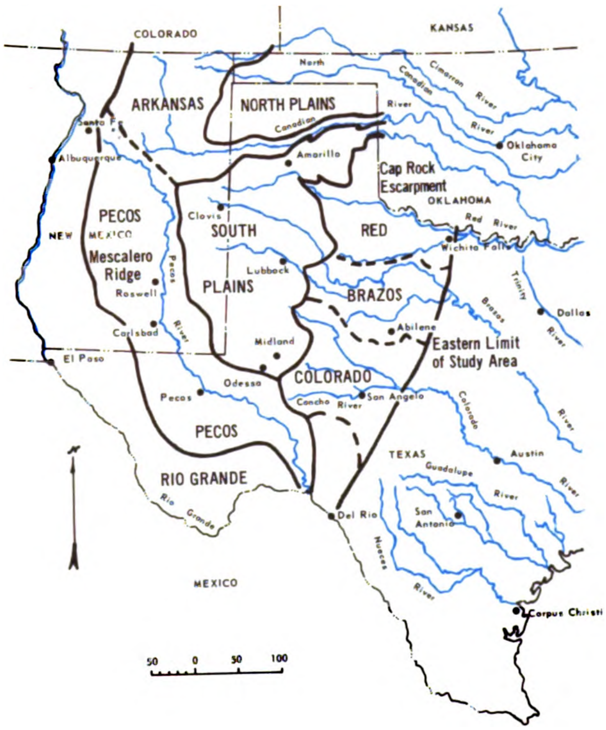


Figure VI-14. ***Eastern New Mexico – West Texas area.***

exception to this procedure, where in anticipation of known declines in ground water, the stagnant growth in economic activity shown in table VI-41 was projected. These projections of economic slowdown could well prove to be too optimistic if more detailed projections based on local factors were made. More information is needed on the composition of the economy of the area and on alternatives to sustaining viable communities. Oil, gas and agriculture are the primary economic mainstays of the area. However, oil and gas production are also projected to decline in the very near time frame.

As noted in table VI-41, a disproportionate number of families in five out of the seven subareas are presently earning less than the poverty level of $3,968. Similarly, for the area as a whole, per capita income is less than the national average and in most cases is projected to decline over time.

PROBLEM RESOLUTION

As stated previously irrigation is beginning to decline in the outlying areas of the ground-water basin today and the decline of irrigated agriculture will become significant by 1980-85. From the solutions standpoint there are several courses of action; two are presented below.

Table VI-40.—*Agricultural earnings as a percent of total earnings by economic subarea and State*

Subarea or state	Year 1969 (percent)	2000 (percent)
1108	27.2	8.8
1109	28.9	11.7
1112	11.2	6.6
1205	27.8	3.9
1208	9.9	4.6
1306	14.9	5.6
1307	15.7	10.9
New Mexico	6.9	2.2
Texas	4.8	1.6

Import Supplemental Water

Over the past several years, considerable study has been made by Federal, State, and private organizations of import possibilities from (a) the Mississippi River, (b) the Missouri River, (c) Alaska, (d) Canada, and (e) the Gulf of Mexico. Of these the Mississippi River source has been considered the most feasible and a reconnaissance grade State-Federal study has been made. The general conclusion to be reached from the study is that the economic and environmental costs are so great at this time that such a plan is not justified in the near future and more specifically not in time to rescue the irrigation economy of the High Plains area.

Land and Water Management Plan

If supplemental water cannot be brought into the area, another alternative is a management plan for the area which anticipates the depletion of the ground-water aquifer. The plan would set out the management procedures and institutional arrangements that should be adopted to minimize the effect of ground-water depletion on the agricultural economy, total economy, and the environment of the High Plains area. The plan should be developed in such a manner that the aquifer will be managed for long-termed use.

A thorough understanding of the social and economic effects of the loss of the irrigated agriculture is needed at the local, State and Federal levels. If the negative effects are of high order, then additional courses of action may be recommended to alleviate these impacts.

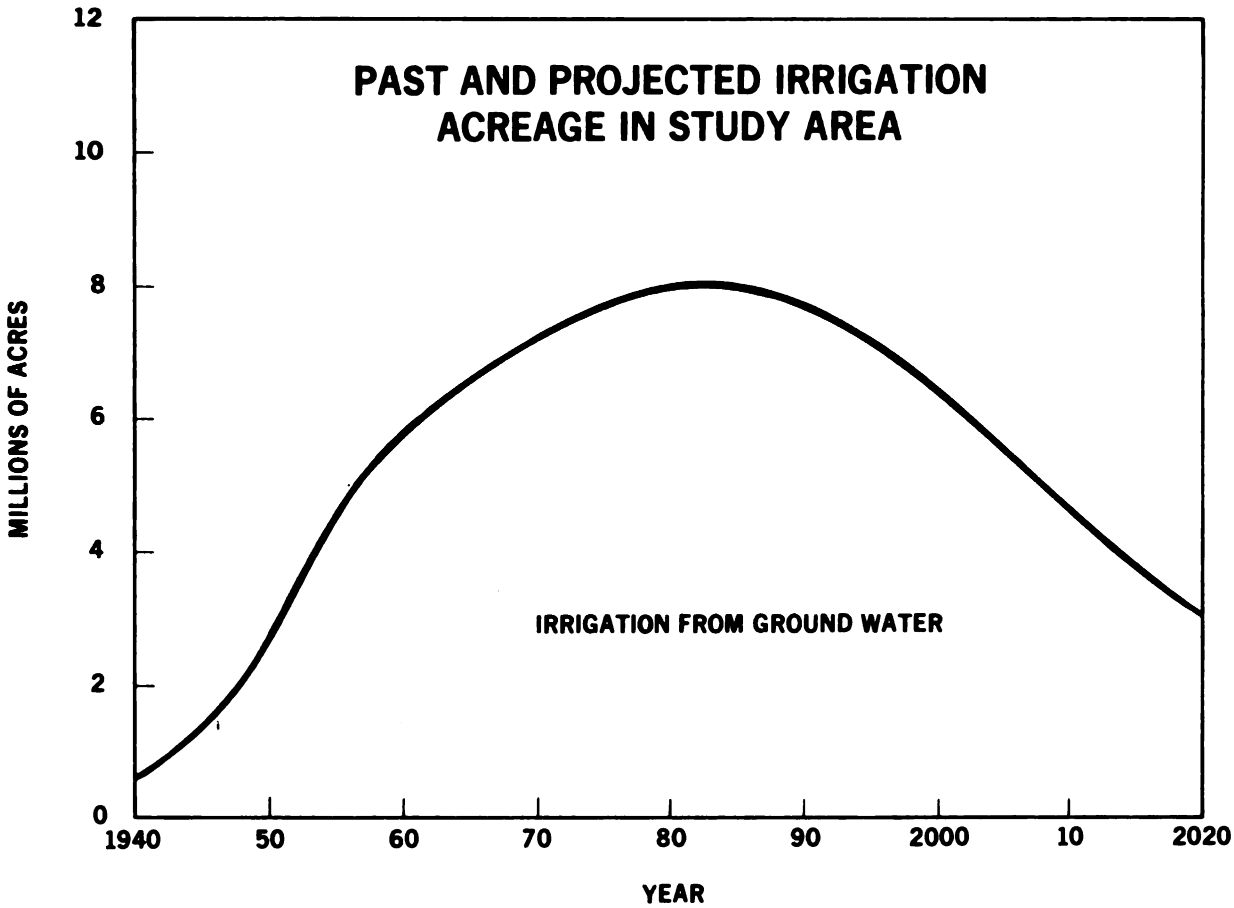


Figure VI-15. Decline in irrigation – eastern New Mexico.

Table VI-41.—*Earnings and employment in High Plains area*

Subarea or state	Rural population[1] (percent)	Families earning less than poverty level[1] (percent)	Unemployed[1] (percent)	Per capita personal income as percent of national income[2]	
				1969	2000
1108	51	36	6.3	80	79
1109	30	12	3.2	111	102
1112	10	13	3.4	94	86
1205	22	20	4.0	88	89
1208	17	16	4.1	100	98
1306	30	28	6.0	76	88
1307	26	15	3.8	97	94
New Mexico	30	18	5.7	77	86
Texas	20	15	3.6	89	91

[1] Bureau of Census Data.
[2] 1972 OBERS data.

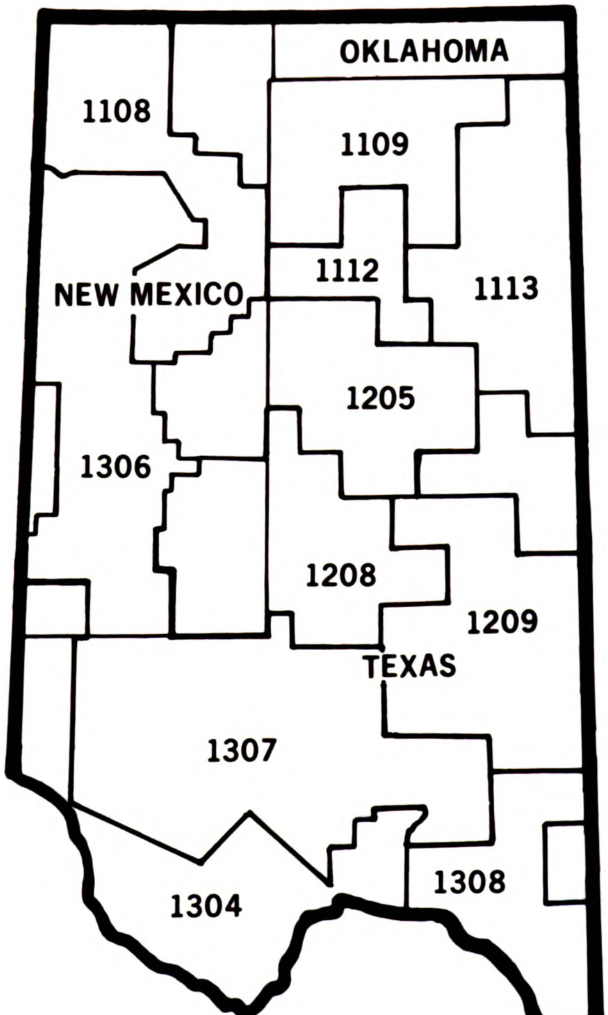


Figure VI-16. Water Resource Council subareas for eastern New Mexico and western Texas.

CONCLUSIONS

1. That the High Plains area is the focal point of an agriculturally oriented economy based primarily on ground-water depletion. Ground-water resources of the Ogallala Formation and the other formations in the plains area have great value as well as significant limitations. Management procedures are needed for the optimum use of the aquifer over time.

2. Unless a supplemental water supply can be developed, ground-water tables will decline and irrigation activity will begin to decrease in 1980 to 1990 time frame.

3. Importation schemes are not economically justified under present economic and social conditions.

RECOMMENDATIONS

1. A State-Federal organization should be formed to investigate and define the ground-water resource and make recommendations regarding its future use. The organization would be responsible for considering the potential of weather modification procedures, ground-water recharge projects, and other augmentation opportunities. Such an ongoing organization would have need of both State and Federal financing but the primary emphasis would be on State control and regulation with technical studies and analysis as required from Federal organizations.

2. A State-Federal interagency level C study be initiated to develop alternative agricultural enterprises geared to the long-term use of ground water in the High Plains area. Such enterprises could involve: more efficient use of water, adaptation of crops requiring less supplemental water, new methods of water application such as drip irrigation, a more balanced irrigation and dry farming arrangement, use of irrigation only as drought insurance, and advanced agronomic practices.

3. A Federal study should be made of the national social and economic impacts of the loss of the irrigation economy of the High Plains area; and of the possibilities of development of alternative non-agricultural enterprises as a replacement for the declining agricultural activity.

NO. 4 – LAND AND WATER RESOURCE PROBLEMS OF THE RIO GRANDE BASIN INCLUDING THE PECOS SUBBASIN

SUMMARY

The Rio Grande and its major tributary, the Pecos River, have major water and related land problems associated with an arid climate. The principal problem is a lack of water to meet all water demands. Presently, new demands are generally met by reducing supply to another function, usually agriculture. The region also has extreme erosion and sedimentation, environmental, flood and salinity problems.

DISCUSSION

The Rio Grande Region, which includes the Rio Grande and the Pecos River Subregions, occupies almost 62 percent of the total area of New Mexico. Utilization of water in the two subregions is subject to provisions of compacts entered into between New Mexico and other states, treaties, adjudications, court decrees, and other litigations related to administration of the available water supplies. Compacts involved cover the Rio Grande and Pecos Rivers and Costilla Creek. The Colorado River and Upper Colorado River Compacts apply to the Rio Grande basin through operation of the San Juan-Chama project which transfers some of New Mexico's Colorado River basin (San Juan River) water into the Rio Grande. There are existing treaties with Mexico governing the international use of the Rio Grande.

The available surface supplies of the two basins are fully appropriated. The total usable annual average surface water supply is estimated to be 540,900 acre-feet for the Rio Grande Subregion and 203,700 acre-feet for the Pecos River Subregion. The estimated 1970 ground-water depletions for the two basins amounted to 318,200 acre-feet for the Rio Grande Subregion and 295,200 for the Pecos River Subregion. Of the total water supply, 150,000 acre-feet of the ground water in the Rio Grande Subregion and 120,000 acre-feet in the Pecos River Subregion are considered as overdrafts on the ground-water reservoir, resulting in a total 1970 supply of 859,100 acre-feet and 498,900 acre-feet, respectively, in the two subregions.

There are large quantities of water in underground storage in the two basins, but only a small part of this is thought to be fresh to slightly brackish, and not all ground water is physically or economically extractable. Sixteen ground-water areas have been declared underground water basins in the Rio Grande and Pecos Subregions. Future ground-water development in these declared underground basins, except for domestic supply, cannot take place without issuance of appropriate orders by the New Mexico State Engineer. Ground water outside such areas is subject only to prior and existing rights within the area and may be developed for beneficial use without the appropriator making application to the State Engineer.

Rio Grande Subregion

In the Rio Grande Subregion, the use of water is limited by State law, the Rio Grande Compact, and the treaty with Mexico. Surface and ground water, except for the closed basins, are interconnected and essentially all the ground-water areas above Elephant Butte Reservoir are in declared underground water basins in which the use of water is administered by the State Engineer.

Approximately 340,000 acres of land are irrigated in the Rio Grande Subregion, some by direct diversion, but most areas are associated with water development projects such as the Middle Rio Grande project from El Vado Reservoir, the Santa Cruz Irrigation District from Santa Cruz Reservoir, and the Rio Grande project from Elephant Butte and Caballo Reservoirs.

Other major reservoirs in the basin include Bluewater, now used for fish and wildlife and recreation, as well as irrigation purposes; Abiquiu, Jemez, and Galisteo, used mainly for flood and sediment control; and Cochiti presently under construction, for flood and sediment control and recreation. The San Juan-Chama project's collection and diversion elements were completed in 1971 and will bring in an average of 110,000 acre-feet per year from the Colorado River basin for M&I, irrigation, recreation, and fish and wildlife purposes.

Pecos Subregion

The Pecos River Subregion is an extremely water-short area and, in addition, has serious water quality problems. Man's activities are a contributing factor relating to the poor quality but the major cause is the soluble nature of the surface and underlying formations. The ground waters of the subregion are interconnected with the surface supply and essentially all ground-water areas are declared underground basins administered by the State Engineer. The use of the flows of the Pecos River in New Mexico are limited by the Pecos River Compact, the Hope Decree, and other court orders.

The major irrigation areas include:

Upper Pecos. – Storrie project near Las Vegas, served by Storrie Lake Fort Sumner Irrigation District, served by direct flows of the river.

Lower Pecos. – Pecos River pumpers who divert from the river in the Roswell-Artesia reach; Pecos Valley Artesian Conservancy District, a large irrigated area served mainly by wells in the vicinity of Roswell and Artesia; and Carlsbad Irrigation project, served by Alamogordo Dam on the Pecos River between Santa Rosa and Fort Sumner and McMillan and Avalon Dams near Carlsbad.

Even with the available storage irrigation projects experience short supplies nearly every year and must resort to local pumping.

The draft on ground water in the Roswell-Artesia area exceeds the recharge by an estimated 125,000 acre-feet per year. This overdraft has caused a decrease in head in the freshwater portion of the artesian aquifer and has resulted in the encroachment of saline water in the vicinity of Roswell. Continued pumping could also eliminate the base flow of the river.

Common Problems in Both Subregions

The following problems are common to both Rio Grande and Pecos Subregions. Urban sprawl problems are in evidence in a few cities especially those that experienced major population increases in the 1960-70 decade. Probably the most serious problems are being experienced at Albuquerque, Las Cruces, and Santa Fe, and to a lesser degree at Espanola, Alamogordo, and Deming.

The two basins being discussed are water-deficient areas with respect to availability of freshwater if present irrigated agriculture is to be maintained. Most problems of land and water resource development and management are related to water shortages. The surface water supplies of both basins are fully or over-appropriated, and for the most part ground water and the surface supply are interrelated and therefore are the same supply. Overdrafts are occurring in both basins.

The projected trend toward urbanization and industrialization of the Rio Grande and Pecos River subregions will require additional municipal and industrial water. The projected water requirements for municipal, industrial, minerals, and power for the two basins are shown in Table VI-42.

Another problem is the need for increased flat-water recreation. While some reservoirs in the Rio Grande Region are operated solely or partially for other purposes, irrigation is the predominant purpose. At the present time, the only water specifically allocated to recreation in a Federal reservoir is a permanent pool of 50,000 acre-feet in Cochiti Reservoir, presently under construction; a permanent pool of 2,000 acre-feet and a temporary pool of 4,500 acre-feet in Brantley Reservoir; a permanent pool of 3,000 acre-feet and a recently authorized temporary pool of 7,000 acre-feet in Alamogordo Reservoir; and a recently proposed short-term minimum pool of 50,000 acre-feet in Elephant Butte Reservoir.

It is estimated that only 20 percent of the existing surface acreage, about 72,000 acres at public lakes and reservoirs, is used for recreation due to the limited number of recreation facilities available. The tabulation in table VI-43 indicates a rapidly increasing State demand for water-oriented recreation and consequent need for additional surface water acreage usable for water-oriented recreation. Visitor impact upon available resources is increasing, often to the point of damage to the resource and detriment to the overall recreation experience.

Two factors which affect the ability of a reservoir to provide recreation opportunities are the magnitude and frequency of reservoir drawdown. Although recreationists are using these bodies of water despite large fluctuations in water surface, the quality of the recreation experience is impaired. Boating facilities

Table VI-42.—*Water requirements for the Rio Grande and Pecos Rivers subregions (1,000 acre-feet)*

Purpose	Year			
	1970	1980	2000	2020
Municipal and Industrial[1]	71	89	133	206
Municipal and Industrial[2]	71	139	303	660
Minerals	22	48	96	171
Power	7	10	49	197

[1] Based on BEA estimates — 1.6 million population in 2020.
[2] Based on Bureau of Business Research, University of New Mexico estimates — 4.6 million population in 2020.

Table VI-43.—*Water surface requirements in acres*

Purpose	Year				
	1971	1975	1980	1985	1990
Boating	0	12,184	59,267	122,768	203,435
Water skiing	0	0	0	18,037	81,282

become removed from the water, boating becomes more restricted, fishing and fisheries are adversely affected, and large, unsightly, barren and muddy areas of reservoir bottom are exposed.

Other problems include water requirements for fish and wildlife; soil erosion and sedimentation; legal problems involved with water rights, adjudications, and reallocations of water; restrictive legal constraints, and salinity from irrigation.

Specific Problems by Subregion

Specific problems affecting the Rio Grande and Pecos Subregions are discussed below.

Rio Grande. – The Rio Grande Subregion is also the area where the greatest population increase is projected and consequently the municipal and industrial needs for water will be greater than in other subregions. Projections have been made in which M&I water requirements will grow from a present use of 55,000 acre-feet to as much as 248,000 acre-feet annually. To meet existing demands transfer of use from irrigation to municipal, domestic, and industrial uses is already taking place. Unless additional water supplies are made available more transfers will be required.

Agricultural water is the main source of water supply for other uses. As urban development continues, more and more agricultural lands will be retired and the water rights transferred to M&I purposes. The apparent continuation of this trend raises the question of the best long-term use of the water to the region.

Habitat along the Rio Grande suitable for waterfowl has been a dwindling resource for over half a century because of Federal and private water development to meet agricultural, urban, and industrial needs. Remaining habitat resources need to be protected along with acquisition, management and restoration of habitat to serve migratory waterfowl and other wildlife.

The Middle Rio Grande from the mouth of the Rio Puerco to Elephant Butte Reservoir is threatened by floodflows from the Rio Puerco and Rio Salado regions. In addition, sediment produced by the two drainages causes major maintenance problems in connection with existing facilities in the Rio Grande Valley which increases nonbeneficial water losses in this water-short area.

The threat of serious floods along the Middle Rio Grande, including Albuquerque and vicinity, continues to be a major concern to local and State interests. A tremendous influx of population has resulted in increased development of properties adjacent to the river. During May and June 1973, abnormally deep snowpack in the mountains of southern Colorado and northern New Mexico caused the largest spring runoff in 15 years. By optimum operation of tributary reservoirs and emergency measures, major flood damage was averted; however, it is apparent that the water carrying capacity of the Rio Grande has decreased through aggradation of the river channel and excessive growth of brush and trees in the overbank portion of the floodway, and therefore the potential for serious flooding has been greatly increased.

The central, western, and part of the southwestern closed basins are included in the Rio Grande basin. The Estancia Valley in the Central Closed basin is heavily developed. The valley is a declared underground water basin, and the supply is being mined. The Tularosa basin, also in the Central Closed basin, has probably reached its limit of development so far as water of good quality is concerned; however, it has additional large quantities of brackish and saline ground water.

The waters in the Southwestern Closed basin, most of which are also in declared underground basins under the control of the State Engineer, are being mined, but the limit to development in most areas is not the quantity but the depth from which the water can be pumped economically.

Pecos Subregion. – M&I use in the Pecos subregion is estimated to be 15,000 acre-feet. Using OBERS projections year 2000 M&I requirements are estimated to be about 63,000 acre-feet. Water for these additional needs will either have to come from conversion of agricultural rights, ground-water overdraft of freshwater aquifers, or desalting of saline ground waters.

Agriculture is the major industry in this area. If other sectors of the economy continue to grow, agriculture activity is expected to decline which could result in serious economic and social dislocations.

The Pecos River has three areas that warrant special discussion. In the reach from Anton Chico to Colonias considerable river losses occur which return to the Pecos River above Puerto de Luna but at a reduced quality. The water lost contains about 130 mg/l of total dissolved solids, and when it reappears the concentration of dissolved solids averages about 2,400 mg/l.

In the Roswell-Artesian basin in Chaves and Eddy Counties the natural and manmade discharge from the basin has exceeded the recharge for many years, the artesian head, the shallow water table, and the base inflow into the river have been declining. The continuing general decline of head in the artesian aquifer has caused saline water which formerly discharged naturally to the Pecos River to encroach into the fresh water portion of the aquifer east and north of Roswell.

If the basin is to support an irrigated agricultural economy, some means of maintaining salt balance will be necessary. Without some discharge to the Pecos River or elsewhere, the basin will be faced with a salt buildup aggravating the conditions caused by the lateral saline water encroachment from the northeast and vertical encroachment from the saline aquifers underlying the artesian fresh-water aquifer.

In the reach from Carlsbad to the New Mexico-Texas State line the river picks up a concentrated brine solution in the Malaga Bend area from an aquifer underlying the area at a depth of about 200 feet. This reach also contains many other sources of concentrated brines which flow into the river. In 1958 the Malaga Bend division, an experimental salinity alleviation program of the McMillan Delta project, was authorized under Public Law 85-333. Construction of the Malaga Bend division was completed in June 1963. Geological Survey is presently preparing an interim report on the project.

The city of Carlsbad and vicinity faces a continuing and serious threat of floods from Dark Canyon and its tributaries and from the Pecos River. The most recent major flood on the Dark Canyon, in 1966, caused an estimated $1 million in damages. Authorization of the Brantley Dam and Reservoir on the mainstem of the Pecos River upstream of Carlsbad precludes the need for further consideration of the flood threat to Carlsbad from the drainage area above that point. However, control of urban flooding from the drainage area below Brantley Reservoir and above Carlsbad still needs to be considered, as well as control of Dark Canyon.

Floods on Dark Canyon are characterized by high peak discharges when compared with total flood volumes. Due to high velocities produced by the steep and narrow channel of Dark Canyon, major floods descend in waves or walls of water. Estimates indicate that since 1893 there have been 15 floods on Dark Canyon that have resulted in considerable damage to urban, public, and private properties in the southern portion of Carlsbad, installations of the Carlsbad Irrigation District and other irrigation systems, county roads and State highways, the Sante Fe Railroad, irrigated croplands, rural homes, and rural public utilities and industrial properties.

The Corps of Engineers is completing level C studies for the Pecos River and tributaries above Santa Rosa this fiscal year (1974). Reservoir sites on the Pecos River and its tributaries have been investigated for single-purpose flood-control projects; however, none has been found to be economically feasible to date.

Also, recently it has been discovered that Storrie Dam in the upper reaches of the Pecos River has serious structural deficiencies. The Bureau of Reclamation has investigated this problem and as a result the New Mexico State Engineer has placed limitations on the amount of water that can be stored in this reservoir. This situation poses serious flood problems and in addition restricts the operation of the Storrie Irrigation project.

PROBLEM RESOLUTION

For each problem presented above there are a number of alternative solutions from which to choose. In some cases, studies have been made or are underway which have or are dimensioning the problem and outlining alternative courses of action. Following is a discussion of the alternative solutions available and some of their consequences.

In both the Rio Grande and Pecos Subregions, only importation of water or weather modification will increase water supply. Total water management could provide some water to meet demands but would not create new water. Waste-water renovation may help meet some future M&I demands; however, Environmental Protection Agency currently restricts reclaimed waste-water use to lawn watering and other nonpotable uses. Also, present waste water is usually used further on downstream, and therefore reuse in the area of first use is usually severely limited or not allowed.

Vegetative management programs could create additional water supplies but to the disadvantage of some fish and wildlife uses. Ground water offers some possibilities; however, in most instances desalting would be required.

In general, any kind of future need will involve transferring water rights from one use to another, and generally agricultural water rights will be transferred or ground-water resources further developed.

Many flood control alternative are being considered in ongoing Corps' studies in the Rio Grande Subregion, these include:

1. Multipurpose reservoirs with flood control, water supply, recreation, and fish and wildlife benefits;

2. Channel improvements;

3. Levee improvements; and

4. Parkways and greenbelts.

A proposed resolution has been transmitted to the House Public Works Committee which, if passed and funded, will permit expansion of the study to include an urban study of the Albuquerque metropolitan area.

Among the many alternative flood control solutions being considered by the Corps of Engineers for the Pecos Subregion is a multipurpose reservoir in Dark Canyon with flood control, water supply, recreation, and fish and wildlife benefits. These planning efforts will be in full compliance with the Pecos River Compact. The Bureau of Reclamation's Brantley project will also protect Carlsbad from Pecos River flows.

The Department of Agriculture has recently completed in cooperation with the State of New Mexico a type 4 study of the Rio Grande basin above Elephant Butte Reservoir. The study gave emphasis to agricultural water use, upstream flooding, erosion and sediment damage, rural development, and conservation treatment of watershed lands. The recommended early action program should be implemented.

Better use of existing Federal reservoirs appears to be a possible solution to the recreation problem. Additional studies are needed. Regarding salinity, better water management and, in some cases such as Malaga Bend, structural solutions are the best alternatives. Studies are needed to determine the best course of action.

CONCLUSIONS

1. The Rio Grande Region, including the Pecos Subregion, is presently experiencing severe land and water use problems.

2. The surface water supply of the region is fully appropriated; however, some good quality ground water is still available if mining is allowed to continue.

3. Without augmentation, new water uses can only be developed at the expense of other uses, mainly through the conversion of agricultural water uses and rights. The long range effects of this conversion needs to be evaluated.

4. There is a large saline ground-water resource; however, development will be expensive.

5. Salinity is a major problem in the Pecos River Subregion.

RECOMMENDATIONS

1. A State-Federal level B study for the Rio Grande basin including the Pecos Subregion should be initiated in 1977 to evaluate current needs, assess ongoing programs and studies, and recommend a total water and related land use plan for the area. In conjunction with the above study, it is recommended that a level C salinity study of the Pecos subregion be initiated in 1979.

2. Based on analysis of increased runoff through weather modification, a demonstration program for augmentation by this method in the Upper Rio Grande Region should be undertaken as soon as practical.

3. The Corps of Engineers initiate a level C study in 1976 to study the flood problems below Brantley Reservoir on the Pecos River.

4. Initiate studies for the following reservoirs with the objective of determining the feasibility of modifying existing Federal reservoir operations and management policies to improve recreational use:

Reservoir	Operating agency
Alamogordo (USBR)	State Park
Elephant Butte (USBR)	State Park
El Vado (USBR)	State Park
Abiquiu	Corps of Engineers
Jemez	Corps of Engineers

The previous five reservoirs should be studied over a 4-year period beginning FY 1976 (phase I). The program should then be reappraised in FY 1980 and other reservoir studies scheduled as appropriate (phase II).

5. Study programs currently underway should be continued and coordinated with the recommended level B study. Studies in this category are:

a. *Corps of Engineers*

(1) Rio Grande and tributaries, New Mexico and Colorado

(2) Review study for flood control and allied purposes on Pecos River and tributaries at Carlsbad, New Mexico, and vicinity

b. *Bureau of Reclamation*

(1) Rio Grande Regional Environmental Planning Study; total water management oriented study of the Rio Grande from Elephant Butte Reservoir to Fort Quitman, Texas.

OREGON

Oregon is an area rich in material resources of land, water, timber, fish and wildlife, and is tremendously endowed with scenic beauty, historical significance, and great recreation wealth. The nearly 97,000 square miles within Oregon's boundaries rank the State tenth nationally in terms of total area and eighth among the Westwide States. Oregon's 2,091,385 people are not distributed evenly over the State, but are located primarily in the western portion. The lands east of the Cascades comprise 70 percent of the area and have only 13 percent of the population. Within the western region the Willamette basin has 12 percent of the State's land area and 70 percent of its population.

Average income in Oregon is neither high nor low when compared with the other States in the West. Only 8.6 percent of the State's families earn less than what is considered as the poverty level; this is a relatively low figure in comparison with most Western States. The counties which have the greatest percentages of per capita income level less than the poverty level are Malheur, Baker, Josephine, Lake, Sherman, Wallowa, Jefferson, and Benton Counties.

With more than half its land held by the Federal Government, Oregon ranks high in that amount among the public land States. Of the 61,664,000 acres of land within its borders, 52 percent – 32,089,000 acres – is owned by the United States and another 3 percent by the State and local governments.

If an explanatory label can be placed on the State of Oregon which sets it apart from other States, it would likely read "maintenance of a desirable natural environment." The people of Oregon are dedicated to that objective and their actions indicate that it is foremost in their minds. Oregon is the first State to pass a bill designed to prevent littering the landscape with beer and soft drink containers through the banning on nonreturnable bottles. The State is also a leader in land use planning, pollution control, and preservation of scenic waterways. It is also one of two Westwide States to have implemented a Scenic Waterways Act to preserve reaches of seven major streams in their free-flowing state.

WATER SUPPLY

Oregon has a large supply of water, but it is unevenly distributed with respect to both area and time. Damaging floods occur every few years, and shortages of water are frequent in eastern Oregon and not unknown in the more humid western section.

Surface Water

Interstate streams form a significant part of the State's water supply. The Snake River, Oregon's eastern boundary for 216 miles, and the Columbia River, Oregon's northern boundary for 309 miles, derive most of their flow from other States. The Owyhee River rises in Nevada and enters Oregon from Idaho. The Klamath, Grande Ronde, and Walla Walla Rivers rise in Oregon and carry significant flows into other States. Goose Lake lies astride the Oregon-California line; its larger tributaries are in Oregon. Large volumes of water are diverted in Oregon each year from the Owyhee River to irrigate land in Idaho and from the Klamath River to irrigate land in California. Interstate agreements are in effect between Oregon and California on the use of the waters of the Klamath River and Goose Lake.

The Columbia River has an average annual discharge of about 195,000 cubic feet per second at The Dalles and about 270,000 ft^3/s at the mouth. The Willamette River, largest intrastate river in Oregon, provides an annual yield of nearly 28 million acre-feet as it joins the Columbia River at Portland. The average annual runoff of all streams in the 96,981 square-mile area in Oregon is about 85 million acre-feet, enough to cover the State to a depth of 16 inches; it ranges from less than 1 inch in semidesert areas of Lake, Harney, and Malheur Counties to more than 100 inches in places in the western slopes of the Coast and Cascade Ranges in northwestern Oregon.

Lakes are an important hydrologic feature of Oregon. Many lakes in the high plateaus of south-central Oregon lose water only by evaporation, and several large lakes have thus become moderately to highly saline; examples are Harney, Summer, and Abert Lakes. The water resources of most lakes are undeveloped, and the lakes are used chiefly for recreation.

Upper Klamath Lake, the largest natural lake wholly in Oregon, covers 90,000 acres. A low dam at its outlet regulates the lake level and controls about 440,000 acre-feet between the levels of 4,137 and 4,143 feet.

Oregon has 61 reservoirs of more than 5,000-acre-feet capacity that when filled cover 280,000 acres and contain more than 10 million acre-feet of water, of which about two-thirds is controlled storage. Reservoirs of notable size include Owyhee Reservoir and seven interstate reservoirs (Brownlee, Hells Canyon, Oxbox, McNary, John Day, The Dalles, and Bonneville). A group of 12 reservoirs provides flood protection, navigation, power, recreation, and other benefits in the Willamette River basin.

Fields of snow and rivers of ice at high altitudes play a significant part in regulating the natural flow of the Snake and Columbia Rivers. The larger glaciers are in Canada or in States other than Oregon; but small glaciers exist on the slopes of Mount Hood, Mount Jefferson, and Three Sisters, covering about 8,000 acres and extending down to about the 6,000-foot level. Streamflow from glaciers has several unique characteristics: (1) precipitation in winter is stored for release in the warm, dry summer period, with little depletion from evaporation or other losses; (2) storage occurs over a long period of wet years, and maximum release occurs during a warm dry cycle; (3) the melt water contains much suspended sediment or "glacier flour," that may be abrasive to turbines, sprinklers, and the like; and (4) the rate of melting has a pronounced daily fluctuation.

Ground Water

A person can drill a well in most places in the State and be assured of obtaining sufficient water for a domestic supply, but to obtain water in large quantities from the ground is difficult because of poor transmissability in many areas. Ground water pumping for irrigation is prominent in only five general areas in the State (Klamath Falls area, French Prairie area northeast of Salem, Hermiston area near Pendleton, Burns area, and Milton-Freewater area).

The potential for future ground water development in many areas of Oregon is marginal. Excess surface water will be needed for the artificial recharging of groundwater aquifer units for proper management of some areas.

The average annual recharge to aquifers in the State is estimated to be about 23 million acre-feet, equivalent to about one-sixth of the average statewide precipitation. The recharge is about equally divided between eastern Oregon and western Oregon. About a quarter of the total recharge occurs in the Deschutes River basin.

The volume of ground water within 500 feet of the surface is estimated at about 250 million acre-feet, or three times the annual runoff of all the streams in the State. At least 80 percent of that total lies in eastern Oregon, where the annual natural recharge is only about 11 million acre-feet. The sustained yield economically recoverable from any aquifer is usually, as a practical matter, considerably less than its annual recharge.

Very large springs fed by ground water bodies rise from volcanic rocks in the basins of the Deshutes, Klamath, Rogue, Umpqua, McKenzie, and Santiam Rivers, giving each of these streams a large, steady base flow of clear water in dry periods. On the Deschutes River alone, the combined flow of springs is about 4,000 cubic feet per second. Smaller springs are common in other areas.

Water Quality

Surface water in Oregon is generally of excellent chemical and physical quality for use in irrigation, industrial processes, or municipal supplies. The dissolved solids concentration of most streams in western Oregon is less than 100 parts per million (p/m) and in eastern Oregon less the 250 p/m. Most of the water mineral content is of the calcium magnesium bicarbonate type. Streams in western Oregon have less than 60 p/m of hardness and are classed as soft water. Those in eastern Oregon range in average hardness from 20 to 150 p/m, with greater hardness at times because of return flows from irrigation. Water temperature is also a critical factor in all Oregon streams having resident trout or runs of anadromous fish.

Ground water generally contains somewhat more dissolved solids than do streams in the same area. Ground water from most sources is of the calcium magnesium bicarbonate type, having dissolved solids between 100 and 300 p/m and hardness between 50 and 150 p/m. Such water is suitable for almost any commercial or public purposes. Water from some fault zones, from marine sedimentary rocks, and from the alluvium of closed basins is more highly mineralized.

Table VI-44 shows estimated 1975 surface water depletions for Oregon by subregions and table VI-45 shows estimated net water supplies available in 1975. The supplies available could be used for either instream use such as for fish, wildlife, recreation, hydropower, or navigation; or could be developed by diversion for consumptive use. Because of physical and economic constraints, much of the water shown as available could not actually be diverted and used.

CRITICAL PROBLEMS

The Westwide problems having a direct impact in Oregon are discussed in this section in more detail. The regional problems affecting the State are listed. This portion concludes with detailed presentations of State specific problems.

Table VI-44.—*Estimated 1975 total depletions[1] for Oregon (1,000 acre-feet)*

Region and subregion	Purpose or cause of depletion: Irrigation	M&I including rural	Minerals	Thermal electric	Recreation[2] F& WL	Other	Reservoir evaporation	Consumptive conveyance losses	Total depletions
Columbia-North Pacific									
Central Snake	876	5	0	0	0	1	158	0	1,040
Lower Snake	202	2	0	0	0	1	8	0	213
Mid-Columbia	922	26	0	0	0	5	242	0	1,195
Willamette	488	138	0	0	0	5	266	0	897
Lower Columbia	7	1	0	23	0		14	0	45
Coastal	366	26	0	0	0	3	209	0	604
Oregon closed basin	654	7	0	0	0	3	206	0	870
Total region	3,515	205	0	23	0	18	1,103	0	4,864
California									
North coastal	135	2	0	0	0	0	434	0	571
Sacramento basin	20	—	—	—	—	—	60	0	80
Total region	155	2	0	0	0	0	494	0	651
State summary	3,670	207	0	23	0	18	1,597	0	5,515[3]

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] No depletions are attributed to mineral development, recreation, or consumptive conveyance losses.
[3] Surface-water depletions — 5,173,000; ground-water depletions — 342,000.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – Instream flow maintenance is important to Oregon. Oregon has established the legality of instream flows as a beneficial use of water for recreation, fish and wildlife, and aesthetics. In fact, provisional values of flow have already been established in major river reaches. It remains, however, to develop the means to implement and finance programs to assure that desired flows can be attained. Closely allied to instream flow requirements is concern for water quality in rivers, streams, and estuaries. Federal water quality standards for control of point source pollution should alleviate much of the problems that exist throughout the State, especially in the Willamette Valley. However, a residual problem will remain that could be mitigated by provision of minimum or optimum flows to assure adequate streamflows.

The environmental data gap in Oregon is addressed in the problem on estuaries and instream flow needs. In addition, the regional problems on the Columbia River estuary, the need to protect and restore anadromous fish, and operation of the main stem Columbia River system bear heavily on the environmental data gap in Oregon. One data need, not addressed elsewhere, concerns Oregon wetlands. There is a need in Oregon to determine not only the extent and relative value of the remaining wetlands but also to survey those areas which can be restored or improved as wildlife habitat in connection with water development. No comprehensive survey has been undertaken in nearly 20 years.

Areas with good potential for restoration or areas with current high values which are vulnerable to developmental pressures should receive early attention in the survey. Agricultural land and water use planning is closely related to many of these critical areas and wetlands data is needed for multiobjective planning.

Table VI-45.—*Estimated 1975 surface water-related situation in Oregon (1,000 acre-feet)*

Region or Subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within sub-region or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Columbia-North Pacific									
Central Snake	0	1,840	0	1,840	0	1,040	800	540	260
Lower Snake	0	2,800	0	2,800	0	210	2,590	820	1,770
Mid-Columbia	0	8,360	0	8,360	0	1,200	7,160	2,440	4,720
Willamette	0	25,470	0	25,470	0	900	24,570	7,440	17,130
Lower Columbia	0	1,100	0	1,100	0	50	1,050	320	730
Coastal	0	38,910	31	38,940	0	600	38,340	0	38,340
Oregon closed basin	0	2,070	0	2,070	0	870	1,200	0	1,200
Total region	0	80,550	31	80,580	0	4,870	75,710	11,580	64,150
California									
North coastal	0	2,740	0	2,740	31	600	2,109	510	1,599
Sacramento basin	0	260	0	260	0	120	140	0	140
Total region	0	3,000	0	3,000	31	720	2,250	510	1,739
State summary	0[5]	83,550	0	83,550	0	5,520	78,030	12,070	66,029

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] No inflow assumed to Oregon, Columbia River and Snake River is included with Washington and Idaho.

Wetlands in the following locations have been identified as needing immediate attention:

Summer Lake	Sycan Marsh
Cow Lake	Carlton Lake
Baker	Klamath Basin
Paulina Marsh	Miller Island
Chewaucan	Catlow Valley
Donner und Blitzen River	Grande Ronde Valley
Deer Island	Sprague River
Warner Valley	Langell Valley
Umatilla Meadows	Silvies River
Goose Lake	Willamette Valley

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC AND RECREATION RIVERS. – The Rogue River was an initial component of the Wild and Scenic Rivers System, while the entire Illinois River is being studied as a potential system addition under Section 5(a) of the Wild and Scenic Rivers Act.

Segments of the following were among a number of "5(c)" rivers (formerly Section 5(d) of P.L. 90-542, The Wild and Scenic Rivers Act) named by the Secretaries of Agriculture and Interior in 1970, whose wild and scenic river values must be evaluated in any Federal planning for other (developmental or control) uses of these rivers: *Deschutes; Grand Ronde* including portions of the tributary Wenaha, Wallowa, and Minam Rivers; *John Day* including portions of the tributary North Fork and Baldy Creek; and the *Snake* (Hells Canyon) and the tributary Imnaha River.

Recently the Secretary of the Interior, acting on findings of a Federal Interdepartmental Study Group, recommended passage of a comprehensive "Administration bill" that calls for study of 16 high-priority rivers within the Westwide States. Included are two Oregon rivers, namely: the *John Day,* including the main stem downstream from North Fork, the North Fork downstream from Baldy Creek and Granite Creek downstream from Clear Creek; and the *Owyhee,* specifically the main stem from the Idaho State line downstream to Owyhee Reservoir, provided however, that the authority of the Chief of Engineers to undertake emergency flood control work along the Owyhee River under the authority of Section 5 of the Flood Control Act of 1941 (55 Stat. 650), as amended (33 U.S.C 701n), shall not be affected by study of this river.

At present, Oregon is one of two of the Westwide States to have enacted a substantive State wild and scenic rivers program. By initiative action in the general election of November 1970, Oregon established a Scenic Waterways System, now referred to as Chapter 390.805 to 390.925, Oregon Revised Statutes. Seven rivers, segments of rivers and related adjacent lands were designated as scenic waterways, as follows:

1. *Rogue River:* Segment from the confluence with the Applegate River downstream to Lobster Creek Bridge.

2. *Illinois River:* Segment from the confluence with Deer Creek downstream to confluence with the Rogue River.

3. *Deschutes River:* Segment from the existing Pelton reregulating dam downstream to confluence with the Columbia River.

4. The entire *Minam River.*

5. *South Fork Owyhee River:* Segment from the Oregon-Idaho border downstream to Three Forks, and the segment of the main stem Owyhee River from Crooked Creek downstream to the mouth of Birch Creek.

6. *John Day River:* Segment from Service Creek Bridge downstream to Tumwater Falls.

7. *Sandy River:* Segment from Dodge Park to Dabney Park.

The State also has a Recreation Trails System which complements the National Trail System and its Pacific Crest Trail.

NO. 16 – THE CHANGING FEDERAL ROLE IN DEVELOPING IRRIGATION PROJECTS. – Agriculture is an important contributor to the economy of Oregon. Even though there is a humid climate during the winter and spring months, irrigation plays an important role in stabilizing the agricultural economy during the predictable dry summer months Willamette Valley. Based on data from framework studies about 1,778,000 acres were irrigated in Oregon in 1969. Eastern Oregon contains vast areas of fertile land that have potential for irrigation development. Moreover, water supplies could be made available but such new supplies are apt to be very costly and beyond the means of private sources. State or Federal assistance would be needed for large-scale irrigation projects.

One means of expanding irrigation service at low capital loss is through better water management and conservation practices to attain better water use efficiency. Sprinkler irrigation applications, close-pipe delivery systems, and automated systems can cut down significantly on water requirements thus making water available for irrigation on additional land.

Regional Problems

Five problems that are regional in scope have a direct effect on the State of Oregon. They are:

NO. 5 – OPERATION AND MANAGEMENT OF THE COLUMBIA RIVER MAIN STEM SYSTEM TO MEET TOTAL WATER USES

NO. 6 – WATER MANAGEMENT PROBLEMS OF THE COLUMBIA RIVER ESTUARY

NO. 7 – MAINTAINING AND IMPROVING ANADROMOUS FISHERIES IN THE NORTHWEST

NO. 8 – CONFLICTS OF WATER USE IN THE HELLS CANYON REACH OF THE MIDLE SNAKE RIVER

NO. 9 – EROSION AND SEDIMENTATION IN THE PALOUSE REGION OF THE NORTHWEST

State Specific Problems

Problems relating to preservation of environmental values and options in Oregon are of highest urgency. These include concern for management of coastal estuaries and practical means of achieving reliable instream flows in selected stream reaches throughout the State. These concerns interrelate in coastal streams which flow into estuaries and are vital to maintaining freshwater inflow to achieve needed salt balance in the estuary.

East of the Cascade Mountains, specific problems focus on total water management of water and related land resources in the Deschutes and Malheur-Harney Lakes basins to achieve optimum balances of resource uses for fish, wildlife, flood control, recreation, water supply, Indian development needs, water quality, and land conservation. Flood control, Indian water needs, and water aspects of energy are problems that occur statewide.

Following are the seven specific problems identified in Oregon. They are approximately located on Figure VI-17.

NO. 1 – ENHANCING INSTREAM FLOWS FOR FISH AND WILDLIFE, RECREATION, AND OTHER ENVIRONMENTAL PURPOSES

NO. 2 – DETERMINATION OF FRESHWATER NEEDS FOR ESTUARIES

NO. 3 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 4 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 5 – OPTIMUM USE OF LAND AND WATER RESOURCES IN THE DESCHUTES RIVER BASIN THROUGH TOTAL WATER MANAGEMENT

NO. 6 – TOTAL WATER MANAGEMENT OF THE MALHEUR-HARNEY LAKES DRAINAGE BASINS WITH EMPHASIS ON THE SILVIES RIVER SUBBASIN

NO. 7 – FLOODING OF HIGHLY DEVELOPED FLOOD PLAINS AND URBAN AREAS IN SEVERAL MAJOR RIVER BASINS

NO. 1 – ENHANCING INSTREAM FLOWS FOR FISH AND WILDLIFE, RECREATION, AND OTHER ENVIRONMENTAL PURPOSES

SUMMARY

Oregon has advanced beyond most other States in the Westwide area in its attention to instream flow values. Not only are instream flow values for environmental purposes recognized as a valid, legal use of water, but the State, with technical assistance from Federal agencies, is actively engaged in establishing the level of desirable flows for these purposes in the major streams of the State. Before the desired flows can actually be introduced into the streams with a guarantee that they will remain for their intended purposes, extensive water resource planning, development, and management will be necessary to overcome institutional,

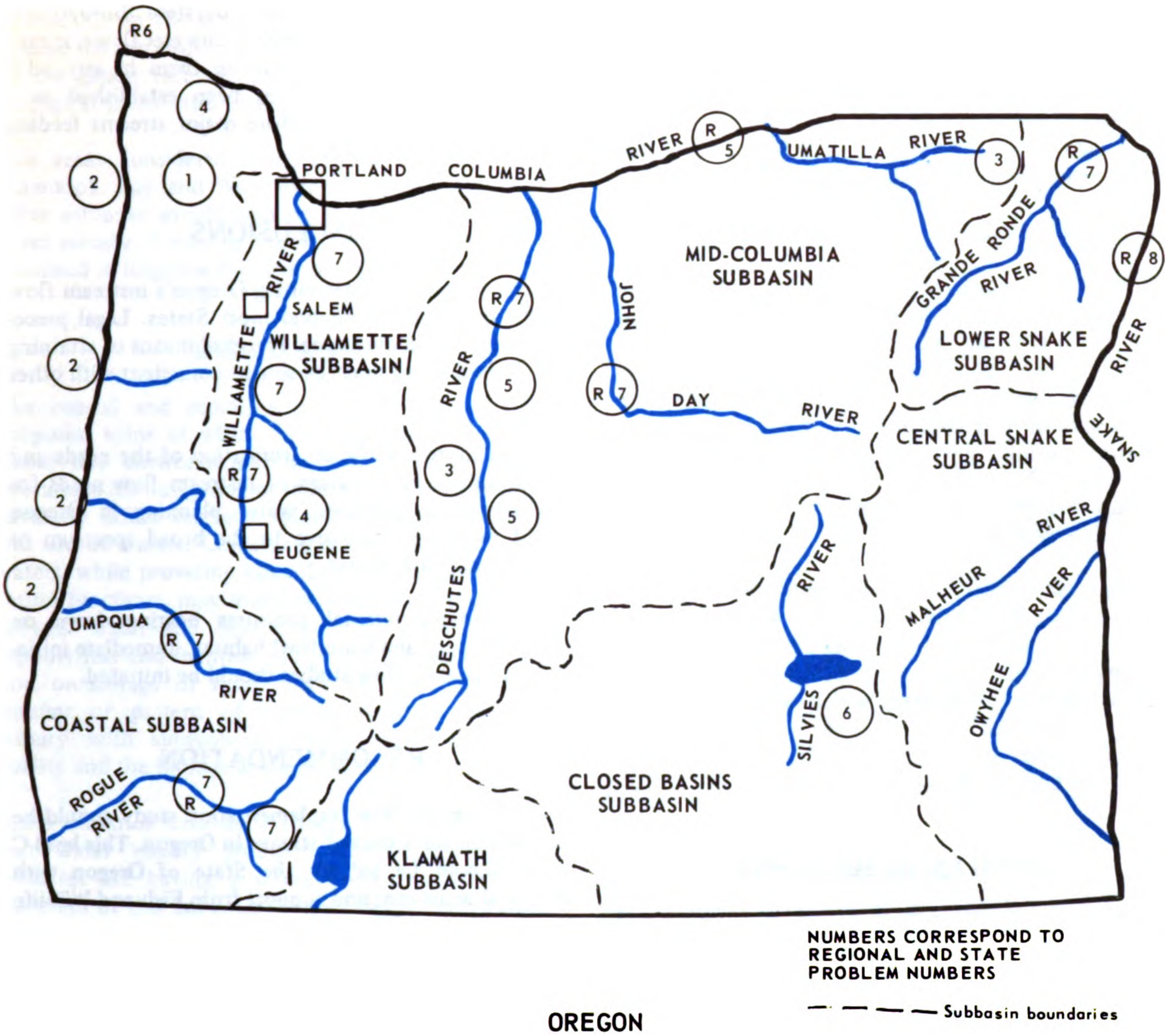


Figure VI-17. ***Critical water problems in Oregon***

financial, and technological problems associated with creating the optimum flow levels.

DISCUSSION

The high level of concern in Oregon for environmental values with respect to the State's rivers and streams has led to the creation of a legal standing for flows in the streambed for such beneficial uses as recreation and fish and wildlife. The State has had a statute allowing for protection of minimum flows for aquatic life since 1955. Moreover, the State in cooperation with several Federal agencies has or is in the process of establishing minimum and optimum flow values for the major rivers of the State. Oregon has established over 300 points where minimum flows are specified; the sum of all these flows totals more than 20 million acre-feet. The work is not completed, and, particularly on these streams in the more arid eastern portion of the State which suffers from seasonal low flows which limit the full realization of sport and commercial fishery and recreation levels, additonal work is needed.

Even after minimum and optimum flow values have been established and their legal standing assured as a general matter, a great deal of effort is needed to realize those flows. Many of the flow values have been set on streams which have an abundant water supply and where the streams are far from being fully appropriated. Many years may go by before a dry period will reduce streamflows below established levels. It is one thing to decide what the minimum level of flow ought to be; it is quite another to guarantee that they be there when needed, particularly when they are in conflict with other established and valid consumptive uses of the stream.

The flow levels that have been or will be established are the minimum flows which would maintain present environmental values. Additional information is needed on the economic and social benefits of these levels and of optimum levels so that water planning studies can give adequate consideration to these needs. State-Federal multiple objective planning studies will be needed in which plans can be formulated to find practical means to serve a variety of purposes, including the instream flow levels.

An important aspect of obtaining these instream flows is establishing equitable cost-sharing formulae in the likely event that substantial costs are incurred, either for physical control structures or for other activities such as purchase of existing water rights. Plans could evolve at the local, State, or Federal level. However, despite program sponsorship, significant financial support at the State level will be necessary.

PROBLEM RESOLUTION

Despite the additional legal status that established instream flow values have attained in Oregon, the concept of instream flow as a coequal purpose with other traditional purposes such as irrigation and municipal water, is more of a goal than a reality. To provide the instream flows, it is likely that storage space will need to be provided either by including it in new facilities or by reallocating existing storage space and uses of water. This will be costly. State-Federal studies will be needed to determine if such reallocation is desirable and practical. Cost allocation and repayment studies would also be needed to establish the practical viability of plans under the applicable cost-sharing policies.

It is difficult to foresee all the problems that could arise in creating a water resource program which has as one of its primary emphasis the creation of instream flows. Therefore, it is suggested that one or two streams be selected on a pilot basis to explore problems associated with this type of development. Since many of the Oregon coastal streams flow into coastal estuaries and are therefore vital contributors to the maintenance of the estuarine ecosystem through provision of adequate and timely freshwater flows, it may be most productive to focus on them in any pilot program. Tillamook Bay has been established as a priority estuary, and therefore major streams feeding the bay could be studied.

CONCLUSIONS

1. The process of determining Oregon's instream flow needs are advanced beyond most States. Legal precedents have been overcome. Practical means of attaining the desired flows must be sought consistent with other needs.

2. With more specific determination of the needs and opportunities in the areas of instream flow needs for environmental purposes, water planning in Oregon could be more responsive to the broad spectrum of public needs and desires.

3. With developmental pressures bearing down on critical fishery and waterfowl habitat, immediate initiation of instream flow studies should be initiated.

RECOMMENDATION

1. An instream flow implementation study should be undertaken on a coastal stream in Oregon. This level C study should be led by the State of Oregon with technical assistance and support from Fish and Wildlife Service, Corps of Engineers, National Marine Fisheries Service, Forest Service, Bureau of Outdoor Recreation and Bureau of Reclamation.

NO. 2 – DETERMINATION OF FRESHWATER NEEDS FOR ESTUARIES

SUMMARY

In comparison with estuaries elsewhere in the country, the natural biological balances of Oregon's estuaries are still relatively undamaged by the use of man. Some Oregon estuaries are further developed by man than others. All face increased pressure from use as recreational outlets, navigation and industrial development, and diversion or storage of water upstream. Any of these activities may change the delicate salt balance, aquatic life, shoreline, and tidal vegetation.

There is a critical need for more environmental information on the estuaries including the effect of upstream flows on the type, quantity and quality of aquatic life in the estuary; effects of dredge spoils on aquatic life; erosion and deposition patterns influenced by navigation facilities such as channels and jetties. Biological inventories of each estuary are also needed.

The areas considered most critical in Oregon are Tillamook Bay and Winchester Bay, although many other estuaries should also be studied. The Columbia River estuary, bordering the State on the northwest, is discussed in Regional Problem No. 6.

DISCUSSION

The coastal and estuarine zone is valued for many purposes, some of which conflict with public recreational and environmental interests. Dredge and fill operations for navigation or industrial development can adversely affect aesthetic values and public access to and use of waters. Construction of jetties and breakwaters, while providing valuable navigation and stabilization functions, may interfere with recreation as well as with water and sand circulation patterns which support fish and shellfish and maintain beaches. Diversion or storage of water upstream may change the amount or pattern of freshwater inflow into the estuary with subsequent adverse effects on water quality and the biological community.

Some estuaries have such concentrated development that water quality problems are occurring. These pressures are having a severe impact on the living resources of this zone. Caution should be exercised to assure that short-term developmental uses of the estuaries is not inconsistent with their overall long-term best use.

The need for planning and management has been recognized in both Federal and State laws. The Federal "Coastal Zone Management Act of 1972" gives the National Oceanic and Atmospheric Administration (Department of Commerce) authority to make grants to coastal States for planning and plan implementation. The Oregon Coastal Conservation and Development Commission (OCC&DC) was established to develop a comprehensive plan for the coastal zone, balancing conservation and development demands. In addition, several State natural resources agencies indicated that no permits of any kind would be permitted in an individual estuary until long-range land and water use planning programs were under way. The coastal and estuarine zone has also been the subject of past studies and is viewed as the top priority problem area in Oregon by the Oregon State Study Team working on the Comprehensive Joint Plan of the Pacific Northwest River Basins Commission.

The planning function, however, has only begun. Estuary planning guidelines have been developed by OCC&DC, but these relate to planning processes and methodology. The OCC&DC plan will be a package of legislative proposals for policies, standards, and criteria for use in local planning efforts rather than a management plan for the coastal and estuarine zone.

Local planning efforts being conducted are hampered by a lack of good information. The relative values associated with different uses of the coastal and estuarine zone, including recreation, have not been adequately identified. The relationships between ustream water and land uses and estuarine environmental and recreational quality have not been determined. The indirect impact on recreation of a loss of fish and shellfish habitat in the estuarine zone have yet to be evaluated. Until this kind of information is available, it will be difficult to develop management plans that effectively balance competing demands and protect the recreational and enviornmental resources of the coastal and estuarine zone.

There is a critical need for level C studies as to the overall amount and timing of freshwater inflows into the estuary required to maintain desirable conditions for the animal and plant assemblages of the estuary which enter into man's use and enjoyment. There is no Federal or federally assisted program presently available which really deals with this problem of the relationship of the upper basin to the estuary. Comprehensive multiple-objective planning cannot take place in the upper basin or in the estuary until those necessary inflows have been determined.

Estuary Problem Areas

Tillamook Bay is the second largest estuary on the Oregon coast, excluding the Columbia River. A recent study includes possible extension of the shallow-draft navigation channel and provision of an additional small boat basin.

Tillamook Bay is an important migration route and rearing area for valuable runs of anadromous salmonoids. Populations of marine fishes are found throughout the bay. Major species include coho, chinook, and chum salmon; steelhead and searun cutthroat trout; lingcod, rockfish, greenling, seabass, red snapper halibut, seaperch, and herring. These fish contribute to important commercial and sport fisheries in the Pacific Ocean, Tillamook Bay and its tributary streams. Crabs, oysters, clams, and shrimp also are or have been harvested commercially. Crabbing and clam digging are important recreational aspects. The area is also an important wintering area for black brant. Other waterfowl and shore birds are found throughout the area.

The Umpqua River, with its tributary Smith River, is the primary contributor to the Umpaqua River estuary. The Corps of Engineers is conducting a study to review the existing navigation project for any modifications that may be needed. The present project provides for two jetties; a training jetty; an entrance channel 26 feet deep with no specified width; an inland channel of 22-foot depth and 200-foot width to Reedsport, about 12 miles upstream; and a side channel to Gardiner, 9 miles upstream. In addition, a small boat mooring basin has been completed in Winchester Bay, a small bay off the estuary. The nature and extent of possible improvements have not been determined.

The Umpqua River supports important runs of chinook and coho salmon, steelhead, and searun cutthroat trout. Umpqua River estuary has good quantities of softshell clams and also supports a herring fishery (for bait). Some striped bass, shad, and sturgeon are taken in the upper estuary. Waterfowl, especially scaup, also use the upper estaury.

Netarts Bay and Sand Lake both support major species of fish, wildlife, oysters, clams, and shrimp. These two bays, which are adjacent to one another, are the two most pristine estuaries along the Oregon coast. With the exception of a domestic sewage with pollution threat to Netarts Bay, neither is in imminent danger of deterioration. However, each presents an opportunity to preserve a unique biological system and should be considered for Federal refuge status.

In addition to the estuaries mentioned above, the following estuaries are receiving intense development pressure and should receive early study attention: Nehalem Bay, Siuslaw River, Coos Bay, Siletz Bay, Alesa Bay, Smith River, and Yaquina Bay.

PROBLEM RESOLUTION

Maintaining planning and study programs at the present rate would allow development of coastal and estuarine lands and upper watersheds, subject to permit approval as necessary from Federal, State, and local authorities. Broad study efforts including OCC&DC and the Comprehensive Joint Plan should continue along the current timetable. Some ongoing studies by separate agencies will produce information on specific resources.

The following study is currently being carried out by the Fish and Wildlife Service in coordination with the Corps of Engineers:

1. Tillamook Bay

    a. Appraise fish and wildlife populations, harvest utilization by sportsmen.

    b. Evaluate project effects on wildlife.

    c. Determine methods to conserve and develop fish and wildlife resources.

Accelerating and broadening study programs and planning efforts would generate greater involvement by State and Federal agencies not fully involved previously. Study programs would be accelerated to provide more information at an earlier date.

Total needs for estuary planning compromise a broad variety of studies such as land use, navigation, biological studies, fish and wildife inventories and plans, flood plain management, and freshwater. Because the Westwide Study is limited to water supply aspects, total estuary planning needs are considered to be beyond the scope of this study. Accordingly, recommendations for new studies below are limited to requirements for freshwater inflow to the estuaries, even though the need for broader studies has been discussed in the problem dimensions above.

CONCLUSIONS

1. The State of Oregon, probably through the OCC&DC, should assume leadership in coordinating estuary studies by Federal and State agencies. Priority should be given to Tillamook and Winchester Bays.

2. Recent Federal and State legislation has given emphasis and priority to planning the best use of coastal estuaries including the optimum blend of development and preservation.

RECOMMENDATIONS

1. Sufficient Federal funding through the "Coastal Zone Management Act of 1972" should be provided to assure that a comprehensive estuary management plan can be prepared in conjunction with the Comprehensive Joint Plan for the Northwest as well as data collection studies and ultimate implementation studies.

2. With continued upstream development, a study to determine the freshwater inflows and requirements of all estuaries is needed. The change in salinity from the freshwater inflow to the ocean is extremely critical for most estuarine organisms. A minimum freshwater requirement for each estuary would be the result of such a study. Federal agencies, particularly the National Marine Fisheries Service, Fish and Wildlife Service, the Bureau of Outdoor Recreation, and the Corps of Engineers, should provide technical assistance for studies of freshwater inflows for estuaries.

NO. 3 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

The primary problem is related principally to lack of development of existing water supplies necessary to support a combination of needs increasing population demands for rural and municipal consumption, industrial and agricultural development, and the maintenance of fish and wildlife habitat on Indian lands. Since reservation water requirements are not fully established, it is critical to determine water needs and development potentials so that water planning can go forward on the reservations according to Indian goals and aspirations to support future Indian community development.

DISCUSSION

The Indian reservation population of Oregon State is approximately 2,800 people. There are 3 main communities, the largest having 1,800 resident Indian people. The majority of the people live in the north-central and northeastern portion of the State. A major proportion of the population is under 25 years of age. Increase in reservation population has been substantial (about 3 percent annually) and the high proportion of young people indicates that population pressures on the reservation communities are going to increase, with all the attendant problems such as the need for adequate housing, adequate education, and adequate community facilities, economic stability, and community health. The Oregon Indian communities are all located in rural areas.

In this rural environment the reservation economy has traditionally been tied to the national resources which exist on or are related to the reservations. Resources such as timber, range, agricultural land, and fisheries have been and are the primary support of the Oregon Indian communities. Per capita income of the Indian communities is substantially below the State levels – $2,379 as related to $3,163 for the State of Oregon. The unemployment rate varies with the different communities; however, it is substantially higher than the State as a whole – the present unemployment is 7 percent for the State as compared to 16 percent for the Indian population as a whole.

Trust lands in the State total 728,000 acres – approximately 569,000 is tribal land and 159,000 acres are allotted to individual Indian owners. Range acreage totals 279,000 and dryfarming occurs on about 98,000 acres. Irrigated acreage now amounts to about 1,800 with an estimated potential of about 39,600 by year 2000. Ultimate irrigable reservation lands are in excess of 100,000 acres. Commercial forestland is in excess of 322,000 acres with a sustained annual cut of 99 million board feet of timber.

Future expansion potential which impact on the need for water for Indian trust land in Oregon are as follows:

1. Continued expansion of timber produce manufacturing and processing.

2. Continued expansion of commercial recreation supported by natural resource base of high scenic value and existing water resources.

3. Intensification of light industrial activity and diversification of reservation economics to provide more services to the reservation communities and surrounding non-Indian communities.

4. Enhancement of present community environment through improved housing and community facilities.

5. Enhancement and restoration of the salmonoid fishery related to reservation waters (present non-Indian water withdrawal has already reduced the flow of the Umatilla River to the extent that it is virtually nonexistent for a period each year).

These needs represent a substantial increase in demands upon the water resource. Reservation lands in the past have been developed at a lower level than surrounding areas. Industrial activity, expanded housing, commercial recreation, and other factors have been expanding substantially in the last 5 years. For example, 166 housing units have been constructed in the period 1968-1972 and a need for 364 units exists currently to to bring the Indian communities into acceptable housing. It is anticipated that the increasing sophistication and capability of reservation communities will result in a much higher per capita use of water in the future.

CONCLUSION

1. Complete knowledge of the quantity and quality of water related to Indian reservations and to the social and economic conditions of the Indians is lacking at this time. A program of complete water resource investigations is now under way through a Bureau of Indian Affairs program. Each reservation is a separate entity, with differing physical characteristics, potential, and need. Therefore, each entity must be researched independently. As time and funding become available, complete resource industry and water management planning will be accomplished for all reservation areas.

RECOMMENDATIONS

1. Indian trust land and water should have a high priority for study in Federal and regional water planning.

2. Indepth water resource investigations and development of water management plans for trust land areas should be continued. Responsibilities should be with the tribes and the Bureau of Indian Affairs with technical assistance from other Federal agencies as required.

3. Indepth planning in Deschutes, Umatilla, and Malheur basins should continue with objectives of conservation, efficient use, and water quality improvement being uppermost. Special studies planning for water storage and water management projects should be pursued which will result in more efficient use and reuse of the total water resource in these basins containing trust land acreage.

NO. 4 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

Oregon's present and expected future demands for water-related energy development stem from hydroelectric generation and water for cooling of thermal electric plants. At the present time there are no known demands for water for development of coal, oil, gas, oil shale, or other basic energy resources because they do not exist in significant amounts in Oregon except for some coal deposits in the Coos Bay and Coquille River areas. These coal deposits are unlikely to be developed because of marginal economic values and environmental conflicts. An important need is for a multiobjective evaluation of remaining hydrosites. Expansion of existing hydro facilities on the Columbia River should be actively pursued. Pumped storage projects may be needed in Oregon after 1990. Thermal plant siting is of critical concern because of adverse effects of thermal discharge.

DISCUSSION

Oregon is presently a heavy importer of power. Electric energy use in Oregon for the year 1970 amounted to about 28 percent of that for the three States in the Northwest. Electric energy generated in Oregon in 1970 amounted to 22,906 million kilowatt-hours (kWh) which was about 22 percent of the energy generated in the Pacific Northwest assuming half of the energy generated by the plants located on State lines attributed to each State. In that year maximum peak generating capacity for Oregon, including existing hydroelectric and thermalelectric plants, was 4,807 (MW) or slightly over 20 percent of the peak capability in the Columbia-North Pacific (CNP) area. One large nuclear thermal-electric power, Trojan, with 1,130 MW is under construction. Even with projected new power supplies for development by the early 1980's in Oregon, including combustion turbines and nuclear powerplants, the State will continue to import a large portion of its electric power.

Seasonal variations in powerloads in the Pacific Northwest are minimized through interchanges of power within the region's predominantly hydroelectric system. Oregon's electric power needs, therefore, must be considered in the context of power production in the Northwest and the effects of existing and potential interties with areas outside the Northwest.

Hydropower

The CNP Comprehensive Framework Study shows only about 2,500-MW nameplate capacity of conventional hydroelectric power potential for Oregon. This includes one-half of the controversial Middle Snake River power potential (see Regional Problem No. 8). The Bureau of Reclamation has studied, or is now studying, a number of multipurpose water development projects which may now be appropriate for power development. The two which appear to offer the best physical potential are Ryan Dam and Reservoir in the Umatilla River basin and Dickey Dam and Reservoir in the Molalla River basin. Also, the Corps of

Engineers has recently studied Days Creek Dam and Reservoir in the Umpqua River basin for possible power additions. New values of hydroelectric power data have been prepared recently by the Federal Power Commission. Most hydro powersites are in competition with environmental values.

Thermal Power

In Oregon, a number of potential sites for nuclear thermal powerplants are under investigation. They would be constructed in the 1980's or later. Site investigations are being conducted by the Oregon Nuclear and Thermal Energy Council, Pacific Power and Light Company (PP&L), Eugene Water and Electric Board (EWEB), Portland General Electric Company (PGE), and by the Public Power Council of the Joint Power Planning Council. Portland General Electric Company filed an application for the Boardman site, filed letters of intent for the Pebble Springs and Fulton Ridge sites, and is actively exploring coastal sites in Tillamook County. Eugene Water and Electric Board has filed a letter of intent for the Big Creek site near Florence. Pacific Power and Light Company has begun investigation of several Oregon sites. The Whiskey Run sites would require ocean water for cooling while the One Horse Slough site near Lebonon would use water from the Santiam River for offstream cooling. A third site is also being investigated in the vicinity of Sutherlin, Oregon.

Geothermal

Geothermal resource areas abound in and along the Cascade Mountains and in various areas of eastern Oregon. Some of the known geothermal resource areas (KGRA's) should be investigated for development of electric energy. The possible geothermal areas of Oregon are, in general, within four contiguous physiographic divisions: the Cascade Range, the High Lava Plains, the Basin Range, and the Owyhee Upland. Together they form a region comprising more than 40 percent of the State's total area. About 80 of the 100 thermal springs known in Oregon are found within the borders of this region.

Pumped Storage

A large potential pumped-storage peaking capability could be developed especially in the Willamette River basin where most of the power requirements are expected to grow. There is also a large potential in the Columbia River Gorge and the Oregon coastal area. In addition, potential pumped-storage sites associated with Prineville Reservoir and with Long-Round Lake in the Klamath basin should be analyzed.

Pumped-storage hydroelectric projects are particularly sensitive to location. Two water storage reservoirs are required with high differential in elevation and an adequate water supply. Pumped storage provides only peaking power and actually consumes three units of energy for pumping for every two units of energy produced which may decrease the desirability of pumped-storage projects during an energy shortage period.

Powerplant and Transmission Siting

In connection with new electric power supplies there is the problem of location of generating plants. There is little flexibility in locating a hydroelectric plant, since foundation, water supply, storage basin, and head (the fall from reservoir to river water surfaces at powerplant)

For thermal projects, either fossil fueled or nuclear, a water supply is necessary regardless of type of cooling system employed. Additional environmental considerations enter into the location of thermal plants. In some States, including Oregon and Washington, agencies have been established to regulate the location of nuclear and fuel-fired thermal powerplants. In Oregon, for example, the areas considered suitable for nuclear plant location are identified in the preliminary January 1973 "State-Wide Siting Task Force Final Report," issued by the Oregon Nuclear and Thermal Energy Council.

Public acceptance and environmental considerations may allow construction of the greater part of future thermal generating plants west of the Cascades. However, public sentiment may dictate the plants be located east of the Cascades which could create problems for locating transmission corridors through the mountains to the load centers.

By the year 2000, assuming that about 60 percent of the new thermal and pumped-storage generation is constructed east of the Cascades, total transmission capacity of about 42,000 megawatts will be required through the mountains. This compares to 10,500 megawatts estimated to be completed by 1976.

By the year 2005, assuming this same distribution of new generation, the transmountain transmission requirements would be some 52,000 megawatts and by the year 2010, this capacity requirement would have grown to about 64,000 megawatts.

Thermal Cooling in Conjunction with Irrigation

An interesting possibility for eliminating thermal pollution from thermal powerplants is to combine water cooling systems with use of warm water effluent for irrigation. This process would alleviate the fishery problem associated with thermal pollution, reduce the cost of power generation by eliminating the need for expensive cooling devices, reduce the high evaporation loss associated with reuse systems, and gain the benefits associated with irrigation. Corollary research needed to perfect such a system includes: (1) the response of crop yield to warm water, (2) greenhouse studies involving high value crops, (3) means of eliminating chemicals used to control slime, algae, or other growths on cooling ponds or towers prior to release of water into river systems, (4) temperature changes and gradients in cooling reservoirs, (5) warm water irrigation effects on disease or insects and soil microbiological changes, and (6) impacts of large nuclear parks and associated irrigation on climate.

The Columbia River south side area near Boardman, Oregon, appears to offer the best immediate prospects for the location of thermal powerplant in conjunction with irrigation. However, safety considerations due to its proximity to a Navy bombing range may rule out a nuclear-fired plant. A coal plant would present less of a hazard but coal would have to be imported.

The economic benefits of irrigation with warm water are not well defined. However, as a minimum there would be a cost saving eliminating cooling water facilities at the powerplant and possibly saving pumping and diversion facilities cost to the irrigation. Large-scale irrigation in the Boardman area has not in the past proved economically attractive. It remains to be proved whether the savings attributable to thermal cooling would change this evaluation.

CONCLUSIONS

1. Development of the remaining large potential hydro and pumped-storage sites in Oregon will be in competition with use of the streams for free-flowing environmental values and will require multiobjective studies.

2. Oregon's power demands will increasingly be met by large thermal plants, either coal fired or nuclear located within the State.

3. Thermal plants will likely be non-Federal and responsibility for environmental studies would rest with the State or the utility.

RECOMMENDATIONS

1. Site selection, timing, and sizing studies for large thermal electric generating plants and transmission facilities should involve close coordination between private and public interests and State and Federal agencies on a regional basis.

2. The remaining new hydroelectric power potential in Oregon and additions to existing powerplants should be reevaluated in light of the energy crisis and new values of power at sites where there are no major conflicts with unique environmental values such as wild and scenic rivers and in designated wilderness areas. Potential multipurpose projects should be reexamined for inclusion in plans for added hydro energy resources.

NO. 5 – OPTIMUM USE OF LAND AND WATER RESOURCES IN THE DESCHUTES RIVER BASIN THROUGH TOTAL WATER MANAGEMENT

SUMMARY

The major problem is that not enough water is available to satisfy all of the interests in the area; and the most obvious means of increasing water supplies, water salvage measures, is hampered by insufficient knowledge of the hydrology of the basin and water laws which offer little incentive for improvement. Inadequate streamflows, major flood damage, Indian water requirements, anadromous fish restoration, water quality, land use, and water supply are dimensions of the problems that require a comprehensive planning effort.

DISCUSSION

The most commonly expressed complaint is the low-flow situation in Deschutes River below the irrigation diversion structures at the city of Bend. The flows in the summer generally remain below 50 ft^3/s, where flows of 700 to 1,000 ft^3/s existed before diversions began near the turn of the century. The reach affected by low flows extends from Bend to Lake Chinook, some 50 miles downstream. Not only is this a detraction from the general beauty of the area, but it also results in a loss of trout production and fishing opportunity.

A number of water supply problems exist in the area. The expense of well drilling has caused many families to use untreated water delivered in the irrigation canals for domestic consumption; and the cities of Prineville, Redmond, and Bend will need additional municipal industrial, and domestic water supplies. Supplemental water supplies are needed for 117,000 acres of inadequately irrigated lands, and owners of other presently dry lands would like irrigation water supplies.

In addition, the best use of some 82,500 acre-feet of unassigned space in Prineville Reservoir has not been determined. Conceivably, much of the water yield from this space could be used to alleviate some of the water supply problems facing the area.

The Deschutes basin has been invaded recently by a growing number of recreation and homesite developments. While some are definite assets to the area, others create serious problems for the county with regard to water supply and waste disposal. The more remote sites are often too distant from water supplies, and the sites along streams threaten to pollute the waters of the area. It is only a matter of time before subdivision of land for homesites also will create major problems for the irrigation districts in the area through division of irrigated lands and resulting service difficulties.

Water quality problems in the Deschutes River basin include irrigation return flows which have long been a source of nutrients and seasonal turbidity; and in the Bend-Redmond area, disposal of raw wastes with their potential for a serious health hazard. Fishkills have been reported at several points where irrigation waters return to the river, indicating that these waters may carry lethal levels of toxic materials, possibly pesticides.

Warm Springs Indian Reservation is located within Deschutes River basin, and the Tribal Council is keenly concerned with maintaining the quality environment of the area and having available to them sufficient water supplies to meet their future needs.

The leakage of water from irrigation canals in the area is recognized by most as requiring study leading to corrective actions. It is a complex problem which raises questions regarding existing water laws and the magnitude, origin, and destination of underground water supplies; and consequently, is beyond the capability of the local people to solve. Until this situation is cleared up, new water developments of any kind will be questioned. Consequently, the problem requires solution in the next 15 years if growth and development are to continue at a reasonable rate.

The 100-mile segment of Deschutes River from Pelton reregulating dam downstream to its mouth is a component of the Oregon State Scenic Waterway System, thus protecting this segment of river from adverse private development and prohibiting the construction of facilities. The Governor of Oregon has requested that this reach of the Deschutes River be made a part of the National Wild and Scenic River System. In response to that request, the Department of the Interior in cooperation with the State and the Warm Springs Indian Tribal Council, is currently considering a segment of the Deschutes for possible inclusion in the National System.

The Deschutes River basin is a prime fishing area for both anadromous and resident fish. Since the construction of Pelton and Round Butte Dams, anadromous fish runs have been limited to the lower Deschutes River System. The primary spawning streams are Warm Springs River, Trout Creek, Bakeoven Creek, Buck Hollow Creek, and Nena Creek. If access were provided past an existing waterfall, White River would also be an important spawning stream.

Deschutes River, because of its even flowing characteristics has practically no flood history except for the major flood that occurred in December 1964. Damages, amounting to nearly $2.5 million, were to railroad and highway facilities along the lower 85 miles of the main river. Damages of about $1.5 million occurred on the tributaries: Crooked River below Prineville, Shitike Creek at Warm Springs, Warm Springs River at Kah-Nee-Ta resort, and White River and Tygh Creek at Tygh Valley. Flooding problems on the main river are not amenable to relief by further storage, because most of the damages occurred downstream from Round Butte Dam where the river was substantially controlled. Multipurpose storage should be beneficial to flood prevention on the critical tributaries, while Crooked River is more suited to a nonstructural solution. No potential channel and levee projects have been identified with the exception of a small project in Juniper Canyon.

PROBLEM RESOLUTION

Potential new sources of water to meet requirements include bypassing an 8-mile reach of Deschutes River upstream from Bend which has seepage losses of 35,000 acre-feet annually, lining existing irrigation canals and laterals to save about 250,000 acre-feet annually, utilizing unassigned storage in Prineville Reservoir totaling 82,500 acre-feet, drilling new wells to use ground water, and constructing new reservoirs. All of these sources appear promising except for the bypass canal which was found to adversely affect fish and wildlife and recreation. A plan is needed within the next 10 years.

Problems in the Deschutes basin will not be solved by one agency; rather, it will require the coordinated efforts of local, State, and Federal interests. The Bureau of Reclamation has in the past constructed major irrigation facilities within the basin and just recently completed framework level planning in the area. Participation is needed from the State Engineer's Office, because of the water law situation; the Geological Survey, because of the surface and ground-water data needed; and the Bureau of Indian Affairs and the Warm Springs Tribal Council.

CONCLUSION

1. A total water management study is needed to solve the problems in the Deschutes basin and advance a plan of development to meet needs. The first stage of the study would examine the water resources of the area through a regional ground-water study and an inventory of all surface water resources.

RECOMMENDATION

1. A total water management study by appropriate State and Federal agencies should be scheduled within the next 5 years. It should be coordinated with other water and related land studies in the basin and with activities of the Pacific Northwest River Basins Commission.

NO. 6 – PROBLEMS AND NEEDS OF THE MALHEUR-HARNEY LAKES DRAINAGE BASINS WITH EMPHASIS ON THE SILVIES RIVER SUBBASIN

SUMMARY

There has been a long history of conflicting demands and opinions regarding the best use of the land and waters of the Malheur-Harney Lakes basin and more detailed investigations are needed of the ecological, cultural, and economic relationships of land, water, and wildlife in order to build a comprehensive plan for the best use of these lands and waters.

DISCUSSION

The Malheur-Harney Lakes drainage, a portion of the Oregon closed basin, includes three major tributary systems, the Silvies River drains about 1,350 square miles and flows into Malheur Lake from the north; the Donner and Blitzen River drains a 1,000 square mile watershed and flows into Malheur Lake from the south; flood overflows from Malheur Lake run into Harney Lake; and Silver Creek, a 900 square mile drainage, flows directly into Harney Lake. The primary economic development and population centers are in the Silvies basin.

Both Malheur and Harney Lakes lie within the 180,850-acre Malheur National Wildlife Refuge. Malheur Lake is the largest freshwater marsh in the Western United States and is world famous for the number and variety of birds, especially migratory waterfowl, it supports. Many species of birds nest on the marsh and adjacent uplands and rely on native food plants until forced to migrate by severe winter weather. Harney Lake, a natural sump with no outlet, is normally too shallow, alkaline, and brackish for most uses. It is, however, heavily used by waterfowl and shore birds during high-water years.

Water has been a problem here since the first settlers arrived, especially in the Silvies River drainage. The problem intensifed in succeeding years as the population increased and more land was occupied. Roads and other obstructions have impeded runoff to Malheur Lake.

Spring flood damage has increased as residential development expanded into the flood plain near the city of Burns (population 3,200), the county seat. Burns and its close neighbor Hines (population 1,400) are the only incorporated municipalities in the study area which is otherwise sparsely populated.

The demand for irrigation water has also increased greatly, and direct diversion has become the principal method for its delivery. Relatively high streamflows occur during the months of March, April, and May, mainly because of snowmelt in the mountains.

Following the high spring runoff, the flows decline rapidly and remain low until about the month of February. Because there are no storage projects in the basin, flood damages occur during the high runoff periods and shortages of irrigation water occur during the growing season. In addition, there are problems and needs relating to drainage, land erosion, minimum flows for fish, municipal water supply, water-oriented recreation, and water supply at the Malheur Lake Waterfowl Refuge, and sidehill flooding at Burns and Hines.

Water management in this basin, particularly on the Silvies River has been further complicated by the needs of Malheur National Wildlife Refuge. The refuge lies at the lower end of the drainage and is wholly dependent on the natural inflow of the Silvies and Donner and Biltzen Rivers. Major storage diversion works are considered by many to be a serious threat to this marsh. Inflow to Malheur Lake is relatively unaltered in quality which has helped maintain it as an outstanding example of a freshwater marsh.

PROBLEM RESOLUTION

One of the primary needs is for an early start on studies to identify the extent and availability of ground water, and to determine the effects on Malheur Lake of surface- and ground-water withdrawals. Until completion of such studies, tapping the ground-water supply is considered the preferable alternative to surface-water development. However, it is recognized that this could also affect Malheur Lake, and the studies should be completed before extensive ground-water development is undertaken.

Preliminary studies by the Corps show that reservoir storage is apparently economically feasible. However, detailed study has been delayed while the Geological Survey undertakes a 2-year water budget study of Malheur Lake. This study will provide basic hydrologic data.

An acceptable solution to water resource problems of the Silvies River basin is one that benefits the refuge or has a minimal adverse effect on it and achieves the objectives of reducing flood damages and provides a dependable water supply for irrigation. Further studies are needed.

CONCLUSIONS

1. The Corps of Engineers has an ongoing investigation of the Silvies River basin which will develop information on the area's flood protection and water supply needs.

2. The Fish and Wildlife Service is prepared to initiate a data collection study and management plan for the best overall use of the Malheur National Wildlife Refuge.

3. Development in the Silvies River basin and other tributary basins could affect fish and wildlife conditions in the Harney-Malheur Lakes.

RECOMMENDATION

1. A level B planning effort should be undertaken in the Malheur-Harney Lakes basin under the leadership of the Pacific Northwest River Basins Commission. The Corps of Engineers' present Silvies River basin study and the Fish and Wildlife Service's study should be major elements in this study and should be continued. Participation should also be by the Bureau of Land Management, Outdoor Recreation and Reclamation, Forest Service, Soil Conservation Service, Oregon Water Resources Board, Oregon Wildlife Commission, and other local and State water and land conservation agencies.

NO. 7 – FLOODING OF HIGHLY DEVELOPED FLOOD PLAINS AND URBAN AREAS IN SEVERAL MAJOR RIVER BASINS

SUMMARY

Although much progress has been made in the last 30 years in alleviating flood problems, flood control or flood damage reduction remain a big problem to the State of Oregon. As expected, the areas of highest need occur where population increases have been experienced and where developments have been made in the flood plain. The highest priority areas of need are along the main stem and tributaries thereto of the Willamette River, the Umpqua River in the Roseburg area, and the Rogue River below Grants Pass. On the Grande Ronde River, near the La Grande area, and in the Silvies River basin, flood damage potential is found in a more rural setting.

DISCUSSION

The basic need relating to flood problems is to reduce potential damages, both present and future, by providing for appropriate use of areas in the flood plain consistent with the degree of hazard and costs of achieving protection. Alternative uses of both water and land in the flood plain and reservoir sites complicate the problem of achieving flood damage reduction and may in some instances preclude structural solutions. Where flood control can be achieved through operation of multiple-purpose reservoirs, at times, empty storage space can conflict with a project's service to other water uses.

There are two major means of reducing flood damages: structural and nonstructural. Structural means include modification of initial storage facilities and construction of new storage, levees, and channel works. Nonstructural means include maintenance of vegetative cover to stabilize runoff and reduce downstream sedimentation and locally enact measures to regulate flood plain use; i.e., zoning flood proofing a development, land treatment programs, and informational programs. Frequently, particularly in the larger river basins, a combination of structural and nonstructural measures will be required to achieve the desired flood damage reduction.

Following are summaries of major flood problems in urban areas of Oregon which require some form of structural solution, possibly in combination with channel improvement and local flood plain management.

Willamette River Basin and Tributaries

The Willamette Basin Comprehensive Study identified the following streams in their early action program. In the Calapooia River basin and Marys River basin multiple-purpose studies are underway at level C to find timely solutions to the area's needs consistent with the environmental and social objectives of the local area. In the Thomas Creek basin, Yamhill River basin, Rickreall Creek, Luckiamute River basin, Amazon Creek, and Santiam River basin, the findings of the Willamette Basin Comprehensive Study for solution to flood problems should be considered preliminary and subject to change as more complete studies considering a full range of economic, social, and environmental objectives are undertaken. The comprehensive study also identified two authorized but unconstructed multiple-purpose storage projects as necessary additions to their flood control program.

Umpqua River

The Corps of Engineers has completed a survey report on the Umpqua River and submitted it to Congress. A multiple-purpose reservoir at the Days Creek site has been authorized. This project would reduce flood damages in the Roseburg area and would be responsive to the needs of the area.

Rogue River

The Corps of Engineers has three multiple-purpose reservoirs authorized in the basin. Two of these are under construction, the Lost Creek project and the Elk Creek project. These projects together with authorized Applegate Dam will reduce flood damages in the entire reach from the dams downstream past Grants Pass.

CONCLUSIONS

1. The ongoing Corps of Engineers survey program will provide an array of alternative solutions. Where projects are authorized but not constructed, the adequacy of the authorized plan needs to be reevaluated using multiple-objective planning concepts.

2. Most structural solutions will provide multiple-purpose water resource developments and opportunities.

RECOMMENDATION

1. The Corps of Engineers program should continue to be closely coordinated with local, State, and Federal agencies and should be compatible with the Comprehensive Joint Plan of the Pacific Northwest River Basins Commission and development objectives of Oregon.

Utah covers nearly 85,000 square miles and is the 11th largest State in the Union, 9th largest in the Westwide area. The State's 1970 population totaled slightly more than 1 million people, making it the sixth most populous of the Westwide States. The greatest concentration of people is along the "Wasatch Front," an 80-mile strip of communities centering on Salt Lake City, lying along the west side of the Wasatch Mountains.

Utah's economy is diversified and based upon industries that will share in the growth of the national economy. The State's vast natural resources have provided a significant part of the economic base in the production of copper, steel, coal, oil, gas, uranium, and precious metals. Using 1969 data, Utah ranked 10th among the 11 Westwide States in per capita income. Government, wholesale and retail trade, and manufacturing were the major generators of personal income. Agriculture is the major economic activity of rural Utah.

Irrigation, dryland farming, and rangeland suitable for livestock grazing are important aspects of Utah's agricultural economy. A wide variety of products, including grains, sugar beets, vegetables, and fruits, is grown. The most important cash crops are wheat and sugar beets. With about 64 percent of its land in Federal ownership, it is second among the Westwide States in this category. Only 17 percent of its land is in private ownership. Forty-seven percent of the land is classified as range or grass land, and another 36 percent is classified as forest. The State's scenic attractions, National parks and monuments, wildlife, and abundance of land are contributing to an increasing tourist industry.

In the next several decades, with expanded population and urban and industrial growth, Utah's water needs could triple. Most of this growth is projected to occur along the Wasatch Front. Local water shortages in the Salt Lake Valley and in the Fremont and Escalante basins could occur in the next 10 years. Other areas experiencing periodic water shortages now are the Seiver River basin and the Cedar City-Beaver area.

WATER SUPPLY

Precipitation is generally scant in Utah, varying widely in different parts of the State. The State's overall average is 13.5 inches per year, with much of western and southeastern Utah receiving less than 10 inches annually. The Wasatch Mountains, which supply runoff to both the Great Basin and Colorado regions, receive 40 to 50 inches of precipitation annually, most of which falls as moderately heavy snowfall in the winter. Snowmelt is a major source of water supply within the State.

Surface Water

Utah is a part of four major water resource regions: Upper Colorado, Great Basin, Lower Colorado, and the Columbia-North Pacific. The upper Colorado and Great Basin regions dominate the water supply situation and practically divide the State in half.

There is considerable contrast between these two regions. The eastern half of the State, which is in the Upper Colorado region, is drianed by a network of streams formed by the Green, Colorado, and San Juan Rivers. The Great Basin region consists of a number of rivers which generally drain toward the Great Salt Lake. These include the Bear River which rises high in the Uinta Mountains, flows into Wyoming through Idaho, and back to Utah to terminate in the Great Salt Lake. The Weber River and its main tributary, the Ogden River, flow westward from the Wasatch Mountains into the Great Salt Lake. Other rivers of importance are the Jordan and Sevier.

More water flows into the State than is contributed from watersheds in the State. The long-term average annual State water supply is estimated to be about 17.2 million acre-feet per year, of which 9.4 million acre-feet is inflow to the State. Because of compacts, treaties, and other decrees, only 1.7 million acre-feet is estimated to be available for future use within the State, either as an instream flow for environmental purposes or for diversion. These values are average annual quantities and physical or economic constraints could likely preclude full utilization.

From a water-use standpoint, 1975 depletions are estimated to be about 4.8 million acre-feet per year. As in the case of all the other Western States, agriculture is the primary user. It is estimated that by 1975, agriculture will deplete about 2.6 million acre-feet of water per year.

Tables VI-46 and VI-47 summarize Utah's estimated 1975 water use and water supply situation.

Ground Water

Although Utah has vast amounts of ground water, because of location, other physical, economic, and

Table VI-46.—*Estimated 1975 total depletions[1] for Utah (1,000 acre-feet)*

Region and subregion	Purpose or cause of depletion							Total depletions
	Irriga-tion	M&I including rural	Min-erals	Thermal electric	Recre-ation[2] F&WL	Other[3]	Reservoir evapor-ation	
Great Basin								
Bear River	427	15	0	0	138	182	18	780
Great Salt Lake	748	103	13	5	269	384	313	1,835
Sevier Lake	858	11	2	0	55	227	70	1,223
Total region	2.033	129	15	5	462	793	401	3,838
Upper Colorado								
Green River	461	4	7	7	6	118	29	632
Upper main stem	16	1	1				42	60
San Juan-Colorado	44	2	1	1	2		3	53
Total region	521	7	9	8	8	118	194[4]	865[4]
Lower Colorado								
Lower main stem	40	2	0	0	20	0	1	63
Total region	40	2	0	0	20	0	1	63
Columbia-North Pacific								
Upper Snake	14	0	0	0	0	0	0	14
Total region	14	0	0	0	0	0	0	14
State summary	2,608	138	24	13	490	911	596	4,780[5]

[1] Includes surface water, surface-related ground water, and mined ground water.
[2] Exclusive of instream flow use.
[3] Primarily evaporation from nonirrigated wet meadows and unmanaged wetlands. No depletion attributed to consumptive conveyance losses.
[4] Includes Utah's share of Colorado River main stem reservoir evaporation, and therefore subregions will not add to region total. Average annual main stem reservoir evaporation assumed to be 520,000 acre-feet; Utah's share, 120,000 acre-feet.
[5] Surface-water depletions – 4,180,000; ground-water depletions – 600,000.

Table VI-47.—*Estimated 1975 surface water-related situation in Utah (1,000 acre-feet)*

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within sub-region or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Great Basin									
Bear River	686	970	0	1,656	0	780	876	435	441
Great Salt Lake	0	2,570	100	2,670	0	1,835	835	28	807
Sevier Lake	0	1,240	12	1,252	3	1,223	26	0	26
Total region	686	4,780	112	5,578	3	3,838	1,737	463	1,274
Upper Colorado									
Green River	1,856	1,950	0	3,826	112	632	3,082	[8]	
Upper main stem	5,088	100	0	5,188	0	60	5,128	0	0
San Juan-Colorado	1,795	601	3[5]	2,399	0	53	2,346	0	0
Total region	8,759	2,651	3	11,413	112	856[6]	10,436[6]	10,255	181[7]
Lower Colorado									
Lower main stem	0	260	0	260	0	63	197	0	197
Total region	0	260	0	260	0	63	197	0	197
Columbia-North Pacific									
Upper Snake	0	30	0	30	0	14	16	0	16
Total region	0	30	0	30	0	14	16	0	16
State summary	9,445	7,721	0[9]	17,166[9]	0[9]	4,780	12,386	10,718	1,668

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletions related to ground-water mining removed from totals presented in "Depletions" table.
[5] Import from Sevier Lake subregion, Great Basin region.
[6] Includes Utah's share of main stem reservoir evaporation and therefore subregions will not add to region total.
[7] Represents the remaining amount of water the State of Utah can develop from the waters of the Colorado River system. Assumes 5.8 million acre-feet availability to Upper Colorado Region States adjusted for 1975 Utah uses, exports, Utah's share of main stem reservoir evaporation, and Bonneville depletions of 164,000 acre-feet.
[8] Henrys Fork and Yampa Rivers are also covered by compacts.
[9] No imports or exports to or from state. All imports and exports are within state and therefore not included in state totals.

quality factors, only a small amount of ground water is used. In 1970, it was estimated that about 760,000 acre-feet of ground water was withdrawn. Most of these withdrawals were used for municipal and industrial purposes in the Great Basin region.

Water Quality

Generally, surface water quality is excellent in the Upper Colorado region. In the Great Basin region, surface water quality deteriorates progressively downstream and becomes very saline in the lower reaches of the Malad, Bear, Jordan, and Sevier Rivers.

Ground-water quality varies considerably and overall is not as good as that of the surface water. The best quality water is found in the areas of natural recharge. Hardness is a problem and in some cases specific chemical concentrations exceed recommended limits for certain uses.

CRITICAL PROBLEMS

The Westwide problems which affect Utah are briefly discussed below. Regional problems having an impact are listed. This portion also provides additional State specific information. Figure VI-18 shows the location of the State and regional problems.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – Development of the mineral resources of the Uinta Basin and other resources of the Upper Colorado region will place a tremendous demand on the water supplies of the basin and, as a result, could affect instream flows needed for environmental purposes. In order to plan for the wise use of all the resources of the Colorado region, studies are needed to ascertain instream flow needs and inventory and evaluate wetlands and riparian habitat.

Of particular interest regarding wetlands is the Bear River National Wildlife Refuge and other waterfowl areas along the eastern shore of the Great Salt Lake. Due to water shortages in the latter part of the summer, the Bear River refuge experiences severe water-shortage problems. Storage facilities would help alleviate this situation. The other waterfowl areas along the Great Salt Lake will be adversely affected by diking and landfill operations associated with further development of the lake's mineral resources and by diversion and use of remaining Wasatch Front water supplies which could adversely affect delicate freshwater-saline water balances.

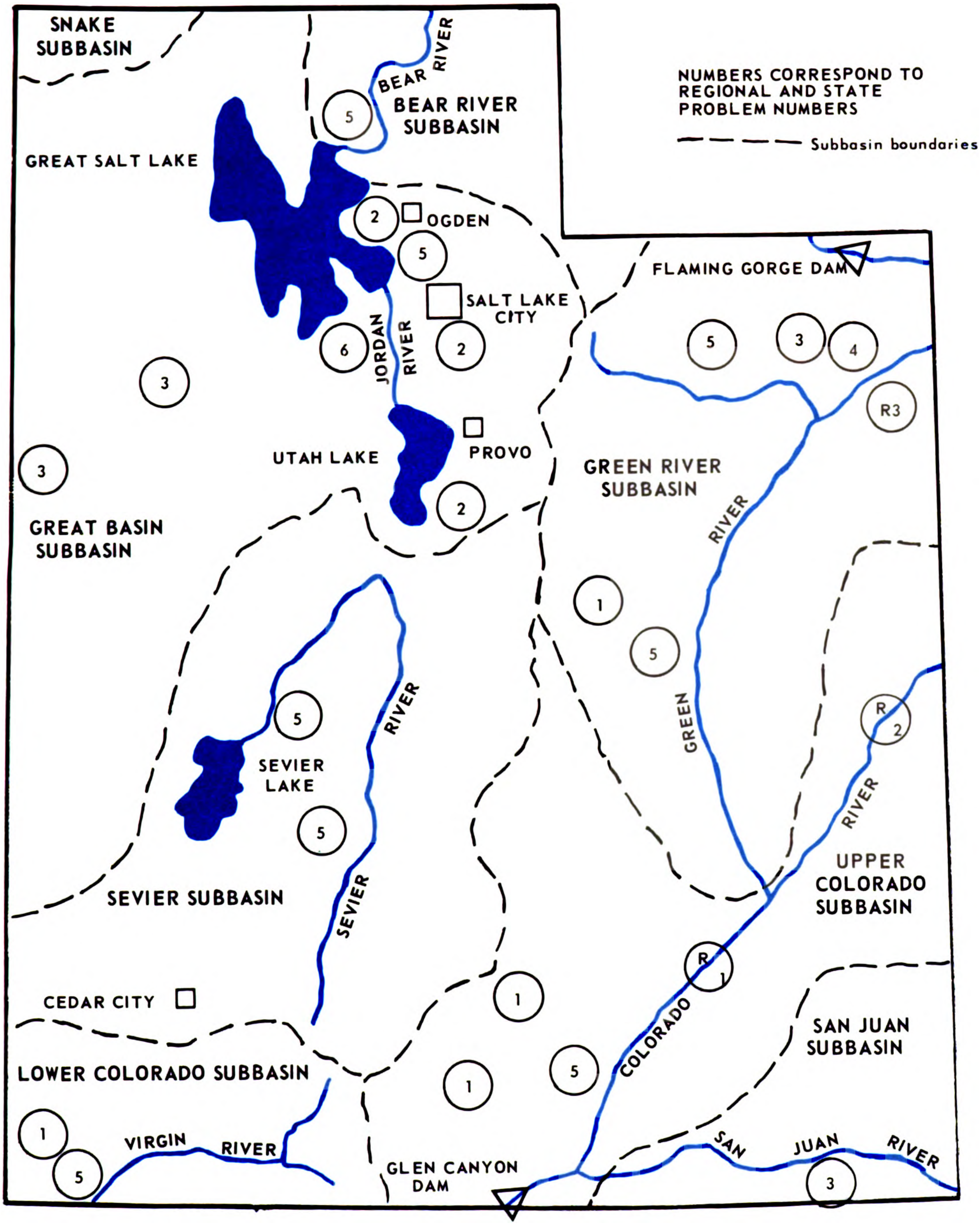
The Green and Colorado Rivers are the home of the humpback chub and Colorado squawfish, two endangered species. Studies are needed to determine the optimum environment for these species and to determine alternative means of preserving these species or limiting impacts of resource developments on their habitats.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. – The Escalante River, from its source to Lake Powell, was among a number of "5(c)" rivers (formerly section 5(d) of P.L. 90-542) named by the Secretaries of Agriculture and Interior in 1970 whose wild and scenic river values must be evaluated in any Federal planning for other (developmental or control) uses of these rivers.

Federal legislation had been introduced into the 93rd Congress to add a major portion of the Colorado River in Utah to the National Wild and Scenic Rivers System as an "instant river." More recently, the Secretary of the Interior, acting on the findings of a Federal Interagency Study Group, recommended enactment of a comprehensive "Administration bill" that calls for study of 16 high priority rivers within the Westwide States. Included are portions of three Utah rivers and one major tributary. The Westwide Study has identified one other river which, because of developing energy-related conflicts and probable degradation of the river's free-flowing values, should be studied as soon as possible. The tabulation in Table VI-48 summarizes information on the latter four rivers.

Table VI-48.–*Utah rivers recommended for study as potential National System additions*

River	River segment
Green	Entire river, except for reach from boundary of Dinosaur National Monument to Jensen, Utah.
White	Entire river in Utah (and Colorado).
Colorado/ Dolores	Utah State line to confluence with Dolores and entire Dolores in Utah (and portion of both rivers in Colorado).
Escalante	Source to Lake Powell.



UTAH

Figure VI-18. Critical water problems in Utah.

Regional Problems

Three regional problems – quality and quantity of the Colorado River and oil shale development – directly affect Utah. They are:

NO. 1 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

NO. 2 – INCREASING SALINITY IN THE COLORADO RIVER

NO. 3 – WATER REQUIREMENTS FOR SHALE DEVELOPMENT IN THE UPPER COLORADO REGION

State Specific Problems

By the year 2000, Utah will approach full utilization of the water available to it; in reality, there appears to be insufficient water to meet competing uses, if maximum expected demands occur. Utah's uncommitted Colorado River water remains to be allocated. The State must decide the best use for this water. The potential users include Indian reservations, municipal growth in the urbanized Wasatch Front, oil shale and coal development, and maintenance of the environmental quality of the area. These uses will be in conflict, depending on ultimate levels of demand or development. Details of these problems are discussed below in the State specific problems. Other emerging problems of concern include flood damage and salinity in major streams of the State. Approximate location of these problems is shown on figure VI-18.

The specific problems in Utah are:

NO. 1 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 2 – WATER SUPPLY FOR POPULATION AND ECONOMIC GROWTH ALONG THE WASATCH FRONT

NO. 3 – NEED FOR WATER AND RELATED LAND DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 4 – IMPACT OF SALINITY ON UTAH'S WATER USER AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

NO. 5 – JORDAN RIVER FLOOD AND WATER QUALITY PROBLEMS AND RECREATION OPPORTUNITIES

NO. 1 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

Utah has large reserves of coal in the Upper Colorado region, far in excess of its own projected energy needs. However, Utah does not exist in isolation from adjacent regions, and its coal reserves could assist in meeting regional energy needs. Because of the relatively isolated location and transportation systems, such development would likely be through mine-mouth thermal electric plants or coal conversion plants rather than export of coal. Significant environmental, economic, and social impacts will occur if and when these coal resources are developed. In addition, a portion of Utah's remaining Colorado River entitlement would be required for the coal development which would be in competition with limited remaining water supplies for development of oil shale, municipal, industrial, and agricultural development and maintenance of the quality of the environment throughout the State.

DISCUSSION

Utah's reserves of high-grade coal are of considerable importance to both the State and the Nation in view of growing concern about energy shortages.

In terms of magnitude, there is enough Utah coal to maintain the present total level of electric generation in the 11 Western States (73,000 MW) for about 200 years, or the projected year 2000 needs (378,000 MW) for about 40 years.

Presently, Utah has a total installed capacity of 1,013 MW (all types) using about 18,000 acre-feet of water annually, primarily for use within the State. Many projections have been made on future regional load requirements and how these loads should or could be satisfied. The Western Systems Coordinating Council, which is made up of private and public utilities in the West, estimates that peak demands for the area covered by the Pacific Northwest Power Pool, which includes all or part of seven States, including Utah, will increase from 26,608 MW today to 45,482 MW in 1985 and 104,808 MW by 2000.

It is estimated that projected development in Utah to meet regional requirements by 2000 would be about 10,000 MW, with a resulting water demand of some 150,000 acre-feet annually. Estimates of power and cooling water requirements from various sources are shown by time frame in table VI-49.

Table VI-49.—*Projections of electric generation development and associated water requirements in Utah*

Sources of projections	1980		1985		1990		2000	
	megawatts	acre-feet	megawatts	acre-feet	megawatts	acre-feet	megawatts	acre-feet
Western Systems Coordinating Council			5,340	80,000			9,860	148,000
Utah State Study Team								
High Range	2,280	30,000					13,720	178,000
Low Range	1,510	20,000					6,610	86,000
Southwest Energy Study					7,000	150,000		

As far as generation mix is concerned, coal is expected to be the main source of fuel until 1990 when nuclear-fueled plants will begin to assume a larger share of the load. As can be seen, substantial development is expected to occur in Utah. Coal development is expected to occur in the Colorado basin part of the State. Significant nuclear development could occur along the Wasatch Front near the population center, assuming that adequate cooling water can be provided. The problems associated with future power development in the State are summarized below.

Upper Colorado Region

Utah's main coal deposits lie in an area of the Upper Colorado region west of the Green and Colorado Rivers, south of the Price River, and north of the Arizona-Utah border. They total about 32 billion tons. This coal could be developed by mine-mouth thermal electric plans, coal gasification, or export of coal.

It is difficult to predict time and location of coal gasification plants within the basin because it is a new technology with many unanswered questions regarding the role gasification will play in meeting future energy demands. Plans for thermal-electric plants can be estimated with more confidence. Present thermal-electric (coal) developments now under active consideration or development are:

(1) Kaiparowits Powerplants is being considered for location about 30 miles north of Glen Canyon Dam on the northwest shore of Lake Powell. A combined venture on the part of several Southwest power companies, Kaiparowits was intended to generate 6,500 MW before 1985 and requires 14.6 million tons of coal per year and up to 102,000 acre-feet of water from Lake Powell. Because of present environmental restraints, the intended capacity may be reduced to 3,000 MW. Further progress is awaiting a decision concerning possible environmental restrictions.

(2) Huntington Canyon Powerplant is located about 20 miles southwest of Price, Utah. It is a Utah Power & Light Company development, originally intended as a four-unit, 1,860 MW, plant using nearly 30,000 acre-feet of water from Huntington Creek (tributary to the San Rafael River). The first unit was placed on line in July 1974, and the other three are scheduled before 1990. Because of environmental damage potentials, however, the plant may be limited to only two units.

(3) An additional two-unit plant known as the Emery County Plant would be built to the south of the Huntington Plant. The Emery County Plant has a projected capacity of about 1,000 MW and present plans call for the first unit to be in service in 1978 and the second unit in 1980. Siting would depend upon location of coal deposits and availability of cooling water supplies.

(4) An additional series of units in a proposed powerplant is also under consideration. The Intermountain Power project proposes to build four 750-MW or six 500-MW coal-fired units at one of three sites under consideration in south-central Utah.

(5) Current interest also is being shown by several private interests in developing a powerplant in the Escalante River drainage which would conflict with recreation and preservation proposals in the Escalante basin.

Water supply, land use, and environmental considerations are the major problems that must be addressed in the area. On an incremental basis, the water supply problem is not associated with the individual powerplant developments since, in the near term, water is available if the proper permits, etc., are obtained. Rather, the water supply problem is associated with the cumulative effects of all development in the region. Utah does not have enough water remaining in its

Colorado River entitlement to meet present and projected long-range water requirements for a significant level of electric power generation, oil shale development, projected transregional diversions, and potential regional agricultural development. Environmental and land use problems will have to be considered in the planning of these energy potentials and may be more significant than water supply in determining the level of development.

Lower Colorado Region

Another development based on Utah coal deposits is the proposed 500-MW powerplant near St. George in southwest Utah. Coal from the Alton Plateau (near Kaiparowits) would be conveyed 45 miles to the powerplant by means of a slurry pipeline. Water for cooling would come from the Virgin River (tributary to the lower Colorado). An endangered species of fish – the woundfin – is virtually restricted to the Virgin River below Hurricane, Utah, and its preservation must be considered.

Wasatch Front

Additional thermal powerplant capacity will be required along the Wasatch Front to meet power demands through 2000. It will likely be fossil fired, although after 1990, some nuclear development may occur. However, seismic activity is a limiting factor in the location of nuclear powerplants along the Wasatch Front. The rate at which thermal power development will occur depends to a great extent upon decisions made with respect to development in the Upper Colorado region, which would effect power available for import to the region. Water supply for cooling could be a very serious problem in this area since most local supplies are fully appropriated.

PROBLEM RESOLUTION

The rate and magnitude of power development in the Colorado River basin portion of the State are dependent on a decision as to the degree of use of the land, water, and coal resources of this area. The selected rate of development in this area will directly affect the rate of power development along the Wasatch Front. The decision will require a careful evaluation of resource location and potential transport, quality maintenance of land, water, and air, location of present and future population centers, and relationships with oil shale development.

CONCLUSIONS

1. The projected regional demand for electric power requires the development of many large new thermal powerplants, especially in areas where major coal deposits are situated.

2. Conflicts with environmental objectives will need to be resolved if thermal powerplants are to be built. Siting problems will be critical.

3. The Upper Colorado region, which has extensive coal resources and large-scale development under way, is a logical location for additional development.

4. The rate and timing of thermal powerplant development in other areas of the State will depend on decisions made with regard to Upper Colorado region development.

5. There are many potential users competing for Utah's remaining entitlement of Colorado River water.

RECOMMENDATIONS

1. The State and public utilities, in cooperation with Federal agencies, should begin studies to identify potential plantsites and site development criteria.

2. Because of environmental concerns, all interested State and Federal agencies should continue to review and monitor the plans currently being developed by the Public Utilities in the Upper Colorado River region.

3. The State should reach a decision on a total plan for use and development of its energy resources as soon as possible to provide guidance for the extensive private development plans already being formulated.

NO. 2 – WATER SUPPLY FOR POPULATION AND ECONOMIC GROWTH ALONG THE WASATCH FRONT

SUMMARY

Population and economic and industrial growth along the Wasatch Front has been phenomenal in recent years, and indications are that growth will continue to take place. Competition for water is intense. Some local supplies, as well as a minor amount of ground water, are available to meet future demands. However, these supplies are not sufficient to meet long-term needs, and water from other sources will be required. The Bonneville unit of the Central Utah project, if constructed as currently planned, will supply enough water to meet Wasatch Front needs through 1990 to 1995. If development of this unit is restricted, other sources such as the Bear River, desalting Great Salt Lake, changing water use (primarily from irrigation to municipal and industrial use), and ground-water development will have to be investigated.

PROBLEM RESOLUTION

If the Bonneville unit is constructed, there will not be any major need to develop additional water supply facilities until the 1990-1995 time frame. However, a change in plan of development to meet environmental objectives not envisioned in the original plan or delays in the construction schedule could occur. If either of these happen, the Wasatch Front area may experience water shortages in the 1983-1987 time frame. Therefore, the near-term problem is directly related to decisions regarding the importation of water from the Colorado River System through the Bonneville unit. There are alternative sources of supply which, although more expensive, could meet partial demands in the area and should receive additional study and delineation.

DISCUSSION

Population growth is creating a demand for more water, more intensive land use, and in turn creating environmental problems along the Wasatch Front. Utah's 1970 population was estimated to be 1,059,000. This represents an 18.8 percent increase over the 1960 population. As shown in figure VI-19, most of Utah's population is concentrated in the Wasatch Front area which is defined as Weber, Davis, Utah, and Salt Lake Counties.

The Wasatch Front area had 822,000 residents in 1970, which represents about 77.6 percent of Utah's population. The area's population has more than doubled since 1940. Numerous projections have been made for Utah's population ranging from 1,231,000 to 1,506,000 in 1980 and 1,542,000 to 2,217,000 in 2000. The majority of this growth is anticipated to take place along the Wasatch Front. Translated into water requirements, this indicates that as much as an additional 200,000 acre-feet per year of M&I water could be needed for the Wasatch Front by the year 2000.

There are water resource development programs underway which will meet Wasatch Front water demands if developed through the years 1990 to 1995. It is estimated that local supplies, if developed, will meet demands through 1985 and that the Bonneville unit of the Central Utah project, if constructed, will meet demands through the years 1990 to 1995. A lawsuit challenging the Bonneville unit has been concluded with the U.S. District Court finding that the final environmental statement is adequate. The District Court finding has been upheld by the U. S. Circuit Court of Appeals. Continued legal action is not expected. However, if there are any substantial delays or significant changes in the project plan, then, to meet projected demands, other alternatives will have to be considered.

Ground-water use in the Jordan Valley has increased from 38,000 acre-feet in 1931 to more than 126,000 acre-feet (1968 level) in 1970. Estimates of additional ground-water development within the safe yield are shown in table VI-50.

Development beyond this level would probably result in difficulties such as salt water intrusion from the Great Salt Lake, widespread interference with existing production wells, and a reduction of surface water supplies.

About 40,000 acre-feet of Weber Basin project water is available to satisfy M&I demands in the next 5 years. Jordan Valley frontal streams could produce an additional 23,000 acre-feet. The authorized Little Dell project will develop 3,200 acre-feet of high-quality water by means of a 30,000 acre-foot reservoir in Parleys Canyon. A 20,000 acre-foot reservoir in Big Cottonwood Canyon could make possible another 9,800 acre-feet. However, there are serious environmental impacts associated with this development. Possibly, an additional 20,000 acre-foot supply could be developed on other streams along the Wasatch Front.

An additional increment of M&I water is continuing to become available yearly through conversion of irrigation uses to M&I purposes. This conversion by private development to M&I use as urban areas expand requires about the same quantity of water per acre. The gross amount involved over the next 30 years is difficult to estimate, but could be about 20,000 acre-feet annually by 2000.

An average of at least 1.5 million acre-feet of water flows into the Great Salt Lake each year and is eventually evaporated from its surface. About 800,000

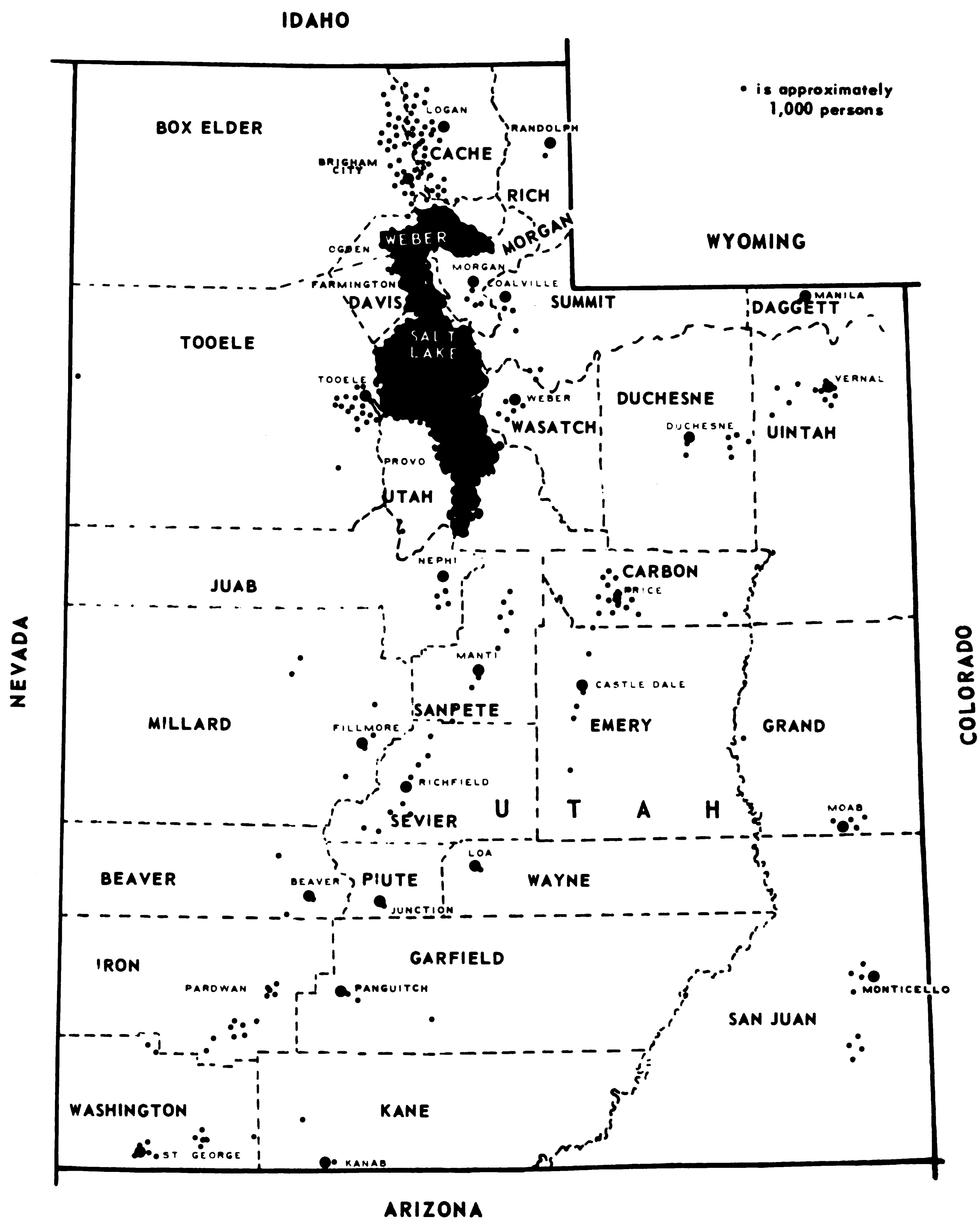


Figure VI-19. Estimated population distribution in Utah.

Table VI-50.—*Groundwater development for Wasatch Front*

Quality and quantities	Area		
	Jordan Valley	Utah Valley	Weber Delta
Approximate range in water quality (p/m)	100-13,000	200-3,500	100-1,000
Estimated recharge (acre-feet/year)[1]	212,000	138,000	70,000
Present well discharge (acre-feet/year)	126,000[2]	72,500	25,000
Surplus (acre-feet/year)	86,000	65,500	45,000
Estimated potential increase (acre-feet/year)	50,000[3]	15,000	20,000

[1] Recharge to principal aquifer system only and does not include recharge to shallow water table zones.
[2] Includes 19,000 acre-feet diverted from springs.
[3] Consists of 30,000 acre-feet of high-quality water and 20,000 acre-feet of low-quality water.

acre-feet of this is from the Bear River, and most of the remainder from the Weber and Jordan Rivers, all of very poor quality.

Capture and re-use of these residual flows by desalting would require three major facilities:

(a) Seasonal regulation by means of substantial reservoir storage (possibly a million acre-feet), or an embankment along the Lake's east shoreline, created by several miles of dikes in Great Salt Lake itself.

(b) Desalting to achieve usable quality. A recent study by the State of Utah, the Office of Saline Water and Dow Chemical considered desalting in conjunction with electric power production and mineral processing. Using reverse osmosis, at-site cost per acre-foot could exceed $150 (1970) prices.

(c) A distribution system.

Probable maximum yield of this alternative would be about 100,000 acre-feet.

About 35,000 acre-feet annually could be obtained by import from the upper Bear River after providing for downstream irrigation demands above Bear Lake. This transmountain diversion could be accomplished by means of a dam on Yellow Creek and 1.9-mile tunnel from that creek to Chalk Creek, a Weber River tributary. A pipeline from the Weber River to Salt Lake County would make possible the distribution along the Wasatch Front. The quality of this water is good enough to be used for municipal purposes with only minimal treatment.

Importation of surplus flows from the lower Bear River below the Federal Migratory bird refuge and the State refuge near the confluence of Bear River and the Great Salt Lake is also possible. Quality of this water is not good enough for municipal use without desalting. Storage is needed for carryover regulation, to meet a municipal demand pattern, and provide a dependable supply for the Federal refuge. About 70,000 acre-feet could possibly be exchanged, or if the lower Bear River water were desalted, as much as 100,000 acre-feet could be made available. Workable agreements between the States of Utah, Wyoming, and Idaho, under the 1958 Bear River Compact, are needed before diversions or development of Bear River water can be accomplished.

CONCLUSIONS

1 . Along the Wasatch Front, population growth and industrial development will continue at a substantial rate.

2. If Bonneville unit is extensively delayed or rescoped, more expensive local supplies such as ground water, desalting of waste water, importation of Bear River water, or development of local streams would be needed to satisfy Wasatch Front demands through the 1990-1995 time frame.

3. If M&I water from the Bonneville unit is available as scheduled, M&I demands will be satisfied through the 1990-1995 time frame.

4. Additional Colorado Region imports may be restricted or limited if the region's oil shale and coal resources are developed in substantial quantities.

5. The retirement of agricultural land and conversion of irrigation water from M&I supply per se will not satisfy all future water needs in the study area, and

could cause different problems associated with urban sprawl and other land use management conflicts.

RECOMMENDATIONS

1. The State should reach an early decision on the allocation and use of the water supplies available to the Wasatch Front area. This will require a level B type study by State and Federal agencies to continue to evaluate the alternatives and to obtain public acceptance of a recommended plan.

2. Should this decision call for early use of local supplies, the necessary studies, including Federal technical assistance, should be programmed.

NO. 3 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

In addition to determining Indian water rights and requirements, there is a need to improve the economic and social status of tribal members. In the case of the Uinta and Ouray Indian Reservations, satisfaction of the Ute Indian Deferral Agreement would satisfy a portion of this economic and social need.

DISCUSSION

Utah has five Indian reservations occupying about 2.3 million acres of about 4 percent of the total land in Utah. As of 1970, about 11,300 Indians resided in the State, an increase of 62 percent over the 1960 census data. About 7,100 Indians reside on reservations. The population by reservation is shown in table VI-51.

All of the reservations, to varying degrees, are experiencing economic and social problems and also problems associated with a rural existence such as lack of good quality water for domestic purposes and for agricultural or industrial development. Problems and potential solutions associated with each reservation depend to a great extent on location, size, population, and resource base. In the case of the Goshute and Skull Valley Reservations, which are small in size and population, there are only limited water development possibilities. In this situation, to improve the economic and social status, alternatives other than water development will need to be investigated.

In some cases, such as with the Navajo and Ute Mountain Ute Reservations, most of the reservations lie in other states. Solutions to the problems of the Utah portion of the Ute Mountain Ute Reservation are closely tied with activities proposed for the Colorado portion of the reservation. In the same way, the Utah portion of the Navajo Reservation is more closely tied to events occurring in Arizona. Only in the case of the Uinta and Ouray Reservation, which lies completely within the State of Utah, is there a significant potential water resource development.

The Uinta and Ouray Indian Reservation is located in northeastern Utah. Agriculture is the main economic activity at the present time. The reservation does have oil, gas, and oil shale resources which have development possibilities. The current rate of economic activity on the reservation has failed to generate the required levels of income and employment needed to accommodate the increasing needs of the tribal population. Because of these inadequacies the Ute Tribal members have perennially been faced with the problems of high rates of unemployment which have fluctuated from 10 to 75 percent. Tribal members also have the problem of sustaining their livelihood on annual earnings which are definitely inadequate by Federal income standards. The present difficulties of the tribe in part can be traced to the hesitancy of private industry to locate on the reservation. The lack of industrial and other types of development has made it difficult for the tribe to solve its problems.

The tribe has indicated an interest in further irrigation development. Presently, this additional irrigation development is guaranteed by the Ute Indian Deferral Agreement. In this Agreement, which was signed in 1965, the Federal Government and non-Indian interests recognized the Indian lands totaling 36,450 acres as served or to be served from the Duchesne River and the Indians agreed to defer development of 15,242 acres of nonirrigated land so that the Bonneville unit of the Central Utah project could be constructed. The agreement also stipulated that year 2005 would be the maximum date of deferral and equitable adjustment would have to be made at that time to permit the immediate Indian use of water so deferred. At the time the agreement was signed, it was assumed that Deferral Agreement requirements would be met by the Ultimate Phase of the Central Utah project which was anticipated to be constructed sometime before year 2005. However, since 1965, the overall development situation in Utah has changed. Competition for Utah's remaining Colorado River entitlement has become intense. Strong

Table VI-51.—*Population and acreage of Indian reservations in Utah*

Reservation	Tribe	1969 Population	Area (acres)
Goshute	Goshute	109[1]	37,524[2]
Skull Valley	Goshute	30	17,444
Uinta and Ouray	Ute	1,274	1,008,192
Navajo	Navajo	4,609[3]	1,195,311[2]
Ute Mountain	Weminuche Ute	1,143[1]	9,459[2]

[1] Total reservation population.
[2] Utah portion of reservation.
[3] Utah population – January 1973.

interest has been expressed in developing the coal and oil shale resources of the Upper Colorado region. Development of these resources could use the entire available supply. There is also a growing interest for water for instream uses for fish and wildlife and other environmental concerns. These changing priorities for water use can have a significant impact on the Ute Indian unit, a component of the Ultimate Phase of the Central Utah project and may result in changes in the plan of development.

PROBLEM RESOLUTION

For all Utah reservations, economic studies and improvements are needed today. In conjunction with these economic studies, water resource studies are needed to determine water requirements for projected development. In the case of the Uinta and Ouray Reservation, satisfaction of the Ute Indian Deferral Agreement by 2005 must be accomplished. However, from an economic development standpoint, it should be satisfied sooner. Because it appears that the Ute Indian unit of the Central Utah project may be delayed for some time, alternative ways of satisfying the Deferral Agreement should be considered in the Bureau of Reclamation's Ute Indian unit investigation studies.

CONCLUSIONS

1. A vital need exists to evaluate present and future Indian water requirements at an early date so that State water resource planning can consider these needs as a part of the total State Water Plan.

2. Action programs should be initiated to improve the economic position of the tribes and their members, including water resource use and development as appropriate.

3. The Ute Indian Deferral Agreement is a Federal commitment which is to be met by 2005. Alternative approaches available to meet the Deferral Agreement should be evaluated.

4. A solution to the Ute Indian Deferral Agreement is needed as a part of the determination of the best use of Utah's remaining Colorado River entitlement.

RECOMMENDATIONS

1. The Federal Government, through the Bureau of Indian Affairs, should implement level B studies with technical assistance from other Federal and State agencies for each reservation so that Indian water requirements can be adequately determined.

2. The State-led interagency Uinta Basin Land and Water Use Study should be completed.

3. The Bureau of Reclamation's Ute Indian Unit Feasibility Investigation should be completed by the end of 1977 and should include alternative plans and recommendations for meeting the Ute Indian Deferral Agreement.

NO. 4 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

SUMMARY

Utah's salinity problems are in the lower reaches of the Sevier, Jordan, Bear, and Malad Rivers and tributaries of the Colorado River. Except for the Sevier River, agricultural production is only slightly affected by salinity. Salinity in the tributaries to the Colorado River do not affect Utah users but do add considerably to the salinity problem of the lower basin States and of Mexico.

DISCUSSION

The Lower Sevier River has high salinity concentrations (often in excess of 2,000 mg/1) which, while having slight effect on hay and grain production, would limit the growing of truck crops and possibly industrial development without treatment such as desalting. The lower reaches of the Bear River, Malad River, and the Jordan River, which drain into Great Salt Lake, have high salinity concentrations often in excess of 4,000 mg/1 and occasionally exceeding 10,000 mg/1. These saline flows are the source of supply for many nesting areas around the eastern shore of the Great Salt Lake which are only slightly affected by salinity.

As far as the Colorado River is concerned, salinity is not a significant problem within the State. However, several Utah sources do contribute to the Lower Colorado region's salinity problem. These sources include natural sources, depletion by irrigation, a relatively small amount from the municipal and industrial return flows, and export of high-quality water out of the Colorado River region.

Natural sources can be classified into point sources characterized by natural saline springs such as LaVerkin Springs near Hurricane, Utah, or diffuse sources. Notable contributors of large amounts of natural diffuse salts include the San Rafael, Dirty Devil, and Price Rivers. Each of these drainages is also affected by manmade uses, so the total amount of dissolved solids measured at their respective confluences with the Green River or Colorado River comprises contributions from both natural and manmade sources.

LaVerkin Springs near Hurricane, Utah, discharges an estimated 8,000 acre-feet of water and 103,000 tons of toal dissolved solids annually into the Virgin River from a series of thermal springs located along both banks and the bed of the river. The Crystal Geyser near Green River, Utah, is a relatively small point source. Its water flows directly into the Green River after being discharged by geyser action from an abandoned oil well. The annual flow of 200 acre-feet of water from this source contains 2,800 to 3,600 tons of total dissolved solids. It is estimated that the Uinta basin contributes an average of about 450,000 tons of salt annually. A significant amount of salinity may result from salt pickup in flows.

The Price, Dirty Devil, and San Rafael Rivers contribute the following amounts of salt:

	Average annual flow (1,000 acre-feet)	Tons of Salt per year
Price	74,000	240,000
Dirty Devil	72,000	200,000
San Rafael	95,000	190,000

Concentrations as high as 8,200 mg/l have been observed. It is estimated that if a total of 390,000 tons of salt were removed from these three rivers, the quality at Imperial Dam would be improved about 23 mg/l. However, in removing these salts, a certain amount of water would be lost to the system.

PROBLEM RESOLUTION

Salinity in the streams of the Sevier and Great Salt Lake subregions are mostly absorbed and this impact is not expected to increase significantly in the future. The Colorado River Water Quality Improvement Program is studying alternative methods of reducing salinity from sources in the Colorado River drainage. For LaVerkin Springs, a plan has been devised that would utilize the reverse osmosis process, together with an evaporation pond that would dispose of the effluent. This scheme will remove most of the salt. About 2,500 acre-feet of the original spring flow would also be consumed annually.

In the case of Crystal Geyser, since the original well intercepted a fault of unknown characteristics, plugging of the well has not appeared to be feasible. A surface disposal plan has been selected to solve this problem. This plan will remove essentially all of the salts produced. Crystal Geyser has been included in the salinity sources to be controlled under the Colorado River Basin Salinity Control Act (P.L. 93-320, 1974).

Management techniques, such as irrigation scheduling, are under way in the Uinta basin of Utah. System improvements on certain irrigated areas are under study. In addition, a far-ranging investigation has been launched on the Price, Dirty Devil, and San Rafael River systems to gather sufficient data for eventually selecting the best means of controlling salinity contributions from these sources.

CONCLUSIONS

1. Salinity is generally not a significant problem to in-State water users.

2. Colorado River salinity is not a significant problem in Utah but Utah salinity sources do contribute to the Lower Colorado region and Mexican salinity problem.

3. Limitation of depletions is not a presently acceptable alternative to the Colorado River basin States.

RECOMMENDATION

1. The Bureau of Reclamation's Colorado River Water Quality Improvement Program and allied Department of Agriculture programs should be continued. From these programs, recommended level C studies should be initiated and justifiable projects implemented.

NO. 5 – JORDAN RIVER FLOOD AND WATER QUALITY PROBLEMS AND RECREATION OPPORTUNITIES

SUMMARY

The Jordan River starts at the outlet of Utah Lake, flows northward through Salt Lake City, and empties into the Great Salt Lake. Severe flooding, causing extensive damage, has occurred in the past. Because the river flows through Salt Lake City, there is a strong interest in developing the recreation potential of the resource in conjunction with the flood protection works.

The Corps of Engineers, in conjunction with the Provo-Jordan River Parkway Authority and other State and Federal agencies, is presently investigating solutions to the flood problems which will also develop the recreation potential of the Jordon River.

DISCUSSION

The problems of the Jordan River can be traced to the growth in population along the Wasatch Front. The four Wasatch Front counties (Salt Lake, Weber, Davis, and Utah) account for less than 5 percent of Utah's land area but contain 80 percent of the State's population.

As a result of this rapid growth, the Jordan River has become a polluted and neglected waterway. Its flood plain has been encroached upon by both residential and commercial interests, and as a result flooding is a continuing problem. Until recently, the river was used as an open sewer as municipal and industrial wastes and other trash were poured or dumped into the river. Most of these problems have been corrected in recent years with construction of waste-water treatment plants and periodic cleanups of the river bottom.

From a recreational standpoint, the river is in an ideal location to help solve the recreational needs of a large urban population.

Floods

The Jordan River and the eastside tributary streams in Salt Lake County have a long history of flooding. The most notable floods occurred in 1862, 1909, 1917, 1922, 1945, and 1952. With the exception of the flood in 1945, which resulted from a cloudburst, the major floods of record have resulted from rapid melting of the mountain snowpack. However, moderate cloudburst floods have occurred in the past. The largest flood reported on the Jordan River and the 1300 South Street Stream Group occurred as recently as 1952. The value of public and private properties in the flood plain of lower Jordan River is over $100 million. Future flood damages in this flood plain are estimated to average about $2 million per year in the absence of better management and control.

Water Quality

The Jordan River at the present time is polluted. Sources of pollution include silt deposition, thermal pollution, pathological and organic pollution from sewage plants and septic tanks, industrial wastes, and mineral pollution from industry and agricultural return flows. These problems become most noticeable during low-flow periods. It is anticipated that these problems will be corrected in compliance with the provisions of P.L. 92-500.

Recreation

Development of recreation facilities in the Jordan River subregion has lagged behind public need. Urbanization is continuing at a rate in excess of the recreation facility development. Sites that are suitable for recreation development are in short supply with the possibility that such sites may be dedicated to other uses in the near future. This situation is due primarily to the present unattractive appearance of the river and surrounding area.

PROBLEM RESOLUTION

Most of the problems are located along the Jordan River below the confluence of Mill Creek. Many solutions from structural to floodway-parkway concepts have been proposed over the years. In 1973, the

State Legislature created the Provo-Jordan River Parkway Authority to coordinate all studies related to the Jordan River and its tributaries. As a result, the floodway-parkway concept has been endorsed by the State as the means of solving the flood problems and providing recreation opportunities along the lower Jordan River. However, some local interests are concerned about the impact the floodway-parkway concept will have on existing storm drains. They are concerned about high flows in the Jordan River which would submerge the storm drain outlets, creating a backwater effect resulting in residual flooding from overflow of the storm drains. The Corps of Engineers in cooperation with the Authority is currently developing proposals and plans to minimize or eliminate this problem. With regard to Jordan River tributaries, the authorized Little Dell project currently in the preconstruction planning stage will provide a high degree of flood protection about 1300 South Street and some protection for the lower Jordan River. It will also provide some municipal and industrial water and recreation.

The Department of the Interior has recently approved a grant to the State from the Land and Water Conservation Fund for the Lower Jordan River Parkway involving the acquisition of lands and development of trails and recreation facilities.

CONCLUSIONS

1. The Jordan River, without proper planning and management, could experience flood disasters greater than the 1952 flood.

2. Due to the river's location, there is opportunity for recreation development.

3. Full implementation of the floodway-parkway plan will solve both the flood problem and meet recreation needs of the area.

4. Implementation of P.L. 92-500 will correct the pollution problems along the Jordan River.

RECOMMENDATIONS

1. The ongoing water quality improvement measures should be continued.

2. The ongoing Corps of Engineers studies and the Provo-Jordan River Parkway Authority studies in the Upper Jordan should be completed to provide for total planning in the Jordan River basin.

3. The ongoing Lower Jordan River Parkway project should be continued.

WASHINGTON

Washington, known as the Evergreen State, is in reality a land of vast contrasts. Within the State, rainfall varies from more than 200 inches annually in the Olympic Mountains to less than 5 inches in parts of eastern Washington. The lush forests of northern and western Washington contrast sharply with the barren, forbidding scablands of central Washington and the treeless wheat fields of the Palouse Hills; the towering, rugged Cascades contrast with the coulees and flat, basalt-covered mesas of central Washington and the level farmlands of the Puget lowlands north of Seattle; the snowcapped volcanoes that crown the Cascades contrast with the magnificent beaches that stretch for miles along the Pacific Ocean.

In population, Washington ranks 2nd in the 11-State Westwide area and 22nd nationally. During the 1950's and 1960's, Washington's population grew by about 20 percent each decade. Washington's population in 1970 was 3,409,000. The projected population increase during the 1970-1980 decade is about 15 percent, with greater increases predicted in subsequent years.

A national trend apparent in Washington is the growing concentration of population in the urban areas at the expense of rural areas. In Washington, this means a greater concentration of people in the western part of the State, especially the Puget Sound area. Outmigration has occurred from the eastern and rural counties. Sixteen of Washington's 39 counties experienced a net rural outmigration, and 10 counties actually lost population during the past decade.

At the beginning of this decade, Washington's economy was in a decline which continued until mid-1971. However, under the impetus of Federal assistance and the recovery in its own industrial economy, Washington has responded with an economic turnaround which has been faster and stronger than anticipated. Total employment has increased, and unemployment is down.

In 1969 per capita income was $3,916 ranking Washington 3rd in the Westwide area and 13th among all States. Washington had in 1969, 7.6 percent of all families below the poverty level which ranked it 10th in the 11-State Westwide area and 42nd nationally in poverty.

Washington, the 20th largest State, contains 42.7 million acres. The largest single landowner is the U.S. Government, which owns more than 15 million acres, or 35 percent of the total land area. Private ownerships total 23.8 million acres or 56 percent. State, county, and municipal ownerships make up the balance. Nearly 23 million acres are forested, while 8.3 million are used for cropland.

Washington contains a total of 22 Indian reservations, two groups of Indian trust public domain allotments, and a group of Indian fishing sites on the Columbia River. The combined tribal, allotted, and Government acreage on reservations or set aside for Indian use within Washington totals 2.5 million acres. The resident Indian reservation population in the State is about 19,000.

WATER SUPPLY

The total water supply in Washington is large; however, its distribution is uneven both areally and seasonally. The maldistribution leads to overall shortages in parts of eastern Washington and to summertime shortages and winter floods in the western part of the State.

Surface Water

Surface water runoff in Washington averages about 26 inches per year – more than 2-1/2 times the average for the United States. This represents a volume of 95 million acre-feet of water per year – probably the largest amount generated in any of the 48 conterminous States. In addition, Washington receives large amounts from rivers that enter from outside its borders, the principal contributors being the Columbia, Snake, Pend Oreille, Spokane, Kettle, Okanogan, and Skagit Rivers. The Columbia River is the largest river in Washington; it drains about 70 percent of the State. The surface water crossing the Canadian border is subject to the general provisions of the Boundary Water Treaty of 1909 and subsequent orders of the International Joint Commission.

Annual runoff in the State varies considerably from year to year. Streamflow records for the Columbia River at The Dalles, Oregon, have been collected continuously since 1879. During this period, the annual runoff has varied from 161 percent of the 85-year average in 1894 to 61 percent in 1926. Large variations can occur in consecutive years, as recorded in 1928 and 1929 when the flow was 119 and 68 percent of the average, respectively. Flow of Quinault River, a coastal stream, also varies annually, from 129 percent of average in 1961 to 64 percent in 1930.

Lakes and reservoirs are an integral part of the water resources of Washington. Except for recreational uses, lakes are mainly undeveloped but are a source of much usable water. Reservoirs store large amounts of water during high flows and release it during periods of deficient flow when it will be of maximum benefit.

Of the nearly 1,000 glaciers in the United States south of Alaska, about 800 are in Washington. They cover an area of 149 square miles and represent 77 percent of the glacier area in the conterminous United States. Approximately 40 million acre-feet of water is currently stored as glacier ice in Washington.

Streamflow from these frozen reservoirs has several unique characteristics which are pertinent to water resource development in the State: (1) precipitation is stored in the winter and released during the summer dry period, especially in July and August; (2) although runoff from the glaciers approximately equals the precipitation when averaged over many decades or centuries, these ice reserves are so large that in hot, dry years the runoff can greatly exceed the total precipitation, and in cool, wet years an appreciable amount of water is stored; (3) this frozen storage is virtually free from evaporation, transpiration, or other losses.

Table VI-52 shows estimated 1975 surface water depletions for Washington by subregions. Table VI-53 shows estimated net water supplies available in 1975. The supplies available should not be considered surplus to expected future needs. Rather they represent water that could be used for either instream use such as for fish, wildlife, recreation, hydropower, or navigation; or could be developed by diversion for consumptive use. Because of physical and/or economic constraints, much of the water shown as available could not be diverted and used.

Ground Water

Large amounts of ground water are present in the basaltic lava rocks of the scabland area of central Washington and in glacially derived or other unconsolidated sedimentary deposits in the Yakima River, the Clark Fork basins, and a few areas around Puget Sound. Ground water is scarce or lies at great depths in most of the Selkirk Mountains, Cascade Mountains, and Olympic Mountains. The coastal slope contains little ground water, except in some local areas where large quantities are available in sand plains. Although ground water is present, it is not necessarily usable because of low transmissability which also causes an exceptionally slow recovery rate. Ground water is being mined in a few locations in the Big Bend area, primarily in the northeast portion.

Water Quality

Most surface water in Washington is of excellent chemical quality and is suitable for municipal,

Table VI-52.—*Estimated 1975 total depletions*[1] *for Washington (1,000 acre-feet)*

Region and subregion	Purpose or source of depletion: Irrigation	M&I including rural	Other	Reservoir evaporation	Total depletions
Columbia-North Pacific					
Clark Fork, Kootenai Spokane	86	50	1	90	227
Upper Columbia	1,718	34	8	780	2,540
Yakima	1,138	36	5	50	1,229
Lower Snake	70	8	3	130	211
Mid-Columbia	238	10	4		252
Lower Columbia	46	31	2	130	209
Coastal	37	20	3	30	90
Puget Sound	236	192	11	190	629
Total region	3,569	381	37	1,400	5,387
State summary	3,569	381	37	1,400	5,387[3]

[1] Includes surface water, surface-related ground water, and mined ground water. Existing instream uses for hydropower, navigation, recreation, and fish and wildlife are not considered depletions. No depletions are attributed to mineral development, thermal electric, generation, recreation, or consumptive conveyance losses.
[2] Surface-water depletions – 4,940,000; ground-water depletions – 450,000.

Table VI-53.—*Estimated 1975 surface water-related situation in Washington (1,000 acre-feet)*

Region or subregion	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
	Modified[1] inflow to subregion or state	Undepleted water yield within subregion or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Columbia-North Pacific									
Clark Fork, Kootenai, Spokane	22,770	2,380	0	25,150	0	230	24,920	700	24,220
Upper Columbia	78,070	10,240	0	88,310	10	2,540	85,760	2,950	82,810
Yakima	0	4,230	0	4,230	100	1,230	2,900	1,240	1,660
Lower Snake	34,162	580	10	34,752	0	210	34,542	170	34,372
Mid-Columbia	130,470	3,630	100	134,200	0	250	133,950	1,060	132,890
Lower Columbia	159,470	15,000	0	174,470	0	210	174,260	4,380	169,880
Coastal	0	25,090	0	25,090	0	90	25,000	0	25,000
Puget Sound	0	38,330	0	38,330	0	630	37,700	0	37,700
Total region	162,192	99,480	0	261,672	0	5,390	256,282	10,500	245,782
State summary	162,192[4]	99,480	0	261,672	0	5,390	256,282[5]	10,500	245,782

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Modified inflow to the State of Washington is listed as:

Subregion 1, from Idaho	22,770,000
Subregion 2, from Canada	72,480,000
Subregion 6, from Idaho and Oregon	34,162,000
Subregion 7, from Oregon	7,160,000
Subregion 8, from Oregon	1,050,000
Subregion 9, from Oregon	24,560,000
Total modified inflow	162,192,000

[5] Modified supply (outflow) computed as total supply minus depletions. Check made as sum of all modified outflows from the state:

Subregion 1 to Canada	19,330,000
Subregion 8 to Pacific	174,252,000
Subregion 10 to Pacific	25,000,000
Subregion 11 to Pacific	37,700,000
Total modified outflow	256,282,000

industrial, and agricultural uses. The glacier rivers carry high sediment loads, partly due to "glacier flour."

CRITICAL PROBLEMS

The major interfaces of the Westwide problems in the State of Washington are discussed in this section in more detail. The regional problems having an impact in the State are listed. Also discussed in detail are the State specific problems found to be critical in Washington. On figure VI-20 are shown the approximate locations of critical regional and State specific problems.

Westwide Problems

NO. 2 – MUNICIPAL AND INDUSTRIAL WATER SUPPLIES FOR SMALL COMMUNITIES IN THE WEST. – There are about 85 cities and communities listed in Washington with water quantity, water quality, or distribution system problems. Pacific beach areas have limited local water supplies and wells are subject to salt water intrusion. Supplies are short for many Puget Sound islands. Communities in east-central Washington are experiencing domestic water supply problems because of declining groundwater aquifers. Importation of additional supplies for groups of communities appears feasible in some instances.

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – The natural environment of Washington is one of its more important assets. Much of Washington's economy is in fact built around its outstanding environmental qualities. With the increasing pressures of urbanization, industrialization, and popula-

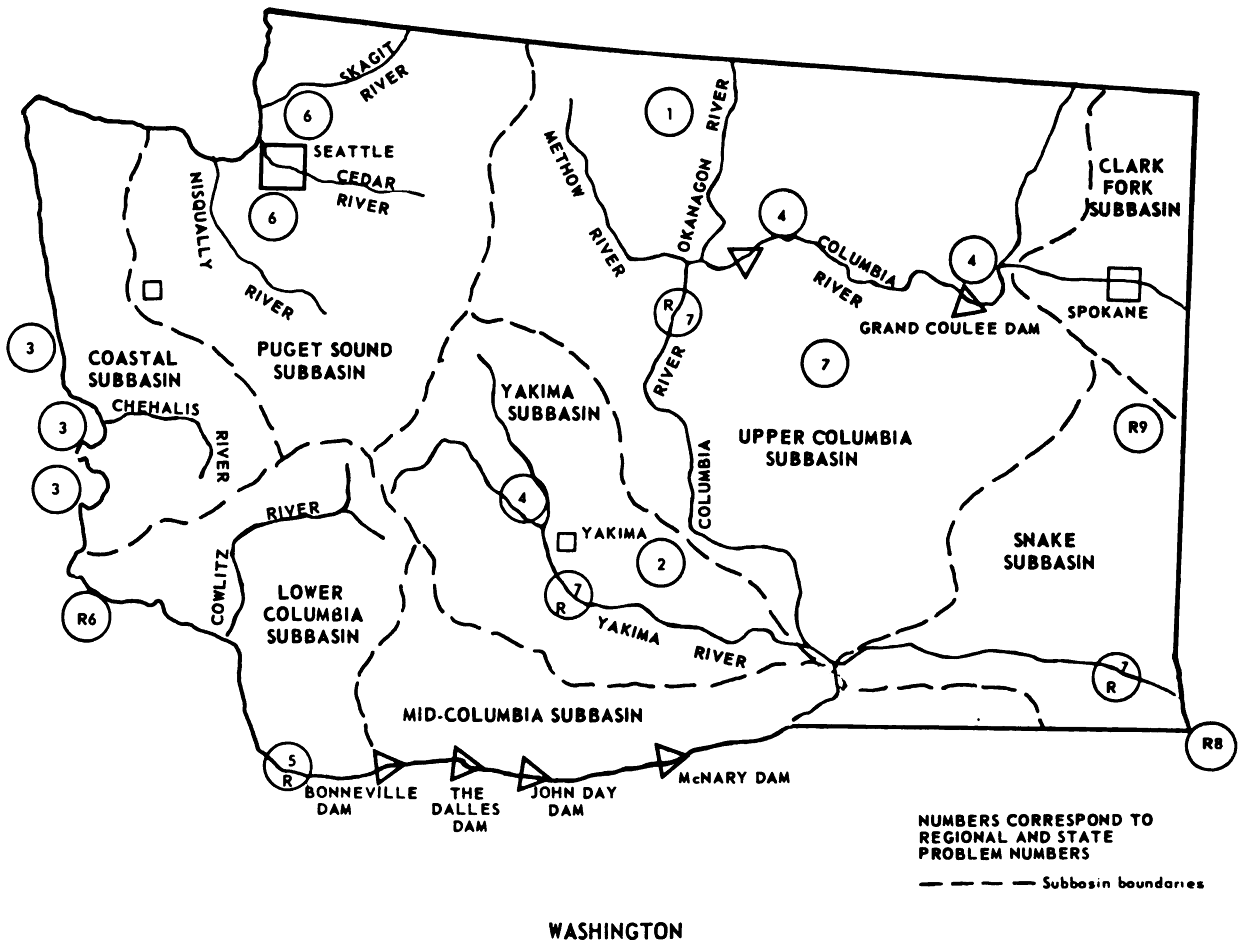


Figure VI-20. ***Critical water problems in Washington.***

tion growth, many parts of the natural environment are being threatened and must be given early consideration for protection.

Determinations should be made on the amount and quality of water needed in the different areas of Washington to provide optimum habitat for fish and wildlife resources. Stream resource maintenance flows (instream needs) should be determined for specific rivers or stretches of rivers and streams for fish, wildlife, water quality, recreation, and other aesthetic considerations.

The coastal and estuarine zone of Washington is one of the most important water resources in the State and is dealt with in detail as a State specific issue.

Washington's wetland areas are an enormously valuable but limited natural resource. No other habitat type supports as great a quantity and diversity of plant and animal species. The three endangered species which occur in Washington, the Aleutian Canada goose, the American peregrine falcon and the Columbian white-tailed deer, are all dependent on the maintenance and preservation of wetlands and certain riparian habitat. While considerable amounts of wetlands have been created by irrigation projects in eastern Washington it is generally estimated that 40 to 45 percent of historic wetlands have been lost. No comprehensive wetlands survey has been undertaken in over 20 years and an updated survey and evaluation is needed immediately so that the preservation, rehabilitation, or development of wetlands habitat can be adequately considered in water development planning.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. – Segments of the following Washington river and tributaries are being studied under Section 5(a) of the Wild and Scenic Rivers Act: the Skagit, including the Cascade, the South Fork, Suiattle, Sauk, and North Fork of the Sauk.

A number of "5(c)" rivers (formerly Section 5(d) of P.L. 90-542) were named by the Secretaries of Agriculture and Interior in 1970, whose wild and scenic river values must be evaluated in any Federal planning for other (developmental or control) uses of these rivers. Segments of the following Washington rivers were included: the Columbia, Grand Ronde, Snake (Hells Canyon), and the Wenatchee, including its tributaries – the Chiwawa and White.

Table VI-54.–*Washington rivers recommended for study as potential National System additions*

River	River segments
Columbia	Main stem from Priest Rapids Dam to McNary Reservoir.
Wenatchee	Entire river, including Lake Wenatchee, and its tributaries, the Chiwawa and White Rivers.
Methow	Confluence of Lost River and West Fork of Methow to head of Wells Dam pool.

Recently, the Secretary of the Interior, acting on findings of a Federal Interdepartmental Study Group, recommended passage of a comprehensive "Administration bill" that calls for study of 16 high-priority rivers within the Westwide States. Included are two Washington rivers. The Westwide Study has identified an additional river which, because of developing conflicts and probable degradation of the river's free-flowing values, should be studied as soon as possible. Figure VI-54 summarizes information on the latter three rivers.

NO. 9 – WATER QUALITY AND POLLUTION CONTROL. – The Washington State Department of Ecology has stated that water quality violations occur in most of Washington's waterways and that many of the most severe pollution problems are within estuarine areas.

A listing of identified water quality and pollution problem areas is presented below. The areas are listed in order of severity of pollution problems and number of people affected.

1. Inner Bellingham Bay
2. Elliot Bay
3. Commencement Bay and lower 1 mile of Puyallup River
4. Ship Canal and Lake Union
5. Port Gardner Bay and inner Everett Harbor
6. Spokane River from Idaho-Washington line to mouth
7. Yakima River from mouth to Sunnyside Dam Bridge
8. Yakima River from Sunnyside Dam Bridge to Wilson Creek

9. Inner Grays Harbor
10. Puyallup River mile 1 to King's Creek
11. Walla Walla River and tributaries
12. Oakland Bay
13. Burntbridge Creek and Tributaries
14. White River from mouth to Mud Mountain Dam
15. Skagit River and tributaries (portion)
16. Chehalis River from Scammen Creek to Newaukum River
17. Palouse River and tributaries
18. South Fork Palouse River and tributaries
19. Port Angeles Harbor
20. Willapa River from mouth to limit of tidal influence
21. North Fork Stillaguamish River

NO. 16 – THE CHANGING FEDERAL ROLE IN DEVELOPING IRRIGATION PROJECTS. – Eastern and central Washington are areas rich in land and water resources. Here agriculture, and especially irrigated agriculture, supports major, stable population centers. It would be desirable to maintain eastern Washington's agricultural production through irrigated agriculture to assist in meeting national and world food and fiber requirement and to stabilize and enhance the quality of life in the more rural population centers away from the coastal metropolitan areas.

Based on historic trends, using 1972 OBERS series C information as a base, projections of Washington irrigated area have been made showing a potential increase of 0.85 million acres by year 2000 and a total increase of 1.18 million acres by year 2020. Using 1974 OBERS series E information on projections as a base, projections of irrigable area would be an added 0.78 million acres by 2000 and a total of 1.06 million acres by 2020. These projections were derived by extending historical trends of irrigated cropland harvested to irrigated area. These acreages are not targets or goals to be planned for, and would vary widely either up or down depending upon such factors as world demand for food and fiber, loss of irrigated land to urbanization, and local, State, and Federal policies toward the use of fertilizer, pesticides, and herbicides.

Both federally assisted irrigation and private irrigation development have contributed significantly to agricultural development in Washington. It is likely the private interests will continue to develop lands, especially close to the Columbia River, by pumping. These tracts, however, will likely be small and scattered and it is doubtful that reliance on private development alone would result in irrigating new lands on the order of 1 million acres. Opportunities for expansion of irrigation exist through expansion of the Columbia Basin project to the East High area, and for major new developments in central and south-central Washington. These developments would be costly and major Federal financial assistance in excess of ceilings now being proposed under recent revised cost-sharing criteria would likely be be needed.

Regional Problems

The State of Washington is directly affected by five regional problems. They are:

NO. 5 – OPERATION AND MANAGEMENT OF THE COLUMBIA RIVER MAIN STEM SYSTEM TO MEET TOTAL WATER USES

NO. 6 – WATER MANAGEMENT PROBLEMS OF THE COLUMBIA RIVER ESTUARY

NO. 7 – MAINTAINING AND IMPROVING ANADROMOUS FISHERIES IN THE NORTHWEST

NO. 8 – CONFLICTS OF WATER USE IN THE HELLS CANYON REACH OF THE MIDDLE SNAKE RIVER

NO. 9 – EROSION AND SEDIMENTATION IN THE PALOUSE REGION OF THE NORTHWEST

State Specific Problems

Discussed below are seven critical water-related problems in Washington. Three of the problems are basin oriented and focus on fostering and promoting efficient coordinated basinwide planning using a total water management approach in the Yakima, Okanogan, and Big Bend basin areas where a profusion of water and related land use problems and solutions threaten to conflict with one another. In the Okanogan basin, international aspects are present because the basin extends into Canada. Indian water requirements are of major concern in Washington as in the rest of the West.

Management of coastal estuaries is a major problem in Washington. Here the focus has been limited to the freshwater supply aspects of estuaries, though the full scope of the problem embraces many other aspects of estuary management.

The State specific problems are:

No. 1 – COMPETING USES AND NEED FOR CLOSELY COORDINATED STUDIES OF WATER AND LAND RESOURCES OF THE OKANOGAN RIVER BASIN

NO. 2 – COMPETING USES AND NEED FOR CLOSELY COORDINATED STUDIES OF WATER AND LAND RESOURCES OF THE YAKIMA RIVER BASIN

NO. 3 – DETERMINATION OF FRESHWATER NEEDS FOR ESTUARIES

NO. 4 – NEED FOR WATER AND RELATED LAND DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 5 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 6 – FLOODING OF HIGHLY DEVELOPED FLOOD PLAINS AND URBAN AREAS IN SEVERAL MAJOR RIVER BASINS

NO. 7 – RESOURCE DEVELOPMENT AND MANAGEMENT NEEDS IN THE BIG BEND AREA

NO. 1 – COMPETING USES AND NEED FOR CLOSELY COORDINATED STUDIES OF WATER AND LAND RESOURCES OF THE OKANOGAN RIVER BASIN

SUMMARY

A variety of competing uses exist for the land and water of the international Okanogan River basin. The numerous demands for water include important instream needs for fish, recreation, and water supply. There is also a need for flood damage reduction. There is a need to examine the interrelationships of all the basin's problems. Among the critical problems in need of solution are: (1) water quality and instream needs, especially for temperature control; (2) flood damage at major communities in the basin amounting to $425,000 annually; (3) recreation use on the river limited by poor quality water; (4) municipal water needed at Okanogan, Omak, and Oroville; (5) anadromous fish and other fish and wildlife threatened by poor water quality and inadequate riverflows; (6) supplemental water for irrigation including rehabilitation and inefficient systems; and (7) water requirements on Colville Indian Reservation (see Washington Problem No. 4).

DISCUSSION

The Okanogan's headwaters are in Canada, and the border bisects Lake Osoyoos through which the river flows. At times, the Similkameen River floods at a higher level than the Okanogan River, creating a reversal of flow into Lake Osoyoos causing damage in both the United States and Canada. Canadian residents in the vicinity of Lake Osoyoos and the upstream chain of lakes on the Okanogan River in Canada are also concerned about water quality. Plans for solving the basin's problems should recognize the problems and needs in Canada.

There is an immediate need to improve water quality in both the United States and Canadian portions of the basin. Municipal and industrial wastes, return flows from agricultural lands, and livestock wastes affect the content and temperature of the Okanogan River. Diversions from the river for various purposes reduce the assimilative capacity and increase temperature of water. Under present conditions recreation use is restricted, and anadromous fish runs are in jeopardy because of poor water quality.

The Okanogan Valley is a major flood damage area. Floods occur largely as a result of high inflows from the Similkameen River and channel restrictions. All major communities in the basin are subject to flood damage. Floods having a 10-year frequency inundate about 2,500 acres of cropland; scatter debris; cause severe erosion; and damage residences, roads, railroads, commercial property, sewage treatment plants, and community water supplies. At times, the Similkameen floods at a higher level than the Okanogan, creating a reversal of flow into Lake Osoyoos, damaging homes around the lake. Average annual flood damages under existing conditions are estimated at $425,000. Future annual flood damages for the Okanogan-Methow subbasin (Columbia-North Pacific Study estimate) are: 1980 – $757,000; 2000 – $1,522,000; 2020 – $3,155,000.

The Okanogan basin provides an outstanding potential for outdoor recreation. However, average coliform counts in some reaches of the lower Okanogan River exceed recommended limits for water-contact recreation and improved waste treatment and minimum flows are needed to make the river safe for recreation use. The Columbia-North Pacific Region Study estimates there are currently 700,000 unmet recreation days each year in the subregion in which the

Okanogan River basin is located. The area draws heavy use from the Puget Sound area of Washington and is adjacent to the recently created North Cascades National Park.

Municipal, industrial, and rural-domestic water uses are projected to increase 250 percent in the valley by 2020. Okanogan, Omak, and Oroville are major users of municipal and industrial water supplies, and expansion of existing facilities will be required to meet growing needs of these communities in the near term.

High water temperatures in the Okanogan River above the tributary Similkameen River interfere with cold water species of fish. Minimum flows need to be established in the Okanogan River to provide a suitable habitat for fish. Anadromous fish are especially affected. Enhancement of streamflows for fish needs to be evaluated.

About 32,000 acres are now irrigated, and about 120,000 acres are potentially irrigable. Several thousand acres, including lands in the Okanogan and Oroville-Tonasket Irrigation Districts have deteriorating distribution systems and face the threat of system failure and water loss. These systems need to be replaced. Potential irrigable lands are generally in scattered small tracts, and the majority are on high benches bordering the rivers. Natural flows in the Okanogan River are inadequate for future irrigation expansion without upstream storage. Some lands, including 10,000 acres on the Colville Indian Reservation, could be served by diversions and pump lifts from the Columbia River.

As discussed in greater detail in Washington Problem No. 4, there is a need for resource development on the Colville Indian Reservation to yield economic and social benefits to the Indians. About 500,000 acres of the Colville Indian Reservation are within the Okanogan River basin and the water rights and requirements of the Colville Tribe must be considered in future planning for the basin.

Okanogan County has been designated as an area having persistent unemployment and underemployment. Water resource development would help alleviate this problem by using the available resources and thus easing the limitations on growth now affecting the area.

PROBLEM RESOLUTION

Several Federal and State agencies have studies, either completed or in progress, each of which considers one or more of the valley issues. Storage sites, both in the United States and in Canada, have been identified and studied to some degree. Each presents certain conflicts among objectives to be considered, for instance there have been recent studies to replace or rehabilitate failing irrigation systems serving established orchards on a rescue basis. Fish and wildlife and Indian interests have been reluctant to endorse these projects because of the lack of an overall basin evaluation to see how these small, individual developments, when considered cumulatively, would affect their respective resources. Independent State and Federal studies of one or more of the issues may solve some of the problems, but they are not designed to result in an overall evaluation of problems and needs and might not achieve the most beneficial overall use of the valley's resources.

Comprehensive water management study, fully coordinated with ongoing Canadian studies, is a necessity to make indepth evaluations of the resource capabilities in the Okanogan basin and to establish an overall plan for the beneficial use of the available resources. A level B study of the Okanagon and Methow River basins is presently being conducted by the Washington State Study Team and coordinated by the Pacific Northwest River Basins Commission.

CONCLUSION

1. As presented in the narrative above, there are a number of pressing problems in the Okanogan River basin, the solutions to which should be closely coordinated to assure that overall optimum management of the basin's water and land resources is achieved.

RECOMMENDATIONS

1. A joint United States-Canadian study should be made of the international aspects of the basin. Present study efforts should be coordinated with Canadian interests. Because of the international aspects, the Federal Government should assume coordination leadership.

2. The Pacific Northwest River Basins Commission's level B study of the Okanogan River basin should be implemented to the extent required to develop adequate detailed plans in compliance with current Federal planning procedures. This is expected to include new study authority and continued adequate funding by all participating Federal agencies such as the Fish and Wildlife Service. Environmental Protection Agency, and the Bureau of Outdoor Recreation to participate in programed special studies such as a

Bureau of Reclamation Water Management Study, the Department of Agriculture's Type IV Study, and the Corps of Engineers Flood Control Studies. The Colville Indian Tribe is expressing a very active interest in evaluating resources, needs, and development opportunities within the Colville Indian Reservation. Water management studies should be coordinated with study objectives of the tribe.

NO. 2 – COMPETING USES AND NEED FOR CLOSELY COORDINATED STUDIES OF WATER AND LAND RESOURCES OF THE YAKIMA RIVER BASIN

SUMMARY

The Yakima River basin has severe problems of poor water quality, flood damage, damage to anadromous fishery, need for supplemental irrigation water, lack of recreation opportunities, Yakima Indian tribe developmental potentials, and inadequate municipal water supplies. The solutions to these problems are interrelated. Several Federal agencies have study programs either underway or proposed to examine various aspects of the total problems. However, there is a critical need to integrate the study of these problems and to develop the best overall plan of development for the basin.

The Yakima River basin is one of five areas designated by the State of Washington as being critically in need of a comprehensive study of solutions to water problems. Summarized below are the major water resource related problems in the basin.

DISCUSSION

Diversions for consumptive uses, agricultural return flows, septic tanks, municipal and industrial waste effluents, and farm animal wastes are major factors now affecting water quality. Increased stream temperatures, excessive aquatic growth, turbidity, sediment, and bacterial organisms are present in the lower reaches of the Yakima River and have curtailed multiple-purpose uses. Increased area growth without adequate safeguards would cause further reduction in Yakima River water quality and quantity.

The basin's population is expected to nearly double by 2020, from 240,000 to 444,000. This increase will place additional demands on area resources and require improved waste water and water quality control measures.

The Yakima basin is subject to recurring flood damages. Flood-susceptible areas include irrigated farmland and portions of Yakima, Ellensburg, Toppenish, Richland, West Richland, Union Gap and other smaller communities. Average annual damages now amount to $1,818,000. Damage reduction measures could include additional storage capacity, improved flood control through development of formalized reservoir operation, levee improvement, flood-plain zoning, and other measures.

About 509,000 acres are now irrigated, nearly 100,000 acres are subject to water shortages of over 50 percent in low runoff years. In addition, the distribution systems of several irrigation districts are in need of early replacement. The efficiency of existing irrigation operations, use of return flows, and the additional storage and recycling of municipal and industrial waste water should be evaluated as potential sources of additional water supplies to meet this need. The total water management investigation will be accomplished through an extension of the ongoing level B study being conducted under the auspices of the Pacific Northwest River Basins Commission.

The Yakima Indian Reservation is located in the heart of the basin and borders on important reaches of Ahtanum Creek and the main stem of the Yakima River. A critical issue is that of meeting water rights of the reservation and evaluating resources, needs, and development opportunities within the reservation. Specific problems include supplemental water supply and flood damage reduction detailed in Washington Problem No. 4.

Projections are that within the next 50 years, municipal water use will nearly triple; industrial use will more than double; and rural-domestic use will increase by 50 percent.

The basin has both resident and anadromous sport fisheries. Despite increased anadromous fish stocking by the State of Washington, salmon and steelhead trout runs have steadily declined primarily due to low riverflows, poor fish passage conditons, and overfishing. Under existing water rights, it is impossible to increase flows for fish without new storage to capture unappropriated peak flows. Resident fish species are also augmented by stocking. The Columbia-North Pacific Region Study projected that the basin will need to support an additional 1,054,000 angler-days by 2020. Wildlife needs must also be met. The basin will need to support 700,000 additional hunter-days.

Although not identified in the Westwide Problem No. 6 for early Federal action, substantial recreation benefits could probably be realized on a number of Washington reservoirs if some adjustments were made in the methods of operation. Kachiss, Keechelus, and Cle Elum are major recreational use reservoirs in the Yakima River basin.

PROBLEM RESOLUTION

There are a number of ongoing or complete studies related to specific problems in the basin. Bumping Lake enlargement, a joint proposal of the Bureau of Reclamation with the Fish and Wildlife Service and the National Marine Fisheries Service, and the Ahtanum unit, which involves the Yakima Indian Tribe, are feasibility studies now under reanalysis and review.

The Bureau of Indian Affairs has worked in the past with the Yakima Indian Tribe to develop and manage natural resources of the reservation primarily through the Wapato Irrigation project. The Yakima Indian Tribe is showing great concern regarding its water and land resources and have a special interest in seeing projects like the Toppenish-Simcoe and Mabton on the reservation developed.

The Corps of Engineers has underway a flood damage reduction study which is seeking to produce a comprehensive flood control plan for the Columbia River and its tributaries including the Yakima River. The Corps also has been authorized to expand the scope of its investigation in the Yakima River basin to allow participation of a regional basis in studies involving water pollution control and abatement, industrial water supply, and other water-related resource development and preservation needs.

The Bureau of Reclamation has been a major participant in the development and management of water and related land of the Yakima River basin and a water management study of the Yakima River basin was begun in Fiscal Year 1975.

A total evaluation of water resource use and water resource development in the basin is needed. A total water management investigation would address itself to total water management in the Yakima River Valley and specifically would: (1) review immediate operating problems and near-, mid-, and far-term development needs in the areas of water quality; recreation, domestic, municipal, and industrial water supplies; fish and wildlife; supplemental irrigation; and flood control; (2) review needs in relation to existing Federal and private system operations and water allocations; (3) identify alternative courses of action including redistribution of water, use of recycled municipal and industrial water, and reuse of agricultural return flows; and development of additional water supplies; and (4) recommend immediate and future action for water resource planning or development in the basin. Institutional restraints which now govern water use and management in the valley would be analyzed in light of present and projected future priorities.

The study would involve coordination and input from State agencies, Federal agencies, State and local organizations, the Yakima Indian Tribe, and the public to assure that all basin needs and attitudes toward resource management are obtained and reflected in potential management and development alternatives.

CONCLUSION

1. There are a number of pressing problems in the Yakima River basin, many of which are being addressed primarily from a functional point of view. These study efforts should continue. However, they should be closely coordinated to assure that an overall optimum management of the basin's water and land resources is achieved.

RECOMMENDATIONS

1. The present level B, C, or special studies underway by Federal, State, and local agencies should continue to be coordinated through the Pacific Northwest River Basins Commission. The studies should address the legal and institutional problems and emphasize more efficient use of available water supplies by integrating the operation of existing reservoir storage with recycled return and waste flows, improved irrigation distribution system and application efficiences, and water exchanges.

2. The Pacific Northwest River Basin, Commission's level B Study of the Yakima River basin should be implemented to the extent required to develop adequate detailed plans in compliance with current Federal planning procedures. This is expected to include new study authority and continued adequate funding by all participating Federal agencies such as the Fish and Wildlife Service, Environmental Protection Agency, and the Bureau of Outdoor Recreation to participate in programed special studies such as a Bureau of Reclamation Water Management Study, the Department of Agriculture's Type IV Study, and the Corps of Engineers Flood Damage Reduction and Regional Urban Water Management Studies.

NO. 3 – DETERMINATION OF FRESH WATER NEEDS FOR ESTUARIES

SUMMARY

The estuaries of the State of Washington as a whole are relatively unspoiled. However, nearly all uses of the estuaries cause conflicts with other uses, and it is essential that appropriate plans be made for proper utilization. Poorly preserved, unplanned or uncontrolled use of the estuaries can result in loss of fish and wildlife habitat, cause pollution, and otherwise adversely affect the environment.

There is a critical need for more environmental information on the estuaries including the effects of freshwater inflows on the type, quantity, and quality of aquatic life in the estuary; effects of dredge spoils on aquatic life; and erosion and disposition patterns influenced by navigation facilities such as channels and jetties. Biological inventories of each estuary are also needed.

At the Federal level the "Coastal Zone Management Act of 1972" provides for grants to States for coastal planning and implementation. The State of Washington has passed a Shoreline Management Act administered by the Department of Ecology. To date no funding has been made available through the Federal act and the planning function has only begun.

The areas considered most critical in Washington are the Puget Sound, Willapa Bay, and Grays Harbor. These are the three largest estuaries in the State and early development of management criteria is essential if extensions of the use of the estuaries are to be made compatible with preservation and enhancement of environmental values. The important Columbia River is discussed as a separate regional issue.

DISCUSSION

Grays Harbor

Grays Harbor is one of three large Washington coastal estuaries. Its shorelines are heavily developed, particularly in the upper estuary at the entrance of the Chehalis River. There are still prospects for maintaining portions of the shoreline as greenbelts and fish and wildlife habitat.

The bay is beset with numerous complex problems created in part by lack of coordinated and planned development. There have been significant losses of fish and wildlife habitat and other environmental damage due to constructed works and overuse by recreationists. Central to these problems and to the future of Grays Harbor is navigation. Channel dredging and jetty work date back to the turn of the century. A 30-foot deep channel now extends 19 miles to Cosmopolis. Plans call for deepening the channel to 40 feet.

Grays Harbor is also being considered for development of a deep-draft harbor capable of handling supertankers drawing more than 60 feet which would present conflicts with environmental values from the alteration of the estuary; changes in tidal prism and currents; dredging outside established channels; and disposal of spoils on tidelands, in the bay, or the open ocean. Space for harbor expansion and facilities is limited and could have severe ramifications for land use, tidelands, and water quality.

More immediate problems involve flooding in the Aberdeen and Hoquiam area, erosion at Point Chehalis, small boat moorage facilities, wood waste disposal, and public access.

The quality of the harbor has been seriously impaired by municipal sewage and industrial (mainly pulp mill) pollution and by the dredging and filling of tidelands. Nevertheless, significant strides have been made in reducing pollution, and there are prospects for restoring water quality to the point of permitting the return of aquaculture, water contact recreation, and estuarine-dependent fish and wildlife populations.

Willapa Bay

This bay is possibly the most representative of natural estuarine conditions of any large bay in the contiguous States. It is one of the largest oyster production areas in the Nation and an important producer of clams, crabs, salmon, and other commercial and sport fishes which are important to the economy of the area. Leadbetter Point and the south end of the bay are components of the 10,000-acre Willapa National Wildlife Refuge which forms a vital link for black brant and other migrating waterbirds.

Industrial, agricultural, residential, and recreational development are the major forms of pressure. The lumber products industry and log exports are economic mainstays. From a pollutional standpoint, the industries concentrated at Raymond have not seriously impacted the bay. Perhaps the chief impact of agriculture has been the diking and conversion of 6,000 acres of tidelands and marshlands.

Overuse by recreationists threaten the natural beauty of Long Beach Peninsula where recreation facility development competes for space with waterfront and lagoon-type housing. Dunes, bogs, and lakes are being overrun and destroyed. Ground-water depletion, salt-water intrusion, sewage drainage, and altered fresh-water regimens present potential health hazards and affect oysterbeds and oyster rearing.

Although expansion of agriculture appears limited, the Willapa Basin project planned several years ago to provide for irrigation of 5,000 acres of existing agricultural land in addition to supply municipal and industrial storage and augmenting streamflows. Likewise, the A'Chote project on the Bear River proposed a plan for providing municipal water for the growing Ilwaco and Long Beach recreation industry. This project, however, would be treating a symptom and ignoring the fact that the carrying capacity of the peninsula area is being exceeded. Land use planning which recognizes the values, capabilities, and limitations of the total systems and which regulates density is essential if the area's endowments are not to be ruined. Development of these potentials could present serious problems to the estuary through alterations of freshwater inflows and introduction of pollutants.

Watersheds around the bay have been extensively logged, contributing large amounts of sediment to streams and tidal flats and adversely impacting fish and shellfish productivity.

Commercial mariculture is getting started at Willapa Bay. Estuaries are ideal for mariculture, and clean water is absolutely essential. There are not many suitable estuaries where experimentation and culture may now be carried out.

Puget Sound

Puget Sound, although technically an estuary, is essentially an inland sea with a network of estuaries, bays, inlets, islands, and passages. The advantages of the sound for deep draft shipping are great. The value of its aquatic resources including anadromous and marine fishes, shell fishes, and waterfowl is immense. Management and protection needs are complex and numerous.

Shoreline development including structures, dredging and filling for boat basins, erosion control, port facilities, residence construction, etc., are causing deterioration of fish and wildlife habitat and waterfront esthetics. An awkward and redundant system of multiple local, State, and Federal permits is now employed to regulate development.

State resource managing and regulating agencies are attempting to develop systematic programs for compiling information and disseminating it. The profusion of independent programs has generated confusion and duplication which hamper the process.

PROBLEM RESOLUTION

Estuary planning requires studies of a broad variety of the possible affecting factors such as land use, navigation, aquatic biota, fish and wildlife inventories and plans, flood plain management, and quantity and quality of freshwater. Because the Westwide Study is limited to water supply aspects, total estuary planning needs are considered to be beyond the scope of this study. Accordingly, recommendations for new studies below are limited to requirements for freshwater inflow to the estuaries, even though the need for broader studies has been discussed in the problem dimensions above.

CONCLUSIONS

1. Recent Federal and State legislation has given emphasis and priority to planning the best use of coastal estuaries.

2. Adequate funding is not yet available from either the Federal Government or the State to carry out extensive planning or plan implementation.

RECOMMENDATIONS

1. The State of Washington should assume leadership in coordinating studies by Federal and State agencies.

2. Coordination should be through the Washington State Study Team which is under the chairmanship of the State and is coordinating the accomplishment of the Comprehensive Joint Plan of the Pacific Northwest River Basins Commission.

3. Federal agencies, particularly the National Marine Fisheries Service, the Fish and Wildlife Service, the Bureau of Outdoor Recreation, Geological Survey, and the Corps of Engineers should provide technical assistance for studies of freshwater inflows for estuaries, Grays Harbor and Willapa Bay.

NO. 4 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

Of the 22 reservations in Washington, major potentials to develop land and water resources for the economic and social betterment of the Indians exist on the Colville, Spokane, and Yakima Reservations. On the Colville Reservation, there is a need to develop municipal water. An irrigation potential exists with water from either ground water, Roosevelt Lake, or in conjunctions with multiple-purpose development of the Okanogan River which forms the western boundary of the reservation. The Spokane Indians have municipal water problems and a need to develop their lands for irrigation to support and maintain a cattle industry. On the Yakima reservation an existing irrigation economy is in need of supplemental water and there is a flood damage threat. Since reservation water requirements are not fully established, it is critical to determine water needs and development potentials so that water planning can go forward on the reservations according to Indian goals and aspirations to support future Indian community development.

DISCUSSION

The Indian reservation population of Washington State is approximately 19,000 persons. There are a total of 22 communities, with a range of population from 25 to 7,480. About 37 percent of the people live in northwestern Washington, 39 percent in the south-central area, just east of the Cascade Mountain Range, and the remaining 24 percent live in the northeast quarter of the State. The major proportion of the population is in the younger age grouping – 59 percent of the Indian population related to reservation communities in the State of Washington are under 25 years of age. Increase in reservation population has been substantial (from 1 to 3 percent annually) and the predominance of young people indicates that population pressures are going to increase, with all the attendant problems such as the need for adequate education, adequate housing, economic stability, and others.

Although a few of the Indian reservations are located adjacent to urban areas in northwestern Washington, the bulk of the reservations are located in a rural environment.

In a predominantly rural economy, the reservation economic activity has traditionally been tied to the natural resources which exist on or are related to the reservations. Resources such as timber, range, agricultural land, fisheries, and minerals have been and are the primary support of Washington Indian communities. Per capita income of the reservation Indian communities are substantialiy below the State levels – $1,252 for Indian people as compared to $3,370 per capita for the State of Washington. Although the Indian communities vary considerably, the unemployment rate is also substantially higher than the State as a whole – the percent unemployed is 7.8 for the State as compared to approximately 25 percent for the State Indian population as a whole.

Trust lands in the State total 2,481,446 acres – approximately 1,928,000 in Tribal land and more than 550,000 in allotted acreage amounts. Commercial forest acreage exceeds 1,570,000 acres, range amounts to 622,000 acres; 23,300 acres are dryfarmed and irrigated acres now amount to over 165,000.

It is estimated that an additional 86,000 acres of irrigable land could be placed under irrigation in the near-term future and an additional 184,000 acres could be in production by the year 2000. A potential exists for substantial further irrigation expansion after the year 2000.

Harvests from forest lands and the processing of forest products is one of the most significant single elements in the reservation economies at this time. A gross, sustained yield harvest of 480 million board feet is taken annually.

Mineral production is less significant, but does occur (primarily uranium ore) in the northeast area.

Future water-related economic expansion potentials in the areas requires the following. The Indian communities should:

(1) Initiate management and production of their own timber harvest.

(2) Assume and expand the operation and processing of agricultural products.

(3) Manage the natural environmental to increase the commercial recreational potential and develop this potential which exists on reservation areas.

(4) Intensify industrial activity where mineral or other (such as electricity) resources are available.

(5) Diversity reservation economies where possible to provide more services to the reservation communities and the surrounding non-Indian communities.

(6) Enhance present community living through improved housing and community facilities.

In terms of water requirements, these developmental needs represent a substantial demand which may exceed the supply in most reservation areas. In the past, the general level of development and consequently the use of water have been at lower levels than surrounding areas. However, it is anticipated that the increasing sophistication and development of reservation areas will result in a much higher per capita water use in the future.

Industrial activity, expanded housing, increased irrigation, and other factors have been expanding substantially in the last 5 years – for example, 488 modern housing units have been constructed in the period 1968-1972, and a need for 1,241 units exists currently to bring the Indian communities into acceptable standard housing.

Exact knowledge of the quantity and quality of water related to Indian reservations is lacking at this time. A program of complete water resource investigations is underway. Each reservation is a separate entity and must be researched independently. The larger reservations, and those with water issues which need resolution immediately, have highest priority, and are under study now. As time and funding become available, complete resource inventory and water management planning will be accomplished for all reservation areas.

Reservations in the northwestern area are in a zone of high precipitation. However, urban expansion and industrial development have impacted upon nearly all reservation communities – causing serious deterioration of both water quality and quantity during recent years. Serious concern exists where fisheries have been either reduced drastically or have been obliterated. Domestic water sources have been affected, both with salt-water intrusion in ground-water reserves and urban or industrial waste effects in surface and ground-water quality. Logging and other environment changing activities such as high construction, etc., have contributed towards high sediment loads in many coastal streams.

The fishery is of high concern. Low flows, high temperature, and deteriorating quality have all been factors in depletion of the salmon resource, which is a traditional source of community livelihood.

The south-central area has much less precipitation than the Northwest. This is an interior area, with precipitation in the mountainous, higher elevation area, which charges the surface and subsurface waters in the valley floor. Concerns here are that the irrigation potential of Indian lands as well as other potential elements such as municipal, industrial, and environmental quality needs will not be adequately met. Preliminary research indicates an estimated water quantity need by year 2000 for tribal irrigation, fish and wildlife, water quality, rural domestic, industrial and municipal needs of 2,471,600 acre-feet. The total water available to meet these needs is 1,968,000 acre-feet, leaving a deficit of 503,600 acre-feet.

The area in the northeastern portion of the State receives moderate to low precipitation; however, large land areas are involved in the watersheds which supply the surface water bordering and related to these reservations.

Water for irrigation and industrial potential has high priority in this area. A great need exists to increase the return on the timber harvest for tribal people. Upstream use of water in the Spokane area has contributed significantly towards deterioration of water quality.

A potential nuclear enrichment plantsite exists in this area. A number of factors such as available water and electric power, isolation from dense, population, and environmental factors appear to favor this potential.

An immense potential exists to develop commercial recreational facilities if planned, implemented, and operated under controlled circumstances which would protect and maintain the present environmental surroundings.

CONCLUSION

1. There is a critical need to determine the economic and social objectives of Indians and the associated water requirements so that total State water planning and development can be fully coordinated and compatible with the needs of the Indian reservations in Washington.

RECOMMENDATIONS

1. Indian trust land and water should have a high priority in Federal and regional water planning.

2. Level B water and land resources inventories should be carried out on Indian reservations in Washington

working closely with the Indian Tribal Councils. Responsibility for conducting studies should be with the tribes and the Bureau of Indian Affairs with technical assistance from the State agencies and other Federal agencies as requested.

3. Indepth water resource investigations and development of water management plans for trust land areas should continue.

4. In water deficit areas, special studies planning for water storage and water management projects should be pursued which will result in more efficient use and reuse of the total water resource in all basins which contain trust land acreage.

NO. 5 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

Washington's present and expected future demands for water related to energy development stem from hydroelectric generation and water for cooling of thermal electric plants. At the present time, the only major use of Washington's coal resources is at the Centralia powerplant. Additional development of coal-fired powerplants is limited by the difficulty of mining Washington coal. No oil, gas, oil shale, or other basic energy resources are known to exist in significant amounts in Washington. The most pressing need is for a multiobjective evaluation of those remaining hydrosites. Expansion of existing hydro facilities should be actively pursued. Pumped-storage projects may be needed in Washington after 1990. Thermalplant siting is of critical concern because of potential adverse effects of thermal discharges.

DISCUSSION

Although Washington is the largest user of power in the Northwest, using 57 percent of regional supply in 1970, it is also a net exporter. In 1970, 69 percent of the region's capacity, amounting to 16,060 MW, was hydro. Washington is expected to continue to be an exporter of power. Potential for new hydroplants and additions to existing plants approach 15,000 MW. In addition, pumped-storage potential in western Washington is enormous having been estimated at 46,000 MW in the Puget Sound area alone. Some of the pumped storage and new hydrosites could create conflicts with environmental values. At existing plants, especially along the main stem of the Columbia River, additional capacity could be installed with a minimum of environmental damage, and could assist in solving the problem of dissolved gas supersaturation which can damage anadromous fish.

Treaties with Canada influence the operation of the Columbia River power system features. Storage has been provided upstream in Canada in exchange for power credits generated at plants in the United States.

The Columbia-North Pacific Comprehensive Framework Study listed the hydroelectric power potential in Washington. The total potential amounts to 1,850 MW of nameplate capacity. Development of peaking additions at existing hydroelectric plants and potential pumped-storage projects would add many thousands of megawatts. Beginning in the late 1980's, the latter may be constructed in conjunction with base-energy thermal plants to provide the large amounts of power needed for the area. Most hydropower sites are in competition with environmental values.

Existing and potentail hydro facilities are expected to shift to a peaking operation to support a baseload of thermal (nuclear) generation. Opportunities exist to add capacity at existing hydro facilities on the Columbia and Snake Rivers. One major opportunity exists at Grand Coulee Third Powerplant where studies indicate that 3,600 MW of capacity in addition to the 3,600 MW of capacity currently under construction and 2,100 MW of existing capacity could be installed to meet system peaking and reserve requirements. Plans for the additional 3,600 MW should give full consideration to the downstream effects on environmental and recreational values of operation of the enlarged powerplant for peaking.

An additional 5,100 MW capacity can be added at John Day, Wanapaum, Priest Rapids, Rock Island, Chief Joseph, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. In addition, 688 MW were recently added at The Dalles.

Thermal power studies indicate that Washington has many potential sites for nuclear-fired thermal plants. Current plans for additional nuclear powerplants in Washington include those by the Washington Public Power Supply System and the Puget Sound Power & Light Company. These projects would total about 4,700 MW.

The potential for additional coal-fired thermal plants is limited. The Centralia coal-fired thermal-electric generating plant, with rated capacity of 1,400 MW, began operation in late 1971 with the second 700-MW unit following in late 1972.

There are numerous known geothermal resource areas (KGRA) in the Cascades, so there is potential for a limited development of geothermal power. However, not much effort has been made to develop the real potential of the KGRA's in Washington.

Washington has a highly developed transmission grid system bringing power from east to west. The greater portion in terms of capacity terminates in the Puget Sound area. However, a large part of the transmission system also extends to the Portland, Oregon, area. Additional east-west transmission line capacity should be provided for in Washington's comprehensive planning by replacing existing lines with high capacity lines wherever possible to minimize the need for new rights-of-way.

Studies have indicated that the peaking requirements of the region could be met until about 1990 by adding generating units at existing hydroelectric projects. When the addition of these units is completed, other sources of peaking power must be developed. The assumption that all peaking requirements could be met by conventional hydroelectric plan expansion by 1990 was based upon scheduled development of thermal plants. Thermal plant construction has been delayed and peak shortages have occurred.

Pumped-storage hydroelectric projects are particularly sensitive to location. Two water storage reservoirs are required with high differential in elevation and an adequate water supply. Also, these projects provide only peaking power and actually consume three units of energy for pumping, for every two units of energy produced which decreases the attractiveness of pumped-storage plants without surplus baseload energy in the power system because of long-term energy scarcity.

Through extensive research, educational, and development programs, there is an opportunity to maximize the efficiency of all energy resources and develop programs for conservation of such resources to avoid critical energy shortages.

In connection with new electric power supplies there is the problem of location of generating plants. There is little flexibility in locating a hydroelectric plant, since foundation, water supply, storage basin, and head (the fall from reservoir to river water surfaces at powerplant) are important essentials in designing a hydroproject.

Likewise, for thermal projects, either fossil fueled or nuclear, a water supply is necessary regardless of type of cooling system employed. Additional environmental considerations enter into the location of thermal plants. In Washington, the Thermal Powerplant Site Evaluation Council has been established to regulate the location of nuclear and fuel-fired thermal powerplants. The Washington Council does not identify appropriate sites as an input to planning; instead, it responds to applications for certification of a proposed site and makes recommendations to the Governor on these applications. A State-designated Counsel for the Environment was provided to represent the public in protecting environmental quality.

The Council has adopted guidelines for thermal powerplant certification which will have a significant impact on site selection. The guidelines provide that utilities must prepare plans that, where applicable, contain provisions for the recreational development and use of the site and adjacent land and water areas and for compensation for any losses or damages to recreation opportunites.

Federal interests are also expanding their programs. The Atomic Energy Commission has initiated a program to develop general environmental siting criteria for nuclear powerplants. These criteria will relate to impacts of the facilities on the environment, including recreation resources and facilities.

Department of the Interior agencies in the Pacific Northwest, working through the Regional Coordinator, prepared and distributed a publication titled "Interim Environmental Guidelines for Thermal Powerplant Site Evaluation – Pacific Northwest," in July 1970. The intent of the guidelines is to assure that full information is presented in any thermal powerplant permit and license applications that come before Interior agencies for review.

Public utility efforts are marked by the 1966 establishment of the Public Power Council, the bulk power supply planning organization for the 10 plus consumer-owned utility customers of the Bonneville Power Administration in the Columbia River basin. This will enhance the capability to develop long-range comprehensive plans that recognize the limited availability of good sites. Working through a consultant, the Council has identified 10 potential sites in western Washington and will narrow down the list through further study. Similar study efforts could be applied to other States as well.

CONCLUSIONS

1. Development of the remaining large potential hydro and pumped-storage sites in Washington will be in

competition with use of the streams for free-flowing environmental values and will require multi-objective studies.

2. Washington's power demands will increasingly be met by large thermal plants, either coal-fired or nuclear, within the State which will pose major plant-siting problems.

RECOMMENDATIONS

1. Site selection, timing, and sizing studies for thermal generating plants and transmission facilities should involve close coordination between private and public power interests and State and Federal agencies on a regional basis.

2. The remaining new hydroelectric power potential in Washington and additions to existing powerplants should be reevaluated in light of the energy crisis and new values of power. Potential projects should be reexamined for inclusion in plans for added hydro energy resources. By 1990, pumped-storage projects should be developed, adequate to meet peaking capacity requirements.

NO. 6 – FLOODING OF HIGHLY DEVELOPED FLOOD PLAINS AND URBAN AREAS IN SEVERAL MAJOR RIVER BASINS

SUMMARY

Although much progress has been made in alleviating flood problems, flood control or flood damage reduction remains a big problem to the State of Washington. As expected, the areas of highest need occur where population increases have been experienced and where extensive developments have been made in the flood plain. The Puget Sound area has many streams that cause flooding of urban and suburban lands. These include, but are not limited to, the Skagit, Nooksack, Stillaguamish, Snohomish, Cedar, and Nisqually Rivers. The Chehalis River, draining into Grays Harbor also floods developed areas. The areas of highest priority for study are the Skagit, Snohomish, and Cedar Rivers in the Puget Sound region, along the Yakima and Okanogan Rivers in central Washington, and along the Chehalis River in southwest Washington.

DISCUSSION

The basic need is to reduce potential flood damages by providing for appropriate use of areas within the flood plain consistent with the degree of hazard and costs of achieving protection. Alternative uses of both water and land in the flood plain complicate the problem of achieving flood damage reduction. Where flood control can be achieved through operation of multiple-purpose reservoirs, at times, empty storage space can conflict with a project's service to other water uses.

Summary of Problems

Following are summaries of major flood problems in urban areas of Washington which require some form of structural solution, possibly in combination with channel improvement and flood plain management.

Puget Sound Region. – The Puget Sound and Adjacent Waters Comprehensive Study identified the need for early action on flood damage reduction on several streams, including the Skagit, Snohomish, and Cedar Rivers. Level C studies under the Puget Sound Study Authority and on the Snohomish River are presently underway.

Yakima River Basin. – Floods in the Yakima River basin occur most often in the spring and early summer as a result of snowmelt in the foothills and mountains. Winter flooding is caused by excessive rainfall occurring in November and December after the ground has become saturated from autumn precipitation or covered by early snows. Average annual flood damages exceed $1.8 million. The Corps of Engineers has underway a study of the Columbia River and tributaries through which flood and other water and related land resource problems of the Yakima basin are being studied. In 1973, the Corps was authorized to expand the scope of its activities in the Yakima basin to allow it to also address water quality management needs. This was in response to requests of Kittitas, Yakima, and Benton Counties.

Okanogan River Basin. – The Okanogan and Similkameen Rivers in combination cause severe flood problems in the basin. Some flooding of rural lands just below the confluence occurs every 2 or 3 years, and every 5 or 10 years there are flood problems in some of the more low-lying urban areas such as Riverside and Okanogan. Floods causing valley-wide devastation took place in 1894, 1948, and in 1972, the last one resulting in damages amounting to $7 million in the United States. Urban levees at Oroville, Omak, and Okanogan were held only by energetic sandbagging efforts. The occurrence of a 100-year flood probably would result in widespread levee failure and catastrophic damage to major cities. The Corps of Engineers is studying flood problems of the Okanogan River basin.

Chehalis River. – The Corps of Engineers has an ongoing study of the Chehalis River and tributaries. This study will consider many possible alternatives.

Skagit River. – The need has been identified for accomplishing flood damage reduction for 90,000 acres, located downstream of Concrete, Washington. The Federal Power Commission license for the Upper Baker project, privately owned and operated, requires that additional storage of up to 84,000 acre-feet be made available for flood control if suitable arrangements are made to compensate the licensee. The Corps of Engineers is completing its investigation of the proposed hydroelectric project operation change. Additional flood control storage on the Baker River should be followed by construction of an authorized levee channel improvement project, located along the Skagit River to further protect Mount Vernon and low-lying agricultural areas.

Snohomish River Basin. – Studies completed by the Corps of Engineers in 1969 and 1973 concluded that the most economically feasible and locally acceptable solution to the recurring flood problems, at this time, is construction of a multipurpose storage project on the Middle Fork of the Snoqualmie River, together with institution of a flood plain management program by King County. The Governor of Washington has requested further review of alternative solutions to Snoqualmie River Flood problems. In 1974 this review was continuing through the efforts of local interests and the Governor's office.

Cedar River. – Flooding occurs nearly annually along this river, causing damages to homes, roads, and anadromous fish spawning. Cedar River inflows into Lake Washington are necessary to permit continued operation of the Chittenden navigational locks and to prevent saltwater intrusion into the lake. Diversion of water in the upper reaches of the river to satisfy municipal and industrial needs of the city of Seattle often conflicts with minimum flow requirements of resident and anadromous fish. The complex problems are being studied by the Corps of Engineers in cooperation with all interested parties through an ongoing level C investigation.

CONCLUSIONS

1. The ongoing Corps of Engineers survey program will provide an array of alternative solutions. Where projects are authorized but not constructed, the adequacy of the authorized plan will be reviewed prior to construction.

2. Most structural solutions will involve multipurpose water use.

3. Zoning or restricted use of the flood plain is an alternative that should be considered.

RECOMMENDATION

1. The Corps of Engineers' studies which address the above problem areas should be pursued and continue to be coordinated with other local, state, and Federal agencies.

NO. 7 – RESOURCE DEVELOPMENT AND MANAGEMENT NEEDS IN THE BIG BEND AREA

SUMMARY

The Big Bend area embraces a vast area in central Washington and is bounded on the north, west, and south by the Columbia River. Within this area is found a variety of natural resource needs and developmental potential including flood damage, irrigation potential, municipal and industrial water, poor water quality in both surface- and ground-water supplies, declining ground-water levels, recreation, and fish and wildlife enhancement, power potential, and environmental quality. A comprehensive approach to basin planning would assure the best long-range use of the basin's resources.

DISCUSSION

Severe flooding in the basin is caused when rainstorms accompanied by snowmelt occur during the winter on frozen ground. Many towns in the basin are only protected against 5- to 10-year floods by levees. At the present time, flood plain zoning is nonexistent in the Big Bend basin.

Approximately every 5 years, some flooding takes place in December, January, and February along Crab Creek. Flooding of Wilson Creek is also a problem especially in the town of Wilson Creek. This area's problem is complicated by the high ground-water table created by irrigation of areas upstream. The town of Ephrata is flooded by flows from floods of 20-year frequency and greater.

Throughout the basin, combinations of storage, channel improvements, levees and watershed protection through land treatment can significantly reduce flood damages. The development and adoption of land use plans and flood plain zoning would be effective in delineating problem areas in the Big Bend basin and controlling future development of urban areas in flood hazard zones.

Generally, the major land use in the Big Bend basin can be grouped into cropland, rangeland, sage and brushland, and other land. The area includes about 4,800 farm-operating units. Distribution of the land use is approximately as follows: Forest – 116,600 acres, or 2 percent of the total land; Cropland – 3,000,000 acres, or 43 percent; Range and Pasture – 2,818,500 acres, or 44 percent; Other Lands, which include roads, farmsteads, and urban lands – 350,500 acres, or 6 percent.

Major ongoing programs of public land management include grazing management, streambank stabilization, burn rehabilitation, dust control, and road and trail restoration. Seventeen soil and water conservation districts exist within the basin.

Damage from flooding to both urban and nonurban land is a problem on about 104,400 acres. Many acres of soils are susceptible to wind erosion. Wind erosion causes drainage and conveyance ditches to silt full which in turn causes the water to be diverted across fields. The chain reaction creates severe water erosion. Additional studies are needed to determine the amount and location of streambank erosion within the basin. Water problems, both quality and quantity, are found in 16 watersheds throughout the basin. Seasonal water shortages occur on about 31,500 acres. Additional water is needed in 36 watersheds in the basin for improving recreation and fish and wildlife. Drainage is needed in many areas to lower the high water table that is damaging cropland and urban land. 2,818,500 acres of range and pasture land require a study to determine and improve grazing management.

Production of crops on irrigated land is a major use of water in the Big Bend basin. The principal source of irrigation water is from the Columbia River which is used on croplands under the Columbia Basin project. Ground-water withdrawal for private irrigation is taking place in Lincoln, Adams, and Grant counties.

About 635,000 acres are irrigated in the Big Bend basin. Of this amount, approximately 31,000 acres are irrigated by pumping ground water. There are about 2,444,000 acres of irrigable lands in the basin.

Federal development by units which are now under management by irrigation districts are: (1) Columbia Basin project – 516,000 acres; (2) Bridgeport Bar – about 475 acres; (3) East unit – 5,000 acres; and (4) Brays Landing unit – 1,300 acres.

Private development includes about 115,000 acres of irrigated land within the basin. Water is furnished by surface and ground water.

Surface water supplies for the Big Bend basin are limited with the exception of those lands under the Columbia Basin project. Irrigation dependent on natural runoff experiences serious annual shortages.

Ground-water supply in Adams, Lincoln, and Grant counties is limited since the water table has declined to such a level, from heavy pumping, that the feasibility of pumping becomes questionable. The State has closed the area to further ground-water appropriation.

Planning and coordination for increased and improved water management through application of irrigation water is needed. The southern part of the basin experiences a high water table caused by the application of water to lands without adequate drainage. The ownership of such excess water remains in question with the Federal Government making claim to all or a portion of the recharged waters.

Some water quality problems exist in the basin. Sediment from the upper reaches of the Crab Creek drainage is a problem, and high concentrations of dissolved salts occur in some waters.

To meet the growing need for food and fiber, supplemental irrigation water could be developed for irrigable lands. Increased irrigation efficiency through closed conduit conveyance and application, such as sprinkler systems, will help manage the supply.

The consumptive use of the water resource for M&I use is small in the Big Bend basin when compared to irrigation use. However, the importance of and requirement for municipal and industrial use must undergo thorough consideration. A sufficient supply of high-quality water is a necessity for both potable and processing uses.

Most of the recorded public systems in the basin derive their source of water from ground water. Ground-water reserves are being depleted in the areas of Othello, Odessa, and Ritzville, and the ground-water table is dropping. The city of Pasco, at the southern end of the basin, uses water from the Columbia River. The Geologic Survey has conducted a study within the basin to identify the ground-water resources.

Future water needs for domestic supply are not clearly identified due to incomplete water supply and comprehensive plans of all utilities serving in excess of 1,000 services. The lack of regionalized water systems has led to a proliferation of small water systems adjacent to larger systems. The small systems are generally substandard and inadequate. There is a need to provide better cooperation and coordination between local bodies of government to develop regionalized systems.

High nitrate concentrations have been reported in the Mesa and Davenport water systems. This is also a problem in the rural areas of Grant and Douglas counties. The cause is not known, but it is suspected that it comes from fertilization of farmlands and contamination of irrigation wells.

The declining water table in the basin presents a problem of competition between irrigation and domestic uses for the limited resource. Long-range planning is needed to resolve this problem. In many communities, the status of water rights is unknown.

Pollution sources within the basin include wastes from municipal and industrial discharge, Hanford Atomic Works, rural-domestic population, irrigation, agriculture animals, land use, and recreation.

Lake and stream enrichment problems occur in the basin due to runoff and waste-water return from agriculture lands using heavy application of commercial fertilizer. The higher value of nitrate-nitrogen concentration reported in wells of shallow depth indicates that the rising water table, created from irrigation return flows in some areas, shows the quality of ground water to be deteriorating. The total impact of irrigation return flows on the ground-water quality needs additional study. Large sediment yields from erosion is severe in parts of the basin. The transport of sediment is a significant water quality impairment. The Hanford Atomic Works is a source of radiological wastes and thermal pollution. This poses a health hazard and increases water temperature.

To attain adequate water quality that meets all levels of standards, there will have to be a basinwide plan which includes a coordinated and cooperative program with a water quality management system. The plan will require action to implement waste controlling techniques and waste reduction needed to meet the required level of quality.

The major recreation areas within the Big Bend basin are as follows: (1) Coulee Dam National Recreation Area which includes the Dam and Roosevelt Lake; (2) Sun Lakes State Park which includes several lakes and Dry Falls; (3) Ginkgo Petrified Forest, a petrified forest of over 200 identified species; (4) Columbia Basin project, which includes several impoundments and seep lakes offering excellent opportunities for water sports and fishing; (5) Columbia National Wildlife Refuge, one of the outstanding refuges in the region.

The basin has a problem of overcrowding and overuse of recreation areas. There is a definite need to look closely at the carrying capacity of public use areas and controls established to protect the resource. Local, regional, and State plans all show a deficiency to meet current and projected needs.

Recreation planning is essential on a basinwide basis for meaningful, coordinated use of water resources. Comprehensive land use studies and enforceable regulations must be established to protect the river environment. Any planned storage projects should consider the potential for recreational use.

Lower Crab Creek has potential for improving habitat for anadromous fish. However, several problems exist which keep the stream from becoming a resource for fish. The high water temperatures during the summer are a limiting factor to anadromous fish production. The water quality in this reach of Crab Creek is an impairing factor. O'Sullivan Dam and two small dams create waterfowl habitat, but in turn, block fish migration. Reservoir operations are for irrigation, and the low flows in the summer do not consider the fish population. Inadequate watershed management contributes to the siltation of Crab Creek.

The irrigation project has reduced the habitat for grouse, and this in turn has reduced the species in the basin. Farming practices have significantly reduced other exotic birds and some bird population has been eliminated. Minimum flow should be established in Crab Creek from the Potholes Reservoir, and water quality has to be improved in lower Crab Creek if these species are to be developed. Habitat preservation and improvement from O'Sullivan Dam to the Columbia River is necessary also.

Several pumped-storage sites in the basin require much more detailed studies to determine feasibility and compatibility with the resources. Dams on Crab Creek may have potential as hydroelectric power sources, but the sites need well-coordinated studies.

Land use planning must be coordinated with water resource planning to fully evaluate any new proposed hydroelectric pumped-storage projects and proposed rights-of-way for transmission lines. Research and study on transmission of higher voltages should be accelerated since the use of such lines could have less impact on land use.

A level B study of the area is presently being conducted by the Washington State Study Team. This study is being led by a representative of the State of Washington and is being coordinated by the Pacific Northwest River Basins Commission.

CONCLUSION

1. The complexity of the water and related problems indicates the need for a study for the Big Bend area.

RECOMMENDATION

1. The Pacific Northwest River Basins Commission is conducting a level B study of the Big Bend area for their Coordinated Comprehensive Plan. The study should receive continued support through Federal agency programs and should be followed by level C planning to the extent required to develop adequate detailed plans in compliance with current Federal planning and authorization procedures.

The State of Wyoming straddles the Continental Divide. The State contains about 97,900 square miles, making it the ninth largest State in the Nation and seventh largest among the 11 Westwide States. The State ranks last among the Westwide States and 49th in the Nation with its population of 332,000. This amounts to a little more than three people per square mile. Its abundant natural resources rank the State high in the production of minerals and energy resources, yet much of its heritage stems from its agricultural and livestock industry. Transportation, important in the settlement of the State, combined with the scenic beauty of open spaces, rugged mountains, forests, and natural parks, makes Wyoming one of the Nation's prime vacation States. It is estimated that about 8 million out-of-State people visit Wyoming each year.

Wyoming is the second highest State in the Union with an average elevation of 6700 feet. Elevations range from 3125 feet in north-eastern Wyoming on the Belle Fourche River to 13,785 feet in western Wyoming at the summit of Gannett Peak in the Wind River Range.

About 47 percent of the land is in Federal ownership and another 42 percent is classified as privately owned. From a land use standpoint 76 percent of the land is used as range and grassland for grazing cattle. Among the Westwide States, Wyoming ranks second in this category, behind Nevada.

WATER SUPPLY

Wyoming watersheds contribute water to rivers of four major water resource regions – Columbia-North Pacific, Missouri, Colorado, and Great Basin.

Surface Water

Most of the streams that originate in the mountainous areas of the State are perennial streams and contribute most of the water yield in the State; however, there are numerous intermittent streams originating in the lower elevations of the State. A major portion – approximately 70 percent – of the annual runoff in Wyoming's streams is snowmelt runoff during the months of April, May, June, and July. Variations in annual snowfall and other forms of precipitation from year to year cause considerable variance from average annual streamflows.

More than 90 percent of the water flowing through the State originates within the State's boundaries. Major rivers include the Green, Snake, Bear, North Platte, Belle Fourche, Wind, Power, and Big Horn. About 72 percent of the land area is drained northward and eastward by the Missouri River system. Tributaries of the Colorado River drain about 17 percent. The remaining 11 percent is drained by the Snake River and by streams of the Great Basin.

Wyoming's rivers yield on the average about 15.4 million acre-feet million acre-feet per year. Another 1.5 million acre-feet per year flows into the State from other States. Because of compacts, decrees, etc., not all of the 16.9 million acre-feet is available for use within the State of Wyoming. It is estimated that 1975 depletions (water use) will be about 3.0 million acre-feet. Irrigation is the foremost water user, accounting for 82 percent of the surface- and ground-water withdrawals. Tables VI-55 and VI-56 summarize Wyoming's estimated 1975 depletions and water supply situation.

The present economy of the State is greatly dependent upon the mineral industries for both employment and associated service and local business. In terms of taxes collected in the State, mineral production is Wyoming's most important industry. The oil and gas industry is presently the largest mineral industry with coal and uranium on the increase. The expanding trona industry also has an important role in the State's economy.

Agricultural activities presently use about 84 percent of Wyoming's land area. The major source of income from Wyoming ranch and farm operators is livestock and livestock products.

Tourism is Wyoming's third largest industry. Beautiful mountain ranges, Yellowstone and Grand Teton National Parks, wilderness, forests, free-flowing streams, wildlife and Western atmosphere contribute to the State's recreational assets. Excellent big game hunting and fine trout fishing are available throughout the State.

From the personal income perspective government, wholesale and retail trade and mining are the major income producing sectors. Agriculture is sixth out of nine income producing sectors.

Development of Wyoming's energy resources, occurring mainly in northeastern Wyoming, and the Platte River and Green River Subregions, will place an increasing demand on Wyoming's available water resources. These increasing industrial demands will affect the present agricultural economy along with the environment of

Table VI-55.—*Estimated 1975 total depletions for Wyoming*[1] *(1,000 acre-feet)*

Region and subregion	Irriga-tion	M&I including rural	Min-erals	Thermal electric	Recreation[2] F&WL	Reservoir evaporation	Total depletions
	Purpose or cause of depletion						
Missouri							
Yellowstone	1,229	22	47	1		138	1,437
Western Dakota	16	7	8	2		34	67
Platte-Niobrara	710	26	10	10		180	936
Total region	1,955	55	65	13		352	2,440
Upper Colorado							
Green River	260	4	22	3	16	94[3]	399
Total region	260	4	22	3	16	94	399
Columbia-North Pacific							
Upper Snake	89	2				5	96
Total region	89	2				5	96
Great Basin							
Bear River	68	1	1			7	77
Total region	68	1	1			7	77
State summary	2,372	62	88	16	16	458	3,012[4]

[1] Includes surface water, surface-related ground water, and mined ground water. No depletions attributed to consumptive conveyance losses.
[2] Exclusive of instream flow use.
[3] Includes Wyoming's share of Colorado River main stem reservoir evaporation. Average annual main stem reservoir evaporation assumed to be 520,000 acre-feet; Wyoming's share, 73,000 acre-feet.
[4] Surface-water depletions — 2,763,000, ground-water depletions — 249,000.

some stream systems. These industrial developments and the accompanying population increase will have significant socio-economic impacts on many cities and towns. United States Census Series "E" projects a population in the year 2000 of 327,000, a decrease from the 1970 population of 332,000. However these values are based on historic trends and do not necessarily take into account large increases in population due to in-migration in response to major natural resource developments. Alternative projections have been made for Wyoming, based on possible energy resource development on a county-by-county basis which show that Wyoming's population may be on the verge of a major takeoff. Estimates are that it could be from 500,000 to 550,00 by 1990 and 575,000 to 633,000 by the year 2000.

Ground Water

Ground water is found at various depths throughout the State. Presently, the majority of wells in the State are not more than 200 feet deep.

Most water wells in Wyoming are drilled to provide dependable water supplies for rural domestic and livestock uses. Many communities depend entirely on underground water for survival. Other communities use a combined water supply derived from both surface- and ground-water sources. The use of ground water for irrigation has increased dramatically during the past decade, principally in southeastern Wyoming. The mineral industries use large quantities of ground water,

Table VI-56.—*Estimated 1975 surface water-related situation in Wyoming (1,000 acre-feet)*

	Average annual water supply				Estimated 1975 water use		Estimated future water supply		
Region or subregion	Modified[1] inflow to subregion or state	Undepleted water yield within sub-region or state	Estimated 1975 imports	Total water supply	Estimated 1975 exports	Estimated[4] 1975 depletions	Modified[2] 1975 supply	Estimated 1975 legal and instream flow commitments	Net water supply[3]
Missouri									
Yellowstone	446	7,218	0	7,664	0	1,359	6,305	3,470	2,835
Western Dakota	0	220	0	220	0	49	171	70	101
Platte-Niobrara	520	1,250	10	1,780	0	795	985	690	295
Total region	966	8,688	10	9,664	0	2,203	7,461	4,230	3,231
Upper Colorado									
Green River	390	1,730	0	2,120	10	392	1,718	1,315	403[5]
Total region	390	1,730	0	2,120	10	392	1,718	1,315	403
Columbia-North Pacific									
Upper Snake	0	4,720	0	4,720	0	96	4,624	4,453	171
Total region	0	4,720	0	4,720	0	96	4,624	4,453	171
Great Basin									
Bear River	140	270	0	410	0	72	338	290	48
Total region	140	270	0	410	0	72	338	290	48
State summary	1,496	15,408	0[6]	16,904	0[6]	2,763	14,141	10,288	3,853

[1] Modified inflow reflects the effects of depletions upstream of State lines. Subregions, therefore, do not necessarily add to regional values.
[2] Modified 1975 supply is determined by subtracting estimated total water use from total supply.
[3] Available for future instream uses such as for fish, wildlife, recreation, power, or navigation or for consumptive use. Physical or economic constraints could preclude full development.
[4] Depletion related to ground-water mining and surface related ground water removed from totals presented in "Depletions" table.
[5] Represents the remaining amount of water the State of Wyoming can develop from the waters of the Colorado River system. Assumes 5.8 million acre-feet availability to Upper Colorado Region States adjusted for 1975 Wyoming uses and exports.
[6] No imports or exports to or from state. All imports and exports are within State and therefore not included in State totals.

particularly in the secondary recovery of oil and the milling of uranium ore.

Ground water yearly consumption uses are presently estimated to be about 133,000 acre-feet for irrigation, 32,000 acre-feet for municipal, domestic, and livestock, and about 50,000 acre-feet for industry.

Water Quality

Except for some of the rivers of the Western Dakota and Yellowstone subregions – Belle Fourche, Powder, and Cheyenne – the quality of Wyoming's surface waters is within established standards.

The quality of ground water in the Western Dakotas, Yellowstone, and Green River subregions is classified as poor. Except for the recharge areas average salinity concentrations are estimated to be in excess of 1,000 to 1,500 p/m, salinity ranges from 200-9,000 p/m. Hardness is high and many toxic elements are present in concentrations higher than recommended by the Public Health Service.

In the Platte-Niobrara Subregion ground-water quality is good with average TDS concentrations for most of the subregion being estimated at less than 600 p/m. In the remaining subregions, Bear River, Snake River and Upper Missouri, average ground-water quality varies from 250 to 3,000 p/m.

CRITICAL PROBLEMS

Several of the Westwide problems directly affect Wyoming. The Westwide problems dimensioned in this portion of the presentation provide additional State specific information not contained in the Westwide Chapter. Regional problems affecting Wyoming are listed. The State specific problems concludes this portion of Chapter VI. Figure VI-21 locates the State and Regional problems in Wyoming.

Westwide Problems

NO. 5 – NEED FOR ADEQUATE ENVIRONMENTAL INFORMATION FOR WATER PLANNING. – Coal and oil shale development in Wyoming will have a major impact on the water resources of the State and on the contribution of the resources to the recreational, fish and wildlife, and general environmental values which make Wyoming an attractive place to live and to visit. In order to adequately plan for the maintenance of these outdoor values, basic information on necessary instream flows, wetlands, and endangered species habitat must be made available as soon as possible so that planning for water for energy development can concurrently consider alternative environmental plans. Basic environmental studies must start immediately if they are to have real pertinency in the nearterm water planning picture and should concentrate on those basins where early coal and oil shale developments are anticipated.

NO. 6 – NEED FOR ADDITIONAL FLAT-WATER RECREATION OPPORTUNITIES. – Most of Wyoming's population is concentrated in the Cheyenne and Casper areas. Demand for additional flat water recreation is increasing in these areas. Several Federal reservoirs are located near these population centers which if operated differently would satisfy these needs. Moreover, most of these reservoirs are at the extreme northern boundary of the Colorado front range metropolitan area and will be increasingly important for meeting the recreation needs of that area as population pressures increase. Glendo and Guernsey reservoirs on the North Platte River are of particular interest. Through better operation of these reservoirs, additional flat water recreation pools could be provided. Presently, under The Bureau of Reclamation's Seminoe Dam Modification Study, consideration is being given to developing new operating criteria for Seminoe, Pathfinder and Glendo Dams and Reservoirs. Guernesey, because of sediment problems which requires flushing each year was not considered a candidate for study. Recreation needs are a part of the Seminoe Study.

NO. 7 – WATER SUPPLY ASPECTS OF WILD, SCENIC, AND RECREATIONAL RIVERS. – Segment of the following were among a number of "5(c)" rivers (formerly Section 5(d) of P.L. 90-542) named by the Secretaries of Agriculture and Interior in 1970, whose wild and scenic river values must be evaluated in any Federal planning for other (developmental or control) uses of these rivers: Green (upper), Gros Ventre, Snake (upper), and the Wind.

Recently the Secretary of the Interior, acting on findings of a Federal Inderdepartmental Study Group, recommended enactment of a comprehensive "Administration bill" that calls for study of 16 high-priority rivers within the Westwide States. Included are portions of three Wyoming rivers. The first two (listed below) are among a group of three rivers in the Westwide States which have been given the highest study priority due to the likelihood of their becoming involved in energy-related development. In addition to the rivers in the Administration

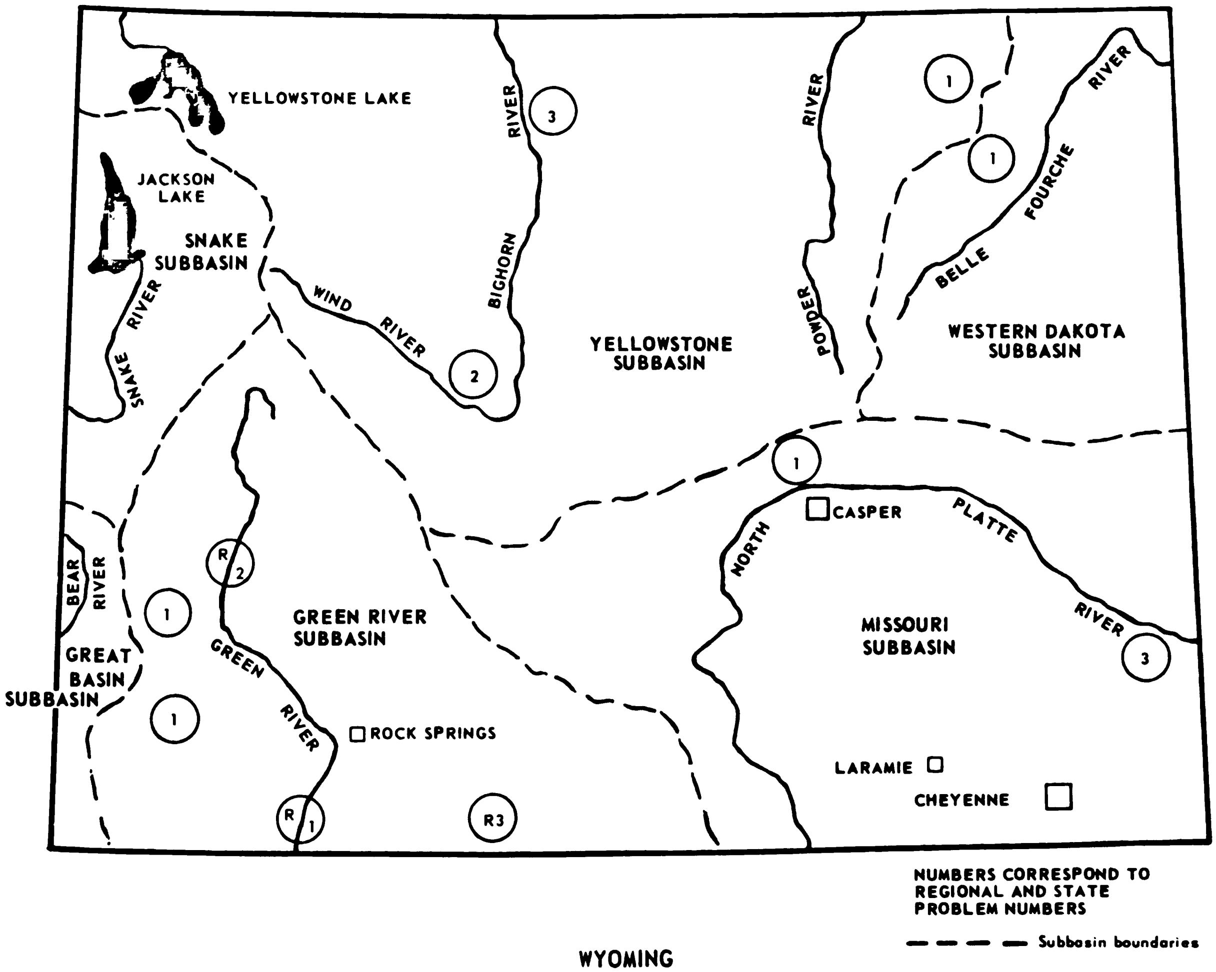


Figure VI-21. Critical water problems in Wyoming.

bill, the Westwide Study has identified two other rivers which because of developing conflicts and probable future degradation of the rivers' free-flowing values should be studied as soon as possible. Table VI-57 summarizes information on the latter five rivers:

Other Wyoming rivers identified by the State Study Team as having significant free-flowing values include the upper Green and tributary New Fork; the Greys Fork, Buffalo Fork, Gros Ventre and Hoback – all tributaries to the upper Snake; the upper North Platte and tributary Encampment; and Shell Creek (Bighorn National Forest).

Wyoming currently has no state-designated wild, scenic, or recreational rivers and there are no provisions for such in Wyoming water law. However, the 1973 State Legislature authorized a study to determine the criteria and need for such designation. The State has taken the position that it is the State's responsibility to administer the rivers within its boundaries, and that the development of scenic rivers programs and other similar programs affecting the water of Wyoming should be under the jurisdiction of the State.

NO. 16 – THE CHANGING FEDERAL ROLE IN DEVELOPING IRRIGATION PROJECTS. – Wyoming has experienced a downward trend in agricultural employment similar to the national trend in agriculture. However, the rate of decline has been lower in Wyoming than in the Nation or the States comprising the Rocky Mountain Region. Agriculture is the fourth largest industry in Wyoming as measured in terms of employment. The income of persons engaged in agriculture during the period 1950 to 1970 has improved because of a

Table VI-57.—*Wyoming rivers recommended for study as potential National System additions*

River	River segment
Sweetwater	Main stem from source to the confluence with Chimney Creek.
Yellowstone	Main stem from Yellowstone Lake to Montana State line, and tributary Clark's Fork in Wyoming (plus portions of both rivers in Montana).
Snake	Main stem from its source to Palisades Reservoir, excluding Jackson Lake. Provided however, that study of this river shall not affect the authority of the Corps of Engineers to undertake maintenance work for the flood protection project along the Snake River authorized by the Flood Control Act of 1950 (64 Stat. 180), nor shall it affect the authority of the Corps of Engineers to undertake emergency flood control work along the Snake River under the authority of Section 5 of the Flood Control Act of 1941 (55 Stat. 650), as amended (33 U.S.C. 701n).
Tongue	Source to Montana State line (and portion in Montana).
Wind	Source to Boysen Reservoir.

decline in the number of persons working in onfarm agriculture.

Wyoming's agriculture is basically livestock oriented. Irrigated and dry cropland which provide a winter feed base are interdependent components of the farm and ranch enterprise.

Although dryland hay and feed grain production is important, the principal production of total feed grain and hay occurs on irrigated lands. The estimated gross annual value of irrigated crop and pasture production in Wyoming is about $76 million. The net return to irrigated land in the State is about $16 million.

Both private and Federally developed irrigation have historically been important to Wyoming's economic development. Most easily developed surface water supplies have now been realized. A potential to expand irrigated areas through development of ground water exists. This would most likely be through local, private means. Wyoming's remaining surface water supplies will, in general, require substantial storage and diversion facilities. The high cost of these enterprises coupled with the likelihood that this water will be used to support development of energy resources throughout the State make it unlikely that Federal investments in major new surface water supplies for irrigation will occur in Wyoming.

Regional Problems

Wyoming has an interest in regional problems 1 and 2 which relate to the quality and quantity aspects of the Colorado River and regional problem 3 which is concerned with oil shale development. They are:

NO. 1 – WATER SUPPLY PROBLEMS OF THE COLORADO RIVER

NO. 2 – INCREASING SALINITY IN THE COLORADO RIVER

NO. 3 – WATER REQUIREMENTS FOR SHALE DEVELOPMENT IN THE UPPER COLORADO REGION

State Specific Problems

The major problem that confronts Wyoming's available water resources in the near term is the development of the vast energy resources of the State to meet its own and the Nation's energy needs. Most of the other problems are directly or indirectly related to providing sufficient water supplies to meet the water requirements of the projected coal, uranium, and oil shale developments. These developments will have an impact on the present environment, communities, and irrigation developments. These energy developments are now taking place on piecemeal basis and are seriously affecting the present agricultural economy of the State. Industry is now purchasing irrigation water for their developments and thus taking presently irrigated land out of production. Additional water developments that would regulate the available unused flows and make these supplies available for industrial and other uses are needed. There are presently numerous Federal agencies planning for the uses of Wyoming water and related land resources. The State believes that a Federal planning office located in the State would provide better assistance in the development of the water and related land resources.

The following specific problems are discussed in the remainder of this section.

NO. 1 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

NO. 2 – NEED FOR WATER AND RELATED LAND DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

NO. 3 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

NO. 1 – WATER REQUIREMENTS TO MEET ENERGY DEMANDS

SUMMARY

The State of Wyoming possesses abundant deposits of coal, uranium, and oil shale, far in excess of its own internal needs. However, with the Nation facing a long-term energy shortage, Wyoming's energy resources may reasonably be expected to play a major role in meeting future national energy needs through export of either coal or processed coal and oil shale into oil and gas or directly into electric energy. Coal development is well underway, and oil shale development is expected to start before 1980. The State, Federal Government, and citizens are concerned about the impact these developments will have on land use, small communities, environment, and water resources. Two areas of the State, northeastern and southwestern Wyoming are the focal points of current coal development activity. Southwestern Wyoming also contains the State's oil shale deposits. The location of Wyoming's major deposits of coal, uranium, and oil shale are shown in figure VI-22. The following discussion will concentrate on the problems associated with development of uranium, coal resources and other energy minerals except oil shale. Oil shale development is discussed in regional problem 3.

Uranium

Wyoming's uranium industry consists of surface and underground mines which produced 85 million pounds of uranium in 1972, recoverable content U^3O^8, which was second to New Mexico. Seven uranium mining operations are in Fremont County, three in Carbon County, one in Natrona County, and one in Converse County. On a national basis, Wyoming ranked second in uranium production in 1969 with 28 percent of the total United States output.

Although Wyoming produces about 29 percent of the Nation's uranium, none of the output enrichment, reactor fuel fabrication, or reprocessing operations are yet performed within the State.

Wyoming's uranium industry is forecast to expand production of uranium ore through the year 2000. Wyoming's peak production is placed at 25,000 tons of U^3O^8 at about 1995. It is also possible that a uranium enrichment facility might be located in Wyoming in view of large amounts of electrical power and water potentially available in the State.

Coal

Wyoming has an estimated 46 billion tons of coal reserves of which about 26 billion tons are mineable by surface mining techniques. Environmental and economic constraints limit these coal reserves to about 21 billion tons of recoverable reserves by current technology. Some 75 percent of Wyoming's coal reserves are in the northeastern region of the State. Other large reserves of low sulfur coal also exist in the Platte and Green River basins. In 1969, 4.6 million tons of coal worth $15.4 million were produced from four underground and eight strip mines operating within the State.

Currently, Wyoming has about 1,845 MW of installed coal-fired thermal powerplant capacity using about 13,000 acre-feet of water. Table VI-58 summarizes the current status of all coal-related activities throughout the State, including major new carbonizing plants used to make coke for industrial use.

Many projections have been made or are being made of future coal development in Wyoming and other States. However, the situation is so dynamic it is impossible to predict with any degree of certainty what the future might be. For the purposes of this report, projections included in Wyoming Water Planning Program Reports are used. It should be pointed out that the Northern Great Plains Resources Study, an interdepartmental Federal-State study, has recently completed a report on the energy resource potential of the five-State area – Wyoming, Montana, North Dakota, South Dakota, and Nebraska – which assesses environmental, economic, and social consequences of various alternative levels of resource development. The objective of this effort has been to provide a data base for future decision making and planning.

Northeast Wyoming and Bighorn River Subregion. – Production of coal for meeting the demands for energy will require various amounts of water,

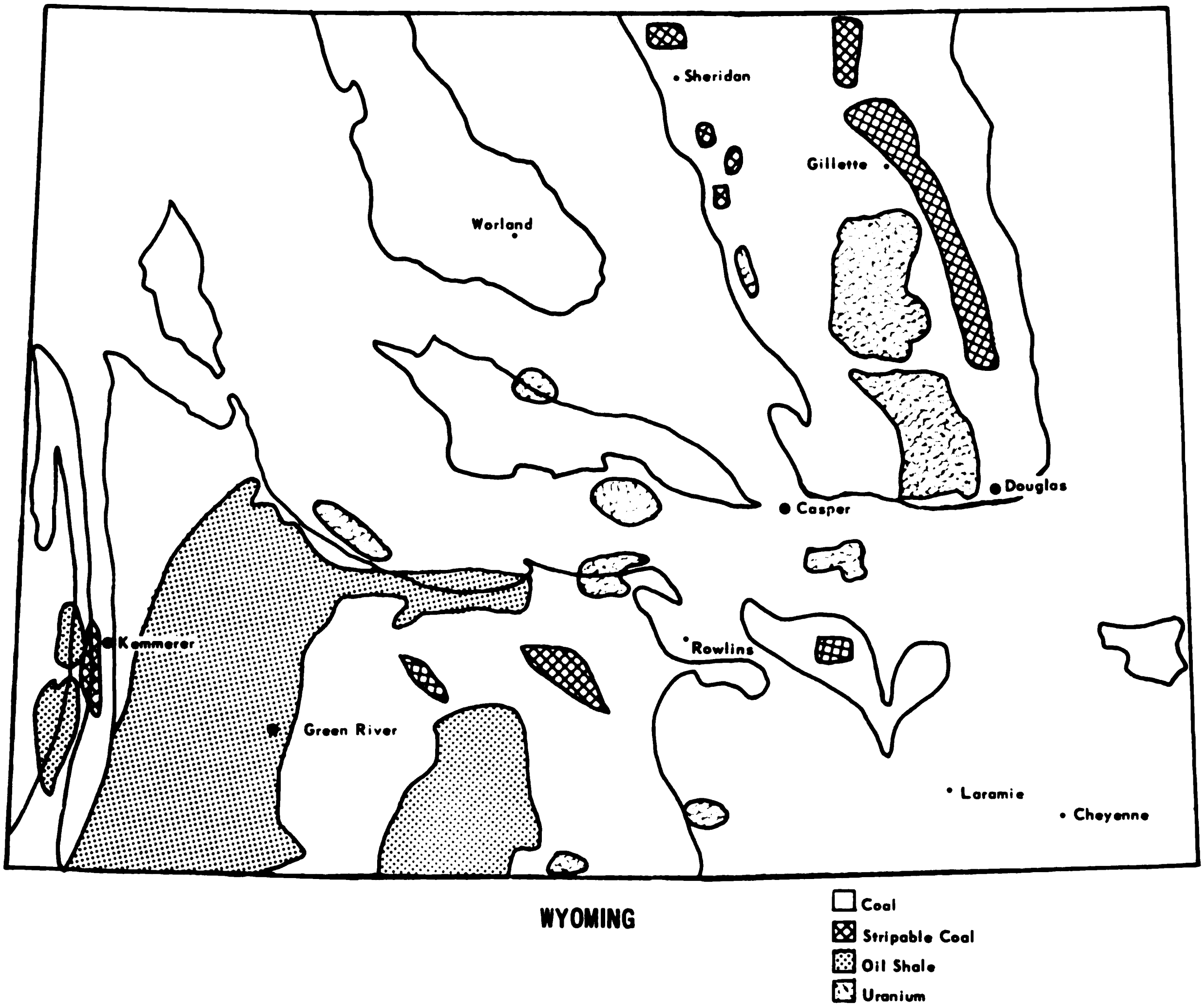


Figure VI-22. Energy mineral deposits in Wyoming.

Table VI-58.—*Status of coal-related activities in Wyoming*

Number of	Area				Total
	Green River subregion	Platte River subregion	Northeastern Wyoming	Bighorn Basin	
Thermal powerplants	1	1	3	–	5
Carbonizing plants	2	–	–	–	2
Coal mines	3	2	2	–	7
Water requirements for all facilities (1,000 AF)	7	5	3	–	15

depending upon the purpose of which the coal is to be used. The Northern Great Plains Resource Program projected a range of production of coal in northeast Wyoming and its use for electric power generation, production of synthetic natural gas, and for export. The conversion of coal to synthetic pipeline gas and export are expected to be the principal use of Wyoming coal.

Water requirements for the Northern Great Plains Program projected levels and uses of coal were estimated by the Bureau of Mines using the following unit water requirements: (1) a synthetic natural gas plant producing 250 MCFD annually would consume about 8 million tons of coal and 10,000 acre-feet of water, or 1,250 acre-feet of water for each million tons of coal; (2) fifty percent of the coal exported from the Northern Great Plains area will be transported via slurry pipeline, requiring 600 acre-feet of water per 1 million tons of coal transported; the balance of coal exported would be by unit train; (3) coal-fired electric powerplants will require 15,000 acre-feet of water annually per 1,000 MW of capacity. A 1,000-MW plant would require about 4 million tons of coal, approximately 3,750 acre-feet of water per million tons of coal, consumed; and, (4) coal mining will consume about 100 acre-feet of water per 1 million tons of coal mined.

Table VI-59 summarizes projected coal production and water requirements for northeast Wyoming. Most of the coal production and associated conversion activity is expected to take place in the Powder River basin and in the vicinity of Gillette, Wyoming, in the Belle Fourche and Cheyenne River drainages.

The extensive level of development represents a probable maximum level of coal use and is due to increased use of coal for conversion to natural gas and for export. Under either future circumstance use of coal for thermal electric power generation in northeast Wyoming is not expected to be large.

Municipal water requirements related to coal development are expected to be modest. With the most probable level of coal development, depletion requirements would be about 7,000 acre-feet by 2000. With an extensive level of development, depletions would be about 14,000 acre-feet by 2000.

In the Northern Great Plains areas of northeast Wyoming, when and where natural precipitation is adequate to restore strip-mined areas to their present rangeland conditions, supplemental water would not be required. However, when land is being revegetated to restore suitable habitat for wildlife, it is possible that larger volumes of water over a longer period of time may be required.

During periods where natural precipitation is inadequate estimates have been made on the most probable plan. By year 2000, most probable level of coal development would require an estimated revegetation of 3,300 acres every year. Assuming that at least 2 consecutive years are needed for establishment of grasses, in a drought year, 6,500 acres would require irrigation. Therefore, 8 inches (12 inc.-4 in.) of irrigation over this land area could require, annually, 4,400 acre-feet. Table VI-60 summarizes this water requirement for the two levels.

Green River and Bighorn River Subregions. – As presented in the Wyoming Water Plan Report, development in the Green River and Platte River Subregion areas is projected in table VI-61.

Specific Problems

Northeast Wyoming. – Wyoming's coal deposits are part of a large deposit of coal extending into southeastern Montana. The problems and uncertainties concerning the physical development of this resource are somewhat similar in both States. The type and magnitude of problems northeastern Wyoming will have to contend with will depend on how the coal resource is used. If coal development follows export trends, water demands will be much lower and mining and processing water requirements could be met from locally available ground water.

If mine-mouth powerplants and coal liquification or gasification plants are constructed in the area, then water would have to be imported from other sources such as the Bighorn River or even the Green River. In either case, reclamation and restoration of strip-mined areas will present major problems in relation to coal development. There are potentials for combining this activity with recreation and agricultural enhancement. Also, there would be a need to provide additional water to the existing small communities and possibly new towns in the area.

Green River Subregion. – In the Green River Subregion, surplus water is readily available from existing reservoirs for use within the basin or possible export. However, additional storage facilities which will be necessary if Wyoming is to utilize its remaining share of the Colorado River could

Table VI-59.—*Estimates of consumption of coal by three major uses and water requirements in northeast Wyoming – 1971-2000*

Coal and water needs	Year			
	1971	1980	1985	2000
Probable level of development				
Amount of coal used for:	(million tons)			
Electric power	2.2[1]	4.2	4.2	8.9
Synthetic natural gas	–	–	15.5	24.2
Export	2.0[1]	30.8	40.8	58.8
Total	4.2	35.0	60.5	91.9
Water requirements for:	(thousand acre-feet)			
Electric power	8.3	15.7	15.7	33.4
Synthetic natural gas	–	–	19.4	30.2
Export	.6	9.2	12.2	17.6
Mining	.4	3.5	6.0	9.2
Total	9.3	28.4	53.3	90.4
Extensive level of development				
Amount of coal used for:	(million tons)			
Electric power	2.2	4.2	4.2	8.9
Synthetic natural gas	–	–	50.4	76.1
Export	2.0	30.8	78.8	275.8
Total	4.2	35.0	133.4	360.8
Water requirements for:	(thousand acre-feet)			
Electric power	8.3	15.7	15.7	33.4
Synthetic natural gas	–	–	63.0	95.1
Export	.6	9.2	23.6	82.7
Mining	.4	3.5	13.3	36.1
Total	9.3	28.4	115.6	247.3

[1] Actual

significantly affect environmental resources. A portion of the Green River has been proposed for inclusion in the National Wild, Scenic and Recreation River System. Wilderness areas exist in the upper areas of the watershed and expansion of these areas is under consideration. This subregion also contains Wyoming's oil shale resources and significant deposits of trona which is a primary source of soda ash. Approximately 22 percent of the Nation's soda ash requirements are being met from Green River trona deposits. Additional trona developments are in the design state. Depending upon the environmental constraints placed on the development of Green River water and the extent of other mineral developments, conflicts of water use may develop.

If the coal deposits are strip mined, there also will be significant land use impacts. This type mining would require major land reclamation programs to be incorporated in the mining operations.

Platte River Subregion. – Municipal and industrial water supplies are already limited in the Platte River basin. Future coal development in this area will require importation water, augmentation, or additional conversion of agricultural water supplies.

Table VI-60.—*Estimated water requirement for revegetation in northeast Wyoming, year 2000*

Range of coal development	Area being mined (acres/year)	Area undergoing revegetation (acres/year)	Supplemental irrigation requirement (acre-feet/year)
Most probable	3,300	6,500	4,400
Extensive	11,100	22,100	14,800

Table VI-61.—*Coal-related development in Green and Bighorn River subregions*

Number of:	Time frame 1980	2000	2020
Green River subregion			
Steam plants	2	2	
Synthetic liquids		1	
Carbonizing plants	2	4	
Coal mines	4	7	
Water requirements for all facilities (1,000 AF)	26	45	
Platte River subregion			
Steam plants	2	5	
Coal mines	3	6	
Water requirements for all facilities (1,000 AF)	20	65	

Industrial water supplies are now being obtained in part by purchasing irrigation water rights and transferring the water use to industrial use rather than developing new surface or ground water supplies. The economic impacts of water rights conversion and land use changes are of prime concern to the State in meeting the new water demands.

Other Energy-related Developments. – United States uranium enrichment facilities at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio, are operating near their ultimate capacities. To meet future demands, the Atomic Energy Commission has projected a need for six new uranium enrichment plants during the 1983-2000 time frame. Up to nine more plants may be needed to meet projected foreign demands. If the gaseous diffusion process is used, large amounts of power and water will be required. For example, an enrichment plant with a separative work capacity of 8,750 metric tons would require 2,000 MW of power and about 30,000 acre-feet of water.

It is possible that at least one of these plants could be located in Wyoming. The problems associated with a project of this magnitude would require a significant planning effort in the water supply, land use, environmental and social impact areas.

CONCLUSIONS

1. Development of Wyoming's proven reserves of strippable, low-sulfur coal is expected to continue at an accelerated pace to meet increased national energy demands.

2. Local surface water supplies, except in the Green River Subregion are not sufficient to meet projected water requirements for possible energy resource development through the year 2000. Depending on the rate and character of development, shortages could occur much earlier.

3. There are many unanswered questions concerning the projections of actual water requirements for coal development. If the coal is primarily mined, processed and shipped out of the State, water demands will be minimal compared to that needed to support mine-mouth power generation or synthetic fuel conversion. Moreover, with onsite coal-fired power generation, the use of dry cooling towers could also significantly reduce the demand for import water and promote development of local supplies.

4. Water for northeastern coal development if that coal is converted to energy at site will require extensive use of local surface and ground water and possibly major imports supplied from distant reservoirs. The level of coal development and accompanying water requirements should be closely coordinated with

developments of southeastern Montana coal to achieve economies of development and to minimize the adverse impacts to the environment.

5. In the Green River Subregion, competition for water supply to meet inbasin coal, oil shale, trona and irrigation development will have significant environmental impacts and affect the availability of water for export to other basins supporting energy development.

6. Any major development of coal reserves in the Platte River basin will require substantial conversion of agricultural water rights for municipal and industrial purposes, augmentation, or importation from adjacent river basins.

7. Restoration of areas to be strip mined will require considerable research and development and could require substantial amounts of water, especially if irrigation is involved.

8. Because of the environmental attributes of the impacted areas, the public lands that will be affected and the Federal responsibilities with regard to water, there is a strong public interest in any future construction of storage facilities.

9. It has been estimated that vast quantities of ground water are available in the State. This relatively unused resource may meet some future water demands, although the costs of production, treatment, and legal constraints that will control the actual amount used are not fully known. It may be desirable to tap shallow ground-water aquifers, especially in northeastern Wyoming. Such use may involve mining of ground water and would be a near-term alternative to large-scale, interbasin transfer of water.

10. Expected population growth in the major coal areas will bring with it community development problems of water supply, waste treatment, and other social and economic impacts which should be considered in any regional planning effort.

RECOMMENDATIONS

1. A basinwide study is needed on the best use of remaining Green River water supplies. In view of adjacent wilderness areas, National forests, and other sensitive environmental areas in the basin, a long study lead-time may be necessary to resolve potential conflicts. A Level B study of the Green River basin is recommended.

2. Considering the potential water requirements of the energy-rich northeastern quadrant of Wyoming, additional basic ground-water data are needed for area planning. Specific data are needed to evaluate and locate ground-water reservoirs, geologic water formations, aquifers, confining beds, and disposal reservoirs. Research is needed on rates of infiltration and recharge as well as general geohydrology of the area. The special study is needed in the immediate time frame (1975).

3. Special planning studies on alternative plans to meet a range of water demands for energy are needed in the coal areas of Wyoming and Montana. These studies are needed now because of the urgency to develop energy resources within national borders. Such studies should be multiple objective and provide for maximum protection of the environment. A Federal-State study, directed primarily at resolving watersupply sources, would also examine the potential needs of community growth, economic development and social impacts involved.

4. Ongoing Department of Agriculture type 4 studies in the Green River and Platte River basins should be continued with increased emphasis on the environmental impacts of strip mining.

5. Special studies on the reclamation of strip-mined areas should be undertaken by the involved land management agencies including the Forest Service and the Bureau of Land Management with technical assistance from the other Federal agencies as required.

6. An intensive special study effort should be undertaken to develop water-related environmental data including: (1) instream flow needs for fish and wildlife, general environmental and recreational uses; (2) inventory data on critical wetlands and riparian habitat; and (3) specific range and habitat requirements of rare and endangered animal and plant species. The study should be led by the Fish and Wildlife Service with participation from the Bureau of Reclamation and the Wyoming Department of Fish and Game.

NO. 2 – NEED FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT STUDIES ON INDIAN RESERVATIONS

SUMMARY

On Wyoming's Wind River Indian Reservation there is a pressing need to evaluate water resource needs. Irrigation is presently practiced, and could be expanded.

Coal and other energy deposit on or nearby the reservation could be developed for the economic and social betterment of the Indians. A hydroelectric power potential also exists. Some of these water uses may be in conflict; and assessment, evaluation, and planning should be carried out to obtain reservation water development needs.

DISCUSSION

The Wind River Indian Reservation, located near the center of the State occupies 1,880,000 acres or about 3 percent of the total land area in Wyoming. About 146,000 acres of the reservation are presently under irrigation. The remaining land is used mainly as pasture. As of 1970, the population was 4,980, representing an increase of 24 percent over 1960 levels. Unemployment is greater than 40 percent, and the median family income is $4,200 as compared to $8,900 for non-Indian families.

There are existing irrigation facilities which are operated either privately or by the Bureau of Indian Affairs. Plans for rehabilitation of the Bureau of Indian Affairs projects have been submitted to that agency's Commissioner. Also, considerable acreage outside the existing project boundaries could be irrigated. Additional irrigation development could solve some of the tribe's economic problems.

Economic activity to develop deposits of coal and oil-bearing shales, while dormant for the most part at this time, are expected to see considerable activity in the future.

Emphasis on increasing demands for energy is evidenced by the increasing number of leases for coal development sought by various energy companies. Development of such leases is contingent on satisfactory agreement between the companies and the tribe with regard to use of water, methods of operation and payment.

Investigation initiated by the Bureau of Reclamation indicate the possibility of hydroelectric development on the reservation. These reports, though preliminary in nature, in view of the increasing demand for energy, indicate more detailed studies should be made.

On the reservation, it is necessary to intermix storage waters with natural flow to compensate for salts and other accumulations detrimental to agricultural pursuits. Reconditioning of return flows for reuse is also practiced in some areas, particularly where downstream diversions for domestic use are involved.

Outdoor recreation, including fish and wildlife propagation, is considered vital to all tribes, inasmuch as this is conducive to the preservation of their original culture and environment. A reminder of historic culture, and continuance of their arts and crafts talents is manifest at all tourist centers. Additional recreation development is anticipated.

CONCLUSIONS

1. Indian trust lands should have high priority in Federal and regional planning for water management and use.

2. There is a critical need to determine the economic and social objectives of Indians of the Wind River Indian Reservation and the associated water requirements so that total State water planning and development can be fully coordinated subsequent to the determination of the needs of the reservations. Studies are needed to evaluate and determine how the utilization of water resources may contribute to the alleviation of present and future Indian economic problems.

RECOMMENDATION

1. Level B studies should be implemented by the Federal Government with leadership by the Bureau of Indian Affairs in coordination with the Indian Tribes and technical assistance from other Federal and State agencies, for the determination of the resource needs of the Wind River Reservation.

NO. 3 – IMPACT OF SALINITY ON WATER USERS AND USERS' CONTRIBUTION TO DOWNSTREAM SALINITY

SUMMARY

Problems associated with salinity occur in Platte, Bighorn and Green River Subregions. The mineral burden of the Green River, because it is a tributary of the Colorado River, carries both interstate and international implications. As such, sources of salinity and water diversions in the Green River Subregion of Wyoming are expected to receive continuing attention in future planning investigations. In all cases, the impact on Wyoming water users is insignificant.

DISCUSSION

Bighorn and Platte Subregions

Although not significant at this time, salinity is increasing in the Bighorn and Platte River Subregions. In the Bighorn River Subregion, saline springs and irrigation return flows between Boysen Reservoir and Bighorn Lake increased salinity from 460 to 620 p/m. In the Platte River Subregion, irrigation return flows have caused increases in salinity. Currently, the salinity of the North Platte River at the Wyoming-Nebraska State line is about 529 p/m.

Green River Subregion

The mineral burden of the Colorado River is the foremost water quality problem in the basin and carries both interstate and international implications. About 535,000 tons of dissolved solids (salts) per year flow past the Green River, Wyoming, gaging station. Presently the main source of salinity in the Green River basin in Wyoming is the Big Sandy River. It is estimated that the Big Sandy contributes ranging from 300 to 3,900 mg/1. The major portion of this salt load comes from natural sources. A proposed control program would remove about 80,000 tons of salt from the Big Sandy and reduce salinity concentrations at Imperial Dam on the Colorado River by an estimated 7 mg/1.

The Blacks Fork and Henrys Fork Rivers also contribute substantial amounts of dissolved solids downstream of the Green River gage. The dissolved solids concentrations are not causing serious problems in the Green River basin. However, these salts contribute to the salinity problem in the Lower Colorado River Basin and Mexico. This problem is expected to increase as the demand for industrial, irrigation, and other water increases. The water of the Green River that passes Green River, Wyoming, contains about 300 to 400 ppm dissolved solids. By diverting this "relatively pure water" from the river, the concentration of salts will increase in the remaining water that is delivered to the Lower Colorado River Basin. The Bureau of Reclamation under the Colorado River Water Quality Improvement Program is investigating different means for controlling salinity of the Colorado River. This investigation program will consider individual problem areas, develop control plans, and make specific recommendations for remedial action.

Under the program, feasibility plans for control of salinity from irrigated areas and high salt input, point and diffuse sources are being prepared. Program studies in the Green River are underway with a feasibility report scheduled for FY 1977.

The State of Wyoming also is evaluating the water quality of the Green River. Sources of salinity and other problem areas will be determined by the State with results due by 1975.

CONCLUSIONS

1. Natural diffusion and irrigation sources within the Green River Basin contribute a substantial amount of dissolved solids to the Colorado River.

2. Both the State of Wyoming and several Federal agencies are investigating the salinity problems of the Green River Subregion.

3. Limitation of depletions is not a presently acceptable alternative to the Colorado River Basin States.

RECOMMENDATION

1. The Bureau of Reclamation's Colorado River Water Quality Improvement Program and allied Department of Agriculture (type IV study) programs should be continued. Based on these ongoing programs and State studies, recommended level C studies should be initiated and effective control programs implemented.

POTENTIAL FEDERAL STUDY AUTHORIZATIONS

Chapters IV, V, and VI have evaluated the critical water-related problems of the West and have made specific recommendations for the next step toward their solution. Recommendations, in many instances, indicate the need for a study requiring Federal direction or participation. These would be new or supplemental Federal studies requiring additional authorizations and/or funding. Current authorized agency studies being conducted by intergovernmental groups such as River Basin Commissions, and level C studies which might be recommended for authorization as a result of ongoing studies have not been included. The potential studies, for the most part, fall in the general fields of environmental needs, Indian study requirements, augmentation potentials of the Colorado River, and total water management studies of river basins.

The studies are listed as either type B, C, or special. The studies designated as type B or C generally conform to current Water Resources Council definitions. Some of the studies, however, do not conform to those designations and have been listed as special studies. The fiscal year in which each study is to be initiated, together with length of study period, is also shown. Estimated costs are provided for each study. If the study is projected beyond the 1976-1980 time frame, a balance to complete is also shown. Agencies expected to participate on a limited basis through their regular program funding are designated by X.

The potential studies are listed in tables VI-64 through VI-76. Studies related to Westwide problems are listed in table VI-64, those related to regional problems are listed in table VI-64, and those relating to specific State problems are listed in tables VI-66 through VI-76, alphabetically by State.

Total Federal agency costs of all potential studies recommended for the 1976-1980 time period amount to 98.7 million dollars. Federal costs of completing those studies extending into the 1980-1985 time frame are estimated at about $67.8 million. Thus, the total Federal agency cost of the recommended program extending over the next 10 years is about $166.5 million. Table VI-62 presents a breakdown of the total cost by time frames for Westwide, Regional and State problems.

Table VI-62.—*Costs of studies (millions of dollars)*

Study	1976-80	1980-85	Total
Westwide	43.4	38.5	81.8
Regional	10.4	–	10.4
State	45.0	29.3	74.3
Total	98.7	67.8	166.5

It is expected that the studies approved for the 1976-1980 time period would be phased into agency programs beginning in 1976. Because of the limitations and constraints of the National budget, these studies would probably begin at a modest rate in 1976 and increase in the successive years.

The costs of the studies, broken down by primary purpose, are as shown in table VI-63.

The studies would be phased into scheduled agency programs as ongoing studies are completed. To put study costs of about $20 million annually into perspective it can be compared to the average annual Federal agency expenditure on water resource investigations in the 11 Western States of some $88 million. States and other non-Federal participants will require their own source of funding and such costs would be in addition to those Federal costs referenced above. It should again be emphasized that there are continuing responsibilities for studies in the West that will be accomplished through ongoing agency programs or identified as a result of current water resource studies.

Table VI-63.—*Costs of studies, listed by purpose (thousands of dollars)*

Purpose	Costs		
	Total	1976-1980	1981-1985
Water for Indian reservations	$ 35,000	$ 9,944	$25,056
Environmental planning	41,850	32,800	9,050
Energy-related resource planning	10,100	9,680	420
Augmentation of water supply (weather modification)	37,650	13,400	24,250
Water quality	13,300	8,000	5,300
Basin studies (level B)	9,550	9,050	500
Estuaries	2,500	2,500	0
Total water management	7,900	6,100	1,800
Flood control	5,300	4,700	600
Municipal and industrial (other than energy)	1,500	900	600
Miscellaneous	1,900	1,650	250
Total	$166,550	$98,724	$67,826

Table VI-64.–*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Westwide problems*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA[1]	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	WW-1	Joint Federal-State-Industry thermal power powerplant siting studies	Spe	1976	5 yrs	5,000	5,000	0	$	$	$	$	$	$		$	$	$	$	X	$	X	X	
2	WW-1	Assessment of selected Westwide hydro and pumped storage sites	Spe	1976	2 yrs	2,500	2,500	0	$	$	X	$	$	$		X	$	$	X		$	$	X	
3	WW-2	Rural M&I water assistance programs – inventory, pilot, and technical assistance	Spe	1977	5 yrs	1,500	900	600	X					X		X	$	$	X					[2]
4	WW-5	Instream flow studies for fish, wildlife, recreation, and water quality	Spe	1976	10 yrs	5,500	2,750	2,750	$	$		X	$	$	X	$	$	$	X		X	$	X	
5	WW-5	Update of inventory of wetlands and riparian habitat	Spe	1976	5 yrs	6,000	6,000	0	X	X				$			$	$			X	X		
6	WW-5	Water-related habitat requirements for big game winter range and threatened and endangered species	Spe	1976	10 yrs	4,500	2,250	2,250		$				$	X		$	$						
7	WW-6	Flatwater recreation needs at existing [6] Federal reservoirs Phase I	C	1977	8 yrs	1,000	500	500	$				$	$				$			$			
		AZ-6 reservoirs				(250)																		
		CA-5 reservoirs				(250)																		
		CO-5 reservoirs				(250)																		
		NM-5 reservoirs				(150)																		
		WY-2 reservoirs				(100)																		

Table VI-64.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Westwide problems (cont.)*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	Study participants: BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
8	WW-7	Study of priority river segments to establish wild and scenic values	C	1976	8 yrs	7,800	4,750	3,050	$	$		X	$	$	X	$	$	$			$	$	X	
9	WW-11	Urban water management, Yakima, Portland;Vancouver, Colorado Springs, Carlsbad, Phoenix	C	1976	10 yrs	10,200	5,100	5,100	X				$	X		X	$	X	X		$	$	X	3
10	WW-16	Federal role in developing irrigation (independent consultant)	Spe	1977	2 yrs	500	500	0	$	X							X	$						
11	WW-17	Precipitation management to achieve streamflow augmentation																						
		(1) Colorado River demonstration	Spe	1976	13 yrs[4]	30,000	8,000	22,000	$	X				X		$		$	X					
		(2) Sierra cooperative	Spe	1976	7 yrs[5]	7,300	5,050	2,250	$	X				X		$		$	X					
			Total			81,800	40,300	22,120																

[1] BIA funding on WW problems will come from Specific State Indian Water Requirement Studies.
[2] HUD and HEW will require funding.
[3] HUD and HEW will require funding.
[4] Including planning and analysis.
[5] Planning began in 1976; $130,000 expended through FY 1975.

Table VI-65.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, regional problems*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	Reg-3	Water supply and environmental data studies for oil shale areas of:																						
		A. Colorado[1]	Spe	1976	5 yrs	2,000	2,000	0	$	$	$		$	$[3]	$	$		$						
		B. Utah[2]	Spe	1976	4 yrs	1,000	1,000	0	$	$	$		$	$[3]		$		$						
		C. Wyoming[1]	Spe	1976	5 yrs	700	700	0	$	$	$		$	$[3]		$		$			$			
2	Reg-4	Total water and related land management of Lower Colorado River main stem	Spe	1977	3 yrs	1,000	1,000	0	$	$			$	$	X	$	$	$	X		X			[4]
3	Reg-5	Supplemental studies for environmental data for Columbia River and tributary study	C	On-going	End 1977	600	600	0	$	X			$	$			$	$				$		
4	Reg-6	Columbia River estuary management plan[5]	B	1977	2 yrs	2,500	2,500	0	$	$			$	$	$		$	$	X	X	$	$		
5	Reg-7	Plan to protect and enhance anadromous fish in the Pacific Northwest	Spe	1977	4 yrs	2,000	2,000	0	$	$		$		$			$	X	X		$	$	X	
6	Reg-8	Instream flow requirements for environmental values for Middle Snake River	Spe	On-going	2 yrs	[3]	[3]	0	$	$			$	$				$			X	$	X	
7	Reg-9	Detailed sedimentation study of Palouse area	Spe	1978	3 yrs	600	600	0	X	X				$		$	X	$	X		X			
			Total			10,400	10,400	0																

[1] Includes impact on ground water.
[2] Includes studies on support compact of White River.
[3] Funding included in Westwide Ref. No. 4.
[4] Coast Guard should participate.
[5] Study emphasis on freshwater supply and would supplement specific site studies.
[6] Funding included in Westwide Ref. No. 5.

Table VI-66.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Arizona*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

						$1,000			Study participants															
No.	Ref	Study title	Study level	Initi-ation FY	Study length	Total cost	Costs 1976-1980	Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	AZ-3	Indian water requirements	B	1976	10 yrs	12,800	3,600	9,200	$		$		X	$		$	$	$	$		$			
2	AZ-5	Ground-water quality study of Phoenix-Tucson area	Spe	1978	3 yrs	300	300	0								$			X					
3	AZ-5	Comprehensive study of Little Colorado River	B	1977	3 yrs	1,500	1,500	0	$	$			$	$		$	$	$[1]	X		$			
4	AZ-5	Comprehensive study of Upper Gila Basin	B	1978	3 yrs	750	750	0	$	$			$	$		$	$	$	X		X			
5	AZ-6	Water requirements for riparian habitat	Spe	1977	3 yrs	600	600	0	$	$			X	$		X	$	$			$			
			Total			15,950	6,750	9,200																

[1] USDA Type 4 study scheduled to start in FY 1975.

Table VI-67.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, California*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	CA-1	Conjunctive use of ground water and surface water in the San Joaquin Basin	C	1977	3 yrs	350	350	0	$	$			$	$		$	X	X			X			
2	CA-2	Determination of factors affecting decline of anadromous fish and wildlife in the Eel and Trinity Rivers Systems	C	1976	5 yrs	[1]	[1]	[1]	$	$			$	$	$		$	$			$	$		
3	CA-3	Ventura County wastewater management	C	On-going	2 yrs	150	150	0	X				$	$							X			
4	CA-3	San Francisco Bay wastewater use study	C	1976	3 yrs	500	500	0	$	X			$	$				$	X		X			
5	CA-4	Thermal plant siting in remote California deserts using ground water for cooling	C	1977	5 yrs	600	480	120		$				X		$				X				
6	CA-7	Indian water requirements	B	1976	10 yrs	2,700	772	1,928	$				X	$		$	$	$	X		$			
			Total			4,300	2,250	2,048																

[1] Studies and funding being determined by State-Federal Task Force.

Table VI-68.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Colorado*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	Study participants: BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	CO-1	Environmental data to evaluate impact of coal development	Spe	1976	3 yrs	200	200	0	X	$	$		$	$[1]			$	$	X		X			
2	CO-1	Water supply for coal development	C	1976	2 yrs	500	500	0	$	$	$		X	$		$	X	$	X		X			
3	CO-3	Arkansas River basin comprehensive plan	B	1979	3 yrs	1,500	1,000	500	$	$	X		$	$		$	X	$	X		$			
4	CO-4	Indian water requirements	B	1976	10 yrs	2,200	628	1,572	$		$		X	$		$	$	$	X		X			
			Total			4,400	2,328	2,072																

[1] Funding included as part of Westwide Ref. 5.

Table VI-69.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Idaho*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

						$1,000			Study participants															
No.	Ref	Study title	Study level	Initiation FY	Study length	Total cost	Costs 1976-1980	Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	ID-1	Instream flow requirements for 13 reaches of streams in Idaho	Spe	1977	4 yrs	500	500	0	$	$		X	$	$[1]		X	$	$	X		$	$	X	
2	ID-2	Indian water requirements	B	1976	10 yrs	400	116	284	$				X	$		$	$	$	X		$	X		
3	ID-3	Comprehensive plans for Boise and Payette River basins	B[2]	On-going	4 yrs	1,000	1,000	0	$	$		X	$	$		$		$	X		$			
[1]4	ID-5	Comprehensive plans for Upper Snake River basin	B[2]	On-going	5 yrs	1,000	1,000	0	$	$		X	$	$[1]	$	$		$	X		$			
			Total			2,900	2,616	284																

[1] Funding included as part of Westwide Ref. No. 5.
[2] Supplemental studies primarily by Interior to accompany ongoing Agriculture and Crops efforts as coordinated by PNWRBC.

Table VI-70.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Montana*

X = Agency is expected to participate with funding through regular program.

$ = Agency will participate and will need additional funds.

						$1,000			Study participants															
No.	Ref	Study title	Study level	Initiation FY	Study length	Total cost	Costs 1976-1980	Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	MT-1	Water supply and collection of environmental data in coal resource areas	Spe[3]	1976	5 yrs	900	900	0	$	$			$	$[1]	X	$	$	$	X		$			$[2]
2	MT-1	Water supply aspects of reclamation of strip-mined areas	Spe	1976	5 yrs	1,200	1,200	0	$	$	$		$	$		$	$	$			$			
3	MT-2	Indian water requirements	B	1976	10 yrs	1,000	284	716	$		$		X	$	$	$	$				$			
4	MT-4	Total water management study on Yellowstone	B	1976	2 yrs	800	800	0	$	$			$	$		$	$	$	X		$			
5	MT-4	Total water management study quality and erosion on Upper Missouri River	C	1978	2 yrs	800	800	0	$	$			$	$		$	$	$	X		$			
6	MT-5	Erosion and sedimentation study of Muddy Creek	C	1979	2 yrs	200	200	0	$	$				$				$						
7	MT-6	Research and demonstration program on land management practices to control saline seeps	Spe	1977	3 yrs	500	500	0		X						$	X	$						
			Total			5,400	4,684	716																

[1] Funding included in Westwide Ref. No. 5.
[2] HUD and HEW included in new population centers.
[3] To be coordinated with the Missouri River Basin Commission's porposed level B Study of Yellostone Basin.

Table VI-71.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Nevada*

X = Agency is expected to participate with funding through regular program.

$ = Agency will participate and will need additional funds.

						$1,000			Study participants																
No.	Ref	Study title	Study level	Initi- Study level	Study length	Total cost	Costs 1976-1980	Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	NV-1	Comprehensive study of the Carson and Truckee Rivers	B	1976	2 yrs	500	500	0	$	$			$	$		$	$	$						
2	NV-3	Indian water requirements	B	1976	10 yrs	4,300	1,228	3,072	$				X	$		$	$	$						
3	NV-5	Comprehensive study of Walker River	B	1978	2 yrs	450	450	0	$	$			$	$		$	$	$						
4	NV-6	Thermal plant siting in remote Nevada deserts using ground water for cooling	C	1977	5 yrs	1,500	1,200	300		$				X		$								
			Total			6,750	3,378	3,372																

Table VI-72.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, New Mexico*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

						$1,000			Study participants															
No.	Ref	Study title	Study level	Initiation FY	Study length	Total cost	Costs 1976-1980	Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	NM-2	Indian water requirements	B	1976	10 yrs	7,700	2,200	5,500	$		$		X	$		$	$	$	X					
2	NM-3	Socio-economic study of impacts from loss of irrigation supported economy of High Plains	Spe	1979	2 yrs	250	250	0	X									$						X[1]
3	NM-3	Ground-water management in High Plains	Spe	1979	2 yrs	200	200	0	X							$		$						
4	NM-4	Comprehensive plan for Rio Grande basin	B	1977	2 yrs	1,400	1,400	0	$	$	$		$	$		$	$	$	X		X[2]			
5	NM-4	Salinity problems on Pecos River	C	1979	3 yrs	700	500	200	$	$			$	$		$	X	$	X		X			
6	NM-4	Flood control problems on Pecos River below Santa Rosa	C	1976	4 yrs	2,200	2,200	0	$	X			$	$				$			$			
			Total			12,450	6,750	5,700																

[1] HUD and HEW participation.
[2] Ongoing study has adequate funding.

Table VI-73.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Oregon*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	Costs 1976-1980	Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	OR-1	Pilot plans for water supply for instream flows for environmental uses on tributaries of Tillamook Bay	C	1978	4 yrs	1,500	1,000	500	$				$	$				$			$	$		
2	OR-2	Estuary freshwater inflow requirements for fish and wildlife	Spe	1976	5 yrs	2,550	2,550	0		$			$	$		$		$			$	$	$	
3	OR-3	Indian water requirements	B	1976	10 yrs	450	128	322	$			X	X	$		$	$	$	X		X	X		
4	OR-5	Total water management study of the Deschutes River basin	Spe	1977	5 yrs	700	500	200	$	$		X	$	$		$	$	$	X		$	$		
5	OR-6	Comprehensive plans for the Malheur-Harney Lakes basin	B	1978	3 yrs	650	650	0	$	$			$	$		$		$	X		X			
6	OR-7	Mid-Willamette urban flood studies	C	1979	3 yrs	1,800	1,200	600	X	$		X	$	$				$	X		$	$	X	
7	OR-7	Rogue River urban flood studies	C	1978	3 yrs	300	300	0	X	X			$	$				$			$	X		
				Total		7,950	6,328	1,622																

Table VI-74.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Utah*

X = Agency is expected to particpate with funding through regular program.

$ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	UT-2	Water supply for the Wasatch front	B	1979	3 yrs	1,500	1,000	500	$	$			$	$		$	$	$	X		X			
2	UT-3	Indian water requirements	B	1976	10 yrs	450	128	322	$				X	$		$	$	$	X		X			
			Total			1,950	1,128	822																

Table VI-75.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Washington*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	WA-1	Total water management study of the Okanogan River basin	Spe	1978	5 yrs	2,000	1,200	800	$	$	$	X	$	$		$	$	$	X	X	$	$	X	
2	WA-2	Total water management study of the Yakima basin	Spe	On-going	6 yrs	2,000	1,700	300	$			X	$	$		$	$	$			$[1]	$		
3	WA-3	Estuary inflow requirements for fish and wildlife in Willapa Bay and Greys Harbor	Spe	1977	4 yrs	1,000	1,000	0	$				$	$		$	$	$	X		$	$		
4	WW-4	Indian water requirements	B	1976	10 yrs	2,500	716	1,784	X				X	$		$	$	$	X		$	X		
5	WW-6	Flood studies for urban areas of Cedar & Skagit River basins (supplemental)	C	On-going	3 yrs	1,000	1,000	0	X				$	$							$	X		
6	WA-7	Implementation plans for the Big Bend area	C	1979	3 yrs	1,000	750	250	$	$			$	$		$	X	$	X	X	X			
			Total			9,500	6,366	3,134																

[1] Costs in addition to Yakima regional urban water management study shown in WW Ref. No. 11.

Table VI-76.—*Summary of recommended new Federal studies and supplemental funding of authorized studies, 1976-1980, Wyoming*

X = Agency is expected to participate with funding through regular program. $ = Agency will participate and will need additional funds.

No.	Ref	Study title	Study level	Initiation FY	Study length	$1,000 Total cost	$1,000 Costs 1976-1980	$1,000 Balance to complete	BR	BLM	BM	BPA	BOR	BSFW	NPS	GS	BIA	USDA	EPA	AEC	CE	NMFS	FPC	Other
1	WY-1	Water supply and environmental studies in coal resource areas	Spe[1]	1976	5 yrs	1,200	1,200	0	$	$			$	$[2]		$	$	$	X		$			3
2	WY-1	Water supply for reclamation of strip-mined areas	Spe	1976	5 yrs	1,100	1,100	0	$	$			$	$[2]		$	$	$			$			
3	WY-2	Indian water requirements	B	1976	10 yrs	500	144	356	$		$		X	$[2]		$	$	$	X		$			1

[1] To be coordinated with the Missouri River Basin Commission's proposed level B study of Yellostone basin.
[2] Funding included as part of WW Ref. No. 5.
[3] HUD and HEW involved in new population centers.

CHAPTER VII
MAJOR PROBLEM AREAS AND GENERAL OBSERVATIONS

Almost 100 specific problems of water and related land resource conservation and development in the 11 Western States have been identified by the Westwide Study as being of sufficient magnitude and importance to deserve attention over and above that which is already being devoted to their resolution. Some of the problems are interrelated; some are overlapping. Nevertheless, because of special characteristics or location, each was identified as a separate problem and treated individually in either chapter IV, V, or VI.

In the closing months of the Westwide Study, considerable thought and attention were devoted to establishing a priority rating based on the seriousness or importance of this impressive array of problems. However, considering the wide range and diversity of the problems; the extensive geographical coverage of the study; and the many disciplines, agencies, states, and other interests involved, a specific Federal priority list was not developed.

Nevertheless, the Westwide Management Group did come to essential agreement that the specifically identified problems for the most part fall into a number of major problem areas, the resolution of which will have widespread impact and importance throughout the 11 Western States. The following major problem areas were so identified and are briefly recapped without priority significance to their order of presentation.

MAJOR PROBLEM AREAS

Water for Energy

The role of Western water in meeting high-priority energy needs is tied primarily to the development of large reserves of coal and oil shale, to the disposal of waste heat from thermal electric and fuel conversion plants, and to supplying associated municipal growth. Major energy resource potentials involve extensive areas of publicly owned lands and a variety of environmental, social, and economic impacts of vital concern to local, State, and National interests. Large new hydroelectric dam potentials are limited but there are opportunities to provide hydropeaking capacity at existing structures. Coordinated regional planning and organizational arrangements for advance selection of energy sites, more efficient approval procedures at all levels of Government, and improved long-range planning are important steps in intergrating good water and land resource management with the conservation and use of the valuable energy assets of the West.

Municipal and Industrial Water Supplies

The major problem in supplying municipal water needs concerns a large number of smaller communities which are either short in supply, have poor water quality, inadequate storage and treatment facilities, deteriorating distribution systems, or difficulties in financing necessary works. A number of State and Federal programs to assist small communities in resolving their municipal water problems are available but lack coordination and uniformity in criteria. Revitalization of rural areas will continue to require additional assistance to provide water supply and other basic community services. There will continue to be opportunities for larger municipalities to participate in established Federal programs serving multiple water resource purposes. This is particularly appropriate where several municipalities may be served by one project or where facilities are located on public lands.

Indian Water Programs

There is a great deficiency in studies of resource potentials and the development of water programs and projects for a large number of Indian Reservations across the 11 Western States. Identification and quantification of water requirements are a requisite to the self-determination of the Indians' future. In some areas there are adequate water supplies to accommodate both Indian and non-Indian needs and studies and implementation programs should proceed without delay. In water-short areas, the competing demands and Indian entitlements to water will depend upon court decisions and orders. In either case, completion of water resource studies are indispensable to decisions on water and land resource development on Indian reservations.

Preservation vs. Development

Since the mid-1960's an increased national concern for preservation of environmental values impacted by water resource projects has become evident. Concerns such as for free-flowing values of streams, wetlands, wildlife habitat, pollution from irrigation return flows, and impacts of water-supply facilities on wilderness areas have increasingly resulted in conflict between development and preservation. For instance, the Wild and Scenic River Act of 1968 established a national policy to preserve selected rivers in a free-flowing state. In the West, 3 of the 11 States have established Wild and Scenic Rivers programs, and several others are considering similar action. During the first session of the 93rd Congress, 13 separate bills have been introduced which propose studies of 28 additional western rivers. Almost every major river in the West has at one time or another had reaches identified by various interests as having free-flowing values worthy of preservation. A substantial number of Americans believe that most of the remaining free-flowing reaches of rivers of the West should be preserved.

Consequently, most major federally planned or licensed water projects, whether they be for energy, flood control, municipal water supply, or irrigation, which are not yet constructed face substantial challenge. Because past water planning policies did not fully anticipate today's needs and values, many of these challenges have been and are being made in the courts where water and land use decisions may be subject to legal technicalities, rather than the orderly evaluation of alternative actions necessary to obtain maximum public benefits. Where past water and land use decisions were made on the basis of earlier policies and priorities, and orderly evaluation of alternative actions necessary to obtain maximum public benefits should take place rather than legal confrontations.

The National Environmental Policy Act, the Federal Power Act as amended, the Wild and Scenic Rivers Act, and the New Principles and Standards for Planning Water and Related Land Resources all emphasize the formulation and evaluation of alternative plans so that tradeoffs are considered during the decisionmaking process. However, serious problems exist with respect to implementing these directives. Federal agencies oriented to structural water development programs have in the past had little incentive or the technical expertise to study and present the free-flowing alternative. Similarly, other agencies charged with conducting wild and scenic river studies have neither the funds nor the expertise to formulate and evaluate the structural alternatives. These studies are further hampered by State laws which do not recognize instream uses such as water quality and recreation sport fisheries as legal beneficial uses and by the lack of basic environmental planning data.

In authorizing, funding, and carrying out ongoing and future studies of structural water developments and free-flowing rivers, additional expertise and funds will be required to formulate and evaluate the alternative plans necessary for sound decisionmaking. Priority should be given to initiating wild and scenic river studies on those western rivers presently being considered for early structural development, particularly those rivers affected by developing new sources of energy.

Environmental Data Deficiency

The great current concern for preservation and enhancement of environmental values is not matched by specific efforts to provide environmental specialists with the necessary data to analyze and predict accurately the consequences of water and related land resources development or to formulate alternative plans to maximize environmental objectives. With the pressures for energy and mineral development projects, critical decisions will have to be made in the near future which will affect a number of environmental factors including streamflows, riparian habitat, wetlands, endangered species, and freshwater inflows to estuaries. To comply with the many Federal and State laws and the approved Principles and Standards for multiobjective planning, it is important that new and supplemental environmental data studies be initiated without delay.

Colorado River Water Supply and Quality

In the next decade or two, the Colorado River will approach the point of full utilization of its natural water supplies. This will give rise to two serious problems which must be planned for now. Water demands of those portions of the Seven State area, dependent upon the Colorado River, will exceed water supplies. Unless the flows of the Colorado River are augmented, future growth within the Colorado River service area dependent upon water will be impeded or the water supplies must be redistributed to better service the growth pattern. The other problem, as full utilization of water supplies is approached, is that the water of the river, particularly in the lower reaches, becomes more and more saline and thus more and more restricted or costly to use. Programs to promote the conservation and best use of the Basin's water supply, to augment water supplies, and to reduce the salts in the river are extremely important to the future of the Colorado River Basin and to the adjoining areas it serves.

Water Conservation and Reuse

The potential for water conservation and resue in the West is significant and must be given increased attention in future water planning. However, there are many aspects of this subject which can be misunderstood and, in many cases, erroneously portrayed. Water conservation and reuse practices do not theoretically increase the natural water supply of a basin such as would occur through weather modification or importation. However, such practices generally permit increased beneficial use of the base supply. Water yield increase from watershed vegetative management practices is essentially a reallocation of water from onsite use to downstream use. More efficient use of water in the irrigation process reduces the associated losses to evaporation, deep percolation, and noncrop consumptive uses. Thus these savings, in effect, are also available for downstream uses; however, they are usually of limited quantities and in water-short areas are used to lessen shortages rather than service new water demands. Wastewater reclamation provides for a higher use but usually at the expense of an existing downstream use. This is generally true for the Western States in all areas except the Pacific Coast where this water has historically been wasted to the ocean.

Increasing the productivity of water in all economic and environmental uses is an important concept in water-short basins. This "stretching" of the water supply to get more output per unit of water input will pay large dividends and extend the date when restrictions in water use may constrain desirable economic growth and development.

Perhaps the most significant long-time benefit from water conservation and reuse practices is the favorable impact on overall water quality. This will result in a reduction in water treatment cost and improve the utility of water for downstream uses. Future water planning studies should give increased attention to water conservation and reuse and provide alternate proposals, both institutional and physical, that could result in better conservation of water supplies.

Augmentation of Natural Supplies

Weather modification offers the greatest promise, both technically and economically, for augmenting the rivers in short supply. Subject to verification by major demonstration projects, precipitation management technology appears to be sufficiently advanced to offer an important source of new water supply to water and potential water-short areas of the west at an estimated cost of under $5 per acre-foot. While progress is also being made in resolving the attendant problems related to the social, legal, and environmental implications of cloud seeding, much remains to be done. In view of the potentially vast importance of weather modification to the West, programs for resolving the remaining social, legal, and environmental problems and for demonstrating the potential of cloud seeding to increase runoff, should be actively pursued. Because of high costs, other sources of augmentation including desalting of geothermal brines and sea and brackish water show limited potential and need further development in technology before large scale application. Research and potential application studies should be continued for geothermal related water supplies alone and in conjunction with electric power production from geothermal wells on public lands.

Coordinated Land Use and Water Planning Including Flood Plain Management

The emerging State and national interest in land use planning reflects the growing viewpoint that water resource development will not play as dominant a role in the West as in the past. Land will be more and more controlling with water use a necessary adjunct and service thus pointing to the need of much greater coordination and integration of planning for these two basic resources in the future. The potential gains from flood plain management provide good examples of the close interface in many western areas especially near population centers, between land use and water control measures. Flood damage protection can be combined with a number of alternative land uses. Pressures for establishment of State and Federal land use legislation are gaining momentum. Large public land holdings and public interests in river systems make it important that effective organizational arrangements be made for coordination of land use and water planning activities at State, regional and national levels.

Future Role of Federally Assisted Irrigation Projects

The past national objectives for assisting the development of the West by federally sponsored irrigation projects are now being questioned. The western economy has become more highly developed, larger subsidies are required as the best projects are completed, and the apparent policy conflict with national farm price support and production control programs are reasons for some of this concern. However, recent worldwide food and fiber shortages, impacts on international trade, the world need for food reserves, and the opportunities for stabilizing the production base through irrigation have brought added concern as to the proper Federal role. In many rural areas in the West, predominantly the Northwest, water and land resources are abundant but large-scale irrigation development would have to rely on Federal financial assistance. Other not too well defined objectives of rural stability and growth, employment for disadvantaged groups, and population distribution currently have received national attention. Additional study is needed in this field as well as on the role of federally sponsored irrigation projects in serving other social objectives.

Protection of Estuaries

The estuaries of the Pacific Coast represent an extremely valuable national resource which is highly susceptible to serious degradation because of the activities of man. Many estuaries, such as those along the northern coast, are relatively undeveloped and provide unique areas of public enjoyment and use. Two of the most critical environmental factors are the quantity and quality of freshwater inflows necessary to maintain desirable salinity gradients, nutrient levels, and substrate conditions for the biota of estuaries. Studies are needed to assist in guiding growth and to protect environmental and scenic values.

Increasing Salinity, Erosion, and Sedimentation

Salinity levels have been rising in many rivers and streams in the West. This has resulted from salt loadings from such sources as natural inflows, irrigation return flows, municipal and industrial wastes, and from the salt concentrating effects of depleting water supplies by consumptive use. Erosion and sedimentation from both natural and manmade causes occur extensively, and in many instances significantly contribute to the problem of salinity. Related damages include loss in agricultural productivity, increased production and water treatment costs, sedimentation of reservoirs and navigable streams, and decrease in recreational and fishery values. A number of ongoing Federal programs dealing with these problems require continued and increasing support; also greater attention should be given to the water quality aspects.

Water and Land Use Planning on Public Land

The 356 million acres of public lands in the 11 Western States, 47 percent of the total land area, require that special attention be given to insuring the availability of adequate water supplies for their best use. The consumptive and nonconsumptive needs for water on public lands have never been fully documented. Unless such water requirements are established, uses for purposes not consistent with optimum use of the lands may prevent their proper management. The Federal Government will have a major role in the provision of water for development of the mineral reserves located on both public and on private lands where the Federal Government has reserved mineral rights. Water on public lands will also be required to meet such broad needs as improving the forest environment and providing sustained timber yields; livestock grazing; wildlife and fisheries conservation and management; recreation, domestic, municipal, and administrative site consumption; firefighting and fire prevention; wilderness preservation; flood and soil erosion control; and preservation of aesthetic and other public values. An accelerated program is needed to determine water requirements for public lands and to obtain recognition of those requirements in Federal and State water law and administrative arrangements.

GENERAL OBSERVATIONS

In the process of identifying and describing water resource problems having priority, a number of observations surfaced concerned future water and related land resource planning and management activities. Some of these observations occurred in the process of preparing an investigation program which would be responsive to the great number of problems identified. Often agreement can be reached fairly readily as to the identity of problems, but less frequently can consensus be reached among study participants as to the proper extent of study involved, the nature of alternative solutions, and where the responsibility for seeking those solutions should lie. The relationships of problem resolution to ongoing Federal programs and in the face of unprecedented backlogs of authorized by unconstructed projects and the uncertainties as to their ultimate disposition turned out to be another complex area of conern. The resulting observations, which reflect general consensus of those involved in the Westwide Study, are summarized in subsequent paragraphs for consideration to guide future studies and provide meaningful input into evolving national water policy.

Improving Water Planning Organizational Arrangements

The experience of the Westwide study effort provided a unique opportunity to test a multiagency, multidisciplinary, and inter-Governmental approach to identifying and planning for solution of complex water problems in the west. Some useful operating mechanisms were established; and a number of improvements were indicated as needed to accomplish meaningful, coordinated water resources planning in the future.

River basin commissions appear to provide the best organizational structure now available under present laws and policies for broadscale regional water and related land planning. Interagency and ad hoc groups provide a useful coordination service but are unwieldy and lack authority to establish overall study priorities and the formulation of alternative plans. Certain deficiencies also hamper river basin commission operations and impose constraints inhibiting aggressive and timely development of plans. These include lack of centralized funding authority, uneven and inadequate funding levels dependent upon participating agencies, and lack of authority over mission-oriented and separately funded agencies. Problems of administration also occur because watershed boundaries establish the geographic area of coverage and are not coincidental with political boundaries. This is true in several States which may have more than one basin commission involved or small geographic but noncontiguous areas included within one or two basin commission boundaries.

Studies based on natural hydrologic boundaries may be suited to the solution of certain water problems but may not be the best approach to resolve more complex natural resource problems where water is only one input in the matrix of decisionmaking. Regionalization along State boundaries should enhance the effectiveness in planning for water and related land resources. Increased participation involving the states, Indian Tribes, local entities and private interest groups is vital to the planning process. The use of State Study Teams with multiagency, multidisciplinary, State, and Federal representation proved to be a successful procedure in the conduct of the Westwide Study. Many of the teams included representation from private and public groups and local participation was encouraged.

Even though there was an extremely close working relationship among Federal agencies in the Westwide endeavor, it was evident on many occasions that differing interpretations of National and State policies and differing agency missions and objectives hampered and inhibited the process of obtaining consensus on what problems were critical, what steps should be taken to resolve problems, and which agencies should lead studies. This has been a problem common to Federal/State interagency study groups. It indicates the need for action at the National level to strengthen organizational arrangements for water and related land resources planning such as the establishment and/or maintenance of a National entity empowered to interpret national policies and to achieve their uniform application among agencies. Provisions should be made for the necessary modification and establishment of regional planning entities along state boundaries as necessary. The organization of multidisciplinary multiagency, State-Federal study teams to provide leadership and guidance to both ongoing and future water and related land resource investigations is recommended as an immediate step toward more effective planning.

Total Water Management for Highly Regulated and Developed River Basins

Most of the highly developed river basins in the Westwide area now are experiencing competing demands which are arising from changing public values. In some basins the available water supply is completely regulated and used. In others the remaining supply is under major controversy between diversion for consumptive use and instream uses. New public voices are demanding increased recreational opportunities, more energy from hydropower projects, enhancement of the environment, protection of fish and wildlife, and improvement in the quality of water flowing in the rivers and streams. On the other hand increasing population, new industrial growth, energy development and continuing increases in irrigated agriculture are competing strongly in the economic arena for additional water.

There is a great potential within these basins to achieve a better balance among various demands for use of the water and to do a better job of satisfying each through management of existing facilities and control structures or with a few key additions to the system. Deriving the greatest overall benefits from a river system through river operation requires careful weighing of the management alternatives.

The overall objective must be to devise an optimum plan for operation so that each use or need will be met proportionately to its public values.

Individual project studies emphasizing a particular purpose do not provide an adequate base for addressing the interrelated problems and needs which require a basinwide systems approach reflecting the input of various agencies and disciplines. Studies should emphasize the possibility for modification of existing projects or their operation as well as possible new additions to the system and recognize all uses and purposes consistent with sound planning while examining all reasonable alternatives. Total water management should emphasize flexibility of system operations to respond to changes in public needs and desires. This report identifies many basinwide studies as either ongoing or recommended. These studies should be conducted in full recognition of total basin plans so that the conflicts may be identified, tradeoffs made, and plans developed for the optimum management and operation of the water and related land resources.

Ground-water Development and Management

As surface water supplies have become depleted particularly in the southwest more and more reliance has been placed on ground water. In some areas such as the New Mexico High Plains, the Central Arizona area and the upper San Joaquin basin in California major economic centers have developed primarily based on the use of ground water for irrigated agriculture. In many areas conjunctive use of surface and ground water has greatly extended the water supply available for use and has proven to be an effective way of maintaining water service during drought periods. In still other areas the extent of the ground-water supply is relatively unknown. Local, State, and Federal interests have made significant expenditures in ground water investigations for many years yet there are major gaps in information. Ground-water studies should be undertaken before water supplies become critical.

Both Federal and State efforts should be intensified in developing ground water information. Effective management of the ground water will require additional data collection and evaluation. In many areas extensive mining of the ground water is occurring. To constitute a permanent supply of water, ground-water withdrawals must become stabilized to the point that they are replaced hy annual recharge. Pollution of ground waters through direct injection or through interactions with polluted surface supplies is occurring. Increased salinity of ground water caused by seepage from irrigation is being experienced. A greater degree of ground water monitoring should be established for early detection of pollution. Selective ground water investigations should be increased in those areas where potential water supplies may be available to meet critical water needs.

Flood Damage Control and Water Planning

Specific flood control programs were considered in the preparation of this report only where they directly related to the primary area of interest of future water supply. On this basis nearly all ongoing flood control programs were intentionally excluded. Only those flood control studies which had potential impacts upon water quality or water quantity, such as projects with storage potentials, were reviewed and then only those with major impacts were included. Local protection projects such as levees and channel control features were excluded, since they have little or relatively minor impact on water quality or quantity. This treatment of flood control programs should not be considered as detracting from their importance but as affirmation of the desire to keep the focus of the study consistent with the enabling legislation. Ongoing flood control or protection studies and programs of the involved Federal agencies are important in meeting the continuing flood hazards of the future.

As recently as January 1974, floods causing serious damages were experienced in California and the Pacific Northwest. These most recent occurrences underscore the fact that the problem of flooding has not vanished. While the problem of floods can never be totally eliminated, past Federal flood control programs have been important in controlling and minimizing floods.

Many responsible leaders, both in Government and private life, have voiced concern in recent years that in spite of the massive Federal flood control programs, flood damages grow larger each year. What often is not recognized is the probable magnitude of these damages had the Federal programs not been in effect. Growth continues throughout the American scene and much of it occurs in flood plains which may require flood protection. Recent national legislation has provided some incentives to discourage development in flood prone areas. The eligibility requirements for participation in Federal flood insurance programs require action by local government to zone and regulate developments in its flood plains. The new Federal cost-sharing provisions of the Water Resources Development Act of 1974, which places nonstructural measures on more of a par with structural solutions, should contribute to better planning for flood plains. Greater emphasis needs to be placed on flood-plain management and various use options. Residential and commercial development may be one of the highest uses but recognition must be given to flood hazards and proper control measures. More interest and concern should continue to be placed on zoning flood proofing, flood insurance, and alternative uses such as greenways, parks, and open space.

Legal and Institutional Improvements

As new emphasis for uses of water has emerged over time, legal and institutional arrangements have not kept pace. Better response to public demands and increased efficiencies in water use could be improved by changes in water law and administration.

The basic water rights laws in the West (first in time, first in right) have served the people well in the development of the West. As competition for water has increased, these laws have been modified to better define "beneficial use," to clarify what part of a diversion right can be transferred to other owners and uses and to better manage surface and ground-water withdrawals for protection of all users. These legal aspects, although designed to protect and treat fairly all rights holders, have complicated the allocation of scarce supplies of water to those uses most important to the rapidly changing cultural and economic conditions. The enactment of Federal and State water pollution control laws has added a new dimension to the legal setting.

The major deterrent to changes in water laws centers in the question of whether the resultant changes will in fact improve current arrangements or will only result in a transfer of benefits from current right holders to others. However, there are several areas where improvements can be made that would result in increased efficiency in water use. The beneficial uses of water and the amount of water that is required to carry on that use should be more precisely defined in the laws of each state to permit consideration of both instream flows for water quality recreation, fishery, and wildlife and diversions for other purposes in planning and managing western water. Those beneficial uses which require withdrawal or diversions should be defined in terms of magnitude as well as quality of return flow. The application of current technology should be assumed in determining the beneficial use values.

The transfer of water from one use to another should consider not only the economic value but also the impact on other resource use. Water has value in all uses even as it flows in the streams. Care must be taken to protect aesthetic and environmental values as well as economic values in future water allocation procedures.

The matter of State water law is the responsibility of the individual States. They, therefore, should take the lead to update all aspects of water law to facilitate the allocation of water to meet changing social demands and to require a high level of efficiency in all uses. Such changes in water law should be commensurate with the proper utilization and conservation of natural resources over time.

Funding Requirements for Level B Studies

An effort was made to have the recommended reconnaissance or appraisal type studies conform to the level B study designation of the Water Resources Council. Considerable difficulty was experienced, however, in both the degree of work permitted under that designation and the funding restrictions. Only the minimum type level B study involving an interagency, multidisciplinary approach, was found appropriate for the 2-year time frame and the average cost of $750,000 being recommended by the Water Resources Council for level B studies. Such a study could only provide for a 10-man team for 2 years including overhead, administrative services and travel, but with no provisions for obtaining new data computer analysis, designs and estimates, technical services, or many other costs normally associated with water resource planning studies.

The level B studies recommended in this report vary greatly by degree of study required, amount of agency participation, length of study, and funding requirements. The degree of study varies from that required for a small isolated area with no data collection or other technical requirements and with results based mostly on analysis of available data and professional judgment through that required for a very complex type study involving full multiobjective planning of numerous alternatives with results that can be used to justify moving the recommended parts of the plan to feasibility studies. Consequently, the funding levels of the level B studies recommended in this report vary considerably due to complexity and length of study expected.

Other studies such as instream flow requirements and powerplant siting studies did not seem to conform to level B studies as currently defined. Consequently, many study recommendations have been placed in a "special" type and will require further analysis and description at the time of authorization.

Trends in Future Water Planning

An inescapable conclusion of the Westwide Study is that the objectives and character of Federal agency water and related resource planning programs are undergoing significant change. Historically, Federal agency planning programs were project oriented with the authorization and construction of new projects in most cases the first objective. Testimony to this is the huge and growing backlog of authorized but unconstructed Federal projects and also of planned but unauthorized projects.

While projects are and will remain important to water resources conservation and development, current trends in planning are placing greater emphasis on much broader objectives attuned to meeting a wide variety of human needs. Under the new Principles and Standards, environmental considerations, as well as those of economic efficiency, are valid objectives of water resources planning, and alternative plans to stress these differing values are required. Many existing authorized but unconstructed projects are being or will have to be reevaluated with these new objectives in mind. The new thrust in planning also centers around major areas involving such matters as total water management, augmentation of water supplies, energy resource development, conservation and reuse of water, environmental quality improvement, water quality improvement, and development of Indian resources.

Water and related planning must be a continuing activity in the West even after the bulk of the desirable water supply and regulation features have been constructed. With water so critical to the economy and the well-being of the western population, there will be a continuing demand for changes in use, technological advancements permitting more efficient and timely use and for information to guide desirable institutional changes. Total water management planning, participated in by both State and Federal water agencies, will become more and more the norm as the remaining water supplies of the West are dedicated to use.

THE STUDY YEARS AHEAD

The manner in which the water and related land resource problems of the West are resolved; the time limit with which they are resolved; and the substance of their resolution can have enormous influence on the economic, social, and environmental future of the West and of the Nation. Involved are issues and resources that can affect deeply the capabilities of this Nation to meet its energy needs which, in turn, affect the very lifestyle of its people. Involved is the future character of one of the great heritages of the West – its wide open spaces, its wild and scenic rivers, its unspoiled wilderness areas. Involved are resources and considerations affecting critically the future of the American Indian. Involved are the futures of several of America's largest and most important river systems – the Columbia, Colorado, Sacramento, San Joaquin, the Rio Grande, and the headwaters of the Missouri.

In reporting out the Colorado River Basin project legislation which authorized the Westwide Study, the Committee of Conference indicated that the investigations and studies to be undertaken pursuant thereto were to reflect only the first phase of study. The Committee stated the intent that the Secretary of the Interior thereafter should continue, pursuant to existing authority, to pursue vigorously the development of a general plan to meet the future water needs of the entire Western United States and that he should make recommendations to this end for further studies as are justified and appropriate.

The investigations recommended herein for the 1976-1985 period are considered essential to the objective of developing a general plan to meet the future water needs of the Western States. The program of studies was structured to reflect present and foreseeable trends in water planning and to accommodate the priorities of the next quarter century. For the program to accomplish its purpose, the 18 involved Federal agencies must support it and include appropriate parts of it in their forthcoming annual budget proposals, which many are now doing for fiscal year 1976. The Administration and the Congress must give followup support. The States and other interests must also demonstrate support and, where called for, take appropriate associated actions. Only through such united support and action will the pressing water and related land resources problems of the West, highlighted in this report, receive timely study and resolution and a responsive plan to meet future water needs evolve.

INDEX

U. S. GOVERNMENT PRINTING OFFICE 1975 - 680-804/230 Reg. 8