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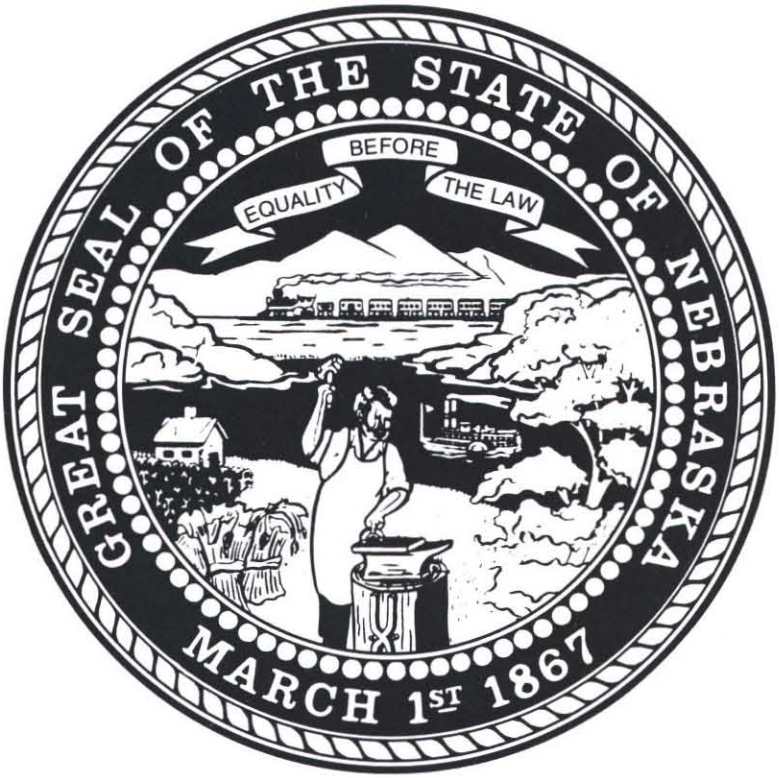
NEBRASKA SOIL AND WATER
CONSERVATION COMMISSION

State Water Plan
PUBLICATION NUMBER 101

Report on

THE FRAMEWORK STUDY

MAY, 1971



J. James Exon
Governor

NEBRASKA'S
STATE WATER PLAN

REPORT ON

THE FRAMEWORK STUDY

NEBRASKA SOIL AND WATER CONSERVATION COMMISSION
MAY, 1971

This report is dedicated to the memory of three individuals who selflessly devoted their energies to the conservation and development of Nebraska's resources for the common good of all her people.

Legislator

Stanley A. Matzke 1898-1969

As a farmer, attorney, legislator and tireless civic worker, he epitomized the concern of the citizen for the public welfare. Because of his efforts in leading numerous private and public organizations, Stanley Matzke became Nebraska's leading advocate of resource development. The trust of his contemporaries and his stirring eloquence brought early fruition to his proposals.

Local Leader

Everett M. Barr 1895-1964

Throughout his life as a student, farmer and conservationist, Everett Barr distinguished himself. His activities in helping found and lead the National Association of Soil and Water Conservation Districts and his leadership of the State Association propelled him into recognition as a conservationist. His dedicated concern for man's stewardship of his environment, long before it became popular, helped make Southeastern Nebraska the "Watershed Capital of the Country" and marked him as a preeminent local leader.

Conservationist and Scholar

Dr. George E. Condra 1869-1958

For a half century, Dr. George Condra, through positions of leadership in Nebraska state government and the University of Nebraska, was an articulate spokesman for soil conservation. The professor was a pioneer leader in the fight to establish Soil and Water Conservation Districts in the State. An author of four books and numerous monographs on Nebraska's geography and geology, Dr. Condra was the nation's first educator to teach soil conservation in an American college. Dr. Condra was state geologist from 1919 until 1954, and was credited with discovering and naming more geological formations in Nebraska than any other scholar.

PREFACE

"There was nothing but land; not a country at all but the material out of which countries are made."

—Willa Cather, My Antonia

The first Nebraska pioneers were made of sturdy stuff. By today's standards, they came to the great plains of Nebraska an impoverished lot. They had few tools—material or technical—with which to meet the challenge of this vast inhospitable land.

However, they had visions nourished through generations of European serfdom. They saw that the land made a man free.

They possessed those qualities of the human spirit which have always served man in his quest for survival. With perseverance, industry, and courage, they forged a civilization from the land the first western migrations shunned.

Some came to take what could be taken from this land, but most came to stay—to build a home. The builders gave the totality of their spirits to its development. A commitment such as this is the essence of love.

Those pioneers loved this land so much they ate roots rather than be starved off it. They watched grasshoppers eat the crops they had planted with the hope of harvest; and again they ate roots. They dug wells, and they saw them turn to dust by drought. Those who stayed and prevailed lived and toiled in isolation with only the reassurance of their vision and spirit.

A century later, the inheritors of this now bountiful land would do well to remember the human struggle and victory of the Nebraska Pioneer. If we allow our streams to become wasted through pollution, and our lands to become idle, this country could again be the "Great American Desert" once depicted on early maps. Across America, the bell tolls out for our environment, our way of life and the heritage which we will leave.

The challenge of our century can be met. Nebraska will continue to grow and prosper; but only with the same love, industry and courage which raised it from the prairie sod.

The wise and prudent development of our resources is the key to our future and the choice is ours.

Prepared
For The
Legislature

By The
Nebraska Soil and Water Conservation Commission
In Cooperation
With

The
1967-1969
Legislative Council Interim Study Committee
on
Ground and Surface Water

Senator Rudolf Kokes
Senator "Pat" Moulton
Senator Herbert Nore
Senator Arnold Ruhnke
Senator George Syas
Senator Glenn Viehmeyer
Senator Maurice Kremer, Chairman

And

The
1969-1971
Legislative Council Interim Study Committee
on
Water and Land Resources

Senator Thome Johnson
Senator Thomas Kennedy
Senator Rudolf Kokes
Senator Maurice Kremer
Senator Herbert Nore
Senator George Syas
Senator Irving Wiltse
Senator Jules Burbach, Chairman

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Farmer, Bellwood

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Robert W. Bell	Assistant General Manager, Metropolitan Utilities District	Omaha
James Cook	Rancher	Mills
Vince Dreeszen	Director, Conservation and Survey Division, University of Nebraska	Lincoln
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Earl Luff	President, Lincoln Steel Corporation	Lincoln
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Warren D. Fairchild, May, 1957—October, 1970

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Marvin Nuernberger
Nebraska Department of Roads

Don Thompson
Governor's Representative

ACKNOWLEDGEMENTS

The Commission gratefully acknowledges the assistance of many persons who by providing data, reviewing reports, and assisting in other various ways made this study possible. Thanks are due not only to those who served on committees and made a direct contribution to the study but to all who have assisted in the Missouri River Basin Study, the Bureau of Reclamation's Nebraska State Water Plan Study and other related studies. Indirectly, through the Commission's extensive use of their results, they have made a major contribution to Nebraska's State Water Plan.

Space does not permit recognition of all individuals who gave assistance, but special credit must be extended to the members of the Technical Advisory Committee and the Special Representatives Committee whose lengthy deliberations and numerous recommendations to the Commission were highly valued.

The steady encouragement of many legislators, particularly Senators Maurice Kremer and Jules Burbach, and the members of the two Legislative Council Interim Study Committees, and the cooperation of former Governor Norbert T. Tiemann are acknowledged with appreciation.

This Study was conducted and report prepared by the Commission's Planning Division Staff.

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Harvey O. Banks
Henry P. Caulfield, Jr.
James E. Goddard

Preparation and publication of this report was supported in part by grants from the Federal Water Resources Council under Title III of the 1965 Water Resources Planning Act.

State of Nebraska

Soil and Water Conservation Commission

January 12, 1971

The Honorable J. James Exon, Governor
State of Nebraska and

Members of the Legislature and

The People of Nebraska

I take great pleasure in transmitting on behalf of the Commission this Report on the Framework Study of Nebraska's State Water Plan. This study was undertaken in response to Legislative Resolution 5 of the Seventy-seventh Session. The Commission believes that it is a significant landmark in planning for the management of Nebraska's most vital natural resources.

This Framework Study is the central feature of Nebraska's State Water Plan and should play a major role in the continuing process of inventorying resources, defining needs, problems and opportunities, setting objectives, and examining available alternatives to meet the objectives. It's major purpose is to provide a broad, conceptual framework for the orderly, efficient development of Nebraska's water and related land resources. This framework, or guide to future development, was prepared not simply considering how to develop the land and water of Nebraska, but rather how that development can best serve the people of Nebraska.

This report presents a broad assessment of the means by which Nebraska's water and related land resources can eventually be developed for fullest use. It contains few detailed plans since flexibility is one of its key elements. People and their future needs are not predictable over a lengthy period of time and therefore we should not completely commit ourselves now on the future use of resources. In preparation of the report we have looked to the challenge of a changing future environment and anticipated progress.

The final decisions on specific objectives to be attained through resource development must ultimately be value judgements reached through the political process. Therefore, the Commission commends the Framework Study to the consideration of the Legislature. It will only be through the Legislature's concerted action that a refined set of objectives for future planning can be prepared. The Nebraska Soil and Water Conservation Commission trusts that after review and critique by the appropriate legislative committees and the entire Legislature, this Framework Study and its recommendations will be translated into action through development of more detailed plans for specific projects. I urge that provision be made for preventing obsolescence of this framework to insure its maintenance as a valuable and current guide to the Legislature, state and federal agencies, and to the people of the State.

Very truly yours,

Robert M. Bell

Robert M. Bell, Chairman
Nebraska Soil and Water Conservation Commission

State of Nebraska
Soil and Water Conservation Commission

January 8, 1971

Mr. Robert M. Bell
Chairman
Nebraska Soil and Water
Conservation Commission

Dear Mr. Bell:

I am pleased to inform you of the completion of the Technical Advisory Committee's final review of the Report on the Framework Study of Nebraska's State Water Plan. The Committee, composed of representatives of all principal Nebraska and Federal resource agencies, has over the past three years thoroughly examined the concepts, procedures, and recommendations of the Framework Study which are presented in the report.

This Committee agrees that the premises on which the study is founded are sound, the procedures of analysis are proper for the purpose of framework planning and, therefore the resulting conclusions and recommendations merit your approval. The Committee recommends that the proposed report be adopted and published as forwarded by this Committee.

Very truly yours,

James Owen

James Owen, Chairman
Nebraska State Water Plan
Technical Adivsory Committee

The following persons served on this Committee:

John Adams	Ag. Extension Service, U of N	David McGill	College of Ag. U of N
Willard Barbee	Nebr. Game and Parks Commission	James Monroe	Nebr. Dept. of Economic Development
Douglas Bereuter	Nebr. Office of Planning & Programming	Keith Myers	U. S. Dept. of Agriculture
Charles Cocks	U. S. Dept. of Defense	Marvin Nuernberger	Nebr. Dept. of Roads
John Davis	College of Engineering U of N	Howard Ottoson	Ag. Experiment Station, U of N
Earl Flanagan	Nebr. Irrigation and Reclamation Assoc.	William Rapp	Nebr. Dept. of Health
Paul Harley	U. S. Dept. of Interior	Gene Reed	Conservation & Survey Div., U of N
Dan Jones, Jr.	Nebr. Dept. of Water Resources	Don Thompson	Governor's Office
		E. S. Wallace	Bureau of Business Research, U of N

State of Nebraska
Soil and Water Conservation Commission

January 7, 1971

Mr. Robert M. Bell
Chairman
Nebraska Soil and Water
Conservation Commission

Dear Mr. Bell:

The Committee members listed below represent thousands of citizens in their individual sponsoring organizations. They have served in an advisory capacity in the development of Nebraska's State Water Plan since its inception in 1966. The various organizations represented on this Committee have special interests in different aspects of development which could have resulted in disruption, bartering and eventual stalemate. The fact that the entire Committee has served in such an efficient and productive manner throughout its existence, is both a tribute to the dedication of its members and an acknowledgement of the importance of the State Water Plan.

The Committee has had the opportunity to review and advise on various parts of the State Water Plan, but we have anticipated with special interest the review of the Report on the Framework Study.

After thorough review the Committee has not unanimously agreed on all specific points of the report. However, the Committee in general concurs with the need for the Commission to take action on the unresolved issues and proceed with the publication of the report and its transmittal to the Governor, the Legislature, and to the people of Nebraska.

Very truly yours,

Earl Luff, Chairman
Nebraska State Water Plan
Special Representatives Committee

Membership of the
Special Representatives Committee

Vance Anderson	Nebraska Well Drillers Association
LeRoy Bahensky	Nebraska Power Industries Committee
Elton Berck	Farmers Union of Nebraska
C. E. Blair, Jr.	Association of Commerce and Industry
Charles Chace	Nebraska Petroleum Council
Joe Churchich	Nebraska Recreation and Parks Association
Robert Colson	Nebraska Irrigation Association
Chet Ellis	Nebraska Assoc. of Soil and Water Cons. Dist.
Melvin Fink	Nebraska Rural Electric Association
Henry Lange	Nebraska Reclamation Association
Roland Nelson	Nebraska Farm Bureau Federation
Frank Phelps	American Water Works Association
Arnold Ruhnke	Nebraska Association of County Officials
Harold Sieck	Nebraska State Grange
Margaret Sutherland	Nebraska League of Women Voters
Joe Thiessen	League of Nebraska Municipalities
Lyle Young	Nebraska Press Association

CONSULTANTS' REPORT

January 11, 1971

Mr. Robert M. Bell, Chairman
Nebraska Soil and Water
Conservation Commission
P. O. Box 94725 State House Station
Lincoln, Nebraska 68509

Dear Mr. Bell:

As consultants to the Commission in the preparation of the Report on the Framework Study, we are pleased to inform you of our views on that report. In developing these views, we have reviewed draft material as well as the final report and have given our comments and recommendations to the Commission's staff at various stages of its preparation. The staff was fully cooperative and receptive, and gave us all possible assistance in the performance of our role.

We believe that the report as presented to the Commission reflects a high order of professional dedication and workmanship and presents, both in its scope and depth of analysis, a useful and flexible guide to an understanding of Nebraska's soil and water resources, of present problems and of various opportunities for further use and development of these resources. Apparent needs for agricultural, domestic, municipal and industrial waters, as well as flood plain management and other purposes of water management, are analyzed. Emphasis on possibilities of expansion of irrigated agriculture--by both private and public action--is justified in view of Nebraska's strong present and potential position relative to other regions in agricultural production.

It has not been possible to include estimates of need to utilize the opportunities outlined, based on analysis of the probable economic demand for goods and services that could be produced, because of limitations of funds and time. Such estimates, as they may be affected by changing population trends and economic growth policies, must be known before investment actions are taken pertaining to major new developments.

Possibly the most useful feature of the report, as a basis for widespread public consideration, is the identification of various interbasin transfer possibilities that could greatly increase irrigated agriculture within Nebraska if and when the demand for agricultural products justifies such action. This increase is in addition to that which could be realized "in basin" through further development of ground and surface waters.

Consideration in the report of the several opportunities for interbasin transfer has very usefully taken into account, in our view, public values of the different potential effects on opportunities to preserve rivers, or portions of rivers, for their environmental qualities and to enhance fish and wildlife and recreation. We are pleased to note the extent to which the opportunities for environmental enhancement have been recognized as well as the need to preserve present environmental, ecological, scientific and historic values.

We concur with the recommendations of the report.

In summary, we believe the Report on the Framework Study lays a sound foundation for the consideration by the State of Nebraska and its people of proper water and related land use within the State, for the more detailed planning efforts that are required, and for decisions that must be made in the light of public discussions of resource availabilities, problems and opportunities for use.

We appreciate the opportunity to have been associated with this important and productive planning effort.

Very truly yours,

Harvey O. Banks James E. Goddard Henry P. Caulfield, Jr.

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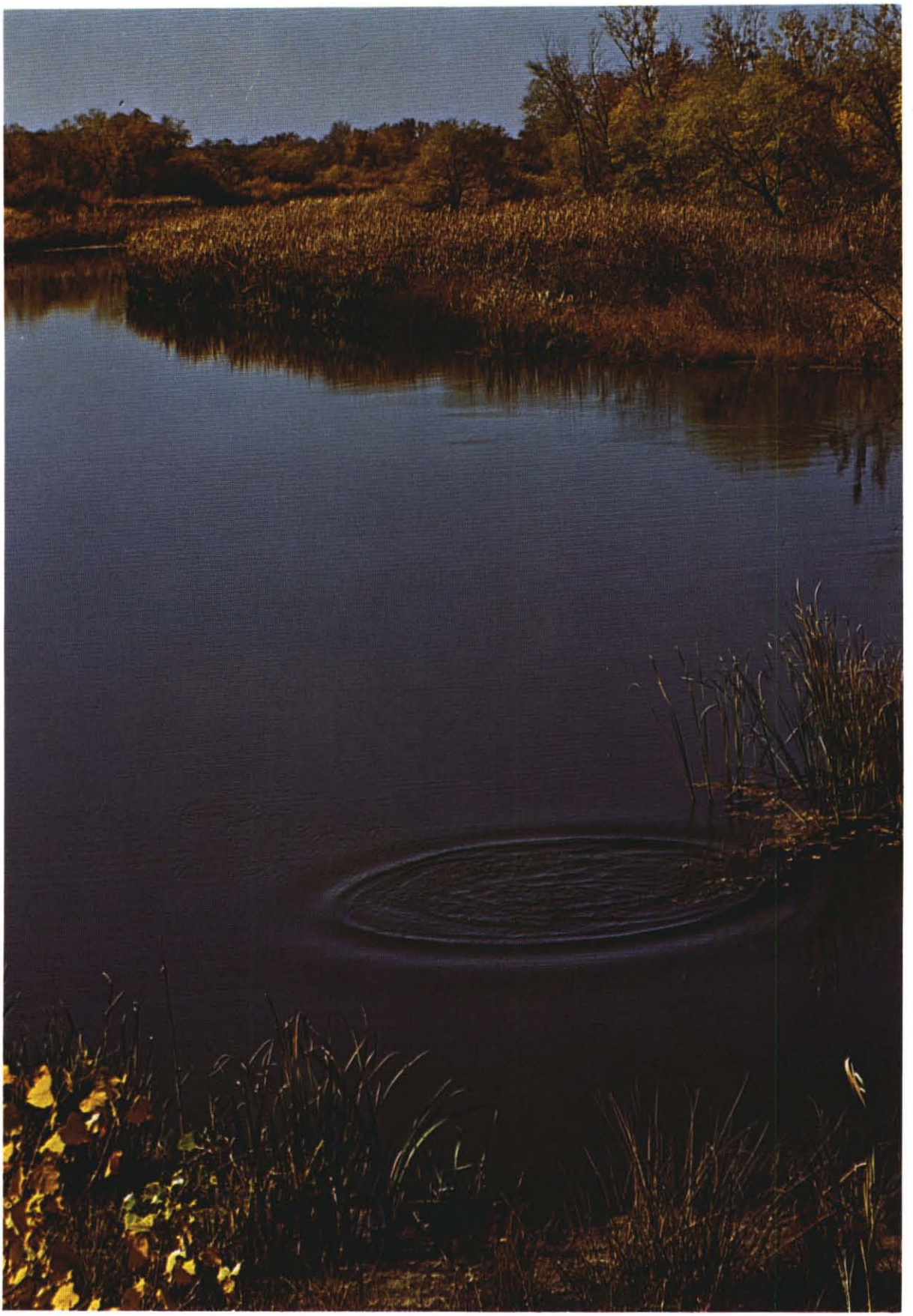


Chapter 1 / INTRODUCTION

Nebraska's State Water Plan

NEED FOR A PLAN

The basic wealth of Nebraska and of the nation depends not on dollars but on the products of our resources which feed us, shelter us and with which we trade.

We have in the past both preserved and exploited resources and found neither a satisfactory policy. Our growing population and our desire for a higher quality of living require the ever increasing use of resources, but use with wisdom, efficiency and restraint.

Nebraska's needs are not unique. Man has always lived with the need to bend nature to his use. If Nebraska is unique in any way it is in the regional disparity of available resources.

Fertile soil, water, timber, and minerals are nature's great gifts to man. In Nebraska, timber and mineral supplies are woefully short but the resources of land and water are among the most extensive in the nation. Nebraska's past was built from the land and water and her future lies in their wise development and use. What then must be done to meet that future, not by chance, but by a design of our own choosing?

Simply stated, there are four basic problems in our use of land and water:

First, contrary to wishful thinking, Nebraska's natural resources are limited in amount compared to potential needs. There is not enough land and enough water for each of us to have all we might desire or to use as each might see fit—so we must share.

Second, natural resources occur not where man wills them but where nature places them. Fertile soils and abundant waters by themselves offer little to man. It is their productive union that multiplies the value of each.

Third, while the land is always with us, the rains have their own time. Flood and drought are different sides of the same coin. If water is to be of maximum beneficial use, it must be under control and available in time of need.

Fourth and finally, water available where, when, and in the amounts required must be of a quality suitable for its intended use.

From the levees of ancient Mesopotamia to the atomic desalting plants of today, man has tried to master these problems with great dams, reservoirs, canals, and other works. By and large he has succeeded in his efforts. Increasingly more powerful technology has been met, however, by the increasing severity of the problems. Resources become more limited and new waters more distant as we first use those most convenient.

Nebraska and the Midwest were once a new land with ample untapped waters. To the settler the waters must have appeared to be unlimited. They lived first near the streams where land and water were joined by nature. Although mineralized in some areas and muddied at times, the waters were relatively free of contaminants and pollutants.

With growth of the population and our economy came the symptoms of the basic resource problems. Competition arose both between individuals desiring to use the same waters and between those who would use the waters for conflicting purposes.

Because water is so basic to our agriculture, our cities and our very lives, its control and development began early. Irrigation projects were built, floodwaters and streamflow were impounded, and great turbines turned falling water into electric power. But the needs have continued to increase. The mounting needs were made plain by the droughts and floods of the 1930's, 40's, 50's, and 60's, and by the gross pollution of many streams from poorly treated or untreated municipal sewage and industrial waste and runoff from agricultural

lands. Massive action was obviously needed, but what action—and when and where?

The Legislature enabled a variety of special purpose districts to begin solving urgent local problems. Small projects abounded and they were generally successful. The help of the Federal Government was sought and obtained in the construction of a few large water projects and the proposal of many more. Laws were enacted to cause a sharing of the waters. In spite of substantial efforts, problems still existed. Lands still went dry, underground waters still receded, floods still killed and wrought destruction, and pollution became more widespread. More understanding and management of Nebraska's resources were needed.

It became obvious that a better appraisal and perspective for future development were needed. The successful integration and efficiency of individual projects and all project purposes should be assured. Conflicting plans demanded reconciliation and the most serious problems required identification so they might have first attention. Urgency was added by the knowledge that others also had a use for Nebraska's waters.

In the face of this enormously complex situation, intuition, experience, and present knowledge were not enough. Facts were required to make such irreversible decisions in the public interest and the Legislature acted—a broad framework plan was to be prepared for the future development and utilization of Nebraska's water resources.

INITIATION OF PLANNING

Among its several authorities the Nebraska Soil and Water Conservation Commission (NSWCC) was assigned responsibility to:

> *"...plan, develop, and encourage the implementing of a comprehensive program of resource development, conservation, and utilization for the soil and water resources of this state...."*

The State Water Plan got its start in 1965 when the Legislature appropriated funds to the NSWCC for water resources planning. A small planning staff was assembled the following year.

The 1967 Legislature provided impetus to the planning effort by giving the Commission a clear directive to develop a state plan for water and land resources development. Legislative Resolution Number 5, unanimously adopted on January 18, 1967, stated:

> *WHEREAS, the water supplies of Nebraska are not so located or of such a quantity to satisfy all present and future needs; and*
>
> *WHEREAS, the state has a responsibility to guide the development of resources so that maximum benefits accrue to the citizens of the state; and*
>
> *WHEREAS, the orderly development and utilization of water and land resources of Nebraska is essential to the fullest utilization of these resources and the economic development of the state; and*
>
> *WHEREAS, such orderly development can only be realized by implementation of a comprehensive water and related land plan; and*
>
> *WHEREAS, no such plan now exists.*
>
> *NOW THEREFORE, BE IT RESOLVED BY THE MEMBERS OF THE NEBRASKA LEGISLATURE IN SEVENTY-SEVENTH SESSION ASSEMBLED:*
>
> *1. That the Nebraska Soil and Water Conservation Commission is directed to analyze the soil and water resources of the state and to prepare a comprehensive water and related land plan for the State of Nebraska, such framework plan to be completed no later than June 30, 1971, and to be known as the State Water Plan.*
>
> *2. That this State Water Plan, in addition to an evaluation of the land and water resources, will also include an examination of legal, social and economic factors which are associated with resource development.*
>
> *3. That a progress report on such plan be submitted to the Legislature during the regular session in 1969 and the final report be submitted to the Legislature promptly upon its completion.*

To enable the development of this Plan, the 1967 Legislature authorized additional planning staff for the Commission and provided a biennial appropriation for state water planning. A Legislative Council Interim Study Committee on Ground and Surface Water was appointed to serve during the period between the 1967 and 1969 legislative sessions. This Committee provided counsel to the Commission during the first stages of development of the Nebraska Water Plan and sought public expression on the general purposes of the Plan. To this end a series of eight regional hearings was conducted at the beginning of the planning effort.

The progress report requested by Legislative Resolution Number 5 was presented to the Legislature in January of 1969. This report included a summation of the work accomplished at that time, an evaluation of problems encountered and numerous recommendations for legislative consideration.

The 1969 Legislature established an Interim Study Committee on Water and Land Resources and this Committee reviewed latter parts of the planning effort and made numerous suggestions to guide completion of the study.

PRESENT STATUS OF NEBRASKA'S STATE WATER PLAN

At the beginning of the study, the Commission, in a document titled *"A Design for Nebraska's State Water Plan,"* proposed four principal activities which, when taken together, would provide the format for Nebraska's long range water resources planning. These four sections of Nebraska's State Water Plan were the Framework Study, the Basin Studies, the Status Summary, and the Special Recommendations.

The Framework Study. The central feature of Nebraska's State Water Plan is a framework for guiding the physical development of the water and related land resources of Nebraska. The detail of study on the Framework is at level A, as classified by the Water Resources Council. This, the main report of the Framework Study, is the Commission's response to Legislative Resolution Number 5 directing the preparation of a framework plan. The Study does not describe details of projects, but concentrates on the broad aspects of planning to establish the general pattern of present and future needs and potential developments, thus maintaining flexibility within the Plan to accommodate the results of more detailed investigations in the future.

The broad framework for development discussed in this report has been divided into two parts: (1) the basic framework, which is based on in-basin water use, and (2) the conceptual schemes for interbasin water transfer and utilization.

In order to keep the Framework current and take advantage of its flexibility, updating on a regular, periodic basis will be required. It would be possible to update the Framework Study shortly after its release, incorporating public and legislative reaction to the document along with changes in status of physical development. Following the initial updating and revision, reevaluation once each decade should be sufficient to keep the Framework current.

The Basin Studies. The second planning activity is a series of comprehensive, coordinated river basin planning studies. These basin studies are intended to be of the type classified as level B by the Water Resources Council. Such a study and plan for water and related land development are to be completed for each of the 13 river basins. These studies are intended to refine the Framework Study and to outline a sufficiently detailed plan for development of a basin's water resources to lead into specific studies of individual projects. In order to accomplish this, economic, legal, and social, as well as physical factors, must be considered in sufficient depth to provide evaluation and selection of the most desirable alternatives for development.

Studies of this type require considerable data collection, field investigation, financial outlay, and time. Such studies, probably requiring three to four years each for completion, can be conducted concurrently.

A study of this type was completed for the Big Blue River Basin in 1968. Because of limitations beyond control of the agencies involved in the study, a specific plan for development could not be presented. This study needs to be supplemented and updated.

Such studies have not been completed for any of the other river basins. A firm schedule for completion of this series of studies is needed so that proper staffing and funding can be determined and provided.

The Status Summary. The third section includes a summary of potential water and related land resources development projects in Nebraska and a summary of the status of present water resource development in Nebraska.

The report on present status of water resources development projects has not been initiated. This report when completed will help establish a firm base from which to plan. It will, in addition, serve the function of providing an historical record of the status of development at this point in time for consideration of future planners.

The first summary of potential projects was completed in 1969 and describes projects which are proposed in a formal manner and whose implementation is pending. It provides concise information on the projects for legislators and local leaders concerning sponsoring organizations, financial arrangements, and steps remaining before project construction.

The Special Recommendations. The last of the four sections is a series of specialized studies of some of the most important issues confronting resource development in Nebraska. This section of the Plan will fulfill the Legislature's request by combining physical, legal, economic, and social considerations into recommendations for appropriate action on the complex legislative and administrative problems of water and water related resources development faced by the Legislature, the Governor, and various subdivisions of State Government. Topics for study were selected by the

Commission in consultation with the Legislative Council Study Committees.

Three recommendations have been prepared and presented to the Legislature and Governor for action. They are titled *"Flood Prevention and Damage Reduction," "Modernization of Resource District Legislation,"* and *"Flood Warning and Community Action."* Legislative action has been taken to implement the first two of these recommendations. No action has been taken towards implementation of the third.

This part of the State Water Plan has been especially effective and its continued prosecution is necessary to ready other proposals for legislative action.

Objectives and Features of the Framework Study

PURPOSE

The overall purpose of this initial portion of Nebraska's State Water Plan is, as the name implies, to provide a broad, conceptual framework for the orderly, efficient development and management of the state's water and related land resources. It is anticipated that this Study will act as a guide to all federal, state and local entities engaged in planning, design, construction, and operation of resource development projects in Nebraska. Specific purposes for which the Study was undertaken include:

1. Determination of Nebraska's major water and related land resource problems, with specific attention to those whose solution is urgent at the present time or will become urgent in the near future.
2. Presentation of a basic framework for development and management of in-basin water resources.
3. Evaluation of presently proposed projects in order to determine whether those proposals are compatible with the state's long-range resource development objectives, and which projects should be endorsed by the State for early implementation.
4. Summarization of the information necessary to analyze the need for change in laws, policies, and institutional arrangements to accelerate resource development in Nebraska.
5. Identification of the more detailed studies required to increase knowledge of Nebraska's resource base and of specific project studies required for the most efficient use of the state's resources.

SCOPE

This report on the Framework Study is one element in the total and continuing program of planning for water and related land development. This overall planning program is conducted in concert with other state, federal and local organizations. The Framework Study is not intended to fulfill all objectives of Nebraska's complete long-range planning program.

This report presents a generalized statewide overview of Nebraska's water and related land resources as well as problems and needs, and a general framework for in-basin development. It is comprehensive in that the entire area of the State and all anticipated types of water uses have been considered in its preparation. The uncertainty of long-range needs, programs, and technology dictated that the Study avoid detail beyond that needed for evaluation and support of specific projects proposed for immediate development.

Certain data, assumptions, and procedures were adopted from other related studies. No new data collection was carried out to obtain information. However, the gaps in existing data were noted.

The lack of factual data frequently resulted in the use of technical judgment to develop appropriate assumptions. The Commission was aided in this by frequent consultation with knowledgable personnel of other state and federal agencies.

The Framework Study is a guide for future land and water resource development in Nebraska. It is not intended to be the basis from which either the worth of a particular project can be measured or the basis for a decision to build or not build. Consistent with the broad purposes of the Framework Study, the costs of potential developments and their apparent benefits were given only limited consideration.

A liberal view was taken in determining what might be practical for accomplishment in the future. However, projections of future development were limited to what can be foreseen under present technology.

Detailed legal investigation of proposals was not within the scope of this Study. However, a survey of present Nebraska water law has been completed, and is bound separately as Appendix D to this report.

The report does not set forth time schedules for the development of specific projects, but it does present a framework into which future projects can be fitted. Where apparent, the relative urgency of needs which will ultimately dictate the priority of projects has been noted.

GENERAL PLANNING GUIDELINES

The Nebraska Soil and Water Conservation Commission set certain guidelines prior to the beginning of the Framework Study. The guidelines which were established determined the nature of the investigations carried out and, to a large extent, influenced the outcome of the Study. The guidelines prescribed important public policy and, as well as directing planners, eliminated patently unacceptable plans. Because of their great effect, it is important that explicit recognition be given to the guidelines.

...Serve the General Welfare

The Framework should strive toward a balance of economic, social, and environmental objectives. These factors, considered together, have impact on the overall quality of life. The general welfare of the people and the quality of their life in present and future Nebraska shall be the overriding consideration in any decisions.

...Be a Statewide Study

Attention shall be given to all parts of the State. No sectional bias shall be shown but the nature of existing and future needs and the distribution of available resources are to be recognized, as they result in varying extents of development.

...Incorporate Presently Proposed Projects

The Framework will include and take into account presently proposed projects. Modifications which may be needed at some future time to adapt individual projects to the overall Framework shall be identified.

...Give Priority to In-Basin Demands

First priority shall be given to in-basin use of water resources for all reasonable foreseeable needs and for all purposes envisioned. All foreseeable water needs within the basin shall be met to a reasonable degree before consideration of water transfers to other basins.

...Emphasize Multipurpose Developments

Wherever possible, water developments should combine all reasonable beneficial uses to increase the economic efficiency of development and conserve the resources used in development.

...Consider Environmental Values

Attention shall be given to the environmental effects of development or the benefits, in appropriate instances, of nondevelopment. The Framework Study shall include, where suitable, the protection of resources to insure their availability for future generations.

...Present Alternatives for Development

The report should present all major alternatives in the long-range development of Nebraska's water resources which were considered. Available significant information on each alternative will be included to facilitate needed decisions. Matters of public policy concerned with the choice of alternatives should be identified.

...Consider Needed Changes in Law

Flexibility in state law, policies and institutional relations is a basic premise of the Study. Long-range development of Nebraska's water resources is subject only to the external constraints of United States Supreme Court decrees, interstate compacts, federal regulations, and the internal constraints of present private investments and established rights. Changes in state law and policy required to accomplish developments thus formulated should be identified.

...Provide a Flexible Guide

The need for flexibility in the Framework is inherent. It should accommodate substantial changes in specific projects which may be dictated by future detailed studies. Individual projects should not be essential to the whole. The general schemes of development generally should be capable of serving needs which may vary widely in magnitude from those presently anticipated.

As the Study progressed, additional planning concepts based on the early phases of investigation were developed. These concepts became additional guidelines enunciated in response to specific questions of policy concerning the Study.

...Progressive Development

The Framework should be capable of progressive development in accord with future needs. The need for massive financial outputs before even moderate benefits are gained should be eliminated where possible by the staged construction and operation of facilities.

...Indefinite Time Schedule

No time schedule for implementation should be presented. The Framework of developments

shown should meet the general conditions expected to exist in the future, but the time at which individual facets of the Framework are implemented is largely a decision of public investment to be made by the Legislature and/or Congress. The base for those decisions will lie in studies of future demand for the goods, services, and benefits of water and related land resources development.

...Full Utilization of Water and Land Resources

In accord with the intent of the Legislature expressed in Legislative Resolution Number 5, the degree of development to be sought in the Study is the reasonably full use of readily available resources without constraint by national production allocations, marketing potential or other similar considerations. Development included should generally suffice through the early decades of the 21st Century and meet the major needs which will exist at that time.

...Water Supply Exchanges

The Study should fully recognize federal, state, local, and private interests in water use. In exchange for modification of water supply for existing projects, a like water supply both in quantity and quality should be provided. Where that is impossible, there must be adequate compensation for injury.

...Only Nebraska Waters Used

The Framework should be formulated using only waters which originate in Nebraska or are provided as dependable inflow under interstate agreements.

...Nebraska Benefits Considered

The Study shall give primary consideration to Nebraska's interests. Effects, both beneficial and adverse, which accrue outside Nebraska shall not be evaluated.

RELATED STUDIES

Considerable information was drawn from other investigations which were either completed or underway during the Framework study period. In most cases, these other studies were not being carried out specifically to support the Framework Study but their data and results were valuable. The major studies used in this fashion included the *Missouri River Basin Comprehensive Framework Study* prepared under the auspices of the Missouri Basin Interagency Committee, the *Nebraska State Water Plan Study* by the U.S. Bureau of Reclamation, the *Nebraska Conservation Needs Inventory* prepared by the Nebraska Conservation Needs Committee, *Outdoor Recreation for Nebraska* prepared by the Nebraska Game and Parks Commission, the *Water Quality Standards for Nebraska* adopted by the Nebraska Water Pollution Control Council, and other miscellaneous reports prepared for consideration of specific projects.

APPENDICES TO THE MAIN REPORT

The wealth of data used in formulating the Framework Study was accumulated over a period of several years. Since its volume precluded inclusion within the text of this report, a series of appendices has been prepared and issued in preliminary form. Because additional data became available as planning progressed, it was impossible to make these appendices all-inclusive prior to completion of the Study. The appendices presently available in preliminary form will be revised to include the additional data collected during the latter stages of planning and to include data from studies being completed by other agencies. The publication and issuance of the appendices in final form will complete the preparation of the Framework Study.

The appendices already available in preliminary form include:

Appendix A—LAND INVENTORY
Preliminary Report June, 1969

Appendix B—INVENTORY OF WATER RESOURCES
Preliminary Report May, 1970

Appendix C—NEEDS AND PROBLEMS
Preliminary Report October, 1970

Appendix D—SURVEY OF NEBRASKA WATER LAW
Preliminary Report June, 1970

Organization of Participants

STRUCTURE OF COMMITTEES AND WORK GROUPS

As the Commission began the Framework Study, four points became apparent:

1. While the Commission could adequately represent and protect the public interest, a means was necessary to inform the general public and offer interested individuals and groups an opportunity for participation.
2. A forum was needed for the discussion of special interests and the effecting of necessary compromises.

3. Liaison with the Legislature as well as local and statewide groups was a must if plans are to be implemented.
4. The Commission had only sufficient staff for leadership, coordination and work on specific areas of the planning program. Therefore, considerable assistance was needed from other resource agencies.

To meet these problems, the organizational structure shown in Figure 1 was developed to provide legislative, policy and technical guidance and assistance to the Commission and its staff on all phases of Nebraska's State Water Plan. The committees and work groups were used fully in the preparation of the Framework Study.

In most cases, the committees shown in Figure 1 were chaired by Commission staff members. The purpose of this leadership was not to dominate, but rather to maintain the final responsibility for the Plan with the one accountable group as assigned by the Legislature—the Nebraska Soil and Water Conservation Commission.

TECHNICAL ADVISORY COMMITTEE

Made up primarily of state and federal agency representatives, this Committee provides technical guidance and information concerning federal and state laws, regulations and policies. This Committee also coordinates participation between the Commission and member agencies. The Technical Advisory Committee devotes extensive time to detailed technical review of procedures and reports. It also makes available to the Commission an accumulated wealth of experience in the technical and administrative direction of planning.

SPECIAL REPRESENTATIVES COMMITTEE

This Committee is composed of representatives of established statewide organizations having a particular interest in water resources development. The Committee members serve a two-fold purpose by evaluating procedures and reports in light of the policies and programs of the organizations they represent and in disseminating information concerning the Study to the members of their organizations.

LEGISLATIVE COUNCIL COMMITTEE

The Legislative Council's 1967-1969 Interim Study Committee on Ground and Surface Water held a series of hearings across the State to encourage local expression concerning Nebraska's State Water Plan. In addition, the Committee, and especially the chairman, was available for consultation as problems arose.

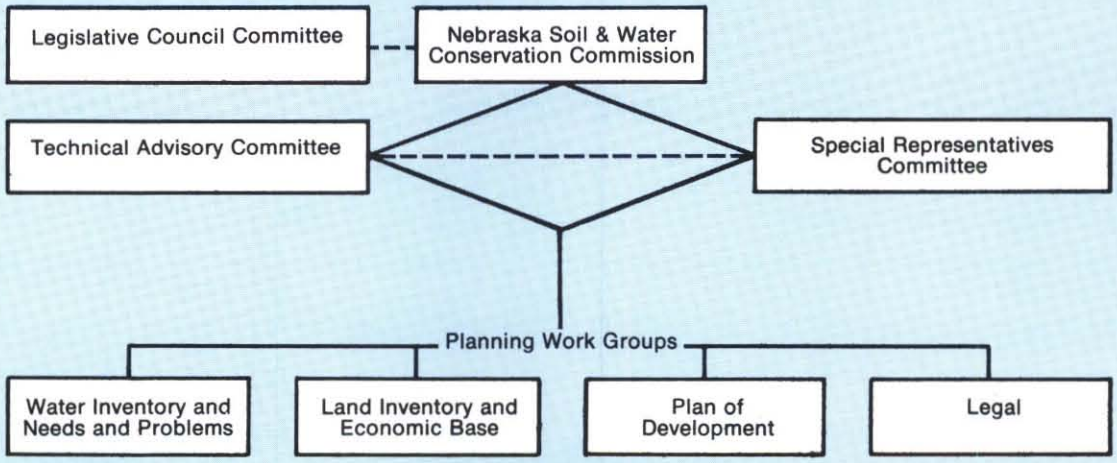
The Legislative Council again established an Interim Study Committee on Water and Land Resources to serve during the 1969-1971 period. This Committee devoted considerable effort to the Framework Study and gave freely of their counsel on many of the more difficult choices faced during the planning process.

The assistance of both Committees to the Commission was invaluable.

PLANNING WORK GROUPS

The planning work groups were responsible for the initial screening of material to be reviewed by the various committees. Individual members were sometimes asked to provide material necessary for preparation of the Framework Study.

FIG. 1 / STATE WATER PLAN ORGANIZATIONAL STRUCTURE



Membership of the work groups was drawn from state agencies, federal agencies and the University of Nebraska.

The organizational membership of the various work groups and the names of their representatives are shown on the inside of the back cover of this report.

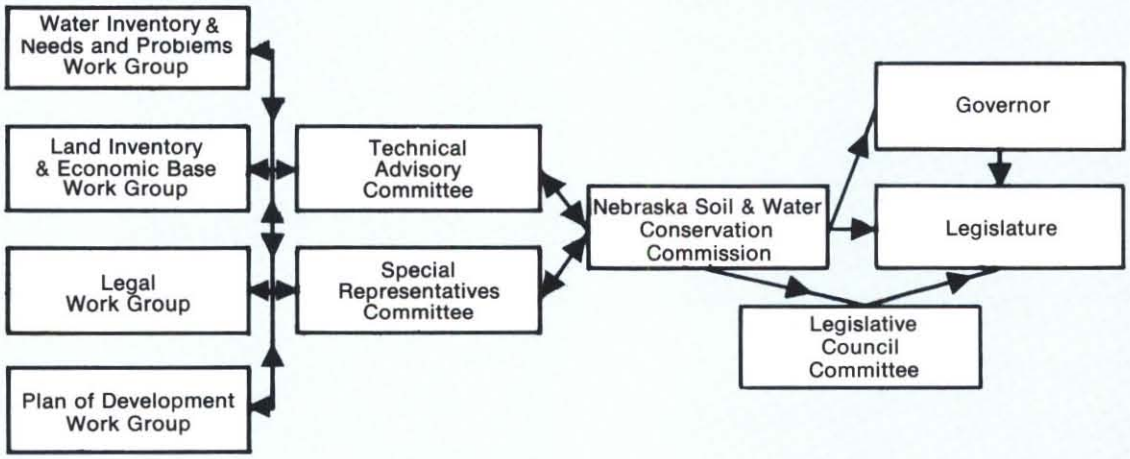
Review Procedures

To insure uniformity, a formal procedure for the review of Nebraska's State Water Plan was adopted. Figure 2 indicates the extensive review given all parts of the Framework Study prior to transmittal of the main report to the Legislature. Each of the principal committees and the Commission reviewed proposed reports and could return them to the other committees or work groups for further consideration or modification.

The reviewing committees provided advice and recommendations to the Commission. In general, no report was presented to the Commission for its action until a consensus had been reached by the reviewing committees on their recommendations.

All resource oriented state and federal agencies were requested to review and comment on the Framework Study regardless of committee memberships. In addition, appropriate representatives of selected local agencies and nationally recognized authorities were consulted as particular problems arose.

FIG. 2 / STATE WATER PLAN REVIEW PROCEDURE



Completion of Nebraska's State Water Plan

ASPECTS OF PLANNING REQUIRING FURTHER STUDY

There are several aspects of planning which could not be adequately considered in a framework level study. Some will require special studies. Included are special economic, engineering, and legal studies which were not available for the Framework Study, but which will be necessary for (1) revision of the Basic Framework, (2) the more detailed river basin studies, and (3) further investigation of potential interbasin transfers of water.

Economic base studies will be required to properly evaluate project feasibility and for consideration of financial aspects of development.

Special engineering investigations will be required for various aspects of the Plan to allow selection of alternative features, preparation of cost estimates, planning designs and other items required in detailed planning.

The social impacts of development have been considered in only a cursory manner and should be further evaluated as more detailed plans are developed in later studies.

Legal implications concerned with water transfer, exchange, and use will require considerable additional study before detailed plans can be prepared for the more complex systems of water use suggested by the Framework Study.

A better definition of local and state goals of development must be provided before specific plans can be formulated. This must be available for the river basin study level of planning.

A general method of financing, which includes an equitable sharing of project development costs among the beneficiaries, should be formulated. No economic analysis has been made of developments included in the Framework, but such an analysis will be necessary at the next level of planning.

Policy decisions required for orderly development of Nebraska's water resources are mentioned in this Framework Study, but more detailed analysis and definition of the required decisions will be necessary in the near future.

Other special studies involving several disciplines may be required during the consideration of environmental, social, and other impacts.

SEQUENCE FOR ORDERLY COMPLETION OF THE PLAN

A schedule for completion of Nebraska's State Water Plan should be developed and acknowledged by the Legislature to insure that the Plan is completed in the most efficient manner. Funding levels should be included as part of the schedule to provide future Legislatures a fiscal guide for the funding needed to complete the Plan. While absolute future commitments of funds cannot be made, a strong guide would help assure continuity of the staff, studies, and programs required to complete the Plan in the sequence provided in the schedule.

The general sequence of completion should be:

1. Completion of Basin Studies
2. Completion of high priority Special Recommendations
3. Completion of Status Summaries
4. General and periodic revision and updating of the Framework Study.

Some of these studies could be carried out concurrently.

Among the river basin studies, first priority for planning should be placed on the proposed Platte River Basin Study in Nebraska. This joint federal-state study is presently being considered for initiation and should be undertaken as soon as possible.

An assured funding schedule for state planning will be necessary to effectively utilize the capabilities of the federal agencies. Federal budgeting procedures require knowledge of workloads several years in advance. Such a funding schedule will also be of assistance in arranging coordinated participation in planning by state and local agencies.

Implementation of Nebraska's State Water Plan

The ability to achieve the benefits of developments included in the Basic Framework lies largely with the Legislature. Unless specific steps are taken to cause development to take place in accord with this document, the Basic Framework will be only an optimistic prediction of what could have been attained.

The benefits of resource development, pointed up in this document, will be achieved only when needed programs and projects, founded on definitive public policies, are aggressively implemented.

REQUIREMENTS FOR IMPLEMENTATION

Plans. Implementation of projects and programs for development, regulation, protection, and use of Nebraska's water and water related resources can be successful only if the projects and programs are based on well conceived and adequate plans.

Plans of a type and detail required by the entity which will consider their implementation are necessary. The opportunities for implementing certain types of plans are often sporadic depending on public sentiment, availability of funds, and changing priorities of need. Generally a wide array of plans must be available to permit a selection of those to be implemented from among several plans serving similar objectives.

The availability of completed plans containing proposals of specific actions to meet specific needs and evaluations of the costs and benefits of such actions is essential to the decision making process of rational implementation.

Funds. Implementation of water resource development programs and projects requires large financial outputs. Costs normally consist both of an initial cost and a continuing cost. Since pro-

grams are normally undertaken only if the benefits, in dollar terms and otherwise, exceed the costs, such outlays of funds are more properly viewed as investments than expenditures.

Implementation of needed programs and projects requires that a portion of our present productivity be reinvested to gain increased future productivity, and that we yield a part of our economic opportunity to preserve and enhance non-economic values.

However viewed and from whatever source, large appropriations will be necessary for the implementation of needed programs and projects in Nebraska.

Institutional Arrangements. Implementation of major projects and programs can be achieved only through proper institutional arrangements. Policies must complement the law, regulations must facilitate action, and each of these must recognize the elements of common custom as they apply to resource management.

The majority of projects and programs included in this Framework have local, state and federal impact. Relationships throughout these governmental levels must be based on mutual understanding and guided by stated and accepted procedures to encourage joint and harmonious action. Conflicts between vested interests will arise. Provision must be made to insure that adequate means are available for discussing all views and yet insure resolution of conflicts so that progress is not impeded.

Many decisions of resource development and use have irreversible effects. Some programs and projects required for the general public welfare may be unpopular with both individuals and special interests. Proper cognizance must be taken by the Legislature of the need, in these instances where public welfare is endangered, to sustain such activities through proper institutional arrangements.

Concerted Action. Projects and programs needed in Nebraska and contained in this Framework must compete with numerous other highly desirable and beneficial uses for public funds, both at the state and federal levels.

When suitable plans are available, nonfederal obligations are assured, and adequate institutional arrangements are made, there still remains the problem of securing the funding and other forms of federal assistance which may be required. Concerted and intensive action at the local and state levels will be required to obtain the type and amount of assistance desired at the time it is needed.

Public bodies especially must see that potentially controversial issues are raised, adequately examined and fairly settled as early as possible in order that decisions, once made, can be supported.

ITEMS FOR LEGISLATIVE CONSIDERATION

Planning. Planning is the first step toward meeting present needs and is the means by which foreseen future problems are mitigated or avoided. The individual citizen has little opportunity to plan for the future on a large scale. Comprehensive planning, including investigations of engineering, economic, social, legal, and environmental alternatives and consequences, is expensive, but it is required for large public undertakings. It is largely a role of government to supply the expertise needed for such planning and to guide the application of that expertise into acceptable proposals.

Goals and Objectives. The range of possibilities available in the use of water and water related resources is almost infinite. The public, through the democratic process, must set the goals which are to be served by resource development. Once goals are set they can be translated, if compatible, into specific quantifiable objectives. It is then possible to prepare plans to reach the objectives.

Clearly stated public goals, determined after full consideration of all interests, are necessary for efficient and productive planning.

Planning Policies. Beyond the establishment of goals and their quantification into specific amounts of desired outputs of resource development, the rules under which these products of development can be attained must be established. These rules are generally established through a series of legislative or administrative policy decisions. The most basic of public policies already exist in law, generally stated in response to some past need. However, planning for the future must deal with problems not yet encountered and questions which have not yet been answered.

Recognition and resolution of major policy issues prior to planning can give guidance to the planner and permit the planning process to concentrate on the preparation of alternatives which not only meet goals and objectives, but meet them in an acceptable fashion. Policies set to guide planning before planning is undertaken, or at least before planning has proceeded to specifics, eliminates or radically reduces the undue influence of special interests.

Implementation of projects included in the Basic Framework would be accelerated by clear statements of legislative policy concerning the responsibility of the State for planning, funding, construction and operation. Other planning policy decisions will involve interbasin water transfer, preference of water use and exchange and recall of in-basin water supplies. The form and nature of protection provided for future basin of origin water use will require lengthy consideration to arrive at

mutually satisfactory solutions. Legislative direction should be given concerning environmental protection where that need conflicts with the opportunity for economic development. These, and perhaps other issues yet unrecognized, exist at the present time. Legislative attention to such matters is necessary if needed additional planning is to be expeditiously accomplished.

Need for Integrated Planning. Presently in Nebraska, a wide variety of state and local agencies carry out planning activities with emphasis on certain aspects of development. With fracturing of responsibilities, agencies are cast into the role of alternately putting forward their programs and defending their assigned interests against the programs and projects desired by others. To this extent agencies can themselves become special interests rather than guardians of the public trust.

The institutional arrangement under which many planning activities are carried out warrants Legislative and Executive consideration. The ever-present possibility for vital planning to become biased must be recognized and procedures instituted to insure that limited agency interests never take precedence over broad public needs.

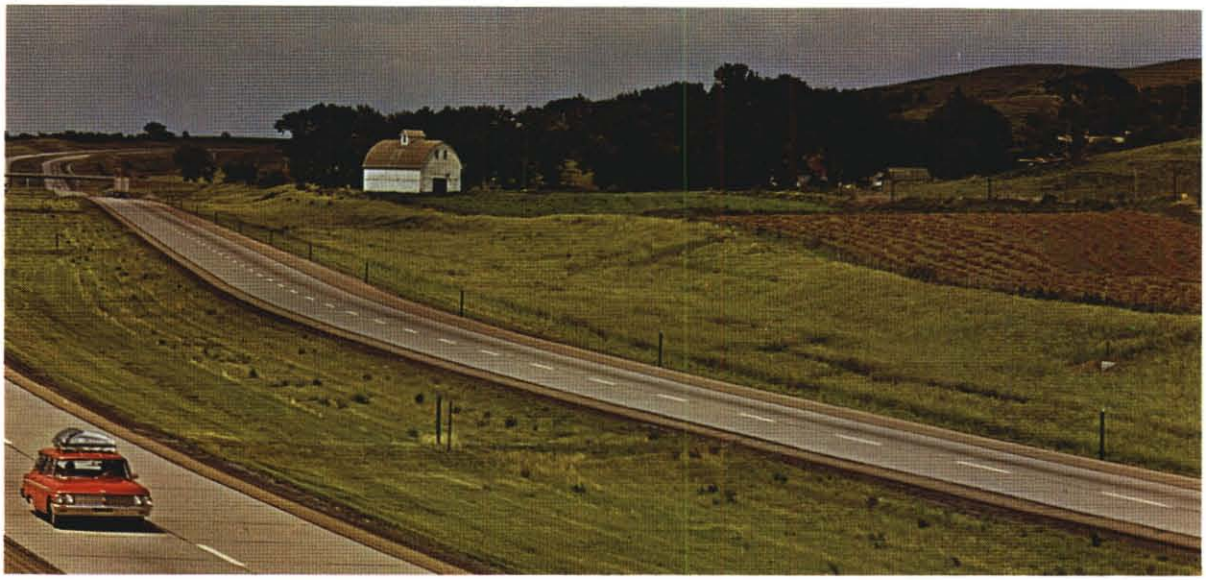
Continuity of Planning. Planning is a highly technical activity which, because of its importance early in the process leading to implementation, requires the highest quality staff available. Major resource development projects typically cost millions of dollars and judgments made by planners and recommendations to decision-makers stemming therefrom have broad public impact.

The recruitment, orientation and training of an interdisciplinary planning staff takes years. Such staffs cannot be disbanded at the end of each element of work only to begin staffing again at the start of the next. The continuity of staff is essential to insure their availability when needed for crucial decisions as well as for prosecution of ongoing programs. In addition, carry-over of staff from planning to project or program implementation is desirable to insure that their operation achieves the full potential conceived during the planning process.

Joint federal, state, and local planning is becoming well established and accepted. To fully participate and to adequately protect its interests, the state's planning program must be geared to a succession of long-term studies with varying completion dates. Planning could be enhanced by the insured availability of appropriate levels of funding over lengthy periods of time.

Funding. Appropriate levels of funding from some source was identified earlier as one requirement for project or program implementation. Financial support for planning, design, construction and operation of projects and programs often comes from a variety of sources. Customarily it is furnished by federal, state, and local governments and by individuals who derive benefits from the undertaking.

An equitable sharing of water development program costs should be clearly established. The State has, in the past, paid less than its share based on the distribution of benefits from various programs. This has placed an undue burden at the local and federal levels and, without an alternate source of funds, implementation of projects has slowed.



Chapter 2 / A DESCRIPTION OF NEBRASKA

In 1820, the explorer Stephen H. Long described the region which included the future State of Nebraska as, "...almost wholly unfit for cultivation and, of course, uninhabitable by a people depending on agriculture for subsistence."

Forty years later, William Gilpin, describing the area west of the "Hundredth Meridian," declared, "The plains are not deserts, they are...the pastoral gardens of the world."

Between these two historical descriptions of the nature of the region lies the true Nebraska. A modern economy based largely on agriculture has been developed and the physical characteristics which determine the availability of natural resources have, to a large extent, dictated the development that has produced the economy and the society of today.

The State Water Plan springs from the need for future resource development, which will be governed by the location and availability of the natural resources and the desires of the current society. This chapter provides a brief description of the physical, social, and economic characteristics of the State which are important to the development of the Plan.

Physical Features of Nebraska

The climate, topography and geological composition of the State have significantly affected the existence and location of Nebraska's natural resources and consequently the efficiency with which they may be used. Nebraska possesses an abundance of water and fertile soil. Its topography, generally flat with gently sloping drainage patterns, complements the resource base resulting in significant agricultural production.

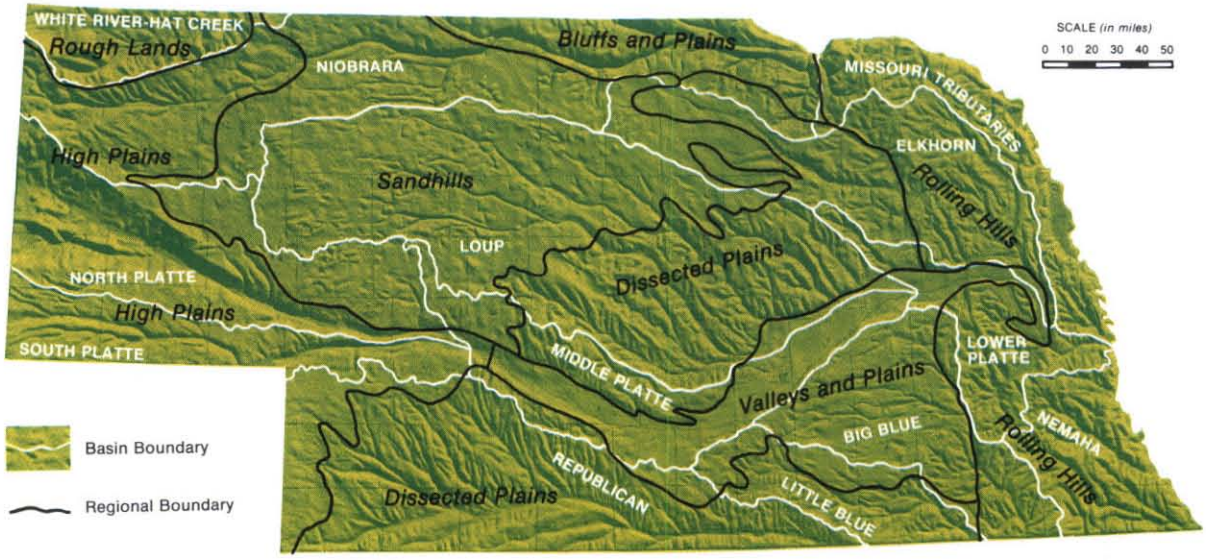
TOPOGRAPHY

The State lies within the Great Plains Region of the nation. Its gently rolling surface is broken by isolated buttes, mesas, ravines, and a number of shallow streams flowing eastward. This generally smooth surface, carved only slightly by river valleys, rises almost uniformly in elevation from east to west. It begins at about 840 feet above mean sea level at the southeast corner of the State and rises to a high point of 5,424 feet in Kimball County in the southwestern corner of the panhandle.

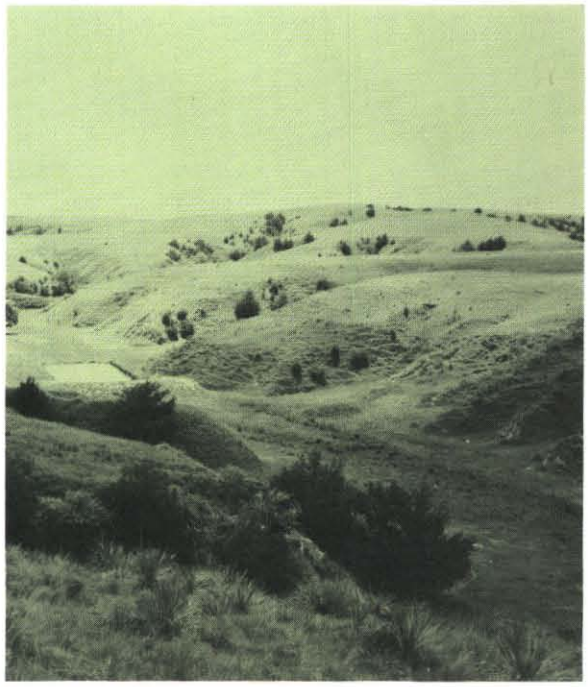
Figure 3, a relief map, shows several distinct features which divide the State into natural topographic regions.

The dominant feature along the eastern border of the State is the rolling hills. These hills are thick deposits of wind blown silt and clay, called loess, which rest on undulating glacial deposits.

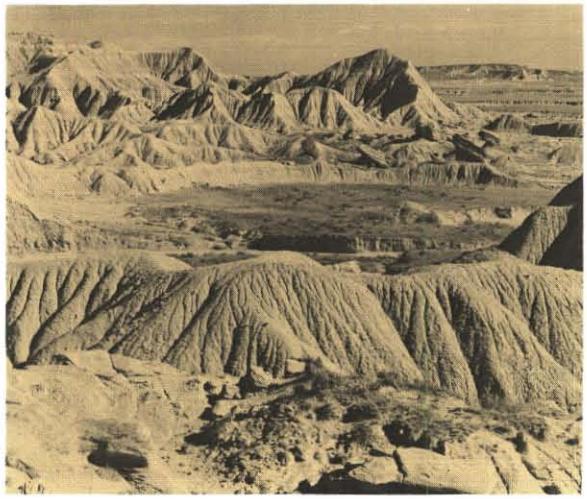
FIG. 3 / TOPOGRAPHIC REGIONS AND RIVER BASINS



West of this glaciated area, the layer of loess was deposited on a flatter surface so it formed a vast, level plain. Part of this flat plain still remains in central Nebraska, but the flat topography of some sections has been eroded by the streams to form flat topped hills. These sections are shown as dissected plains in Figure 3.



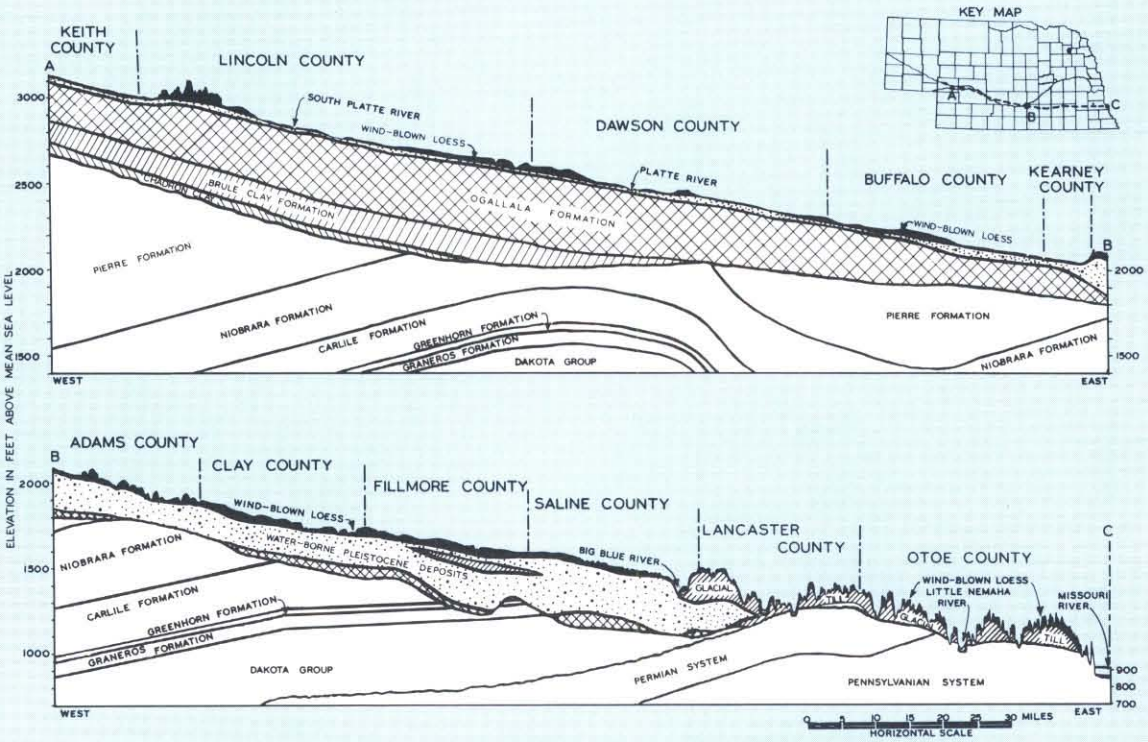
North and west of the loess plain is the Sandhills, a landform topographically unique in the United States. This area is made up of about 20,000 square miles of sand dunes held in place by a cover of native prairie grasses.



The western part of the State is largely undissected, high plains or tables divided by major stream valleys. The exceptions are Wildcat Ridge, located just south of Scottsbluff; a sandstone escarpment known as the Pine Ridge in the northwestern corner of the State; and the badlands and canyons forming the rough land north of the Pine Ridge.

Figure 3 shows the major features of the surface drainage pattern of the State, which is one of the determining factors in the availability and use of the land and water resources. This drainage pattern has been used to divide the State into 13 river basins for the Framework Study as shown on Figure 3.

FIG. 4 / GEOLOGIC PROFILE ACROSS SOUTHERN NEBRASKA



GEOLOGICAL CLASSIFICATIONS

AGE	TYPICAL FOSSILS	ERA	SYSTEM	SERIES	ROCK TYPE, GROUP OR FORMATION	CLASS
MILLIONS OF YEARS AGO		CENOZOIC (Modern Life)	QUATERNARY	RECENT	Dunesand, loess and alluvium	MANTLE ROCK
				PLEISTOCENE	Loess, silt, clay, sand and gravel, glacial till, volcanic ash	
2	Mammoth		TERTIARY	PLIOCENE	Ogallala formation	BEDROCK
				MIOCENE	Hemingford group	
					Arikaree group	
				OLIGOCENE	Brule clay formation	
					Chadron clay formation	
70	Dinosaur	MESOZOIC (Middle Life)	CRETACEOUS	UPPER	Lance formation	
					Fox Hills formation	
					Pierre shale formation	
					Niobrara chalk formation	
					Carlile shale formation	
					Greenhorn limestone formation	
					Graneros shale formation	
	Plesiosaur			LOWER	Dakota sandstone group	
135			JURASSIC		Sandstones and shales	
180			TRIASSIC		Sandstones and shales	
225		PALEOZOIC (Ancient Life)	PERMIAN		Shale, limestone, dolomite, gypsum, anhydrite, sandstone, siltstone, chert	
280	Brachiopod		PENNSYLVANIAN		Limestone, shale, sandstone, coal	
310			MISSISSIPPIAN		Limestone and dolomite	
350	Corals		DEVONIAN		Dolomite and shale	
400			SILURIAN		Dolomite	
440	Crinoid		ORDOVICIAN		Dolomite, sandstone, shale	
500			CAMBRIAN		Dolomite and sandstone	
600	Trilobite	PROTEROZOIC	PRECAMBRIAN		Igneous and metamorphic rocks	

Source of Data: Conservation and Survey Division, University of Nebraska

GEOLOGY

The topography of the State is determined in part by the structure of the underlying geologic formations. The material below the soil is known as either mantlerock or bedrock. Bedrock is older, and it generally occurs in definite layers, or strata, beneath the mantlerock.

The oldest strata of bedrock are the Precambrian rocks. On top of these once molten or strongly altered rocks are layers of sedimentary rocks such as limestone, dolomite, sandstone, shale, and chalk. A cross section showing the bedding and sequence of some of these rocks is shown in Figure 4.

The sedimentary bedrock which exists today was not formed by continuous deposition. Much of it was deposited at a time when Nebraska lay at the bottom of a prehistoric sea. After deposition these formations were elevated above sea level and eroded, then later depressed below sea level and covered by younger sediments, only to be raised and eroded again. These shifts in elevation plus the accompanying erosion and deposition developed unconformities, or breaks, in the regular sequence of deposition and irregular surfaces between layers.

The configuration of the bedrock surface beneath the mantlerock is important because it sometimes determines the availability of ground water. In some places, buried bedrock valleys filled with alluvial sediments are the only good source of water for wells.

Some sedimentary bedrock formations, such as chalk and shale, are generally too impermeable to yield water to wells, but they are important because they restrict the downward movement of ground water from the porous deposits above. Other sedimentary rocks, such as the sandstones, do provide water to wells.

The Ogallala formation is an important water source in much of central and western Nebraska, and the sandstones of the preceding geologic age are important aquifers in the panhandle. In the east, the Dakota sandstones also produce good quality water in some areas.

The combined thickness of the sedimentary rocks in Nebraska varies from a minimum of about 500 feet in the southeastern part of the State to around 9,000 feet or more in some of the western counties.

The mantlerock lies on the older bedrock. It includes the geologically youngest formations and is generally composed of layers of loosely consolidated or unconsolidated material deposited during the Pleistocene, or Ice Age, and later.

After the bedrock was formed and partially eroded, the eastern part of Nebraska was invaded at least twice by glaciers. These mountainous sheets of ice, containing large quantities of soil and rock, dammed the streams that flowed eastward with their burden of materials eroded from the rocks to the west. These streams, and those flowing from the glacier, deposited thick layers of silts, clays, and sands and gravels west of the glaciated region. These sands and gravels are an important source of ground water in the central part of Nebraska today.

As they melted, the glaciers deposited the mixture of clay and boulders they had accumulated in their southward advance, leaving the eastern part of the State covered with glacial debris, known as till, after they disappeared. Because of its composition this glacial till is a poor source of ground water and high yielding wells are difficult to locate in the eastern part of the State.

During the later glacial periods, strong winds whipped the fine sandy alluvium into dunes to form the Sandhills. Silt, clay and some of the finer particles of sand were carried farther eastward to combine with the dust blown from the broad flood plains to form the layers of loess now covering most of the State. At the same time, the streams eroded material from the uplands and deposited it along their valleys. This material, called alluvium, is generally both porous and permeable and, therefore, a good source of water in many areas of the State.

CLIMATE

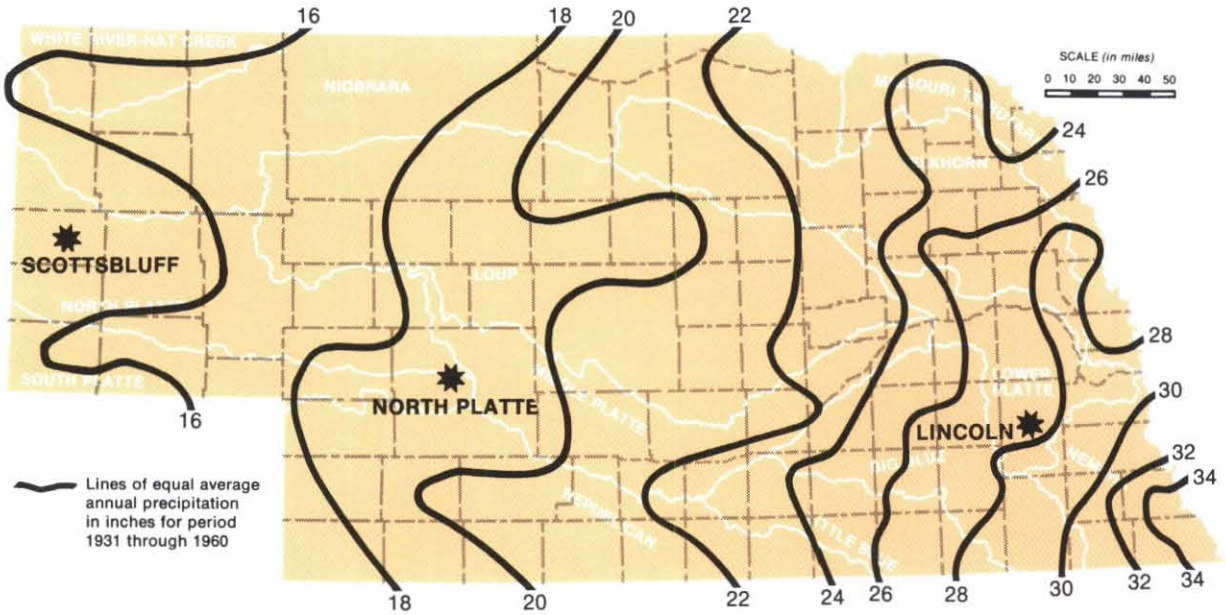
A discussion of the climate is essential to a complete description of the State, but climate alone is not enough. Climate is the average course of the weather over a period of years, but Nebraska's weather is seldom average. The extremes or the deviations from the average are essential parts of the description.

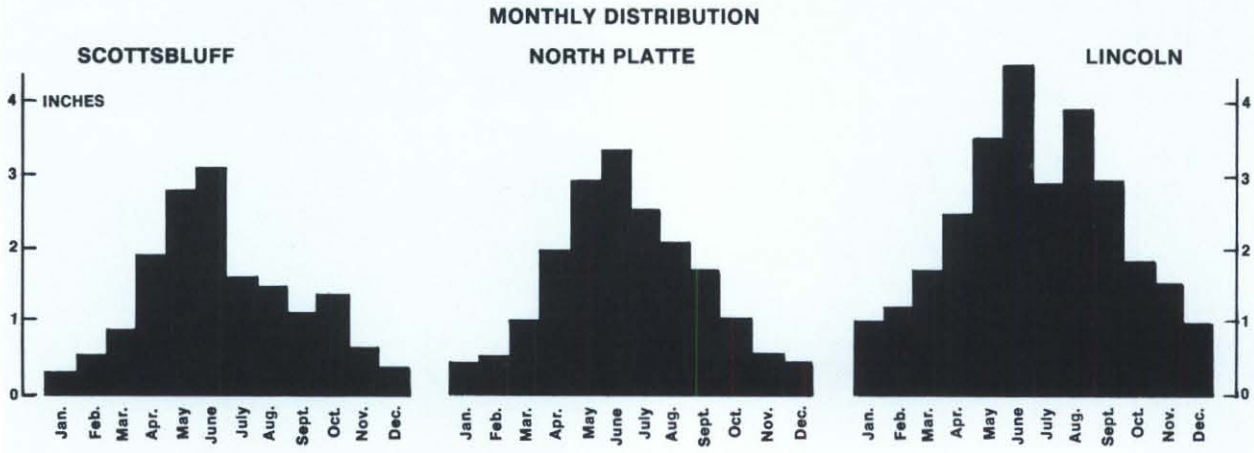
Nebraska's weather is typical of the interior of a large land mass in the temperate zone—variable. Rapid weather changes are caused by invasions of large masses of warm, moist air from the Gulf of Mexico; hot, dry air from the southwest; cool, dry air from the north Pacific Ocean; and cold, dry air from the polar regions.

Precipitation, temperature, and wind largely determine the character of the weather and the climate.

Precipitation. On a statewide basis, precipitation is sufficient to provide abundant water resources, but the amount of precipitation received varies across the State. The average annual precipitation decreases fairly uniformly from about 35

FIG. 5 / PRECIPITATION CHARACTERISTICS





Monthly distribution of average annual precipitation in inches for period 1931 through 1960

inches in the southeast corner of the State to less than 16 inches in the western panhandle. Figure 5 shows lines of equal average annual precipitation for the period from 1931 through 1960.

The amount of rainfall received by adjacent areas may vary widely during a given year. Intense thunderstorms are common in Nebraska and such storms are generally localized in extent, seldom covering large areas of the State. In some instances, heavy storms have covered only one or two small watersheds, causing destructive flash floods in one watershed and none in the neighboring areas.

The amount of rainfall received at any location generally varies considerably from year to year. Figure 6 shows the recorded annual precipitation at Lincoln and North Platte, as well as the average, for the same 30-year period used in Figure 5.

These graphs show that very few years between 1931 and 1960 were average. They also show periods of several years of below average rainfall alternating with periods of high rainfall. The most

noticeable periods of low rainfall occurred in the 1930's and mid-1950's. The 1930's, of course, are infamous for drought and the "Dust Bowl" it created. The drought of the middle 1950's was nearly as severe.

Droughts have severely affected most of the State at one time or another. The periods of 1887-1896, 1924-1927, 1931-1941, and 1952-1956 were particularly severe. In many other years, major drought disasters have been avoided only by the barest of margins.

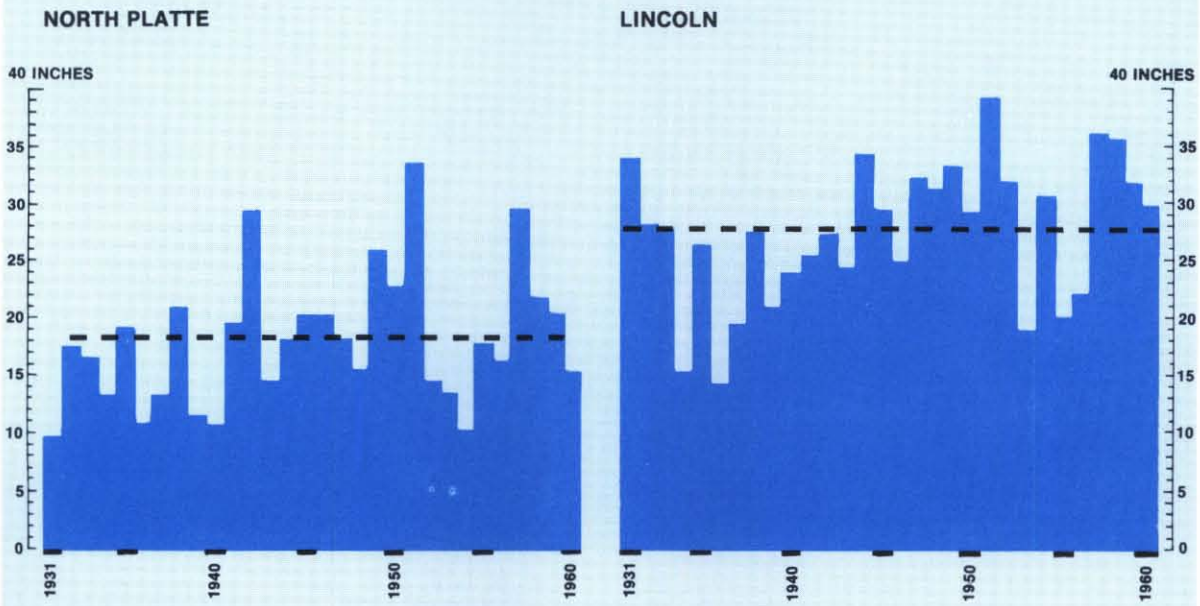
Droughts are not restricted to years with low annual rainfall. They have occurred in years with average total precipitation because the monthly distribution of the rainfall throughout the year did not follow the normal pattern.

Most of the precipitation received in the State is from spring and summer rains, but appreciable amounts occur as hail during those seasons or as snow and sleet in the winter. In Nebraska, about 80 percent of the average annual precipitation normally falls during the crop growing season from April through September. The normal monthly distribution of precipitation is shown for three locations in Figure 5.

This normal distribution cannot always be relied upon to grow crops. Figure 7 shows the normal distribution by months at Lincoln and North Platte compared with the recorded highs and lows for each month. It can be seen that in some years the rainfall in the summer months is negligible and in other years it is several times the normal amount. Two dry months in summer could result in crop failure, and one wet month in the fall could prevent harvesting.

Monthly precipitation figures, like annual totals, can also be misleading. Because much of the summer rainfall comes from intense thunderstorms, the total precipitation for two months could come in

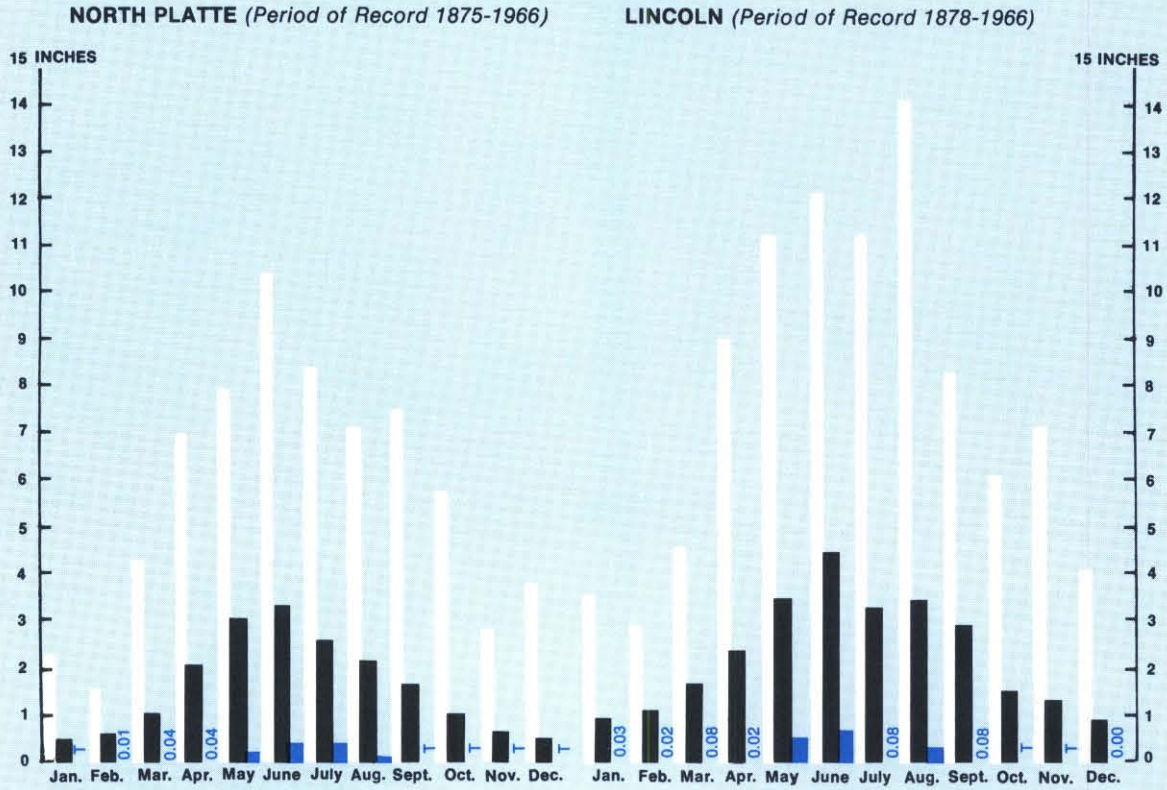
FIG. 6 / ANNUAL PRECIPITATION



Dash line indicates annual average (1931-1960)

Source of Data: U.S. Weather Bureau Climatic Summaries

FIG. 7 / MONTHLY DISTRIBUTION OF PRECIPITATION



Source: *Selected Climatic Maps, Missouri River Basin Comprehensive Framework Study*

one or two days at the beginning of the first month, and one or two days at the end of the second month. In effect, there would be practically two months of drought, but the monthly records would show sufficient moisture for good crop growth.

The intense storms can produce not only the total monthly rainfall but a large share of the annual rainfall as well. In the two weeks between June 3 and June 16, 1967 a series of storms dropped more than 13 inches of rain on Grand Island. This was over 54 percent of the total rainfall for the year at that location. During those two weeks, the city was flooded by waters from the Wood River, Prairie Creek, and Silver Creek, and approximately 1,800 buildings were damaged by these waters and groundwater pressures.

Temperature. Due to the invasion of large air masses from the north or south, air temperatures in Nebraska may vary widely from day to day. However, mean temperatures on a monthly basis vary only five to ten degrees between widely separated areas. Table 1 shows minimum, mean, and maximum temperatures recorded at several locations across the State.

TABLE 1 / TEMPERATURE MEANS AND EXTREMES AT SELECTED STATIONS
(Degrees Fahrenheit)

Location	Normal Mean a/		Extremes b/	
	January	July	Record High	Record Low
Lincoln	24.9	79.4	117	−24
Scottsbluff	25.3	74.7	110	−45
Valentine	20.0	75.4	110	−38
Norfolk	19.4	77.0	113	−26
North Platte	24.0	76.1	112	−35

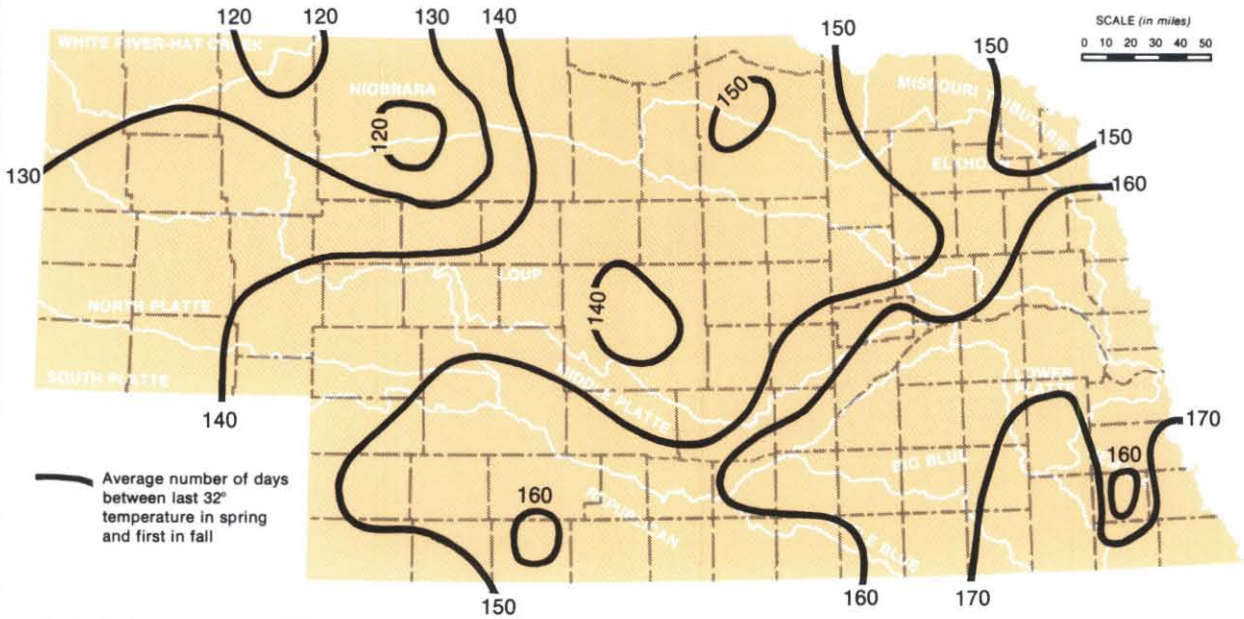
a/ *Average Annual for period 1931 thru 1960*
b/ *Prior to 1968*

Source of Data: U.S. Weather Bureau Climatic Summaries

Crop growth depends on adequate moisture and a warm growing season of sufficient length. The frost-free period between the last spring and the first fall air temperature of 32°F varied from a low of about 120 days in the northwest to a high of about 170 days in the southeast for the period 1921 to 1965. Figure 8 shows the variation in the average number of frost-free days across the State.

Wind, Sunshine, and Humidity. Wind has a secondary, but important effect on the state's resources. While principally related to evaporation and erosion, it significantly affects comfort and safety, particularly when using water for hunting, swimming, and boating. Winds in Nebraska are generally from a southerly direction in the warmer seasons and from a northerly direction in the win-

FIG. 8 / FROST-FREE PERIOD



Period of Record 1921-1965

Source of Data: NOAA Climatologist for Nebraska

FIG. 9 / PREVAILING DIRECTION AND MEAN SPEED OF WIND

Wind speed in miles per hour

Period of Record through 1960

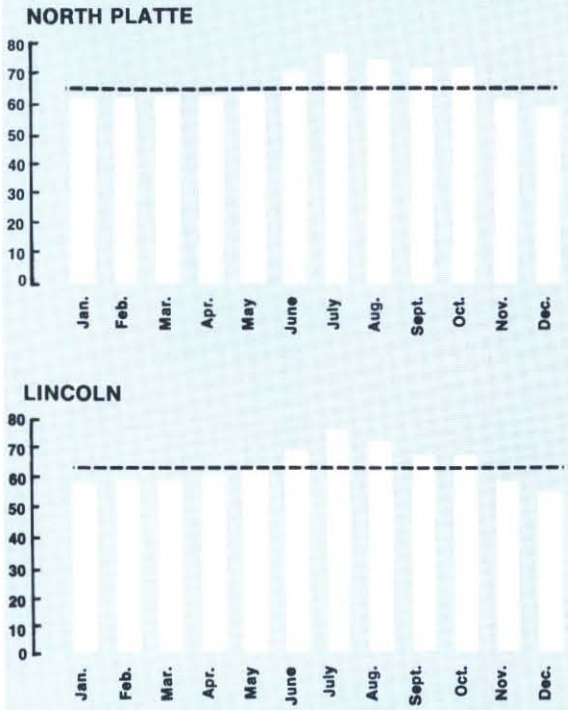
Source: *Selected Climatic Maps, Missouri River Basin Comprehensive Framework Study*

ter. Prevailing directions and average speeds for one month during each season of the year are shown in Figure 9. Winds of high velocity are normally of short duration and associated with severe thunderstorms, but persistent winds strong enough to cause soil erosion and affect outdoor activities are not unusual.

Sunshine and humidity also affect water resources through their effect on evaporation and plant transpiration. Figure 10 shows the average monthly percentage of daylight hours during which sunshine was received at Lincoln and North Platte. Figure 11 shows the mean monthly relative humidity at Omaha and North Platte.

Evaporation. Moisture returns to the atmosphere by evaporation from water surfaces and the soil, and from plants through the transpiration process. Evapotranspiration, a combination of evaporation from water and soil surfaces and plant transpiration, is the largest source of transfer from surface water and the ground water reservoir to the atmosphere, and large amounts are lost without direct benefit to mankind.

FIG. 10 / PERCENTAGE OF POSSIBLE SUNSHINE



Based on Period 1921-1970

Source of Data: NOAA Climatologist for Nebraska

Evaporation from free water surfaces occurs in lakes, storage reservoirs, and canals. The rate of evaporation is largely dependent on wind speed, temperature, and relative humidity. The average annual total loss in inches by evaporation from lake surfaces across the State from 1946 to 1955 is shown in Figure 12. Many reservoirs in Nebraska are comparatively shallow with respect to their volume and the resulting large surface area combined with the high evaporation rates common to the Great Plains can significantly reduce available water supplies.

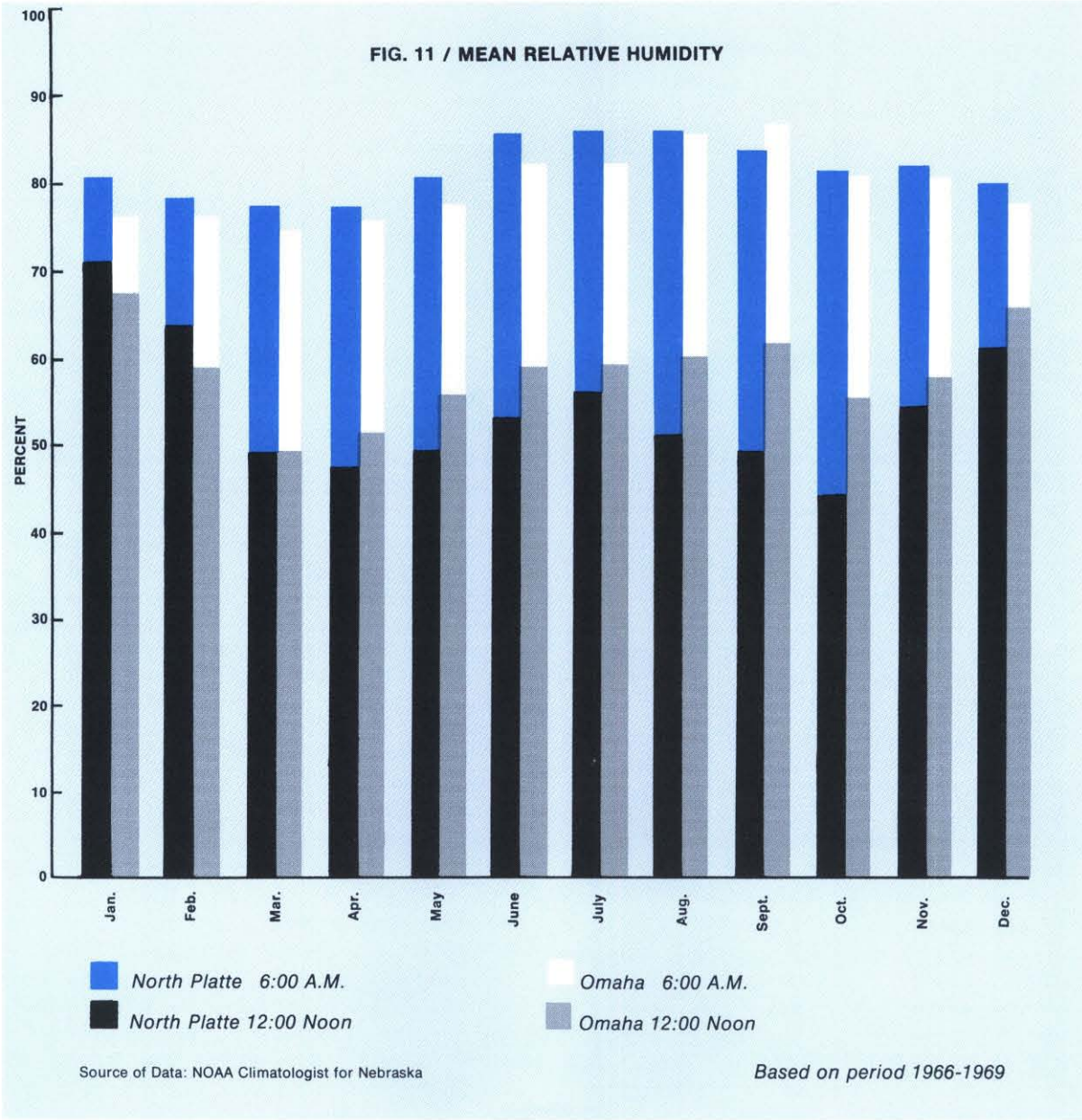
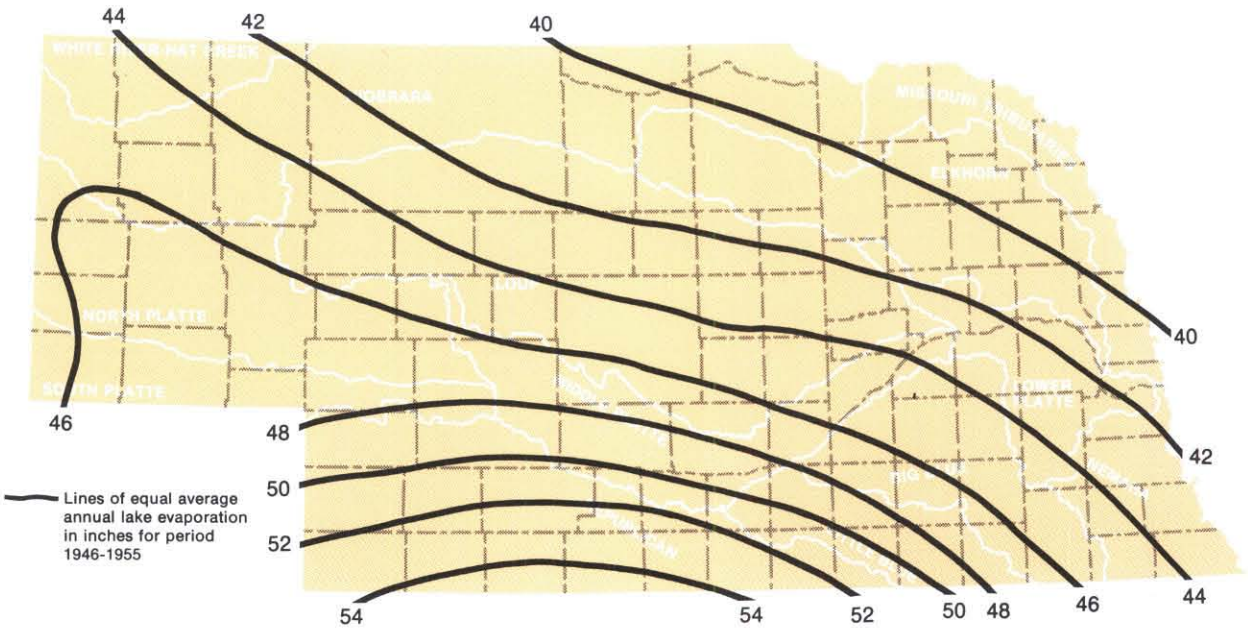


FIG. 12 / TOTAL LAKE EVAPORATION



Source: *Evaporation Estimates for the Missouri River Basin, MRB Comprehensive Framework Study*

Natural Resources

The natural resources of Nebraska include soil, water, timber, minerals, fish and wildlife. Soil and water are abundant in Nebraska, but the imbalance in the distribution of the fertile soil and the water often hinders economic growth.

THE LAND RESOURCE

In Nebraska, the land's greatest economic value stems from its ability, when supplied with adequate water, to support an intensive, productive, agricultural economy.

Agricultural Land Capability. Nearly all the land in Nebraska is capable of producing agricultural or related products. However, the suitability of the land for cultivation varies considerably depending upon topography and soil characteristics. The productivity of the soil depends mainly on its physical properties and the limitations caused by climate, erosion, drainage, or chemical concentrations.

The U. S. Department of Agriculture land use capability classification system groups land into eight classes. The risks of soil damage and limitations of use become progressively greater from Class I to VIII. Land in the first four classes is capable of producing cultivated crops, trees, pasture or range plants. Land in Classes V, VI, and VII are best suited to production of adapted native grass and trees. Land in Class VIII is not capable of agricultural production, but it provides wildlife habitat and scenic benefits.

Figure 13 shows the approximate acreage of each capability class within the State. Land in the first four classes is arable, or fit for cultivation by plowing or tillage. About 55 percent, or 27 million acres, of the agricultural land of the State is arable, but much of it is limited in its use by wind and water erosion. In addition, over two million acres of the Class II and III soils have good physical characteristics, but their use is generally limited by insufficient rainfall.

Over 19 million acres of agricultural land in Nebraska have soils which are suitable for irrigation. Of this total, about 7 million acres are classified as Type A soils, which are highly suitable for irrigation. They are capable of sustained irrigated crop production under good management practices.

In addition, 4,300,000 acres have soils which are moderately suitable for irrigation (Type B). These soils may have minor limitations or conditions which can be corrected at low cost. They usually require moderately intensive irrigation and conservation management.

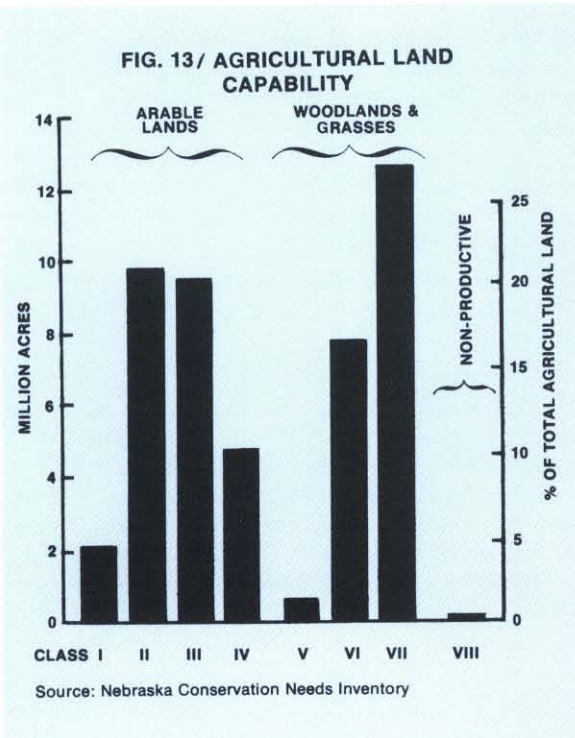


FIG. 13/ AGRICULTURAL LAND CAPABILITY

Source: Nebraska Conservation Needs Inventory

Type C soils have limited irrigation suitability. They have severe limitations in physical, topographic, and drainage characteristics. Type D soils are not irrigable in their present condition, but could be made irrigable by major improvements such as drainage or flood control. There are nearly 8,000,000 acres of land in these last two types.

The amount of land with soils in each irrigation suitability type in each river basin is shown in Table 2.

The totals shown in Table 2 as irrigable do not indicate whether individual irrigable areas are large enough to justify development. The total acreage shown as irrigable represents a maximum amount which must be reduced when other factors such as availability of water and size and shape of units are considered.

These reductions may be offset by new techniques of irrigation management and the development of new irrigation equipment. In the past few years the development of new techniques of irrigating with sprinklers and controlling native vegetation with chemicals have made it possible to raise row crops in the Sandhills, which were not considered arable or irrigable in the past. This practice is so new that it is impossible to accurately predict its future growth or its long term effect on the ecology of the area.

There are large blocks of land in the State that are well suited for irrigation. The largest area is in the upper part of the Big Blue and Little Blue River Basins in Adams, Clay, Hamilton, Polk, York, Fillmore, Butler, Seward, and Saline Counties. Nearly 70 percent of the agricultural land of the Big and Little Blue River Basins is so located and of such a character and quality that it would appreciably benefit from irrigation. This vast fertile area, comprising over 3,000,000 acres, is potentially one of the most productive agricultural areas in the nation.

Other large areas with soils highly suitable for irrigation development are located in the tablelands in Cheyenne, Deuel, Perkins, and Chase Counties; a section of the Central Loess Plains in Kearney and Phelps Counties; and along the valleys of most of the major streams in the State—especially the broad, flat valley of the Platte River.

Areas of moderate suitability are common in the Elkhorn, Nemaha, and Republican River Basins. Here slope is generally the limiting factor. Some areas in Holt and Rock Counties in the northcentral part of the State and along areas of the Platte River require substantial structural improvement before irrigation development is feasible.

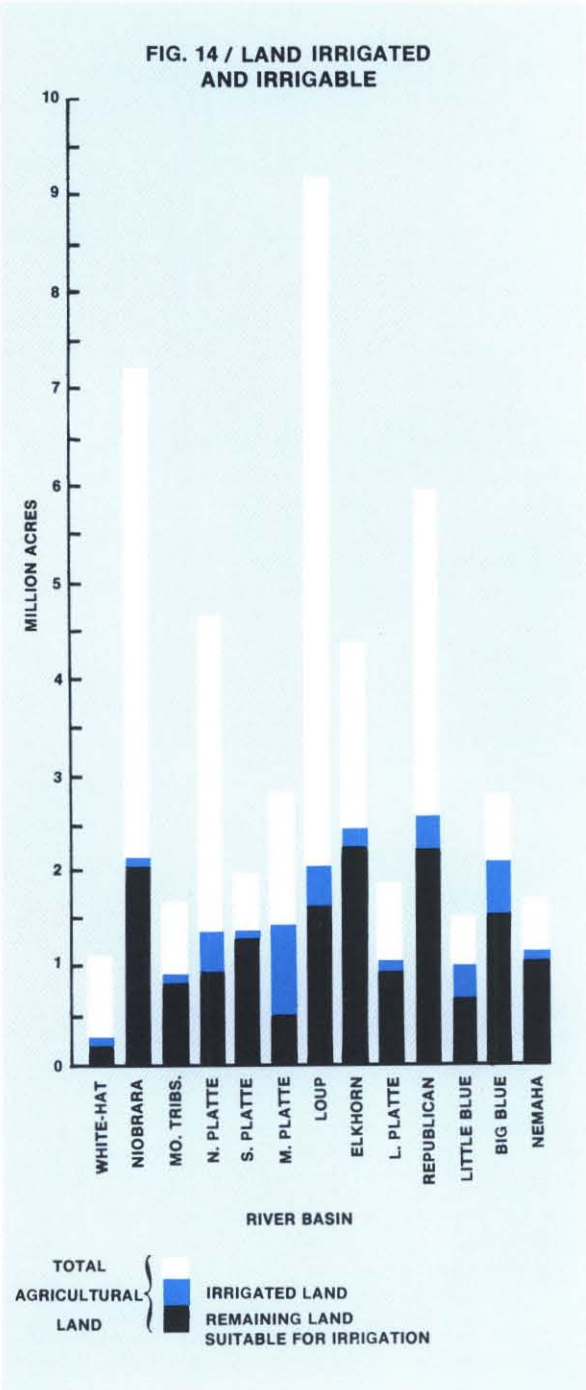
Large blocks of lands presently classified as nonarable by U. S. Department of Agriculture standards exist in the Loup and Niobrara River Basins and along the North Platte River. Much of this is in the Sandhills where irrigation from ground water with sprinkler distribution systems is presently taking place and, while in its infancy, could become widespread.

The White River-Hat Creek Basin also contains significant amounts of nonarable land because of rough lands and poor soils.

TABLE 2 / SUITABILITY OF LANDS FOR IRRIGATION

River Basin	Area (1000 Acres) Suitability Type A	B	C	D	Total
White River—Hat Creek	42	60	117	7	226
Niobrara	585	597	781	220	2,183
Missouri Tribs.	198	173	371	54	796
North Platte	343	363	453	103	1,262
South Platte	387	354	422	58	1,221
Middle Platte	821	163	295	125	1,404
Loup	647	369	634	349	1,999
Elkhorn	757	484	804	266	2,311
Lower Platte	306	275	496	68	1,145
Republican	967	626	821	112	2,526
Little Blue	649	147	216	18	1,030
Big Blue	1,148	355	468	35	2,006
Nemaha	165	344	542	36	1,087
STATE TOTAL	**7,015**	**4,310**	**6,420**	**1,451**	**19,196**

Figure 14 shows the variation which exists between river basins in terms of the amount of irrigable land compared to the area presently irrigated. These variations are due to the availability of ground and surface water; the amount of rainfall and its reliability; and the quality of land. The amount of land irrigated is only a small proportion of the land suitable for irrigation in a number of basins.



Land Ownership and Use. Ninety-four percent of the land in Nebraska is privately owned. The remainder is owned and managed by several agencies of the federal, state, and local governments. The publicly owned land is in numerous individual tracts distributed throughout the State, but the largest amount of public land is located in the western part.

Federal ownership totals 665,531 acres in forests, grasslands, wildlife refuges, national monuments, reservoirs, and other miscellaneous holdings.

Significant amounts of land distributed throughout the State, totaling 1,625,096 acres, were until recently owned by the State and under the management of the Board of Educational Lands and Funds. Authority was granted in 1969 to sell such lands, and the total has changed slightly. The University of Nebraska owns nearly 21,000 acres; the Game and Parks Commission either owns or administers nearly 180,000 acres; and the Roads Department also owns substantial lands. Other state agencies own small tracts of land.

The preponderance of the privately owned land is used for agricultural purposes. According to the 1964 Census of Agriculture, 35 percent of the farms in the State were operated by full owners, 35 percent by part owners, and the remaining 30 percent by tenants.

Privately owned nonagricultural lands within the State are used mostly for urban dwellings, commercial property, industrial areas, and railroad rights-of-way.

Approximately 96 percent of the total area of the State, including part of the publicly owned land, is used for agriculture. Areas used primarily for recreation, fish and wildlife occupy less than one percent of the land, while transportation, urban and

TABLE 3 / PRIMARY USES OF LAND AND WATER AREAS IN 1966

Use	Acres	Percent
Agricultural	47,570,000	96.1
Cropland	(20,050,000)	(40.5)
Forest & Woodland	(1,240,000)	(2.5)
Pasture & Range	(25,440,000)	(51.4)
Other Agricultural	(840,000)	(1.7)
Recreation, Fish & Wildlife	380,000	.7
Transportation, Urban & Other	940,000	1.9
Water	540,000	1.1
Mineral Industry	30,000	.1
Military	40,000	.1
STATE TOTAL	**49,500,000**	**100.0**

Source of Data: 1969 Conservation Needs Inventory

TABLE 4 / ESTIMATED CURRENT AGRICULTURAL LAND USE

River Basin	Percent of Total Agricultural Land: Non Irrigated Cropland	Irrigated Cropland	Pasture and Range	Forest and Woodland	Other Agri. Land	Total Agri. Land (1,000 ac.)
White R.-Hat Cr.	12	1	71	14	2	1,270
Niobrara	18	2	78	1	1	7,310
Mo. Tribs.	71	1	19	5	4	1,700
No. Platte	15	7	76	1	1	4,760
So. Platte	64	5	30	0	1	1,990
Mid. Platte	19	31	46	2	2	2,840
Loup	16	4	78	1	1	9,430
Elkhorn	52	2	41	2	3	4,340
Lo. Platte	73	6	14	3	4	1,860
Republican	46	6	46	1	1	5,940
Little Blue	57	16	23	2	2	1,640
Big Blue	60	22	14	2	2	2,800
Nemaha	72	0	20	5	3	1,690
STATE TOTAL	**36**	**7**	**53**	**2**	**2**	**47,570**

Source: 1969 Conservation Needs Inventory

other uses require only an additional 2 percent. Table 3 presents the current estimated use of Nebraska's 49,500,000 acres.

About 19.6 million of Nebraska's 27 million arable acres are being cultivated, and 1.3 million acres classed as nonarable by U. S. Department of Agriculture standards are under cultivation. The proportion of land devoted to cultivated cropland and various other agricultural uses varies significantly from year to year. The average amount of land used for different agricultural purposes in each basin in recent years is summarized in Table 4.

About 97.5 percent of the land in the State is useful for recreation, fish and wildlife purposes, and about 380,000 acres are primarily devoted to these uses. The 340,000 acres comprising the Nebraska National Forest and the Oglala National Grasslands, which were included with agricultural uses in Table 3, have above average importance for these purposes. Public lands available for recreation, fish and wildlife purposes are summarized in Table 5.

Nearly 400,000 acres of private land and water are available for recreation, fish and wildlife purposes, including fee fishing and hunting areas, golf courses, vacation cabins and camping areas. This is a secondary use of most of this land, especially the areas used for hunting and fishing.

The two percent of Nebraska's land used for transportation, urban, and other purposes is distributed throughout the State, with the heaviest concentration in the populous eastern section. Transportation uses, including lands devoted to highways, roads, railroads, and airports, represent the largest proportion of this category. Urban development probably occupies less than one-quarter million acres, or 0.3 percent of the total state area.

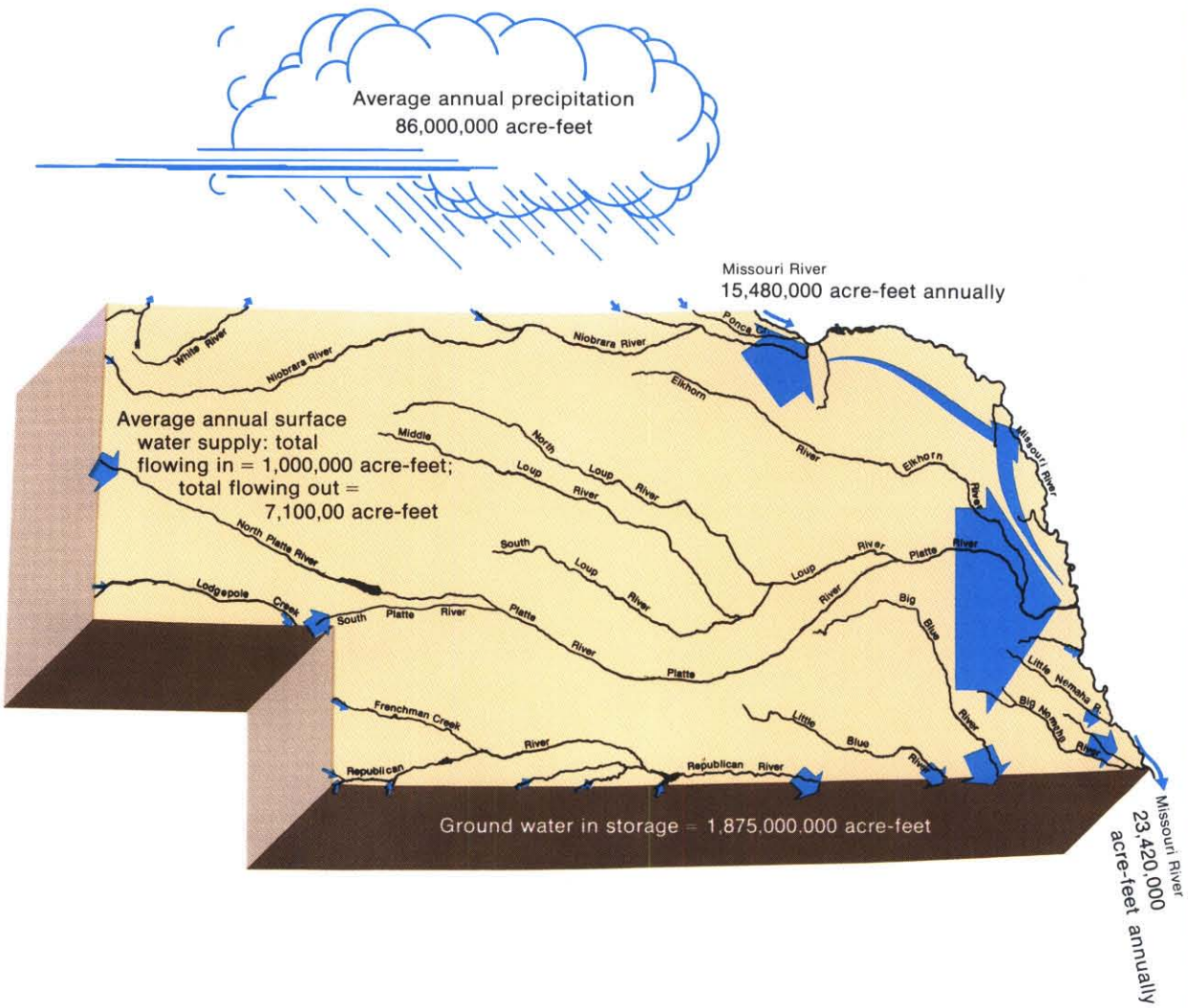
Military installations occupy another 40,000 acres. These lands are administered by the U. S. Department of Defense.

TABLE 5 / PUBLIC LANDS AND WATERS AVAILABLE FOR RECREATION, FISH, AND WILDLIFE PURPOSES

Type of Area	No.	Acres
National Monuments	3	6,300
Federal Fish and Wildlife Areas	42	161,600
Natl. Wildlife Refuges	(5)	(149,300)
Waterfowl Production Areas	(37)	(12,300)
National Forests and Grasslands	4	339,600
Bessey Div., Nebr. Natl. Forest		(90,400)
Niobrara Div., Nebr. Natl. Forest		(115,600)
Pine Ridge Div., Nebr. Natl. Forest		(39,300)
Oglala Natl. Grasslands		(94,300)
State Areas	177	186,300
State Parks	(5)	(4,000)
State Recreation Areas	(55)	(94,000)
Special Use Areas	(75)	(72,600)
State Historical Parks	(8)	(1,700)
State Wayside Areas	(26)	(1,000)
Fish Hatcheries	(6)	(2,000)
Undeveloped State Areas	(2)	(11,000)
Other Areas	3	2,600
STATE TOTAL	**229**	**696,400**

Source: Nebraska Game and Parks Commission

FIG. 15 / NEBRASKA'S WATER SUPPLY



THE WATER RESOURCE

Nebraska's water resource consists of large quantities of both surface and ground water. The average annual streamflow into the State is about one million acre-feet, whereas the average annual outflow is about seven million acre-feet. Nearly two billion acre-feet of ground water is stored beneath the State, although a significant portion of it is not physically or economically available. Figure 15 shows a simplified picture of the state's water supply. It does not attempt to detail the complex relationships between precipitation, evapotranspiration, ground water storage and streamflow.

Surface Water. All surface water in Nebraska eventually drains into the Missouri River. The Niobrara, Platte, and Nemaha Rivers drain directly into the Missouri River, and the Republican, Big Blue, and Little Blue Rivers are tributaries to the Kansas

River which flows into the Missouri River at Kansas City. Other smaller streams either flow directly into the Missouri River along the eastern border of the State or are tributary to larger streams which empty into the Missouri River.

The State was divided into 13 river basins and a number of subbasins for the Framework Study. Whenever possible, a major river or system of rivers, such as the Republican River or Loup Rivers, was used as a single entity to maintain the integrity of the drainage basin, provided the basin was of manageable size for planning purposes.

In the case of the Platte River, it was necessary to divide the basin into several sections to retain manageable-sized planning units. In other areas it was necessary to group a number of small basins together. In the northwest, the White River and Hat Creek were added together, and in the east the drainage areas of all the small streams entering the Missouri River north of the mouth of the Platte were combined into the Missouri Tributaries River Basin.

South of the Platte River, a number of small tributaries to the Missouri were added to the drainage areas of the Big and Little Nemaha Rivers to create the Nemaha River Basin. These basins and the principal subbasins are shown in Figure 16.

Nebraska's topography varies from flat tablelands and river bottoms to steep rolling hills and dissected plains. Soils vary from porous sands to tight clayey silts. Consequently, surface runoff varies greatly from one region to another.

The porous nature of the Sandhills allows precipitation to infiltrate at a high rate, resulting in little direct runoff to streams and large quantities of water percolating into the ground water reservoir. Therefore, flood peaks are relatively small, and the base flow is relatively large and very constant because the water is released gradually from the ground water reservoir. In the hard land areas, however, runoff varies greatly depending upon the amount and intensity of precipitation.

The average annual recorded flows for the period 1954-1963, the maximum and minimum recorded for the entire period of record, and comparisons with the average are shown in Table 6 for various locations across the State within the Sandhills or the hard land areas. The table shows the constancy of flow in streams draining Sandhills areas and the wide variation of flow from streams in hard land areas.

Records of streamflow in Nebraska date back to 1894 while some records of flow in the Missouri River along the Nebraska border start 20 years before that date. There are now about 350 sites on Nebraska streams, including the Missouri River, where some type of streamflow data is collected. The number of sites varies as some are discontinued and others are added to meet changing needs. The data is published by the U. S. Geological Survey in cooperation with other federal and state agencies in *Water Resources Data for Nebraska.* Part 1 contains surface water records and Part 2 contains records of water quality.

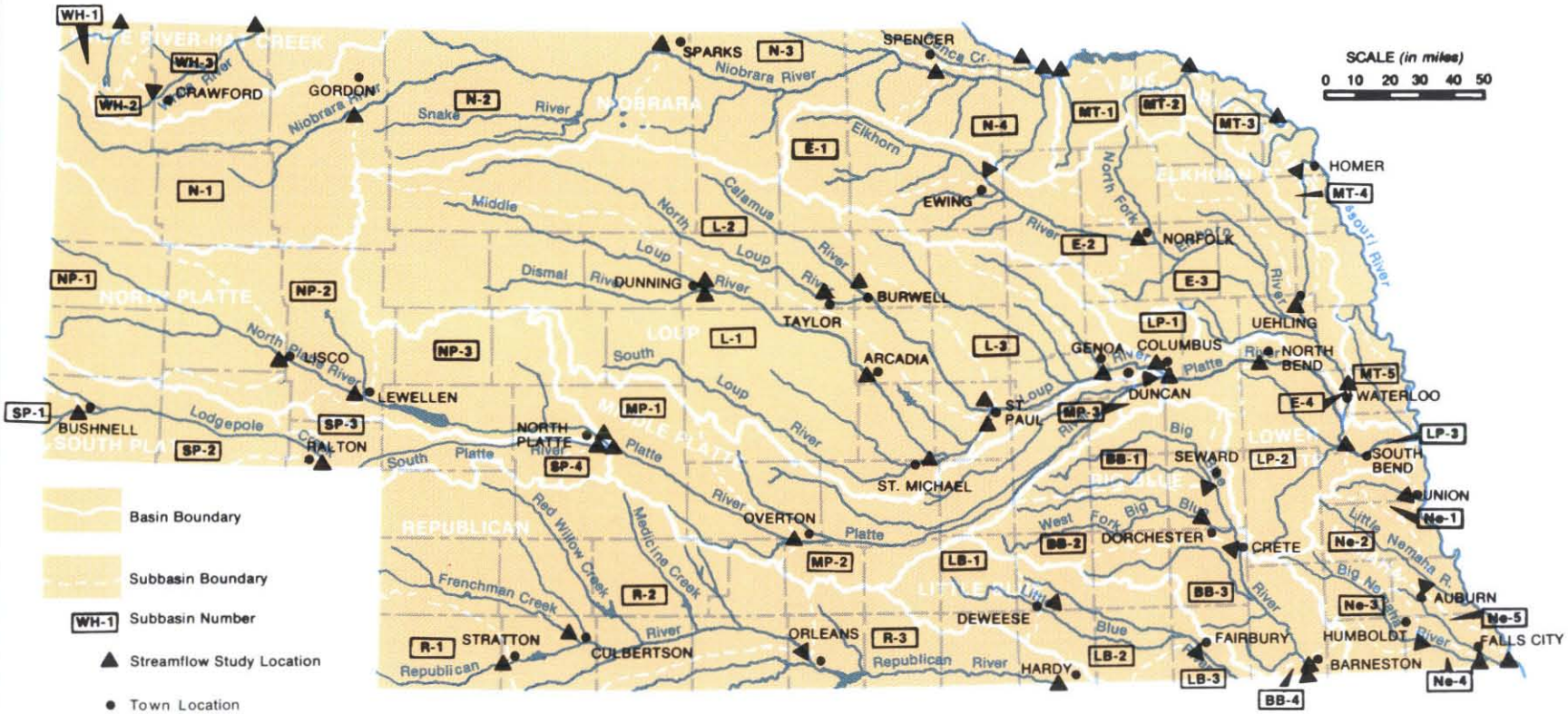
The records for these gaging stations provide some general information on the flood characteristics of different basins in the State. Table 7 shows peak discharges for a number of stations around the State, and the total drainage area above the gaging station as well as the area which contributes directly to flow in the stream. It also shows the

TABLE 6 / ANNUAL STREAMFLOW AT SELECTED STATIONS

Location	Average (1954-1963) (afa) a/	Recorded Maximum (afa)	% of Ave.	Recorded Minimum (afa)	% of Ave.
Sandhill Drainage					
Niobrara R. near Sparks	609,100	638,400	105	526,920	87
Niobrara R. near Spencer	1,104,400	1,495,000	135	793,300	72
Dismal R. at Dunning	236,500	246,400	104	221,500	94
North Loup R. at Taylor	349,000	402,000	115	257,000	74
Middle Loup R. at Dunning	291,400	309,500	106	264,900	91
Hard-Land Drainage					
Logan Cr. near Uehling	123,500	289,300	234	48,070	39
Maple Cr. near Nickerson	45,200	153,200	339	3,770	8
Elkhorn R. at Waterloo	833,300	1,957,000	235	301,700	36
Little Blue R. near Fairbury	260,600	740,000	284	77,760	30
Big Blue R. at Barneston	564,900	1,600,000	283	83,240	15
Nemaha R. at Falls City	393,600	1,455,000	370	62,910	16

a/ Acre-feet annually

FIG. 16 / FRAMEWORK STUDY RIVER BASINS AND STREAMFLOW STUDY LOCATIONS



average discharge per square mile of directly contributing area. Some areas, especially in the Sandhills, drain into pothole marshes and lakes which have no direct connection with the streams, so these areas were not used to compute the amount of flood flow per unit of area.

The table shows that the largest flood ever recorded did not occur in the largest basin, but in the smaller Republican River Basin. It is also interesting to note that although the second largest flood occurred in the lower part of the Platte River, most of the floodwaters came from the smaller Elkhorn River Basin instead of the immense area to the west. The greatest discharges per unit of area shown in the table occur in the smaller, hilly basins of eastern Nebraska, and the unit discharge from the small basins in the Sandhills contrasts sharply with these figures.

Historical streamflow records for the period 1954 through 1963, adjusted to reflect conditions of development in 1970, were used as the basis for future water supply estimates in this Framework Study because this period was fairly representative of long term streamflow records in most basins. Estimates of historical streamflow adjusted for 1970 conditions were made for some locations during the Comprehensive Framework Study of the Missouri River Basin by the Missouri Basin Interagency Committee. These estimates were used to account for the development expected by 1970 in adjacent states in which some streams have their sources. Estimated average annual streamflow adjusted for 1970 levels of development is shown for selected stations in each river basin in Table 8. The location of these stations is shown in Figure 16.

The present quality of Nebraska's water, both on the surface and in the ground, is generally good and usually adequate for most beneficial uses. Some localized water quality problems now exist, and its is anticipated that more will occur in the future.

Water quality can best be discussed on the basis of physical,chemical, and biological characteristics. The two chief physical properties affecting Nebraska's water quality are sediment or other solids in suspension, and temperature. Important chemical characteristics are those related to the beneficial uses of water for domestic supply, agriculture, and industry. Biological characteristics are generally related to public health.

The principal pollutant of the state's surface water is sediment. Erosion is greatest in the east-

TABLE 7 / PEAK DISCHARGE IN NEBRASKA STREAMS

Station	Total Drainage Area (Sq. mi.)	Direct [a/] Drainage Area (Sq. mi.)	Peak Discharge (cfs)	Discharge Per Unit Area (Direct) (cfs/sq. mi.)
		Under 1000		
Middle Loup R. at Dunning	1,760	80	932	11.6
Elkhorn R. at Ewing	1,400	740	7,500	10.1
Bazile Cr. near Niobrara	440	440	68,600	155.9
Weeping Water Cr. at Union	238	238	60,300	253.4
		1000 to 6000		
M. Loup R. at St. Paul	7,720	3,200	72,000	22.5
Elkhorn R. at Waterloo	6,900	5,900	100,000	16.9
Frenchman Cr. at Culbertson	3,080	1,560	15,000	9.6
Lodgepole Cr. at Bushnell	1,361	1,361	16,500	12.1
Big Blue R. at Seward	1,099	1,099	15,300	13.9
Big Blue R. at Barneston	4,444	4,444	57,700	13.0
Big Nemaha R. at Falls City	1,340	1,340	51,400	38.4
		Over 6000		
Niobrara R. near Sparks	8,090	8,090	10,200	1.3
Niobrara R. near Spencer	12,100	12,100	27,400	2.3
Republican R. near Hardy	22,400	22,400	225,000	10.0
North Platte R. at Lisco	30,700	30,700	20,100	0.7
Platte River near Overton	61,700	61,700	37,600	0.6
Platte River near South Bend	88,800	88,800	124,000	1.4

a/ Some basins have areas which do not contribute to streamflow directly but indirectly through ground water instead.

ern and southern part of the State, so water quality degradation from sediment is most severe in these areas.

Concentrations of suspended sediment as high as 27,600 milligrams per liter (mg/l) have been recorded on the White River and up to 20,700 mg/l on Logan Creek in the Elkhorn River Basin. Water with sediment concentrations in this range is often described as "too thin to plow but too thick to drink." These high sediment loads usually occur during periods of high or flood flows. Lesser but excessive concentrations have been recorded on many other eastern and southern streams. When the streams are not in flood, usual concentrations of suspended solids range from 50-300 mg/l.

No network of physical quality sampling stations has been established to enable conditions throughout the State to be adequately investigated.

Increased water temperature, or thermal pollution, is generally caused by use of the water for cooling of thermal electric power plants and other industrial plants. It can sometimes accelerate eutrophication of surface waters and affect fish habitat in cold water streams. There is no evidence of adverse effects of thermal pollution in Nebraska, but records are sketchy and data is not collected on a regular basis throughout the State.

Pathogenetic bacteria are usually introduced into surface water through the disposal of partially treated sewage, but the potential for pollution by livestock wastes from large feedlots has increased in recent years. In addition to the obvious health hazard they cause, such organic wastes also have a biochemical oxygen demand (BOD) which can deplete the dissolved oxygen content of the receiving stream. In some instances, the oxygen level in the stream has been lowered below that needed to support aquatic life, occasionally resulting in fish kills and offensive odors.

Chemical agents enter surface water from many sources to degrade its quality. Some chemicals are

TABLE 8 / ESTIMATED ANNUAL STREAMFLOW AT SELECTED LOCATIONS UNDER 1970 CONDITIONS

River Basin	Subbasin Name	No.	Stream Location	Streamflow [a/] (1000 afa)
White River-Hat Creek	Hat Creek Above State Line	WH-1	State Line	4.5
	White River Above Crawford	WH-2	Crawford	12.9
	White River-Crawford to St. Line	WH-3	State Line	17.6
Niobrara	Niobrara River-St. Line to Gordon	N-1	Gordon	74.9
	Niobrara River-Gordon to Sparks	N-2	Sparks	493.4
	Niobrara River-Sparks to Spencer	N-3	Spencer	1027.6
	Niobrara River-Spencer to Mouth	N-4	Mouth	1292.3
	Ponca Creek-State Line to Mouth	N-5	Mouth	68.4
Missouri Tributaries	Bazile Creek Above Mouth	MT-1	Mouth	75.4
	Bow Valley Creek Above Mouth	MT-2	Mouth	80.6
	Aowa Creek Above Mouth	MT-3	Mouth	33.4
	Omaha Creek Above Homer	MT-4	Homer	25.2
	Papillion Creek Above Mouth	MT-5	Mouth	80.7
North Platte	N. Platte R.-State Line to Lisco	NP-1	Lisco	647.8
	N. Platte R.-Lisco to Lewellen	NP-2	Lewellen	713.5
	N. Platte R.-Lewellen to N. Platte	NP-3	North Platte	332.2
South Platte	Lodgepole Cr.-St. Line to Bushnell	SP-1	Bushnell	7.6
	Lodgepole Cr.-Bushnell to Ralton	SP-2	Ralton	5.1
	S. Platte R.-St. Line to No. Platte	SP-3	North Platte	74.5
	S. Platte R.-North Platte to Mouth	SP-4	Mouth	617.7
Middle Platte	Platte R.-North Platte to Overton	MP-1	Overton	437.8
	Platte R.-Overton to Duncan	MP-2	Duncan	370.5
	Platte R.-Duncan to Loup River	MP-3	Loup River	370.5

(continued)

TABLE 8 (CONTINUED) /
ESTIMATED ANNUAL STREAMFLOW AT SELECTED LOCATIONS
UNDER 1970 CONDITIONS

River Basin	Subbasin Name	No.	Stream Location	Streamflow a/ (1000 afa)
Loup	Middle Loup River Above St. Paul	L-1		
	(M. Loup R. Above Dunning)		Dunning	285.9
	(Dismal R. Above Dunning)		Dunning	236.5
	(M. Loup R.-Dunning to Arcadia)		Arcadia	470.1
	(S. Loup R. Above St. Michael)		St. Michael	161.8
			St. Paul	653.9
	North Loup River Above St. Paul	L-2		
	(Calamus R. Above Burwell)		Burwell	227.6
	(N. Loup R. Above Taylor)		Taylor	348.1
			St. Paul	677.5
	Loup River-St. Paul to Genoa	L-3	Genoa	318.9 b/
	Loup River-Genoa to Columbus	L-4	Columbus	424.8 b/
Elkhorn	Elkhorn River Above Ewing	E-1	Ewing	116.4
	Elkhorn River-Ewing to Norfolk	E-2	Norfolk	330.7
	Elkhorn River-Norfolk to Waterloo	E-3		
	(Logan Creek Above Uehling)		Uehling	119.4
			Waterloo	809.2
Lower Platte	Platte R.-Loup R. to North Bend	LP-1	North Bend	1896.7
	Platte R.-North Bend to South Bend	LP-2	South Bend	3122.5
	Platte R.-South Bend to Mouth	LP-3	Mouth	3183.7
Republican	Republican R.-St. Line to Stratton	R-1	Stratton	109.4
	Republican R.-Stratton to Orleans	R-2		
	(Frenchman Cr. Above Culbertson)		Culbertson	64.1
			Orleans	188.6
	Republican R.-Orleans to Hardy	R-3	Hardy	244.6
Little Blue	L. Blue R. Above Deweese	LB-1	Deweese	103.0
	L. Blue R.-Deweese to Fairbury	LB-2	Fairbury	252.2
	L. Blue R.-Fairbury to State Line	LB-3	State Line	328.0
Big Blue	Big Blue R. Above Seward	BB-1	Seward	71.7
	Big Blue R.-Seward to Crete	BB-2		
	(West Fork Above Dorchester)		Dorchester	124.1
			Crete	239.6
	Big Blue R.-Crete to Barneston	BB-3	Barneston	554.2
	Big Blue R.-Barneston to St. Line	BB-4	State Line	571.7
Nemaha	Weeping Water Cr. Above Union	Ne-1	Union	47.8
	Little Nemaha R. Above Auburn	Ne-2	Auburn	180.3
	Big Nemaha R. Above Humboldt	Ne-3	Humboldt	151.6
	Big Nemaha R.—Humboldt to Falls City	Ne-4	Falls City	382.9
	Big Nemaha R.—Falls City to Mouth	Ne-5	Mouth	483.0

a/ Average annual streamflow based on recorded flows for the period 1954 through 1963, depleted for 1970 conditions of development

b/ Does not include flow diverted through Loup River Power Canal to Platte River, which averaged 1,219,700 afa from 1954 through 1963

dissolved naturally from soil and rock by percolating water, while others are introduced in runoff as residuals from agricultural chemicals applied to the land and from municipal and industrial wastes.

Very little information is available on the chemical quality of surface water in the State. From an examination of the records of chemical and water temperature data collected at U. S. Geological Survey sampling stations around the State from 1964 to 1967, however, it can be concluded that the chemical quality of water in all major Nebraska streams can be regarded as generally good.

The highest concentration of dissolved solids recorded during that period at any location affecting Nebraska's streams was 1,720 mg/l on the South Platte River at Julesburg, Colorado just upstream from the state line. Hardness, sodium adsorption ratio, specific conductance, and pH were also higher there than at other locations.

The existing regular water quality sampling network in Nebraska contains so few stations that it is difficult to generalize the results to apply to a whole region or stream system. Two streams in a region could be substantially different in characteristics, and a single station on a long river might be affected by local conditions showing poor quality which exists only in a short reach of the stream, while the rest of the river could have much better quality. Only a detailed survey and a full network of stations can provide complete information on the water quality in any region.

Ground Water. Nearly two billion acre-feet of ground water are estimated to be in storage in Nebraska. This water is not evenly distributed throughout the State and it varies in accessibility.

Aquifers of sands, sandstones, and gravels deposited during and immediately preceding the glacial periods constitute the largest reservoir of good quality ground water in Nebraska. This reservoir underlies the entire central and westcentral part of the State in much of the Niobrara, North Platte, Middle Platte, Loup, Big Blue, Little Blue, and Elkhorn River Basins. Most of the state's well irrigation occurs in these areas.

Large quantities of water are stored in older formations but its quality is often undesirable and the rocks often are so impermeable that, when tapped, their water yield is small. These older formations lie deep under the western one-third of the State.

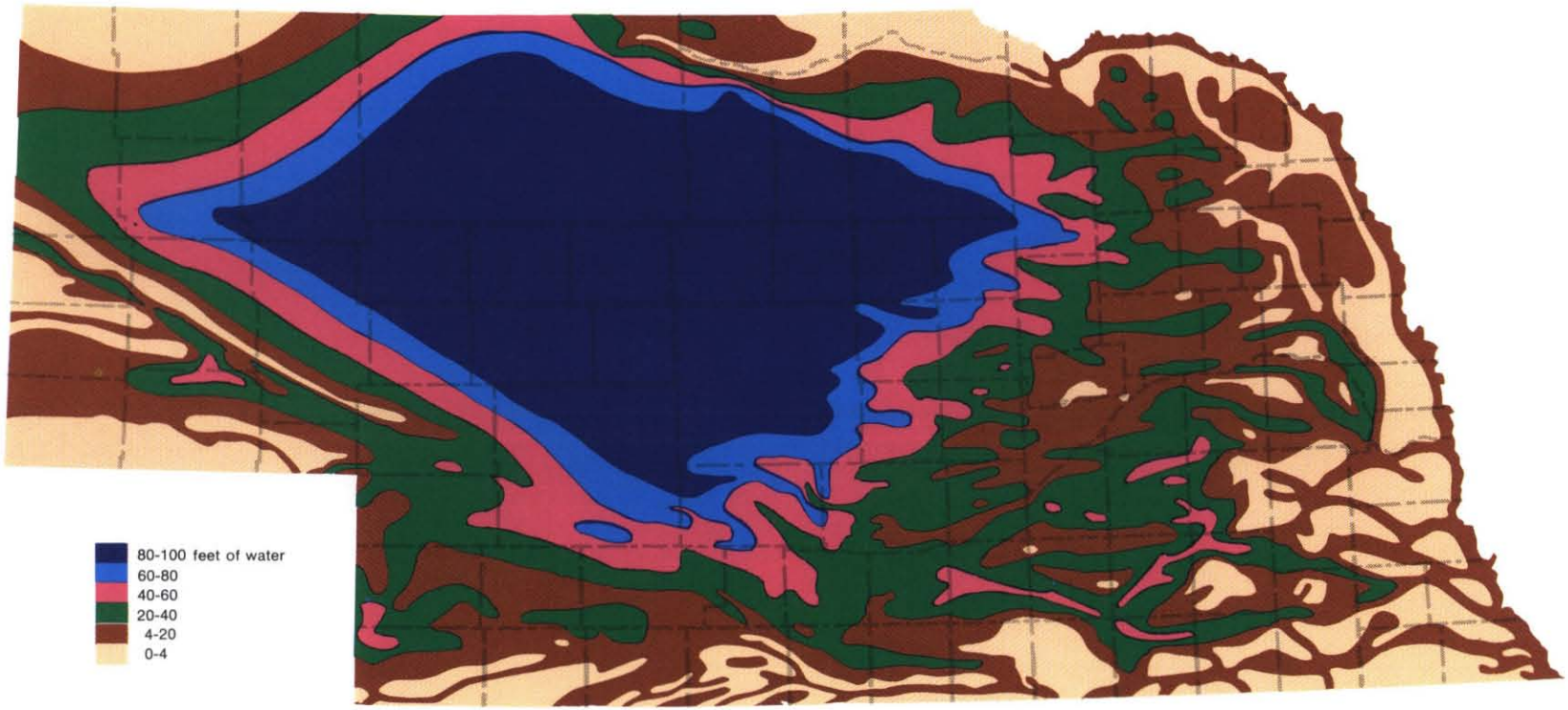
In the easternmost parts of Nebraska these older formations were exposed to weathering for long periods of time. This process enlarged cracks and fractures and developed solution openings which increase the yield of water to wells. In many cases this source is being used for domestic and municipal supplies.

Weathered limestones provide local sources of fresh water in places in the southeastern part of the State. While some sandstone formations are also potential small scale aquifers, the water is of undetermined quality and is probably very highly mineralized.

The dolomite and sandstone formations yield fair quality water in the Omaha area, but in other areas yield water which varies in quality.

The amount of ground water estimated to be stored in permeable materials at reasonable depths is shown in Figure 17. This does not include water stored in the older bedrock formations which may

FIG. 17 / GROUND WATER IN STORAGE



NOTE: A storage coefficient of 0.20 was assumed for volume estimates. Each foot of water represents 5 feet of permeable water-bearing material composed of Pleistocene, Pliocene and Miocene deposits of the principal reservoir

Source: Conservation and Survey Division, University of Nebraska

be of low quality, nor does it include water stored in the finer textured materials interbedded with more permeable materials. The Figure shows the amount of water which could be recovered presuming that the aquifer will yield two-tenths of a foot of water for each foot of thickness.

Figure 18 gives an indication of the quality of the ground water found at comparatively shallow depths. Ground water in the deeper parts of the reservoir probably contains more total dissolved solids than indicated, but little information is available on the actual composition of water below 400 feet in depth.

Ground water occurring at comparatively shallow depths is generally of good quality but is moderately hard. Bacteriological contamination occurs only in very localized situations, generally from improper waste disposal. Physical properties of ground water are generally good. There is no turbidity under usual conditions and the temperature of the water from the principal aquifers is generally about 55°F.

Chemical quality of the ground water is related to the amount and quality of recharge water and the nature of the materials through which it moves and is stored.

Ground water of poor quality occurs at shallow depths in some western Nebraska valleys. This is due in part to the high concentrations of dissolved solids in the streams resulting from the irrigation of lands upstream, and to the further concentration of these dissolved solids by evapotranspiration after this water percolates into the local ground water reservoir.

In the central sandhills area, ground water quality is very good with total dissolved solids concentrations less than 170 mg/l. Concentrations in the remainder of the State range between 170 and 700 mg/l with the exception of the extreme northwest, northeast, and southeast corners where total dissolved solids concentrations are more than 700 mg/l in many areas. Water with chemical concentrations in this middle range is generally satisfactory for most beneficial uses with little or no treatment.

Throughout most of Nebraska the water table remains at a relatively constant level and fluctuates mostly with precipitation. There are some areas, however, where the water table has changed consistently over a period of years. Areas where the rise or decline has been five feet or more during the period of observation are shown on Figure 19.

The extent of the decline in the ground water table has become significant in four areas of the State. Generally, in each area, the amount of water withdrawn for irrigation exceeds the salvage of natural discharge and the recharge from precipitation, so pumping for irrigation results in a reduction of water in storage.

The largest of the four areas is located in the Big and Little Blue River Basins and extends through parts of Adams, Clay, Fillmore, Thayer, Saline, Hamilton, York, Seward, Polk, and Butler Counties. The amount of recharge through precipitation in this area is less than the amount withdrawn, and because of the geologic and hydrologic conditions, part of the irrigation water pumped is being taken from stored ground water.

Another area where the decline has been consistent occurs along the northern edge of the Platte Valley in Dawson, Buffalo, and Hall Counties.

Here many irrigation wells are concentrated on the valley terraces, and large quantities of water have been pumped. The decline of water levels has been limited in most areas, however, because the depth to static water levels is generally less than 30 feet and in some areas is less than 15 feet. Therefore, a large part of the water withdrawn has been salavaged from what would ordinarily escape from the ground water reservoir by natural means.

The greatest declines have occurred on terraces to the north of the river where the depth to water is greater and the water bearing materials are thin.

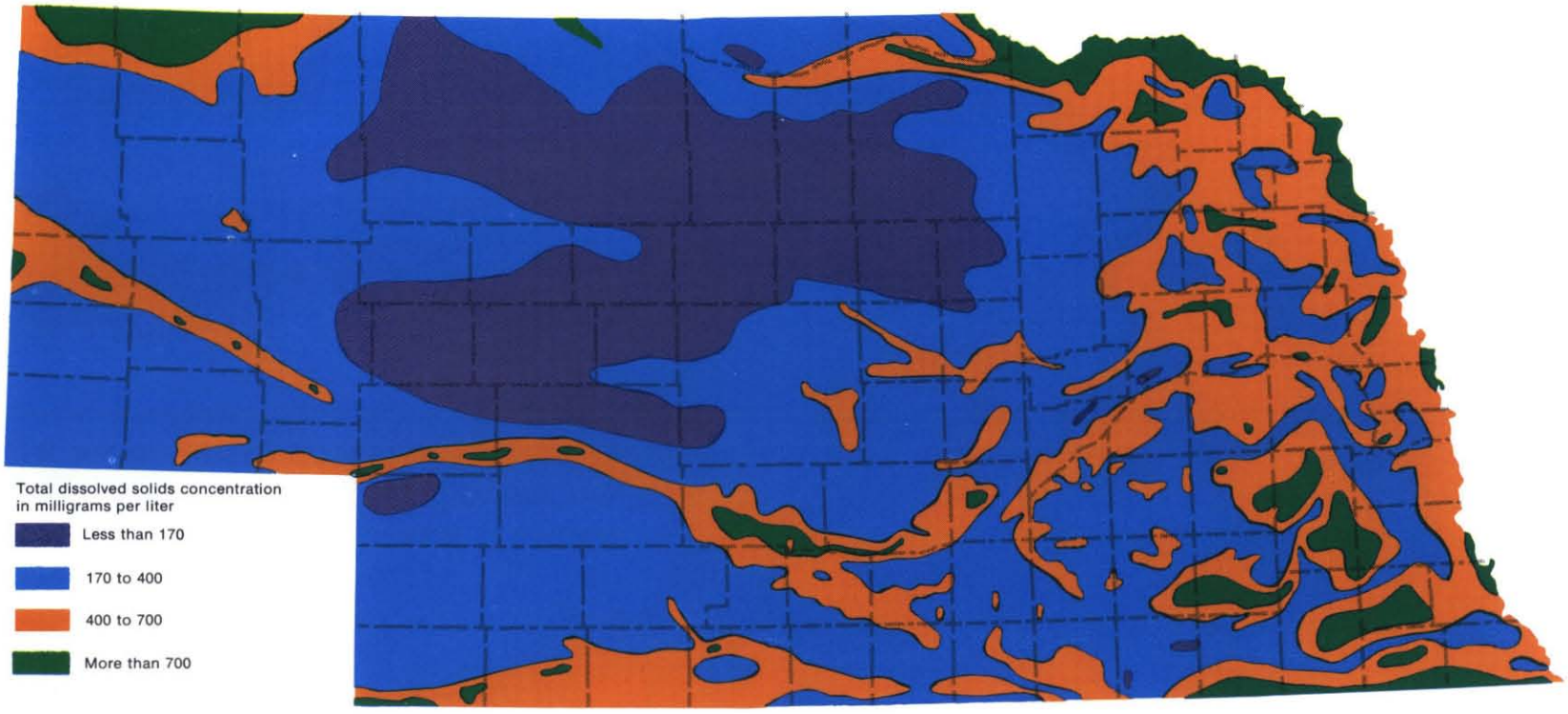
An area around Alliance in southeastern Box Butte County has experienced the largest water table decline. A hydrograph of the water level in a well in this area is shown in Figure 20. In some places the water table has lowered 40 feet since observations began in 1946. There is very little recharge to ground water in this area, so nearly all water pumped comes from storage.

A small area in Holt County has also experienced a decline of 10 to 15 feet in recent years. Conditions causing the decline here are similar to those in Box Butte County.

One area in the State is experiencing a rise in the water table. The area covers parts of Dawson, Frontier, Gosper, Phelps, and Kearney Counties. A hydrograph of a well located in Kearney County is also shown in Figure 20 contrasting the two trends cited.

The rise in the water table in this area began after introduction of surface irrigation water by the Central Nebraska Public Power and Irrigation District in 1941. Canal seepage and some excess irrigation water percolate into the ground water reservoir and, due to its slow lateral movement, only small amounts leave the area. Reservoir storage has therefore increased rapidly.

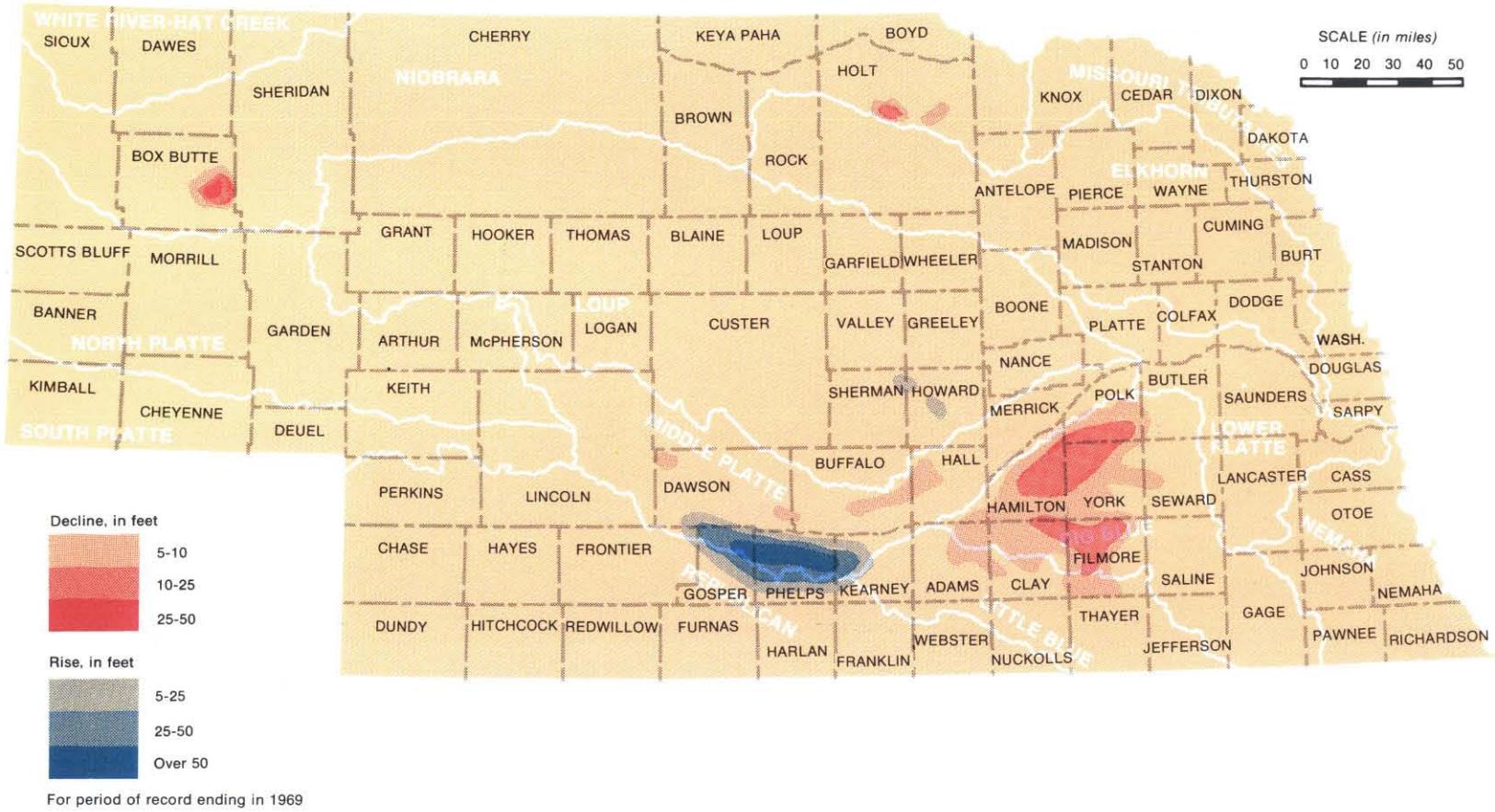
FIG. 18 / GROUND WATER QUALITY



NOTE: Samples taken from wells generally less than 400 feet deep

Source: U.S. Geological Survey,
College of Agriculture, U. of N.,
Conservation and Survey Division, U. of N.,
Nebraska Department of Health

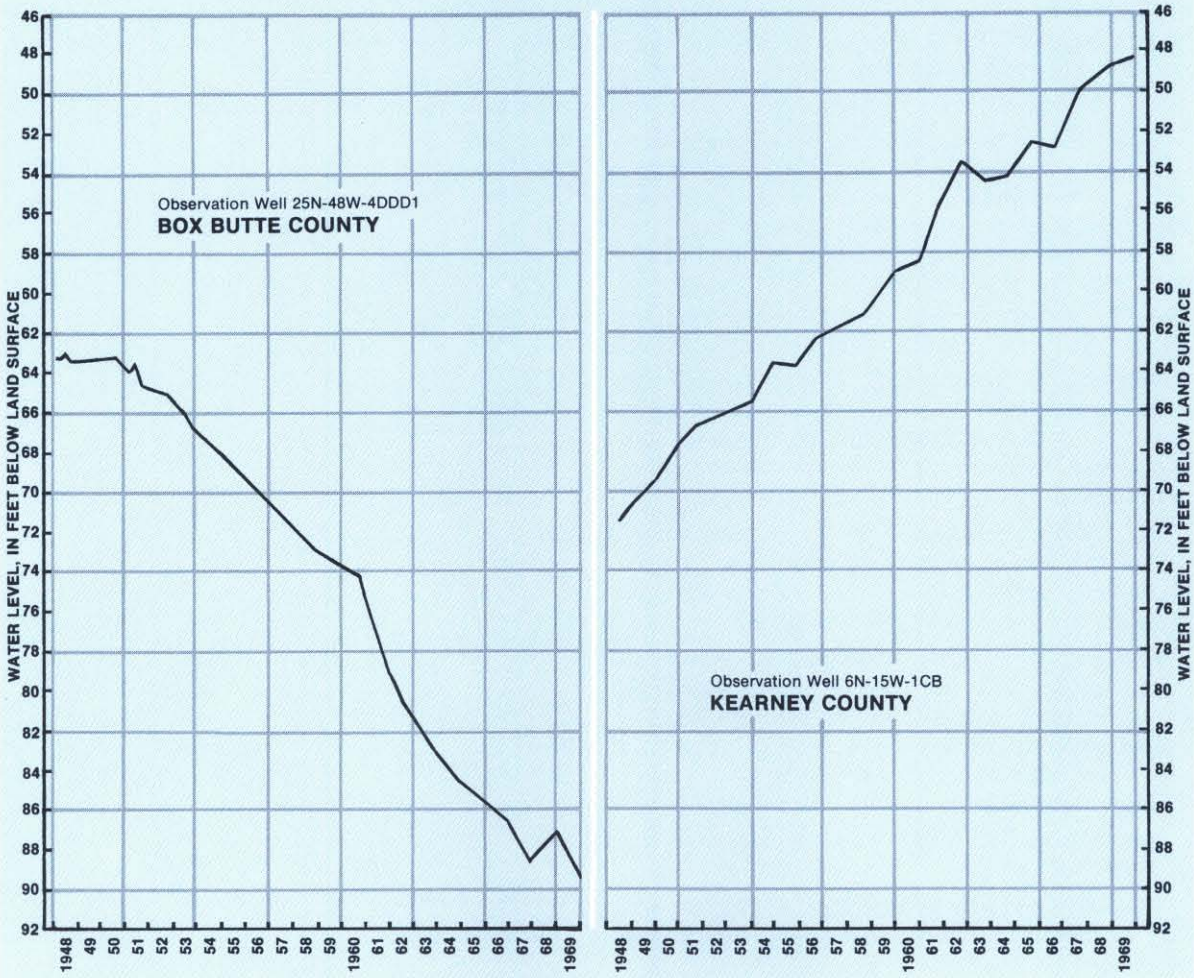
FIG. 19 / AREAS WHERE GROUND WATER LEVELS HAVE CHANGED CONSISTENTLY



For period of record ending in 1969

Source: Conservation and Survey Division, U. of N.

FIG. 20 / WELL HYDROGRAPHS



Source: Conservation and Survey Division, University of Nebraska

In some areas of Phelps and Gosper Counties, the water table has risen as much as 70 feet since 1945. There are reports of 90-foot increases since intensive irrigation was introduced. Many low areas are becoming waterlogged where the water table is now at or near the ground surface during wet periods.

THE MINERAL RESOURCE

Presently Nebraska produces only six of the more than 80 minerals on the industrial trade market. These are clay, gas, oil, sand and gravel, limestone, and volcanic ash. In the past, the State also produced coal, potash, and salt, but production of these minerals is no longer economical.

The dollar value of nonmetallic mineral production in Nebraska is significant to the state's economy. An estimated $74.8 million was realized from production in the State during 1968.

Metallic minerals, such as lead, zinc, iron, and gold are sometimes found in small amounts within the State in various geologic formations, but these resources are not suitable for commercial production under present conditions.

Oil and Natural Gas. The State of Nebraska so wanted the oil industry that in the 1930's a bonus of $15,000 was offered for the first oil-producing well in the State. In 1939 the first producing well was drilled in Richardson County. In 1949, the Nebraska oil industry was bolstered by the discovery of oil in Cheyenne County. Oil was first produced in the McCook area in 1959.

In recent years, the secondary recovery of oil by water injection has formed a prominent part of the total oil production in the State. In 1968, over 13 million barrels of crude oil worth nearly 37 million dollars and about 8.5 million cubic feet of natural gas worth about 1.5 million dollars were produced in Nebraska.

Sand and Gravel. Nebraska's thick deposits of sand and gravel are widely distributed, principally along streams and their flood plains. This resource has substantial economic importance. The value of 1968 production was about 13 million dollars. Sand and gravel are used mainly in highway construction and concrete manufacturing. Other uses include fillers, railroad ballast, and industrial sands.

Stone. Only limestone is quarried to any large extent in Nebraska. It exists under almost all of the State, but it lies at considerable depth everywhere except in the eastcentral and southeastern portion of the State.

Generally, the limestone produced in Nebraska is used for concrete aggregate, roadstone, cement production, riprap, agricultural lime, wallstone, and as a filler in various other products.

A limestone known as "native lime" occurs in the upper layers of bedrock at a number of places in northcentral Nebraska. It has been quarried in considerable quantities near Scotia for use in chemical manufacturing and to some extent for local building material.

About 7.5 million dollars worth of stone was produced in 1968.

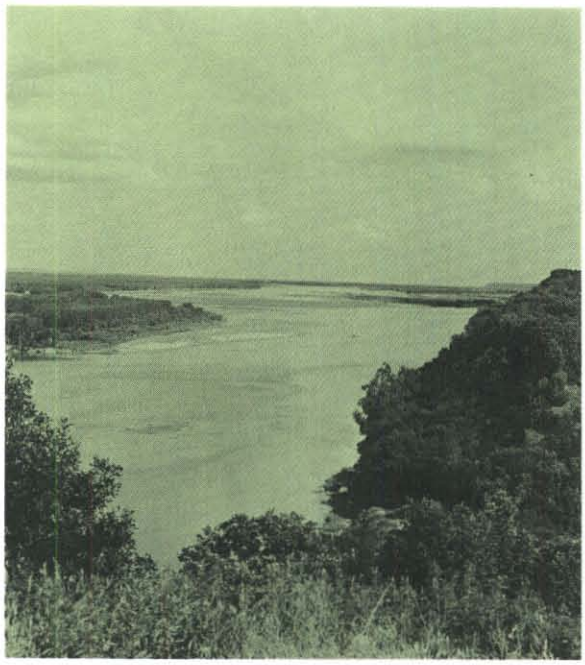
Clay. Clays, found in all geological formations, have a wider distribution than most other economic minerals. Clay is used for a variety of products—brick, tile, cement, light-weight aggregate, and pottery. Most of the clay is mined from open pits in the eastern part of the State.

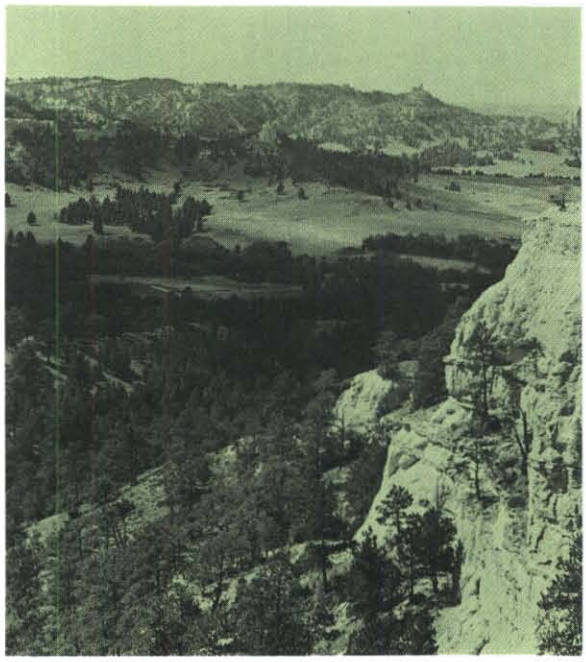
Volcanic Ash. This light grayish colored material, used primarily as a scouring agent in cleansers, occurs quite widely in Nebraska in beds varying in thickness from a few inches to 18 feet or more. Once this mineral was produced commercially in Harlan and Frontier Counties, but production is now limited to one plant located at Callaway which operates only periodically.

THE TIMBER RESOURCE

The timber resources of Nebraska are very limited. Less than three percent of the State is covered with natural timber. Bottomland hardwood types including cottonwood, elm, ash, and oak located in the eastern and central portion of the State comprise about one-half of the timber resource. The remaining half is the ponderosa pine type in the western portion of the State. The best trees of the more desirable species have been taken for fuel, fence posts, building material, and furniture, leaving present forests and woodlands made up largely of defective trees and low value species.

Nevertheless, in 1968 there were about 60 sawmills in the State producing mostly rough lumber and pallet stock. In addition, there are over 80 growers raising more than a quarter of a million Christmas trees for wholesale and retail markets.





FISH AND WILDLIFE RESOURCES

Nebraska provides excellent habitat for many species of wildlife. Because of its geographical location, many factors, including the change in elevation from the lowlands of the east to the highlands of the southwestern panhandle and the change in average annual precipitation from over 30 inches to less than 20 inches, combine to produce this habitat. In Nebraska, the deciduous forests and fertile, tall grass prairies of the east gradually change to the coniferous forests and mixed and short grass prairies of the west.

This provides a wide range of habitat for a variety of fish and wildlife species. Thus, substantial numbers of various species flourish in this setting provided their ecosystems are not disrupted by either nature or man.

Waterways and adjacent lands are particularly valuable habitat for fish and wildlife. Stream reaches which have especially high significance for fish, wildlife, and outdoor recreation are shown on Figure 21.

Wildlife. Among the species sustained by the varied habitat in the State are such small game animals as rabbits and squirrels. Big game species include deer, both whitetail and mule deer, and

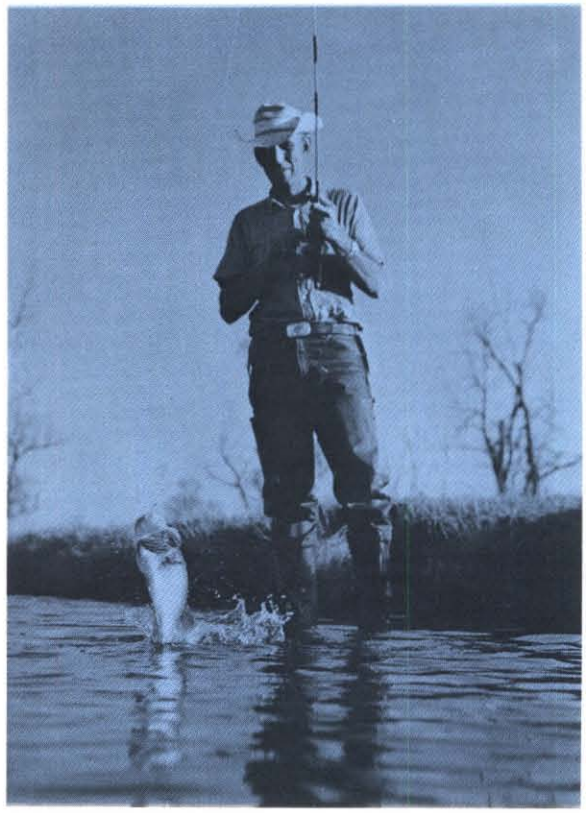
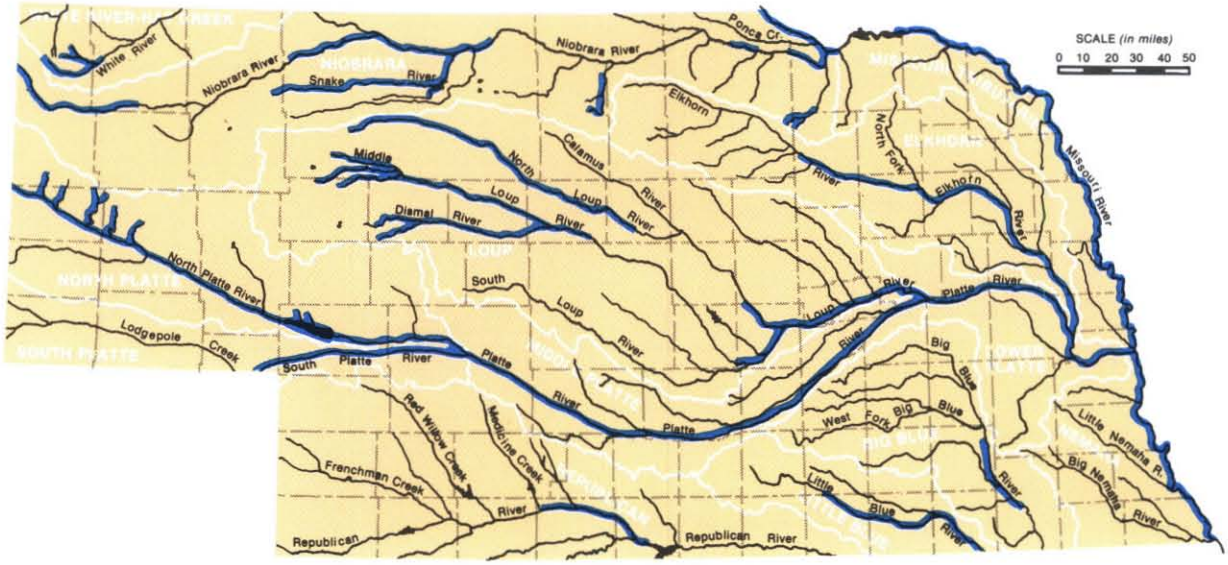


FIG. 21 / STREAM REACHES WITH SPECIAL SIGNIFICANCE FOR FISH, WILDLIFE, AND OUTDOOR RECREATION



Source: Nebraska Game and Parks Commission

antelope. Upland game birds include pheasants, quail, grouse, and turkey, and waterfowl nesting or migrating through Nebraska every year. Fur bearing animals such as muskrat, beaver, mink, and raccoon are trapped, along with a number of less popular fur bearing species.

In addition to the major, well known species of fish and wildlife, 326 species of birds and 66 species of mammals, classed as non-game species, are found in the State. These animals are an important part of the state's total resources because their presence contributes to the total environment of the State.

Fish. In Nebraska, reservoirs, natural lakes, streams, farm ponds, and gravel pits all contribute to the sport fishery. Streams primarily support a warm water fishery.

The waters of the State produce bass, pike, catfish, crappies, bullheads, perch, bluegills, and carp to fishermen, and a variety of fish not commonly sought by sportsmen.

Trout fishing, a popular activity, is highly restricted in potential due to the state's scarcity of cold water streams.

Utilization of the Resource. Hunting and fishing are popular activities with Nebraskans. In recent years, about 225,000 fishermen have purchased permits in the State annually. Hunting permit sales have been more variable from year to year but generally total almost 200,000 annually.

The annual harvest of pheasants by about 150,000 resident hunters has exceeded one million roosters since 1958. Rabbits and squirrels are less sought after by sportsmen. The estimated annual cottontail harvest has varied between 366,000 and 647,000 from 1960 to 1968. However, rabbits and squirrels could sustain heavier hunting pressure.

The number of hunters, and often their success, generally varies with the game population. Waterfowl hunting has traditionally been popular, but the number of hunters declined from 64,100 in 1957 to a low of 18,100 in 1965. This sharp decline was caused by a reduced flyway population of ducks due to shrinkage of wetland habitat from drainage and recurrent droughts on the waterfowl breeding grounds. The decline in hunters also has been due to a general decline in pheasant numbers from the high levels in the mid-1950's.

The number of trappers does not compare with the number of hunters, but nearly 2,000 trappers took almost 97,000 pelts worth over $176,000 during the 1967-1968 season.

The People

In the final analysis, it is the people of the State who determine the course of its development. Natural resources make development possible, but it is the people who determine for what the resources will be used and how well they will be used. In fact, aside from essential natural resources, it is the character of the people, their ambition, energy, and ingenuity, which determines if an area is to grow and prosper, or stagnate.

The pioneers who settled Nebraska were of hardy stock. They carved homes and farms out of a vast, hostile prairie, and survived countless hardships and setbacks to create the social and economic foundation upon which Nebraska is built. Their very character has been one of the most important contributions to Nebraska's growth.

POPULATION GROWTH

Nebraska's population growth rate has been erractic. It started slowly, gained momentum, grew fastest before the turn of the century and then slowed again. Figure 22 shows the population growth since the first census was taken in 1854; the population distribution between rural and urban areas; and projections of future population and distribution.

Even though settlement began before Nebraska became a territory in 1854, it was not significant until after the Civil War and statehood in 1867. Between 1840 and 1866, an estimated two and one-half million migrants traveled westward over the several trails across the State, but only a very few settled.

The importance of transportation systems, particularly the railroads, to the settlement of the area was recognized by the state and federal grovernments. They granted railroad companies over 8 million acres of land as an incentive to build systems in Nebraska. To sell this land and build a market for their services, railroads encouraged settlement through cash bonuses offered to Easterners and steerage fares offered to Europeans willing to resettle on the Plains.

By 1890, the initial settlement of agricultural land in the State was nearly complete and the periods of rapid population growth were over.

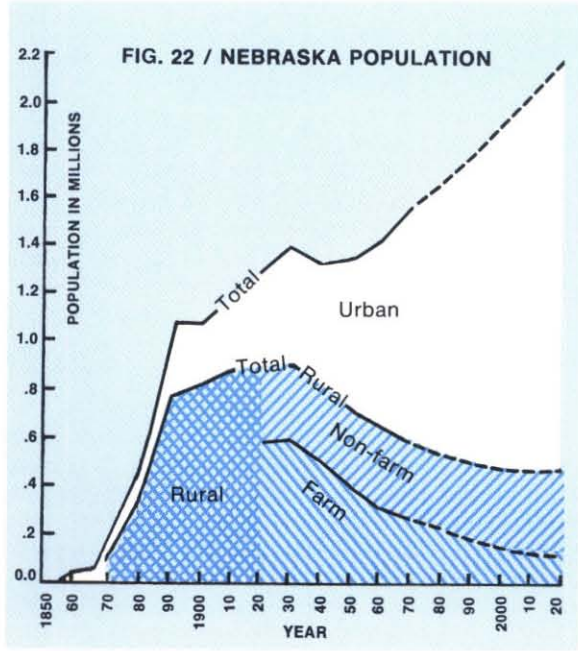
Growth was fairly steady until drought and depression in the 1930's brought severe hardships and forced many farmers from the land. The population continued to decline until the economy turned upward during World War II. Since then, the total population of the State has been growing slowly, even though the farm population has continued to decline.

Nebraska's population growth rate has been much slower than the national or regional growth rates. Nebraska's total population increased by about 7 percent from 1940 to 1960, compared to approximately 17 percent for the Missouri River Basin and 36 percent for the nation as a whole. Nearly 75 percent of the increase in the Missouri River Basin was concentrated around Denver and Kansas City. The population of the remainder of the Basin grew only 5 percent.

The population density in Nebraska is about 19 persons per square mile compared to 65 for the continental area of the United States and approximately 15 for the Missouri River Basin.

Projections of Nebraska's future population were one of the factors used in estimating future water needs for this study. Population projections for 1980, 2000 and 2020, based on the continuation of present trends, were developed by the Bureau of Business Research of the University of Nebraska at the request of the Commission. The Planning and Development Regions (PDR) outlined by the Nebraska Department of Economic Development were used as the geographical basis for these projections.

The technique used in arriving at these projections was purely statistical. Three methods were used for each area and one projection was selected on the basis of statistical tests. The total state population was not broken down by the Bureau of Business Research into any of the conventional



sectors such as urban, rural or farm, but merely presented to the Commission as one total for each time period. The resulting totals for 1980, 2000 and 2020 were 1,610,000; 1,850,000; and 2,150,000.

These state totals were then broken down by sector and by areas and municipalities for the Framework Study, based largely upon historical trends, especially the more recent trends, and technical judgment.

POPULATION DISTRIBUTION

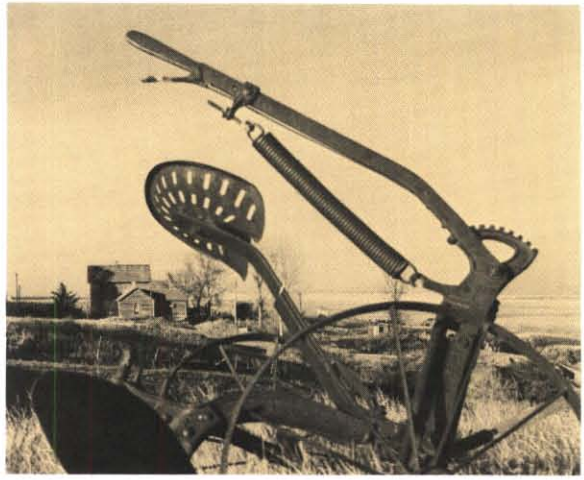
Throughout Nebraska's history, agriculture has been the main source of livelihood for the people of the State and region. Even though agriculture remains the basis of the state's economy, significant changes have taken place since 1900. In particular, the labor requirements of agriculture have declined, and Nebraska's population, like that of the rest of the nation, is rapidly changing from rural to urban. In 1900, less than 25 percent of the state's population lived in urban areas with a population over 2,500. Today, urban population accounts for about 60 percent of the total.

The character of the state's population is a significant factor in the differential rates of population growth between Nebraska and the nation. Nebraska's population has been highly oriented to agriculture and, almost without exception, rural areas of the United States have suffered losses in population. Table 9 compares the growth rates of the urban, rural, and rural non-farm sectors of the population of Nebraska and the nation since 1900 and 1940.

TABLE 9 / COMPARISON OF NEBRASKA AND U.S. POPULATION GROWTH RATES

	Percentage Change			
	1900 - 1960		1940 - 1960	
Sector	Nebr.	U.S.	Nebr.	U.S.
Urban	+202	+274	+50	+51
Rural Non-Farm	+ 38	+186	+10	+89
Rural Farm	− 48	− 45	−40	−50
TOTAL POPULATION	**+ 32**	**+136**	**+ 7**	**+36**

This table indicates that the growth rates of urban population in Nebraska and the entire United States have been similar, particularly since 1940. Further, the national and state rural farm populations have both declined during these periods. The changes in the rural non-farm sectors have been significantly different, however, accounting for much of the difference in total population growths. In part, this is because large unincorporated suburban areas have developed in many parts of the United States, but not in Nebraska.



These comparisons show that the decline in rural farm population in Nebraska has been greater than the national average from 1900 to 1960, but significantly less than the national figure during the last 20 years of that period. This indicates that losses in Nebraska were much greater prior to the Second World War and the rate of decline has since decreased in this State while it was still increasing in the rest of the nation. If these trends continue, the future rate of growth of the total population of the State could be substantially greater than it was from 1940 to 1960.

The distribution of population in the State with respect to age and area is relatively unbalanced. Less than 15 percent of the population lives in the western half of the State, while nearly 50 percent of the population lives within a 50 mile radius of Omaha.

One of the significant characteristics of the population of an area, beyond numbers, is the age of the people. On the average, Nebraska's residents are older than the national or regional populations. The median age of the Nebraska population is over 30, compared to just under 28 for the United States. Estimates for 1968 indicate that 12.3 percent of Nebraska's population is 65 years of age and over, compared to 9.6 percent for the United States. Only Iowa and Florida have a higher percentage of their population in this age category. The net out-migration of nearly 700,000 residents since 1900, many of them from the younger age groups of the labor force, has been the prime contributor to the imbalance in age distribution. The migration of the younger rural people has tended to concentrate rural land and wealth in the hands of older people.

Development of the Economy

When Nebraska became a state, most of the people in the country were farmers and ranchers. Most of the pioneers came to this State because of its agricultural land, and Nebraska's economy has been largely based on agriculture ever since. No resource is as abundant in Nebraska as the land resource, and the water resource has generally been sufficient to utilize the land for crops.

ECONOMIC HISTORY

The Territory of Nebraska was organized in 1854, but it was not until the depression of 1857 had ended the speculators' dreams of easy riches that agricultural development began in earnest. Agricultural development was stimulated by the Homestead Act of 1862, but distant markets and insufficient transportation retarded its growth. Completion of the transcontinental railroad through Nebraska not only improved transportation, but the railroads themselves stimulated the development of agriculture by their efforts to sell and settle the lands they had been given.

State population and the number of farms grew fastest between 1867 and the drought of the 1890's. This severe drought caused the failure and consequently the emigration of many farmers who had not learned the techniques of farming the relatively arid prairie. Those who remained learned how to survive and some even prospered under such adverse conditions.

The application of supplemental water to hay and crop land began almost as early as settlement. By 1860 four miles of canals had been constructed near North Platte to divert streamflow for irrigation. Since then there has been a continual growth of irrigation, with periods of rapid expansion during each drought.

The drought in the 1890's and the enaction of a water rights filing system in 1895 particularly stimulated filings for rights to divert surface water. The normal streamflows during the irrigation season in western Nebraska became greatly overappropriated. A number of projects developed during this period had to be abandoned soon after construction due to lack of a dependable water supply.

Irrigation development was accelerated by enactment of the Federal Reclamation Act in 1902. This authorized the development of projects to supply water to government lands being opened for settlement, and to private lands. The North Platte Project, which included the construction of the Pathfinder Dam and canals to irrigate lands in eastern Wyoming and western Nebraska, was one of the early projects.

About 1910 farmers began using ground water for irrigation. With the mass production of the internal combustion engine, tractors were available to power low head centrifugal pumps. At first, irrigation by wells was limited to valley lands which had water bearing gravels at shallow depths.

Irrigation developed gradually until the major drought in the 1930's intensified the need for irrigation. Reservoir storage project proposals made as early as the turn of the century were revised and funded. Enactment of the Nebraska Public Power and Irrigation District Law in 1933 assisted this development, and resulted in the construction of several projects to irrigate lands in central Nebraska.

Development of the turbine pump made irrigation from deep wells possible and irrigation spread to the tablelands of western and central Nebraska. The first major increase in well development came in 1940 when about 1500 wells were installed. The drought of the mid-1950's brought another surge which peaked in 1955, when over 3000 wells were installed.

The introduction of irrigation technology and the development of new seeds, new management methods, and new machines started an agricultural revolution which is still affecting the economy of Nebraska. Capital in the form of machines replaced the labor of men on the farm, forcing people from the farm to the city. More people were required to build the machines and provide supporting services than to produce the crops, so jobs were created in urban areas, providing additional impetus to the shift from rural to urban living.

PRESENT AND FUTURE DEVELOPMENT

Nebraska's economy is still based largely on agriculture. However, the nature of agriculture and the economy as a whole has changed, and will continue to change in the future. A look at the present state of the economy, and the balance between its various parts will help in understanding what can be expected in the future and how the economy relates to Nebraska's State Water Plan.

Industries. Agriculture and agri-business are still the state's major industry, but manufacturing, trade, and services are becoming an increasingly large part of the economy. Agriculture and manufacturing are the largest segments of the economy using water and land resources.

Total on-farm agricultural investment in Nebraska was estimated at nine billion dollars in 1966. Nearly two-thirds of this total was invested in real estate. The value of agricultural real estate has in-

creased by about 87 percent from 1958 to 1968, with the dollar value per acre in 1968 averaging $139.

While the total number of farms and ranches in the State declined from about 135,000 in 1934 to an estimated 74,000 in 1969, farm and ranch size has increased concurrently. In addition to larger units, operators have been able to increase per acre yields in recent years through the use of fertilizers, herbicides, insecticides, new seed varieties, irrigation, and other management techniques.

Irrigation has made it possible for producers to increase total production and limit yearly fluctuations in production. Improvement of irrigation equipment and management practices has made it possible for more farmers in various areas of the State to irrigate their land. At present, slightly over three and one-half million acres are developed for irrigation. This is only about one-sixth of the total cropland, but it accounts for about one-third of total crop production. Increased crop production from irrigated areas also contributes to increased and stabilized livestock production. Thus, the economic impact of irrigation is closely related to cash receipts from both livestock and crop sales.

Marketing is an integral and highly important part of the agricultural economy of the State. It includes the processing and the distribution of products to the farm and from the farm to the consumer.

Agricultural marketing has changed substantially in recent years. In some instances, companies have been structured so that all the various functions from production to retailing are internally controlled.

In addition, consumer incomes, tastes and preferences have changed, resulting in new marketing methods. Between 1947 and 1965, per capita income more than doubled in the United States while per capita food expenditures increased only 44 percent. At the same time, the farmer's and rancher's share of this total declined, because of increased marketing costs.

Various agricultural trends, such as larger units and increased productivity, are expected to continue in the future. Projections based on these trends indicate that average farm size will nearly double by 2020 while the number of farms will decrease by half. Gross agricultural income, in constant dollars, is expected to more than double by 2020, but at the same time agricultural employment is expected to be less than half of current levels.

If there are no major changes in crop acreages, estimates of future yields indicate that crop production in 2020 will be approximately double present production. Estimates of future yields from non-irrigated and irrigated lands indicate the state's agricultural production capability can be increased several times in the future by investments in improved and extended irrigation and application of improved management practices.

The importance of manufacturing in Nebraska's economy has steadily increased in the past 25 years. The number of people employed in manufacturing has increased while farm employment has decreased. Between 1958 and 1967 manufacturing employment increased 34 percent, and the value added to products by manufacturing increased by about 110 percent.

According to the 1963 *Census of Manufacturers,* the last census for which complete data is available, the value added by manufacturing in Nebraska was about three-quarters of a billion dollars. Preliminary figures from the 1967 census indicate that the value added by manufacturing had increased to 1.1 billion dollars in 1967.

In 1963 food products accounted for approximately 40 percent of all value added by manufacturing, and machinery and equipment accounted for another 20 percent. Between 1958 and 1963 the value added to food products increased 20 percent.

The total number of manufacturing establishments in the State has also grown steadily, from 1,553 in 1958 to 1,611 in 1963 and 1,676 in 1967. In 1963, about 70 percent of the establishments employed less than 20 persons, and only 7 percent employed more than 100 people. Between 1963 and 1967, however, the number of firms employing 20 or more increased 11 percent, while the total number of firms grew only 4 percent, indicating a trend toward larger establishments.

Manufacturing is largely concentrated in the populous eastern part of Nebraska. In 1963, four eastern counties, led by Douglas County, had 787 of the 1,611 establishments in the State. These concerns produced 534 million dollars, or 70 percent, of the three-quarters of a billion dollars added to the value of products in the State that year. Seventy-two percent of the labor force employed in manufacturing worked in these four counties.

Because of the state's economic orientation to agriculture, many manufacturing plants have located here in order to process agricultural products or to manufacture supplies and equipment for the agricultural industry.

Nonagriculturally oriented manufacturing plants in Nebraska generally produce items which utilize relatively high amounts of labor and are not raw material or market oriented.

Unless technological advances create new products that require raw materials which are not in de-

mand at the present time, future expansion in manufacturing in Nebraska will probably be of the same type as existing industries. Since the raw materials which are most abundant and most capable of expansion are agricultural products, the future of manufacturing in Nebraska will undoubtedly continue to be allied with agriculture.

While recreation and tourism are primarily service industries, they also contribute to the state's total economy through the utilization of natural resources such as fish and wildlife.

The purchase of hunting permits, sporting arms, and ammunition by nonresident hunters to shoot wild game contributes to the state's economy through the use of a natural resource in the same manner as the sale of an agricultural product, such as a beef carcass, in the markets of Chicago or New York. Though payment is not made directly for the meat, substantial expenditures must be made to obtain it, and in some instances, a fee must be paid for the use of the land to hunt the wild game.

Unfortunately, very little data is available on the direct economic contribution of recreation and tourism; even less data is available on the indirect contribution to the state's economy.

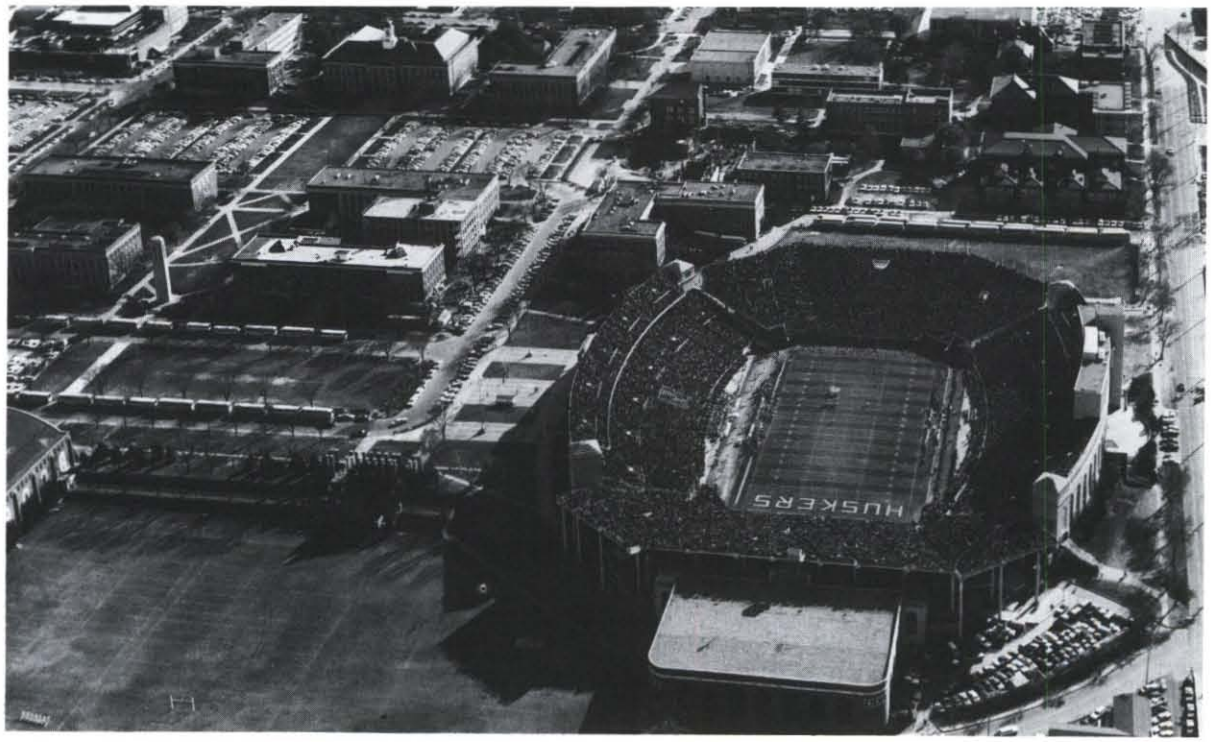
However, the value of tourism to Nebraska must be substantial. There are a number of attractions in Nebraska which draw large numbers of tourists annually. Several major transcontinental highways cross the State, carrying tourists and migrants who spend money in motels, restaurants, gas stations, and retail stores.

Estimates of the value of the tourist industry in this State, based on national figures, range up to 125 million dollars annually.

No figures are available on the total value of recreation to Nebraska, but several examples may be indicative of its magnitude.

Every year, crowds of over 65,000 (many from out of state) pay up to $6.00 per seat per game to watch the University of Nebraska's Cornhuskers play football. In addition to the price of tickets, money is spent on food, souvenirs, gasoline, rooms, and other incidentals. Add to this the value of other college, high school, and professional games played in all sports, and their economic impact seems obvious.

Recreational activities in which a person can participate also contribute to the economy. No data is available on the amount of money spent on bowling, roller skating, golfing, or camping, but some information has been collected on hunting and fishing. According to the 1965 National Survey of Fishing and Hunting, expenditures for these sports are very large. Hunters and fishermen spend money on food, rooms, bait, guns, and a wide variety of other equipment and services. The 1965 data show average annual expenditures of fishermen as about $103 and hunters nearly $83.



One example of the economic impact of recreation is the number of hunting and fishing permits sold and their value. In 1969, the value of permits sold to residents was over 1.5 million dollars, and nonresidents purchased just over one-half million dollars worth of permits. In addition, the Nebraska Game and Parks Commission collected nearly $150,000 through the sale of upland game stamps.

These examples represent only a small fraction of the value of recreation to the state's economy because definitive information is incomplete, and only a thorough study of the industry would reveal the real magnitude.

Other resource oriented industries make up only a small part of Nebraska's economy. For example, only 0.3 percent of the labor force is employed in mining and 3.7 percent employed in construction.

Services such as transportation, trade, finance, and government employ about half the labor force.

Employment. The 1969 civilian labor force in Nebraska was estimated at about 660,000—an increase of about 25,000 workers, or four percent, from 1960.

Although this is a modest change in numbers, the composition of the work force has changed significantly. Manufacturing employment in Nebraska has increased from 67,000 in 1960 to about 86,000 in 1969. With the exception of the services industry, employment in manufacturing has increased more percentage wise since 1960 than any other industry in Nebraska.

Table 10 presents average annual manufacturing employment by industry group for 1965 and 1969. With the exception of construction materials, all categories of durable goods have shown a significant increase in employment. The food products industry showed no change from 1965 to 1969.

Omaha still accounts for about 40 percent of all manufacturing employment even though employment has increased only slightly since 1960. Lincoln is second in manufacturing employment, and Grand Island, Columbus, and Fremont follow in that order.

The percentage of total employment engaged in manufacturing in Nebraska is presently about one-half the national percentage, but the percentage of agricultural employment in Nebraska is at least triple the national figure. Comparisons between the Missouri River Basin Region and the nation show similar relationships.

The most striking change in employment has been the decrease of about 50,000 agricultural em-

TABLE 10 / AVERAGE ANNUAL MANUFACTURING EMPLOYMENT

ITEM	1965 Employees	1965 %	1969 Employees	1969 %	% Change 1965-69
Manufacturing (Total)	69,000	100.0	86,000	100.0	24.6
Durable Goods	29,500	42.7	45,200	52.6	53.2
Construction Material	3,500	5.1	3,800	4.4	8.6
Furniture & Fixtures	1,400	2.0	1,700	2.0	21.4
Metals	5,600	8.1	8,100	9.4	44.6
Machinery & Equipment	15,400	22.3	22,800	26.5	48.1
Other Durable Goods	3,600	5.2	8,800	10.3	144.4
Nondurable Goods	39,500	57.3	40,800	47.4	3.3
Food Products	26,400	38.3	25,900	30.1	−1.9
Meat	12,100	17.5	11,100	12.9	−8.3
Dairy	3,100	4.5	2,900	3.3	−6.5
Grain mill	3,600	5.2	4,200	4.9	16.7
Bakery	1,900	2.8	1,700	2.0	−10.5
Other Food	5,700	8.3	6,000	7.0	5.3
Textile Products & Apparel	1,900	2.8	1,900	2.2	−0−
Paper & Allied Prod.	1,000	1.4	1,300	1.5	30.0
Printing & Publishing	5,900	8.6	6,300	7.3	6.8
Chemicals	2,300	3.3	2,400	2.8	4.3
Petroleum, Rubber and Leather	2,000	2.9	3,000	3.5	50.0

Source of Data: Nebraska Department of Labor

TABLE 11 / SUMMARY OF EMPLOYMENT IN NEBRASKA

Employment Category	Average Annual Employment						Percent Change	
	1960		1965		1969			
	Number	Percent	Number	Percent	Number	Percent	1960-1969	1965-1969
Agriculture	160,000	25.9	127,300	20.8	107,600	16.7	−32.7	−15.5
Manufacturing	66,800	10.8	69,000	11.3	86,000	13.4	28.7	24.6
Mining	2,700	0.4	1,900	0.3	1,700	0.3	−37.0	−10.5
Construction	24,400	3.9	23,700	3.9	25,500	4.0	4.5	7.6
Transportation, Communication & Utilities	37,700	6.1	36,100	5.9	36,700	5.7	− 2.7	1.7
Trade	93,600	15.2	103,000	16.8	117,500	18.3	25.5	14.1
Finance, Insurance & Real Estate	22,600	3.7	25,500	4.2	28,000	4.4	23.9	9.8
Services	58,400	9.5	67,300	11.0	78,900	12.3	35.1	17.2
Government	79,500	12.9	89,300	14.6	96,900	15.1	21.9	8.5
Other	71,800	11.6	68,200	11.2	63,200	9.8	−12.0	− 7.3
STATE TOTAL EMPLOYMENT	**617,500**	**100.0**	**611,300**	**100.0**	**642,000**	**100.0**	**4.0**	**5.0**
STATE UNEMPLOYMENT a/	**17,200**		**19,500**		**14,600**		**−15.1**	**−25.1**
STATE TOTAL LABOR FORCE	**634,900**		**631,400**		**657,600**		**3.6**	**4.1**

a/ Does not include persons involved in labor-management disputes who are included in the total labor force

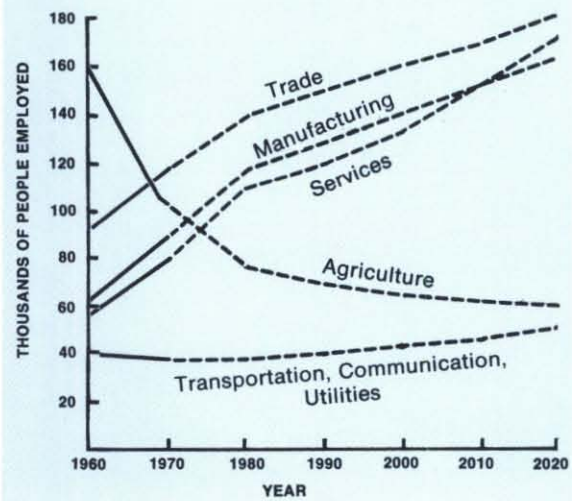
Source of Data: Nebraska Department of Labor

ployees since 1960. Even so, agriculture directly accounts for about 16 percent of the total employment in the State. In addition, agriculture indirectly results in significant amounts of additional employment through the sales of goods and services to agriculture, and the marketing and processing of agricultural products. It has been estimated that as much as 65 percent of Nebraska's employment is dependent on agriculture.

Table 11 shows agricultural employment has decreased by about one-third since 1960, but recent figures on agricultural employment indicate that the rate of decrease in this category has lessened in the last two years.

Employment projections for 1980, 2000 and 2020 were made for the same industries included in Table 11, assuming that the current rate of employment, 43 percent of the total population, would remain constant for each of the three time periods. On this basis, it is estimated that total employment in Nebraska will be 710,000 in 1980; 800,000 in 2000; and 920,000 in 2020. Anticipated employment trends for selected industries are shown in Figure 23.

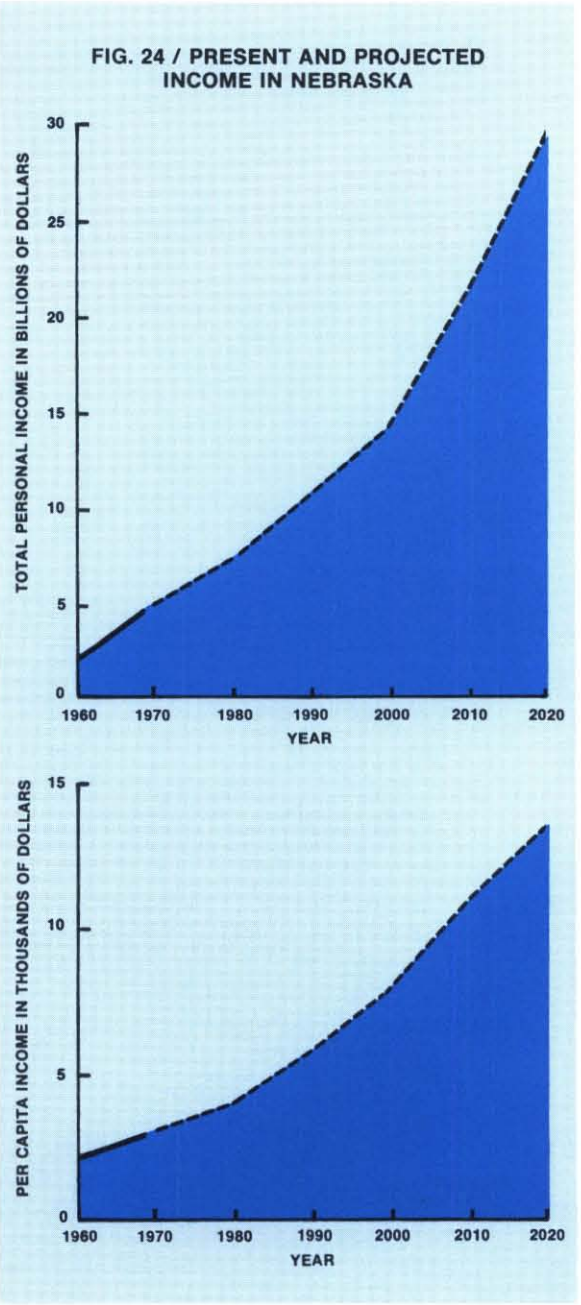
FIG. 23 / PRESENT AND PROJECTED EMPLOYMENT IN SELECTED INDUSTRIES IN NEBRASKA



Income. From 1948 to 1968, per capita personal income in Nebraska increased 112 percent, compared to gains of 125 percent in the Plains Region and 140 percent in the nation. Using this same period, the state total for personal income growth lagged further behind. This is attributed to the lower rate of population growth for the State, as compared to both the region and the nation. Nebraska's per capita personal income in 1968 was slightly higher than the average for the neighboring states within the Missouri River Basin, but below the national average.

Total personal income in the State has more than doubled in the past twenty years, from just under two billion dollars in 1948 to 4.6 billion dollars in 1968. During the same period, total personal income in the United States tripled.

Agricultural income has increased significantly in recent years. Although year to year fluctuations due to crop conditions and agricultural price changes occur, the average cash receipts per farm have tripled since 1950, from about $7,000 to over $20,000. In recent years, sales of livestock and livestock products have accounted for about two-thirds of total cash receipts from farm production, with crops accounting for the remaining one-third.

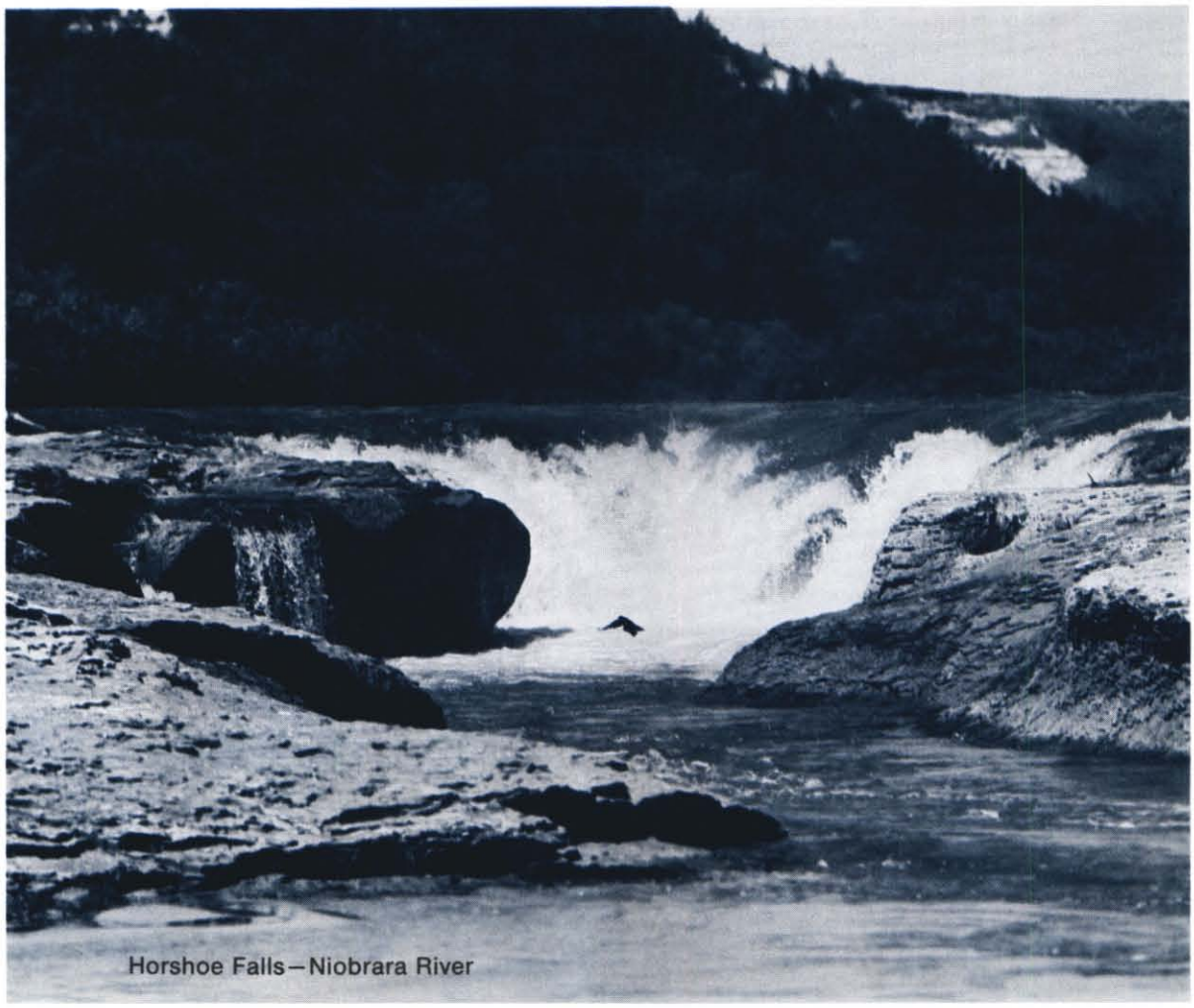


Projections of total personal income and per capita personal income for Nebraska are shown in Figure 24. The greater growth of total personal income reflects the anticipated growth of the state's population.

These projections of income, employment, and industrial growth indicate that the future of Nebraska's economic development will be largely dependent upon two basic resources—land and water. Expansion of the state's economy most likely will be a continuation of the present trends; agriculture will probably be the backbone of the future economy.

Crop production can be increased by irrigation, particularly in the central and western part of the State. Even in the east, where average annual precipitation is greater, supplemental irrigation can stabilize crop production. Land suited for irrigation is available, but development depends on the availability of water.

Rural employment is expected to continue its decline, while urban employment will continue to increase. With an expanding economy providing more leisure and the growth of the urban population, demand for all forms of recreation is expected to increase. Water based recreation and tourism are expected to become increasingly important segments of the economy.


Horshoe Falls—Niobrara River

Quality of Life and Environmental Relationships

A plan for resource development strives to improve the lives of the people dependent upon those resources. That is, the collective resources of a state must be employed so that the quality of each person's life is improved.

When a society economically progresses beyond subsistence level, the term "quality of life" assumes added dimensions. The existing economy and standard of living in Nebraska, as in the rest of this nation, provides much more than just food and shelter. Our economy provides necessities for nearly everyone, and items considered luxuries a generation ago have become commonplace, almost necessities. With the attainment of this standard of living, the number of working hours has declined and increased leisure has become available to more people, while the society in which they live has become more complex.

This complex society places increased stresses on the individual, making the available leisure and the amenities, physical and cultural, which it can provide, more important to the quality of life.

Our environment, that is, all that surrounds us, gives a society its material standard of living as well as these amenities. Air, land, water, plants, animals, and people, which have all been discussed previously as physical characteristics, natural resources, and human characteristics are also vital elements in our environment, essential to the quality of life to be enjoyed.

Clean air and pure drinking water are vital to survival; fresh water for industry and crops is essential to our economy; and physical amenities such as open space, natural beauty, scientific and historic cultural values, fish and wildlife do much to improve the quality of life.

ENVIRONMENTAL CONSIDERATIONS IN WATER RESOURCE DEVELOPMENT

Water is a resource and a vital element of the environment. A plan for water resources must first insure adequate supplies of domestic water. It must also add to the general security of society by reducing the threat of floods and by guarding against the pollution or contamination of drinking water and food supplies.

In Nebraska, development of water resources is essential to the development of the economy which has given the standard of living enjoyed today. Ground water has been developed to provide water for industry. Ground and surface water play an important role in irrigation and power generation and the Missouri River has been developed for navigation to improve commerce.

Further development in the future will be essential to maintaining and expanding the economy in order to further improve the quality of life, but it will be necessary to plan future projects so they do not pollute the resource and make it unsuitable for use by all segments of society.

Water resource development can also enhance the physical environment thus improving the life of each citizen. Reservoirs for the development of water resources provide open expanses of water for the enjoyment of many people. They also provide habitat for fish and wildlife, which are sources of pleasure to nature lovers as well as hunters and fishermen.

Nature's gifts are the first to be adversely affected by detrimental effects on the environment, and all projects must be planned to enhance the environment and minimize damage to it. Whenever possible, releases from reservoirs can be used to upgrade fish and wildlife habitat downstream, and eutrophication and pollution which ruin habitat and natural beauty must be held to the minimum in such projects.

SUMMARY OF ENVIRONMENTAL ASPECTS OF NEBRASKA'S RESOURCES

The resources included in this chapter are components of the total environment. The interaction and quality of these resources largely determine the quality of the environment, so their relationship to the environment must be included in a description of Nebraska.

Air and Climate. Nebraska's air is relatively clean —an important contributor to our present environmental quality. Dust is the only widespread pollutant, and other problems are local in extent, mainly confined to a few urban areas. The climate is temperate and the weather is variable, so there are four seasons which are not extreme in any way but provide a wide range of conditions. The weather and climate are conducive to the production of crops and the enjoyment of outdoor recreation.

Land. The land produces an abundance of crops to assure survival and provides a high standard of living as well. It also provides amenities to improve the quality of life. It provides scenes of natural beauty—mesas, buttes, and river bluffs, or rolling, wooded hills and scenic rivers and reservoirs; and open space for "elbow room" on broad expanses of prairies stretching as far as the eye can see.

The land also provides valuable assets to our culture in the geologic formations and the fossils they contain, which provide scientific knowledge and historic interest. The change in the land and the consequent change in plants and animals also provides unique variations of interest to scientist and amateur alike.

Nebraska also has many places that are legendary in the history of frontier settlement. This proud heritage, on which much of our culture is based, was provided by the hardy pioneers who settled the plains.

The waterways of the State played an important part in the settlement of the West. The Missouri River provided a route for exploration and later for trade and transportation of people and supplies. Two of the greatest overland routes for covered wagons, the Mormon Trail and the Oregon Trail, followed the Platte River, and the "Iron Horse" took the river route as it spanned the continent.

Water. In Nebraska, water is relatively clean and plentiful. Most of the State has plenty of good ground water suitable for drinking and large areas have sufficient ground water available to irrigate crops, which expands the economy of the area. Water also provides amenities to improve the environment such as open space, natural beauty, and recreation.

The lakes, reservoirs and streams in the State provide opportunities for boating, water skiing, and swimming. The quality of much of the surface water is suitable for body contact so water recreation can be enjoyed without concern for health.

The waters of the State also provide opportunities to enjoy forms of outdoor recreation which take place next to water. Most people enjoy hiking, picnicking, or nature study more when they can be near water. Many of the public recreation lands in Nebraska are located at reservoirs to provide opportunities for such day-use activities.

Among the most popular recreational activities in Nebraska are fishing and hunting, and the water resources of the State provide a number of opportunities for these pursuits.

The People. The social part of our environment is as important as the physical. The people of Nebraska have as much to do with the quality of their lives as the resources they employ.

The population of the State in 1970 was slightly less than 1.5 million. Since there are few barriers, such as mountains or deserts, to hinder residential development, Nebraska's 49.5 million acres are not over populated. The concentration of population in the eastern part of the State does make most of the surface water area, which is located in the central and western parts of the State, unavailable for everyday outdoor recreation, however.

Nebraska's population and its economy have long been oriented toward agriculture. Many of the people have an agricultural or rural background, but farm population has declined in recent years as urban population increases. Consequently, the younger generation is becoming increasingly more urban oriented.

As the urban population increases and more leisure time becomes available, amenities in the physical environment will probably become a more important consideration.

Chapter 3 / EXISTING WATER RESOURCES DEVELOPMENT AND PROBLEMS, FUTURE NEEDS AND OPPORTUNITIES

Plans for the the future are based upon existing development and tailored to solve existing problems, satisfy future needs, and take advantage of opportunities for additional development.

The purpose of the examination presented in this Chapter is to establish the existing base of development from which planning can proceed, identify areas of the State that have existing or evolving water and related land resource problems, and show where future problems, needs, and opportunities for development are likely to emerge.

Municipal and Industrial Water

Municipal and industrial (M&I) waters are often supplied from the same source and through the same system, but for discussion purposes the two use classifications are separated here as far as available information permits.

MUNICIPAL WATER SYSTEMS

Municipal water systems, including all forms of central water supply except rural water systems, provide water principally for household use; fire protection; street cleaning; irrigation of lawns, gardens, parks and golf courses; commercial establishments; processing; and manufacturing. Water used for processing and manufacturing, although an industrial use, is included as a municipal use when supplied from municipal systems.

Present Use. Nearly a million people, or about 70 percent of the state's population, received their water from municipal systems in 1960. Since 1960, population growth, rural-urban population shifts, and installation of central water supply systems have further increased the number of people served. Nebraska Department of Health records show that as of January 1, 1969, 463 cities, towns, and villages had central water supply systems.

All communities, except Omaha and Crawford, obtain all of their water from wells. In 1968, Omaha developed a well field near the Platte River to supplement its surface water supply from the Missouri River. Crawford still utilizes only surface water which it diverts from Dead Man Creek and from the White River.

Table 12 shows by river basin the 1963 annual use through municipal systems. Statewide use total nearly 184,000 acre-feet annually (afa), or an average of about 167 gallons per capita per day (gpcd). The amount of municipal per capita water use differs widely from a low of 40 gpcd to a high of 333 gpcd depending upon the amount of industrial water use, location within the State, availability of water, and other factors. Average per capita water use generally is greater in the larger communities.

Municipal water use is largely nonconsumptive in quantity. Much of the water is either returned to the water table or discharged to streams, but without proper treatment quality may be lowered to the point that it is unfit for other uses.

Future Requirements. Estimates of future municipal water requirements were based upon population projections through 2020 for each community in the State and upon estimated future per capita water use rates. The rates projected for future use varied according to the size of community and its location within the State as shown in Table 13. A continuation of present use rates was projected for communities where present use currently exceeds the future use rate estimates.

TABLE 12 / MUNICIPAL WATER REQUIREMENTS

River Basin	Present Use [a/] (afa)	Estimated Future Requirements [b/] (afa)		
		1980	2000	2020
White River - Hat Creek	1,580	2,500	2,700	3,100
Niobrara	4,400	6,200	6,300	6,300
Missouri Tributaries	72,000	176,700 [c/]	226,800 [c/]	278,900 [c/]
North Platte	9,400	16,000	18,500	20,500
South Platte	3,900	5,500	5,400	5,300
Middle Platte	13,200	27,600	33,000	38,200
Loup	5,800	10,300	10,700	10,800
Elkhorn	13,300	26,400	30,100	34,200
Lower Platte	26,830	57,600 [d/]	76,600 [d/]	99,200 [d/]
Republican	8,140	12,400	12,900	13,400
Little Blue	3,340	4,700	4,600	4,100
Big Blue	16,100	26,800	28,700	31,200
Nemaha	5,530	10,000	10,800	12,000
STATE TOTAL	**183,520**	**382,700**	**467,100**	**557,200**

a/ Based upon (1) normal usage data reported by 270 systems in 1963, and (2) 1960 populations and estimated future use rates (Table 13) for nonreporting systems. Present municipal use includes industrial use from municipal systems.
b/ Includes 80 gpcd allowance for future industrial use from municipal systems
c/ Includes Omaha metropolitan area requirements—(Douglas and Sarpy Cos.)
d/ Includes Lincoln metropolitan area requirements—(Lancaster County)

Water requirements of municipal systems, including an allowance of 80 gpcd for general industrial development, are expected to more than double by 1980 and triple to about 557,000 afa by 2020. The estimated future requirements are shown in Table 12. The large increase in the 1980 projected use over present use is caused by assuming installation of 16 additional central supply systems, adjusting use rates for present low users to the estimated future use rates, and an allowance for industrial use. The allowance for industrial use alone accounts for almost 30 percent of the projected withdrawal in 1980.

Problems and Needs. Detailed analysis of the ability of ground water aquifers to support the projected future requirements for each municipality is beyond the scope of the Framework Study. Only general studies were possible.

Water quality planning objectives were established by the NSWCC in cooperation with other state and federal agencies for use as a planning guide in the Framework Study to determine the suitability of ground and surface water supplies for various uses. These are not to be confused with the *Nebraska Water Quality Standards.* The planning objectives set criteria for judging raw water acceptibility as "desirable" or "usable" for domestic, including municipal; industrial; and irrigation purposes. These criteria are presented in Appendix C, *Needs and Problems.*

Ground water is generally plentiful across the State. Most future M & I water requirements can be met from present ground water sources by expanding and improving present well fields.

Some localized areas may have difficulty in locating sufficient quantities of water for their needs. General areas where problems are presently encountered are the following river basins: White River-Hat Creek, lower portion of the Niobrara, Missouri Tributaries, Nemaha, portions of the Lower Platte, and the southern portion of the Republican.

Most ground water in the State is of suitable quality for domestic use. Disinfection is generally the only treatment required.

TABLE 13 / ESTIMATED FUTURE MUNICIPAL WATER USE RATES
(1980, 2000, 2020)

People Served	Per Capita Water Requirements in gpd		Allowance for Industrial Use from Municipal Systems in gpcd
	East of PE Line*	West of PE Line*	
Under 2,500	80	120	80
2,500-10,000	125	150	80
Over 10,000	200	200	80

** Refers to precipitation effectiveness line which is located at about the 98° Meridian*

Tests of nearly a thousand wells in 400 communities show that samples in about 200 communities had one or more chemical impurities in concentrations higher than the planning objectives defined as "usable". This does not necessarily mean that all the supplies for a community have undesirable characteristics, since a number of wells may be supplying the sytem, and the wells may not all have the same characteristics.

Excess iron and manganese are the most prevalent chemical components that degrade the state's ground water below "usable" criteria for domestic purposes. This condition was found in 189 locations shown in Figure 25, mostly in the eastern one-third of the State. Although these chemicals usually produce no adverse physiological effects, they do give water an objectionable taste and stain water fixtures.

Excess sodium, sulphates, chlorides, and nitrates are found in some well samples from widely scattered locations. These may cause physiological distress in humans. Excess sodium was found in 30 communities (Figure 25), excess sulphates in nine communities, excess chlorides in two communities and excess nitrates in one community. Locating another source of supply is usually less costly than removing these chemical impurities.

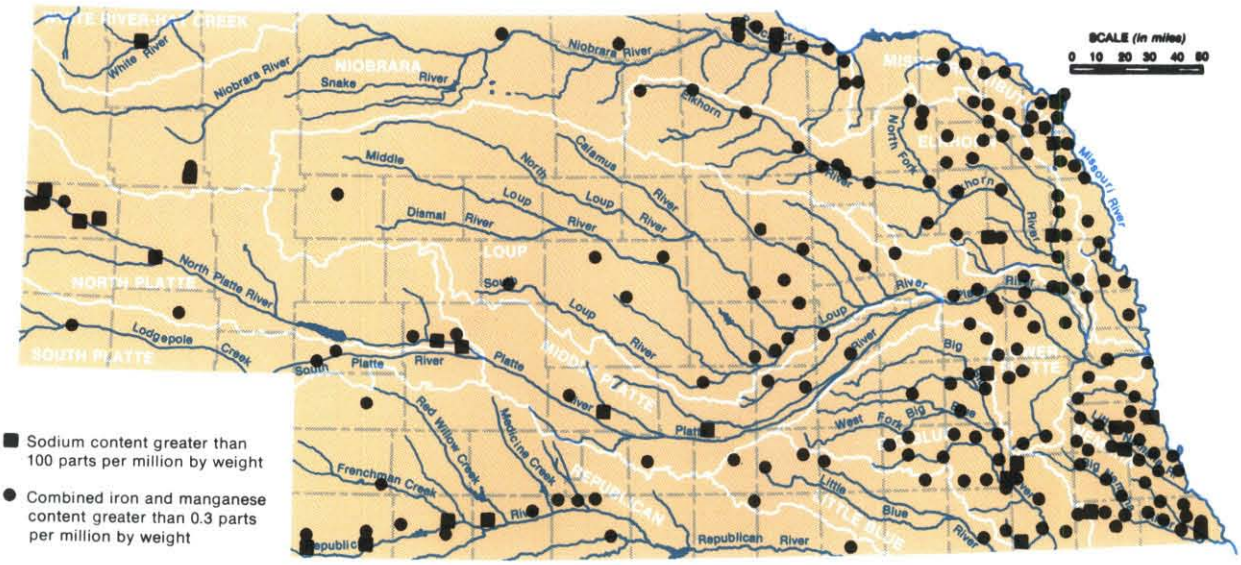
Most of these chemical impurities are introduced naturally, but some have been introduced by man. Additional treatment, especially the removal of iron and manganese and the reduction of hardness, would improve these supplies.

Ground water quality can be generally maintained at its present level. However, some local ground water supplies may become contaminated with disease causing organisms or excessive concentrations of chemicals, particularly where the water table is near the land surface or wells are near streams. Prevention of ground water contamination will be contingent upon the prudent use of fertilizers and pesticides, and the effective regulation of other sources of pollution, both natural and man-made.

Most municipal water pricing systems are based on a decreasing unit price as more water is used. If conservation of the water resources of the State is to be encouraged, then studies should be conducted to determine the effect of holding unit prices of water constant, or increasing unit prices of water for increasing use.

No locally insurmountable municipal water supply problems are expected during the planning period. With increasing urban populations, greater per capita water use, and lowering of ground water

FIG. 25 / LOCATION OF WELLS WITH EXCESSIVE CONCENTRATIONS OF SODIUM OR IRON AND MANGANESE



Based on samples taken in 1968 and 1969

Source of Data: Nebraska Department of Health

levels, it may be necessary for several cities to expand their well fields or construct new ones.

Artificial recharge of municipal well field aquifers with either local surface water or treated sewage effluent may become increasingly common as improved technology becomes available and social acceptance becomes established. The importation of water from other basins for municipal supplies may be necessary in some cases if an adequate local supply is not available.

PRIVATE INDUSTRIAL WATER SYSTEMS

Many Nebraska industrial firms have developed their own water supply systems. The most complete information available on the amount of water presently used by these systems is contained in a 1968 survey of 563 industrial firms made by the Nebraska Department of Health. All industrial firms using significant amounts of water were inventoried. Present industrial use by private systems was estimated from this data.

Estimated future industrial water requirements from private sources were based on present use and the anticipated increases in water use necessary to accommodate growing industrialization.

Present Use. About 350 firms listed in the 1968 survey processed food. Of these, 264 processed meat, 52 processed dairy products, 4 processed sugar and 33 processed other foods. Most food processing plants are located near eastern population centers, with the exception of sugar processing plants which are located in the North Platte River Valley. Eight fertilizer manufacturing plants requiring large quantities of water have recently located in the State. Five of these are in the Big Blue River Basin.

Approximately 330 of the firms surveyed receive their water from municipal systems. Omaha, Lincoln, Grand Island, Norfolk, Beatrice, McCook, and Nebraska City furnish water for most of the industries in their communities. Therefore, a great deal of the water withdrawn for industrial use is included in the data for these systems.

Water use data was not obtained for the approximately one hundred firms which produce sand and gravel since their use is largely nonconsumptive.

The remaining 130 firms use private wells or surface water supplies to meet their requirements.

Present industrial water use through private systems is estimated at almost 90,000 afa as shown in Table 14. Except for Omaha, this water is supplied almost exclusively from ground water. Fertilizer manufacturing utilizes about 27,000 afa; sugar processing about 19,000 afa, part of which is supplied from surface water; and secondary petroleum recovery and oil refining about 12,000 afa. While older meat processing plants are generally supplied

TABLE 14 / INDUSTRIAL WATER REQUIREMENTS

River Basin	Present Use a/ Through Private Systems (afa)	Estimated Future Requirements (afa)					
		Private Systems			Allowance for Industrial b/ Use in Municipal Systems		
		1980	2000	2020	1980	2000	2020
White River - Hat Creek	0	c/	c/	c/	700	800	900
Niobrara	60	90	150	200	2,100	2,000	2,000
Missouri Tribs	25,660	30,200	35,300	36,500	51,000	65,000	79,500
North Platte	25,130	25,410	28,540	33,000	4,600	5,300	5,800
South Platte	7,110	7,370	7,700	8,000	1,800	1,800	1,700
Middle Platte	14,140	14,780	22,200	23,800	7,400	8,700	10,000
Loup	410	600	3,100	3,600	4,200	4,300	4,400
Elkhorn	6,570	8,550	13,200	15,000	8,600	9,900	10,700
Lower Platte	3,780	5,730	7,330	10,000	16,900	19,600	22,400
Republican	220	540	1,070	1,500	3,800	3,800	3,900
Little Blue	1,410	2,130	2,960	3,400	1,700	1,600	1,500
Big Blue	4,300	5,600	7,450	9,000	7,600	8,300	8,900
Nemaha	0	c/	c/	c/	3,600	3,900	4,300
STATE TOTAL	**88,790**	**101,000**	**129,000**	**144,000**	**114,000**	**135,000**	**156,000**

a/ Water used by industries with private systems surveyed by Nebraska Department of Health in 1968. This represents nearly all of the industrial use through private systems.

b/ Included in "Estimated Future Requirements" in Table 12

c/ Less than 5 afa

by municipal water systems, many newer plants have developed their own water supplies. Meat processing plants with private systems use an estimated 11,000 afa.

Although most industrial use of ground water is nonconsumptive in quantity, such use may add chemicals and pollutants to the water or change its temperature to the extent that it becomes less desirable or unfit for other purposes. Individual firms at various locations do have high consumptive demands that are important on a local basis.

Future Requirements. Agricultural processing is Nebraska's major industrial activity, and will undoubtedly remain so for some time.

The biggest industrial water users, particularly large meat packers, sugar processors, and fertilizer manufacturers, are expected to continue the present trend toward the development of their own supplies. The meat processing industry is expected to decentralize with medium to large plants tending to locate near regional trade centers. The manufacture of fertilizer will likely show the greatest increase in water use with new plants tending to locate near areas of greatest fertilizer demand.

Water requirements of industries with private systems are estimated to approach 144,000 afa by 2020. An additional 156,000 afa is included in the projected municipal system requirements for industrial use. Table 14 shows the distribution of estimated future industrial water requirements by river basin.

Problems and Needs. The raw water quality requirements of different industries vary greatly and are dependent primarily on the type of industry, industrial processes used, and degree of water treatment provided. Information is not available on industries which now have raw water quality problems, but statewide the problem is believed to be minor.

Ground water is generally of poorest quality for industrial use in the southeast, in the northeast along the Missouri River, and in the northwest. However, raw water quality problems can be encountered in other isolated locations across the State. As existing industries expand their facilities and as new industries seek to locate in Nebraska, potential water sources should be investigated to determine their suitability for specific needs.

Provided communities use good judgment in encouraging industrial expansion, no general widespread industrial water supply problems are expected except in those areas where communities already have difficulty in meeting nonindustrial demands. Presumably, communities with water supply problems will correct the situation before encouraging or allowing additional major water users to draw from their systems.

Rural Domestic and Livestock Water

Rural domestic water users include all persons not served by municipal systems.

PRESENT USE

About 424,000 people, or 30 percent of the state's 1960 population, currently obtain their domestic water supply from private systems or from rural water distribution systems. About 80 percent of these people live in homes served by running water. The remaining 91,200 persons obtain their water from hand-operated pumps or in some other manner.

Present rural domestic water use, almost entirely from ground water, is estimated to be about 27,000 afa as shown in Table 15.

Livestock consume about 103,000 afa. The geographic distribution of this use varies considerably. As shown in Table 16, present livestock water use is highest in the Loup River Basin followed by the Elkhorn, Republican, and Middle Platte River Basins.

About 81 percent of the current livestock water supply comes from ground water. Small farm ponds, dug ponds, lakes, and streams furnish most of the remainder.

FUTURE REQUIREMENTS

If the present trend of installing pressure water systems in rural homes continues, essentially all rural households will have running water by 1980. As a result, rural use rates are expected to increase to 80 gpcd in eastern Nebraska and 120 gpcd in central and western Nebraska.

Table 15 shows estimated future rural domestic water requirements by river basin. Total requirements are projected to increase significantly to almost 37,000 afa by 1980 due to the higher per capita use rates. The total use is expected to drop slightly by 2000 because of loss of farm population and then increase again by 2020 due to a projected increase in rural non-farm population near major cities.

TABLE 15 / RURAL DOMESTIC WATER REQUIREMENTS

River Basin	Present Use a/ (afa)	Estimated Future Requirements (afa)		
		1980	2000	2020
White River - Hat Creek	240	350	300	300
Niobrara	1,600	2,300	1,900	1,800
Missouri Tributaries	3,750	2,000	1,800	1,800
North Platte	1,720	3,400	3,000	3,300
South Platte	770	1,450	1,300	1,300
Middle Platte	2,350	4,100	4,200	4,800
Loup	3,100	4,700	4,000	3,800
Elkhorn	3,680	4,600	4,300	4,800
Lower Platte	2,640	4,000	3,700	4,400
Republican	2,200	2,700	1,900	1,800
Little Blue	1,450	2,400	2,300	2,400
Big Blue	2,300	3,800	4,000	4,100
Nemaha	1,500	1,900	1,800	2,000
STATE TOTAL	**27,300**	**37,700**	**34,500**	**36,600**

a/ Based upon 1960 census population figures

Future projected increases in livestock water requirements are based on anticipated growth of the livestock industry. Livestock production is expected to double by 2000 and nearly triple by 2020. Therefore, livestock water requirements will increase to almost 200,000 afa by 2000 and to about 284,000 afa by 2020. Table 16 includes the future projected livestock water requirements by river basin. Ground water will remain the principal source of supply. The number of farm ponds and dug ponds providing livestock water is expected to remain fairly constant. However, a shift is expected toward the construction of larger reservoirs to provide a more dependable supply.

TABLE 16 / LIVESTOCK WATER REQUIREMENTS

River Basin	Present Use a/ (afa)	Estimated Future Requirements (afa)		
		1980	2000	2020
White River - Hat Creek	1,100	1,500	2,100	3,000
Niobrara	8,900	12,900	17,200	24,500
Missouri Tributaries	8,100	10,400	13,900	20,900
North Platte	4,600	6,600	8,900	12,700
South Platte	1,600	2,300	3,100	4,400
Middle Platte	10,100	14,600	19,500	27,800
Loup	17,000	24,600	32,900	46,800
Elkhorn	16,300	23,600	31,600	44,900
Lower Platte	5,900	8,500	11,400	16,200
Republican	10,800	16,000	22,200	31,000
Little Blue	4,800	7,100	9,900	13,800
Big Blue	8,400	12,400	17,300	24,100
Nemaha	5,400	7,000	9,300	13,900
STATE TOTAL	**103,000**	**147,500**	**199,300**	**284,000**

a/ Based on livestock on hand January 1, 1966

PROBLEMS AND NEEDS

Rural water supply problems are expected to remain minimal in areas where supplies are presently adequate. Individuals will continue to need information on location and availability of suitable water sources, procedures for safe installation of wells, and water quality testing services.

In some areas of the State, rural ground water supplies are not adequate from either a quantity or quality standpoint. General areas where problems are presently encountered are the following river basins: White River-Hat Creek, lower portion of the Niobrara, Missouri Tributaries, Nemaha, portions of the Lower Platte, and the southern portion of the Republican. Continued development of rural water distribution systems is expected to eliminate many of the present domestic and livestock water problems in these areas where water is scarce or unsuitable. As of 1969, six rural pipeline systems serving 52 ranches had already been installed in the White River-Hat Creek River Basin and additional systems are being considered. Several rural water systems are presently being investigated or are under construction in the Nemaha River Basin. Another is under construction in the lower Niobrara River Basin. Need exists for development of rural water systems in other water deficient areas.

Systems of this type will require careful design, construction, and operation. Problems will arise if they develop in the path of expanding urban areas, if they are not of proper size, or if they are developed on a random and unrelated basis. In addition, such systems offer a high potential for bacterial contamination, particularly in urban fringe areas if sewer systems are not provided with the water distribution systems.

Flood Damage Reduction

Flooding is one of the most severe and widespread water resource problems in the State. Most floods in the State are caused by intense thunderstorms, but others result from general rainfall of long duration, snowmelts, ice jams, and debris clogged channels. Structural flood control measures were among the first public works and they are still being planned and constructed as rapidly as funding permits. Flood damage is increasing in spite of these efforts because investments in flood plain development are being made at an increasing pace.

EXISTING IMPROVEMENTS FOR FLOOD CONTROL AND PROTECTION

Many structural improvements have been completed by both private and public interests for the protection of local areas, or for the reduction of flood stages on streams. In 1967, a flood plain regulation program was initiated by the State of Nebraska to supplement structural measures by regulating future flood plain development to prevent additional increases in flood damage.

Structural Improvements. Complete data is not available on such structural improvements as levees, channel improvements, and dams which have been constructed by private individuals, nongovernmental organizations and municipalities. However, private interests have been responsible for many miles of stream channel straightening, numerous levees, and several dams and reservoirs which help reduce flood peaks by storing floodwaters.

The majority of the flood control projects in the State have been constructed by federal agencies, primarily the U.S. Army Corps of Engineers and the Soil Conservation Service (SCS). Some of the structures built by these agencies are located partially or wholly in adjacent states, but provide benefits to Nebraska. Dams on the Missouri River mainstem above and adjacent to Nebraska provide substantial protection to Nebraska lands along the river. Other structures upstream from Nebraska on the North Platte, Republican, and South Platte Rivers reduce flooding on those streams in Nebraska.

Reservoirs of reclamation projects constructed and operated by the U.S. Bureau of Reclamation, primarily for irrigation, often provide significant flood control for downstream areas.

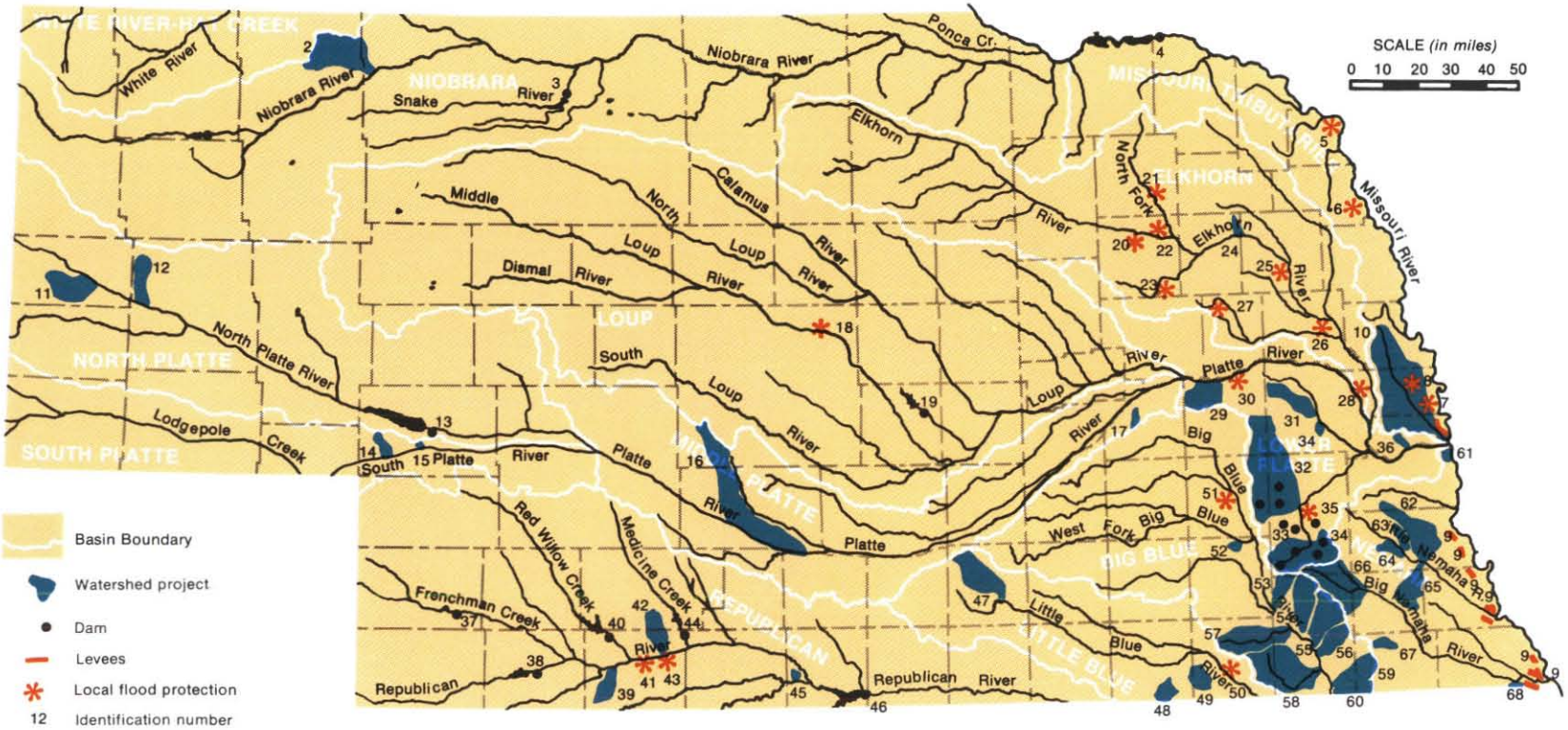
The existing and funded structural improvements in Nebraska intended primarily for flood control include impoundments ranging in size from large reservoirs to small floodwater retarding structures, channel improvements, and levees. Information about the number and magnitude of these improvements for each river basin is given in Table 17.

The locations of flood protection projects, either existing or funded for construction, are shown on Figure 26. Some reservoirs shown, such as Lake McConaughy, are primarily for other purposes, but do provide substantial flood protection.

Nonstructural Measures. Flood plain regulation provides for proper uses of the flood plain consistent with the potential flood hazard. With planned

FIG. 26 / IMPROVEMENTS PROVIDING FLOOD CONTROL

(Existing or funded as of Nov. 1, 1970)



KEY TO WORKS OF IMPROVEMENT

Project or Structure

1. Box Butte Reservoir
2. Antelope Creek Watershed
3. Merritt Reservoir
4. Lewis & Clark Lake
5. Bank Stabilization (All along Missouri River)
6. Blackbird Creek Local Protection
7. Omaha Local Protection
8. Little Papillion Creek
9. Missouri River Levees
10. Papillion Creek Watershed
11. Gering Valley Watershed
12. Wildhorse Creek Watershed
13. Lake McConaughy
14. Brule Watershed
15. Cure Watershed
16. Spring Creek (Dawson) Watershed
17. Jones Creek Watershed
18. Sargent Unit (Irrigation)
19. Sherman Reservoir
20. Battle Creek Local Protection
21. Pierce Local Protection
22. Norfolk Local Protection
23. Madison Local Protection
24. Pilger Watershed
25. West Point Local Protection
26. Hooper Local Protection
27. Clarkson Local Protection
28. Waterloo Local Protection
29. Bellwood Watershed
30. Schuyler Local Protection
31. Cottonwood Watershed
32. Oak Middle Creeks Watershed
33. Salt Creek Reservoirs (10)
34. Upper Salt Creek Watershed
35. Salt Creek Bank Stabilization
36. Turtle Creek Watershed
37. Enders Reservoir
38. Trenton Dam (Swanson Lake)
39. Dry Creek South Watershed
40. Red Willow Dam (Hugh Butler Lake)
41. Indianola Local Protection
42. Dry Creek Watershed
43. Bartley Local Protection
44. Medicine Creek Dam (Harry Strunk Lake)
45. Stamford Watershed
46. Harlan County Dam and Reservoir
47. 32-Mile Creek Watershed
48. Bowman-Spring Branch Watershed
49. Buckley Creek Watershed
50. Fairbury Local Protection
51. Seward Local Protection
52. Dorchester Watershed
53. Clatonia Watershed
54. Little Indian Creek Watershed
55. Bear-Pierce-Cedar Watershed
56. Mud Creek Watershed
57. Cub Creek Watershed
58. Big Indian Creek Watershed
59. Plum Creek Watershed
60. Mission Creek Watershed
61. Plattsmouth Watershed
62. Wilson Creek Watershed
63. Brownell Creek Watershed
64. Ziegler Creek Watershed
65. Spring Creek (Johnson) Watershed
66. Upper Big Nemaha Watershed
67. Rock Creek (Pawnee) Watershed
68. Walnut Creek Watershed

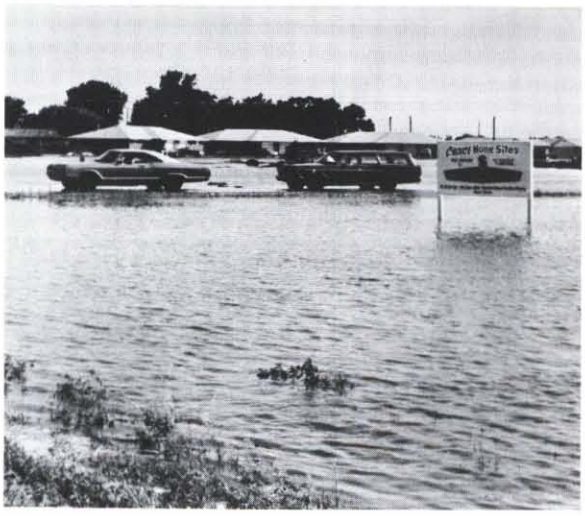
Source: *Missouri River Basin Comprehensive Framework Study*

TABLE 17 / SUMMARY OF EXISTING AND FUNDED PRINCIPAL STRUCTURAL FLOOD CONTROL IMPROVEMENTS
(November 1, 1970)

River Basin	Flood Control Reservoirs: Number	Flood Control Reservoirs: Approximate Flood Storage in Acre-Feet	Miles of Channel Improvement	Miles of Levees
White River - Hat Creek	0	0	0.0	0.0
Niobrara	3	3,000	0.0	0.0
Missouri Tribs.	0	0	6.5	15.9
North Platte	12	6,000	41.0	34.0
South Platte	2	1,000	N.A.	0.0
Middle Platte	12	5,000	38.0	0.0
Loup	0	0	0.0	0.0
Elkhorn	1	300	14.5	14.3
Lower Platte	81	144,000	33.0	N.A.
Republican	23	765,000	3.8	1.2
Little Blue	20	8,000	19.8	2.8
Big Blue	159	43,000	28.6	1.5
Nemaha	91	19,000	0.0	0.0
STATE TOTAL	**404**	**994,300**	**185.2**	**69.7**

and effective regulation of uses made of the flood plain, intensive development subject to high damage is avoided and increasing future flood damage due to additional development is thereby prevented. Flood plain regulations are generally used to supplement structural flood control measures. If regulations are adopted before the flood plain is developed however, flood damage can be prevented from mounting to the point that expensive structural measures are necessary.

Since passage of the Nebraska Flood Plain Regulations Act in 1967, a program has been developed for delineation of the flood plains of watercourses and drainways of the State that would be covered by a flood of 100-year frequency; for the establishment of floodways thereon; and for the determination of minimum standards for regulation of land use within these floodways. Local political subdivisions have primary responsibility for regulating use of their flood plains and are encouraged by the act to use the flood plain delineation information as a basis for adoption of flood plain regulations which meet or exceed the state's minimum standards. These regulation measures may be in the form of building codes, subdivision regulations, zoning ordinances, service regulations, health regulations, urban redevelopment, evacuation, flood proofing, and removal of obstructions to flood flows. Final responsibility and authority for regulation of the flood plains of the State is vested in the Nebraska Soil and Water Conservation Commission and is to be exercised in the event local subdivisions do not regulate use of their own flood plains.



Since enactment of the flood plain regulations act, several municipalities and counties have adopted flood plain zoning ordinances. The State has assumed responsibility for enforcing flood plain regulations in one community which elected not to zone its flood plains. Other local subdivisions have zoning ordinances pending and the Corps of Engineers has completed or is in the process of completing several additional flood plain information studies. The status of flood plain zoning ordinances and studies is tabulated in Table 18.

TABLE 18 / STATUS OF FLOOD PLAIN ZONING ORDINANCES AND STUDIES
(October, 1970)

Local Governmental Unit	Zoning Ordinances Adopted	Zoning Ordinances Pending	Flood Plain Study Available	Flood Plain Study In Progress	Applications for Flood Plain Study on File
Douglas County	X		X		
Sarpy County	X		X		
Omaha	X		X		
Millard	X		X		
Bennington	X		X		
Ralston	X		X		
Bellevue	X		X		
Papillion [a/]	X		X		
LaVista	X		X		
Lincoln		X	X		
Columbus		X	X		
Beatrice		X	X		
Grand Island		X	X		
Wahoo				X	
Fairbury				X	
North Platte				X	
Red Cloud				X	
Sidney					X
Hastings				X	
Broken Bow				X	
Meadow Grove					X
Tecumseh					X
Cass County					X
Saunders County					X
Dodge County					X
Colfax County					X
Butler County					X
Platte County					X
Hall County					X

a/ State enforcement

PROBLEMS AND NEEDS

Floods are natural occurrences. The flat bottom lands along the rivers have been created and gradually shaped by the streams over a period of thousands of years to carry periodic overflows. Nearly every year some Nebraska streams overflow and cause damage.

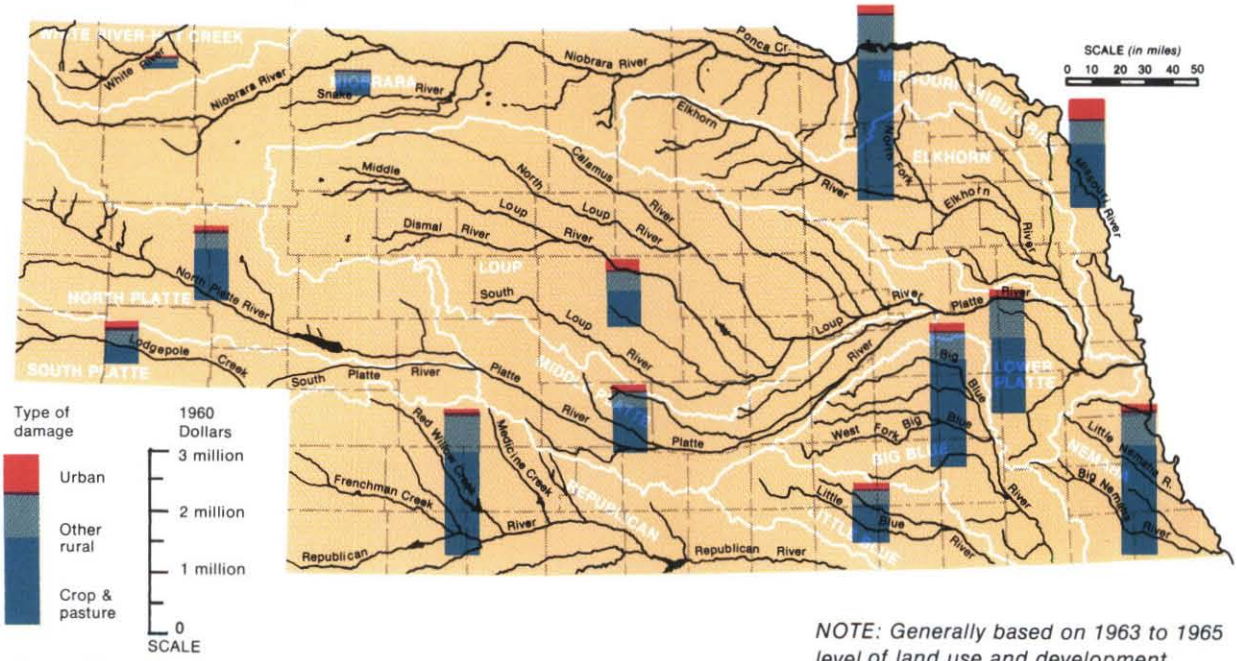
While floods are natural occurrences, the damage they do is largely the result of man's encroachment upon the flood plains. Houses, bridges, crops and man's other investments placed in the flood plain are damaged by floodwaters, causing serious losses to both private and public interests.

Nebraska's pioneers found that the waterways and their valleys provided the best transportation routes, good irrigable farmland, and consequently the best sites for trading centers. And so these lands along the streams were settled early and were developed rapidly. As soon as settlement began flood damage started and it has been increasing ever since.

Not even drought periods provide safety from floods. One of the worst floods in Nebraska's history occurred in the middle of a severe drought in 1935. The flood, about three times greater than any recorded before, roared down the Republican River valley flooding 25 towns, taking 110 lives, and causing millions of dollars damage. The chance of recurrence of such destruction has been reduced by the construction of a number of large reservoirs on the Republican River and its tributaries. No other stream in the State is now as well controlled as the Republican, but even here the possibility of floods has not been entirely eliminated.

Existing and Developing Problems. About three million acres in Nebraska, approximately 6 percent of the total land, are subject to damaging floods. In the early 1960's, the average annual damage caused directly by flooding was estimated at about 21 million dollars. The potential losses are undoubtedly greater now. Of that total, about two-thirds was damage to crops and pasture, nearly one-fourth was damage to other rural property, and about one-tenth was damage to urban areas. The estimated damages sustained in each basin are shown in Table 19 and depicted graphically in Figure 27.

FIG. 27 / AVERAGE ANNUAL FLOOD DAMAGE BY RIVER BASIN



Source: *Missouri River Basin Comprehensive Framework Study*

NOTE: Generally based on 1963 to 1965 level of land use and development

TABLE 19 / DISTRIBUTION OF FLOOD DAMAGE

River Basin	Area Subject To Flooding (1000 Acres)	Average Annual Flood Damage a/ in Thousands of Dollars			
		Crop & Pasture	Other Rural	Urban	Total
White River - Hat Creek	36.0	67.1	41.2	1.0	109.3
Niobrara	118.2	209.9	136.7	16.4	363.0
Missouri Tributaries	390.9	1,138.4	396.3	371.1	1,905.8
North Platte	184.2	962.1	272.6	64.1	1,298.8
South Platte	142.2	442.3	213.2	121.2	776.7
Middle Platte	367.9	835.7	278.6	50.0	1,164.3
Loup	214.7	663.5	282.3	206.3	1,152.1
Elkhorn	410.9	2,432.3	733.6	208.3	3,374.2
Lower Platte	331.9	1,288.7	684.0	203.0	2,175.7
Republican	320.1	1,704.3	600.0	23.2	2,327.5
Little Blue	109.0	739.8	210.8	13.0	963.6
Big Blue	267.9	1,930.6	371.7	169.4	2,471.7
Nemaha	265.5	1,797.4	698.5	43.9	2,539.8
STATE TOTAL	**3,159.4**	**14,212.1**	**4,919.5**	**1,490.9**	**20,622.5**

a/ *Generally based on 1963 to 1965 level of land use and development*

Source: *Missouri River Basin Comprehensive Framework Study*

Those streams which overflow their banks most often and the communities most affected by flooding are shown in Figure 28.

Local efforts to control flooding in the Elkhorn and Nemaha River Basins by straightening channels without concern for the slope of the stream or its potential for erosion have led to serious erosion damages. As these streams are shortened, their slopes become steeper and the velocity of flow is thereby increased. The increased flow velocities cause streambank erosion, channel deepening, and extension of tributaries upstream through gully erosion. Unless structural measures are used to stabilize these stream slopes, the erosion process will continue until the equilibrium between flow velocity and soil resistance again becomes established.

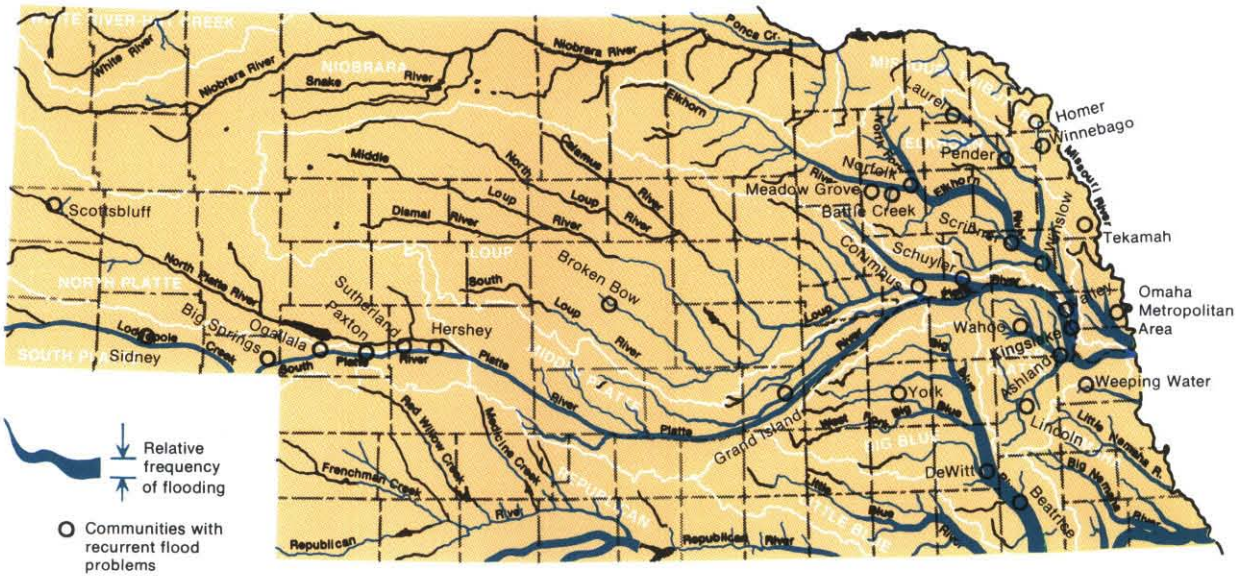
Dutch elm disease is indirectly aggravating the flood problem along many small streams in Nebraska. As elm trees along watercourses become affected with the disease and die, they often fall into the stream channels. Flood flows carry the dead trees downstream where they sometimes damage bridges and other structures or form log jams which raise flood heights.

Future Needs. The average annual damage caused by floods is increasing steadily. Because of population growth and the rural-urban shift, urban areas are growing rapidly and encroaching more on flood plains. Changing the use of the land from agricultural to urban not only increases the land value, but it generally increases runoff and places more obstacles in the path of the flow, thus raising flood heights and increasing damages.

Action is needed to reduce present flood damages and to prevent increased future damages. This can be accomplished by the control of floodwaters and the control of flood plain development. Reservoirs store water and land treatment reduces runoff to eliminate or reduce flood heights; channel improvements including snagging and clearing operations increase the capacity of channels; and levees and flood walls to keep floods away from man's improvements. Existing improvements of these types are credited with preventing over 10 million dollars worth of damage annually in Nebraska. More such structural measures are needed, but by themselves they are not sufficient to cope with the problem.

In the United States during the past thirty years, flood damages have been increasing in spite of huge investments in efficient flood control structures. Nebraska is no exception. Nonstructural methods of controlling future flood damage are also needed. Proper flood plain management can promote the wise use of these areas to increase

FIG. 28 / CURRENT FLOOD PROBLEM AREAS
(1970)



Based on historical flood damage records of the Corps of Engineers adjusted to current conditions

their utilization while holding damage to a minimum. Building codes, service regulations, subdivision regulations, and flood proofing can prescribe building design and heights which will prevent or minimize damage. In areas prone to high damages, zoning ordinances may completely prohibit building construction to prevent excessive flood damages.

Nebraska's flood plain regulation program has been hindered in the past by a lack of public acceptance. If this program is to be effective and future increases in flood damages are to be averted, increased funding to fully implement the program and a strong effort to educate the public on the merits of this program will be necessary.

Other supplemental measures such as flood forecasting and warning systems, along with organized flood fighting, flood insurance and relief systems, can also provide major assistance. Very little can be done to forecast flash floods. However, warning in advance of forecasted major floods can prevent considerable damage. Emergency plans and organized relief systems can aid in the aftermath of floods and reduce suffering and loss. Flood insurance, available when the flood plain use is regulated, will also alleviate some individual economic loss.

The need in the State of Nebraska for reduction of flood damages is critical. This reduction may be accomplished by:

1. An accelerated program of watershed management and construction of needed flood control structures.

2. Intensive implementation of a nonstructural flood protection program including flood plain use regulations, flood insurance, flood warning systems, and disaster assistance.

Irrigation

Irrigation development has been sporadic in Nebraska because it is influenced so much by periodic climatic conditions. Some irrigation systems were installed soon after settlement. Development continued slowly for the next few decades until 1895 when enaction of a statute establishing a filing system for water rights coupled with the drought of the 1890's brought mass filings for water diversion from streams. Later, droughts in the 1930's and mid-1950's generated additional surges in irrigation development.

Technological developments, such as the internal combustion engine, turbine pumps, and sprinkler systems gave impetus to irrigation development, particularly ground water irrigation.

Federal and state legislation, too, had its impact. The Federal Reclamation Act of 1902 authorized the development of projects to supply water to government lands being opened for settlement. About 350,000 acres have been developed for irrigation in the State under the terms of this Act.

In 1933, the Nebraska Legislature passed a law authorizing the organization of public power and irrigation districts. Under this law, public power and irrigation districts encompassing over a quarter million acres were organized and with the aid of federal grants and loans, facilities were constructed.

Irrigated acreage has continued to increase with the advent of new distribution systems and higher yielding strains of feed grain crops. Areas that were not irrigable using other service methods are now being irrigated with the aid of rotary self-propelled sprinkler systems.

EXISTING DEVELOPMENT

Approximately three and three-fourths million acres in Nebraska were developed for irrigation by 1970. This acreage is classified according to water source (either ground or surface) and river basin in Table 20. There may be some duplication in these acreages because wells are used to augment surface supplies in some areas.

TABLE 20 / ESTIMATE OF EXISTING IRRIGATION DEVELOPMENT
(January, 1970)

River Basin	Area Irrigated in Acres		
	Surface Water	Ground Water	Total a/
White R.-Hat Cr.	26,600	1,400	28,000
Niobrara	59,700	95,300	155,000
Missouri Tribs.	6,000	17,000	23,000
North Platte	364,600	33,400	398,000
South Platte	34,300	53,700	88,000
Middle Platte	296,400	610,600	907,000
Loup	121,200	267,800	389,000
Elkhorn	20,400	134,600	155,000
Lower Platte	9,600	93,400	103,000
Republican	107,700	289,300	397,000
Little Blue	13,300	318,700	332,000
Big Blue	40,200	701,800	742,000
Nemaha	7,800	5,200	13,000
STATE TOTAL	**1,107,800**	**2,622,200**	**3,730,000**

a/ Total irrigated acreage may be too high in some basins because of conjunctive ground-surface water use on the same lands.

The amount of irrigation and its intensity varies with location and the amount of precipitation received during the growing season.

The complexity of irrigation facilities varies from those involving only the simple diversion of stream water for irrigating meadows to systems supplying water through self-propelled rotary sprinklers or semi-automated gates and valves located in concrete laterals or buried pipe networks.

Surface Water. The total acreage now irrigated from surface water is an average year is about 1.1 million acres. Location of this acreage is shown according to basin in Table 20.

The annual diversion rate usually varies from about one to over three acre-feet of water per acre of land (AF/acre) depending on location and efficiency of the system.

Most acreage irrigated from surface water is located in the North Platte, Middle Platte, Loup, and Republican River Basins. A major part of this acreage is irrigated as part of an irrigation district or system having a storage reservoir(s), distribution canals and laterals.

Streambank pumps withdrawing water from rivers and creeks serve the next largest area irrigated from surface water. This practice is most prevalent in the Elkhorn, Big Blue, and Loup River Basins.

The method least used is the simple diversion structure with a distribution canal. Runoff is quite variable across most of the State making this type of system unreliable without storage reservoirs. Such systems are also subject to damage by floods and incur substantial maintenance costs. Simple diversion is most prevalent in the White River-Hat Creek and Niobrara River Basins.

The general locations of the major irrigation systems supplied from surface water are shown in Figure 29.

Most federal irrigation projects have been constructed by the Bureau of Reclamation under the Federal Reclamation Act of 1902 and supplements thereto. After construction, and a 5 to 10 year development period, these projects are normally turned over to the operating districts. Projects constructed by the Federal Government are briefly described in Table 21.

Several areas have been developed for irrigation by special purpose districts in accordance with provisions of the 1933 Nebraska Public Power and Irrigation District Law. These districts with some of their more important characteristics are tabulated in Table 22.

TABLE 21 / FEDERAL IRRIGATION PROJECTS IN NEBRASKA
(1970)

River Basin	Project or Unit	Acreage Irrigated	Storage Reservoir	Reservoir Capacity in 1000 AF (Conservation and Dead)
North Platte	North Platte	164,000 a/	Pathfinder (Wyo.)	1,000
			Guernsey (Wyo.)	49
			Lake Alice	11
			Lake Minatare	61
Niobrara	Mirage Flats	11,600	Box Butte	31
	Ainsworth	34,000 b/	Merritt	74
Loup	Sargent	12,700 b/	Sherman (Exchange only)	66
	Farwell	48,000 b/	Sherman	66
Republican	Frenchman	21,100	Enders	44
	Meeker-Driftwood	16,400	Swanson	120
	Red Willow	11,100	Hugh Butler	38
			Swanson	120
	Cambridge	15,600	Swanson	120
			Harry Strunk	37
	Bostwick	22,800 c/	Harlan County	343

a/ An interstate project, total of 215,000 acres irrigated in Nebraska and Wyoming
b/ Acreage shown is not completely developed
c/ An interstate project, total of 62,200 acres irrigated in Nebraska and Kansas
Source: U.S. Bureau of Reclamation

FIG. 29 / MAJOR AREAS IRRIGATED FROM SURFACE WATER SYSTEMS

(1970)

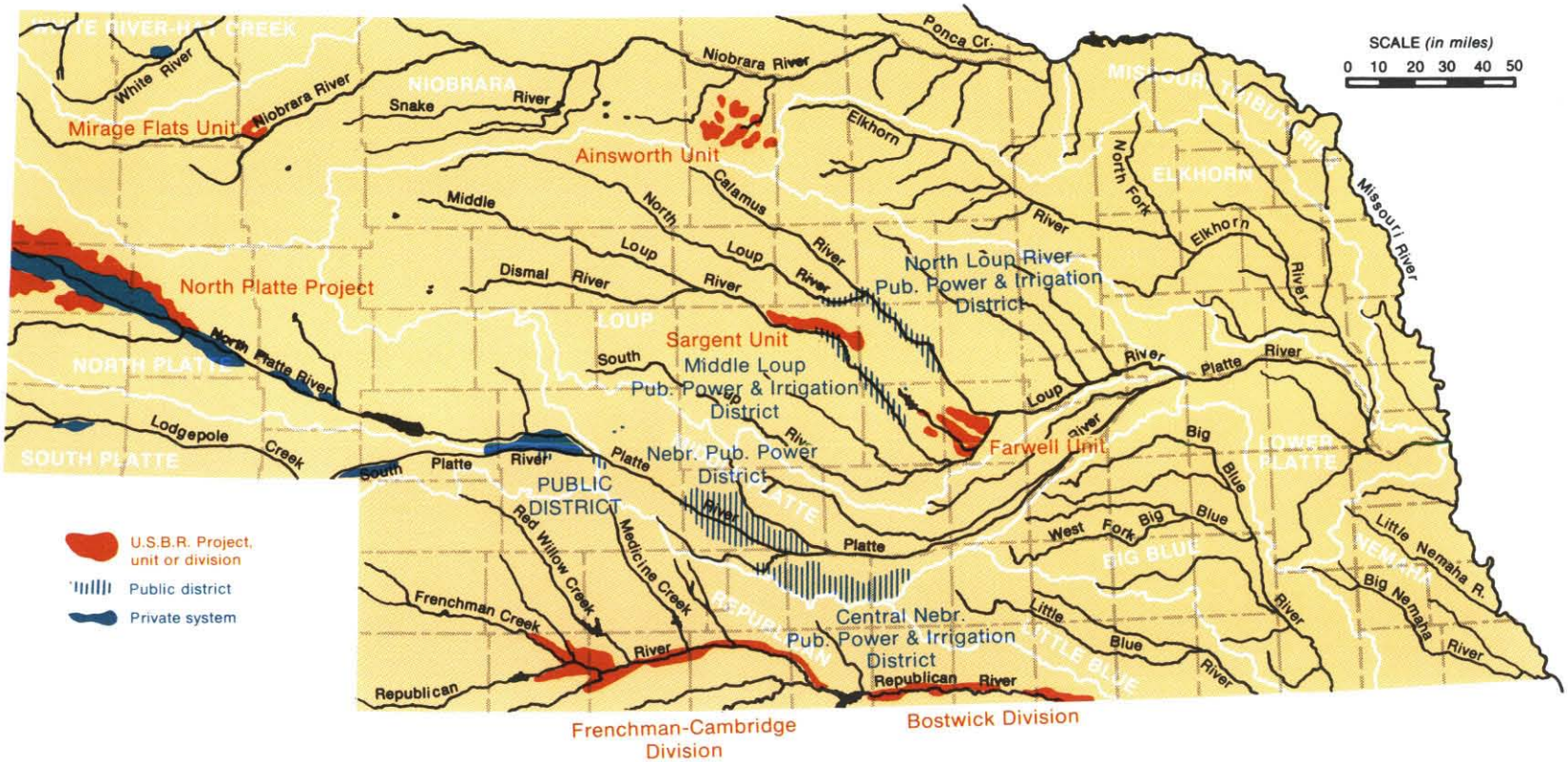


TABLE 22 / PUBLIC POWER AND IRRIGATION DISTRICTS
(1970)

River Basin	District	Acreage Irrigated	Storage Reservoir	Reservoir Capacity in 1000 AF
Middle Platte	Nebraska Public Power [a/]	100,000	Sutherland	80
			Maloney	6 [b/]
Middle Platte	Central Nebraska Public Power and Irrigation	130,000	McConaughy	1,948
			Jeffrey	6
			Johnson	50
Loup	Middle Loup Public Power and Irrigation	25,000	--	--
Loup	North Loup River Public Power and Irrigation	29,600	--	--

a/ Formerly Platte Valley Public Power and Irrigation District. Includes the Gothenburg, Dawson County, and Kearney Districts canals and Cozad, Orchard-Alfalfa, Thirty Mile and Six Mile private canals

b/ Storage right of 6,000 AF but actual reservoir capacity is greater

Source: Nebraska Department of Water Resources

Considerable early irrigation development was accomplished by individuals or small groups. Some of these systems were quite primitive, but many have since been improved. The majority of these cooperative or community systems are located in the North Platte River Valley. Table 23 shows some features of the larger systems.

Ground Water. Irrigation development utilizing ground water from valley aquifers lying at shallow depths began in the western and central parts of the State as early as 1910. Use of modern equipment now allows developments of tablelands at heights of several hundred feet above water bearing materials.

Extensive ground water irrigation developed during the drought of the thirties and early forties and gradually spread eastward. The rate of well installation peaked during the drought of the mid-fifties. Figure 30 shows how the rate of irrigation well installation fluctuated from 1910 to 1968.

It is estimated that about 2,600,000 acres are presently irrigated from ground water. The general areas being irrigated from ground water are shown on Figure 31 and an estimate of the area presently irrigated in each river basin is shown in Table 20.

One of the most extensive areas irrigated from ground water covers the western and central portion of the Big Blue River Basin and the northern part of the Little Blue River Basin. Significant irrigation development did not begin in this area until the late forties, but about 1,000,000 acres are now being irrigated from ground water.

About 600,000 acres are presently being irrigated from ground water in the Middle Platte River Basin. This was one of the first areas of the State to extensively develop ground water for irrigation. Most of the best land has already been developed and present activity is largely confined to the development of less suitable lands and replacement of existing wells.

The most rapid new development is taking place in the Republican River Basin on the tablelands of Chase, Perkins, and Frontier Counties. Rapid development is also taking place in the upper part of the Elkhorn River Basin, especially in Holt and Antelope Counties.

The amount of ground water pumped varies markedly from year to year and from area to area. The statewide average annual consumptive use of ground water is about one acre-foot per acre irrigated. This use varies, however, from about six inches in the east to nearly two feet in the western part of the State. The amount pumped to supply this requirement varies from operator to operator and is dependent on the efficiency of the system, type of soil, topography, and precipitation pattern.

EXISTING PROBLEMS AND NEEDS

With nearly four million acres of land irrigated in Nebraska, there are bound to be some irrigation problems. In general though, Nebraska has a large amount of irrigable land, relatively abundant water resources, and few major physical development problems.

However, some local problems do exist. Current irrigation problems of a physical nature are mainly related to amounts of water—too little or too much.

System Distribution Networks. Distribution systems typically develop some problems as they become older. Originally, the main concern was

TABLE 23 / IRRIGATION DISTRICTS AND PRIVATE SYSTEMS
(Developments over 2000 Acres in 1970)

River Basin	District or Canal	Acreage Irrigated	Type of System a/	Storage Reservoir
White R.—Hat Cr.	Whitney	9,800	C	Whitney Lake
North Platte	Alliance	7,500	A	
	Beerline	2,100	B	Pathfinder b/
	Belmont	14,350	A	
	Birdwood	5,300	A	
	Blue Creek	2,500	A	
	Browns Creek	6,200	B	Pathfinder b/
	Castle Rock	6,500	A	
	Central	2,100	B	Pathfinder b/
	Chimney Rock	5,200	B	Pathfinder b/
	Cody-Dillon	4,700	A	
	Empire	2,100	A	
	Enterprise	7,600	B	Glendo
	Gering	14,200	B	Pathfinder b/
	Graf	2,100	A	
	Keith-Lincoln Co.	6,150	B	McConaughy
	Lisco	3,500	A	
	Midland-Overland	2,200	A	
	Minatare	9,500	A	
	Mitchell	13,600	B	Glendo
	Nine-Mile	5,200	B	Glendo
	North Platte	14,100	B	McConaughy
	Paxton-Hershey	7,300	B	McConaughy
	Short Line	3,000	A	
	Suburban	5,600	B	McConaughy
	Tri-State	66,400	B	Pathfinder b/
	Winters Creek	5,700	A	
South Platte	Kimball	4,500	B	Oliver
	Western	12,600	A	
Republican	Haigler	2,000	A	

a/ *Type of System:*
A – *Diversion from stream only*
B – *Diversion from stream plus storage*
C – *Diversion from storage reservoir*
b/ *Served under Warren Act Contract from Pathfinder Reservoir*
Source: Nebraska Department of Water Resources

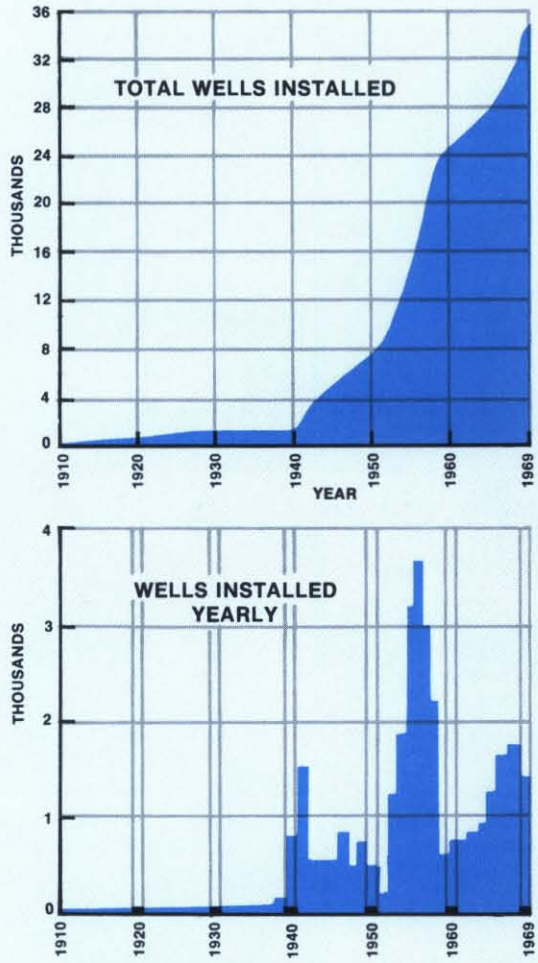
getting water to the points of need. As more and more systems were constructed and the water supply became limited, increasingly efficient use became necessary for the newer systems.

Many of the distribution system losses are causing permanently wetted areas, growth of phreatophytes and other undesirable plants, and problems of erosion and siltation where wasteways and cross drainage structures are not adequately protected and maintained. However, costs prohibit needed improvements in many smaller, older systems. This is especially true of many of the systems in the North Platte River Basin where canals of one district often closely parallel those of another which further reduces the efficiency of service. In that Basin there are more than 30 systems with a total canal length of over 1,000 miles serving only about 170,000 acres.

Excessive Water Application. Overwatering and associated losses sometimes result from the delivery schedules maintained by some districts. With water available only on a predetermined schedule, irrigators tend to apply water when available regardless of crop needs. This often causes application of excess water which results in deep percolation losses, leaching of plant nutrients, and irrigation runoff which may create drainage problems.

Insufficient storage reduces flexibility in scheduling and consequently the efficiency of these sys-

FIG. 30 / IRRIGATION WELL INSTALLATION



Note: Includes only registered wells

Source of Data: Nebraska Department of Water Resources

tems. Additional reservoir storage closer to the service area would allow greater flexibility in delivery and improve the efficiency in several systems. This is particularly true in the Middle Platte River Basin where additional storage is needed for regulation on the Central Nebraska Public Power and Irrigation District (CNPP&ID) service area, commonly referred to as the Tri-County Project.

Ground water irrigators also often apply more water than necessary either because of a poorly developed system or labor costs involved in adjusting the rate of application. Resulting problems are similar to those caused by excess surface water application. Research and educational efforts are needed to develop and acquaint irrigators with more efficient irrigation methods.

An unusual potential problem is developing in the Big Blue River Basin because of excessive water use. During certain periods of the year, surface water appropriators are using water which is largely excess runoff from land irrigated from ground water farther upstream. If efficiency upstream is improved or regulations to reduce wastage of water are instituted, downstream appropriators may lose their source of irrigation water.

Drainage. Excessive application of irrigation water can create drainage problems. These may involve only limited areas or be as extensive as those currently existing in the multi-county service area of the CNPP&ID. As shown on Figure 19, this area has experienced a substantial rise in the water table (as much as 90 feet) since surface water irrigation was initiated in the early forties. During recent years, the rising water table has caused basement flooding in several areas, some inundation of agricultural lands, many wetted areas, and concentration of minerals on the lands after evaporation. The principal reasons for this rise are excess canal seepage losses, poorly planned land development, and lack of natural surface drains.

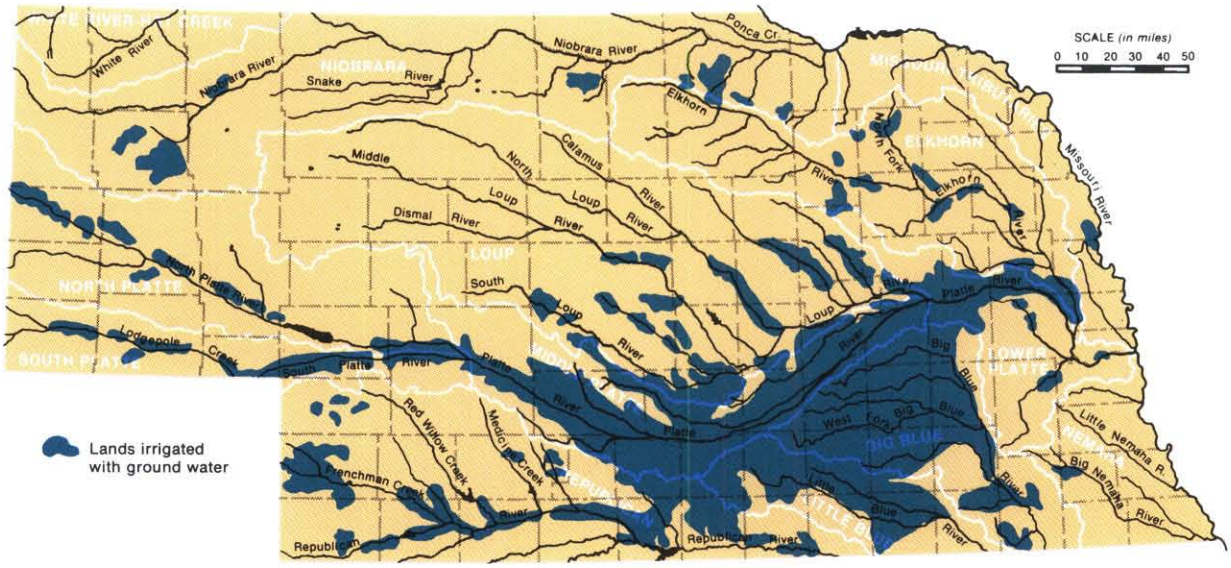
Drainage of excess irrigation water is needed in many of the existing systems. Some areas lying below existing district canals or laterals in the North Platte River Valley experience drainage problems which are due partly to seepage losses from the canals.

Another problem directly related to drainage is the current practice of filling existing drainageways as a part of land development for irrigation. Many of the private ground water irrigators have filled or rerouted existing natural drains, many times into road ditches, in an effort to enlarge or simplify their systems. This practice has created many problems, particularly that of increased flooding, where natural drainways have been changed.

Insufficient Water Supply. Some areas served by surface water distribution systems have water supply shortages nearly every year, primarily because of inefficient canal and lateral systems. Canals and laterals are often poorly constructed and maintained and lose much of the diverted water through leakage. Systems experiencing a shortage because of poor distribution facilities are the Whitney Irrigation District in the White River-Hat Creek Basin, and many of those adjacent to the North Platte River both above and below Lake McConaughy. Improvement of distribution facilities, including the elimination of some canals by consolidation of districts, is needed to provide an adequate supply of water to the lands of these districts.

Water supply shortages normally occur on some smaller systems which have little or no storage to supplement natural streamflow. Precipitation vari-

FIG. 31 / GENERAL LOCATIONS OF LANDS IRRIGATED WITH GROUND WATER



Based on Nebr. Dept. of Water Resources well registrations

ability in Nebraska makes storage necessary on most streams. Even with storage, many systems do not have adequate capacity to provide for peaking requirements during hot, dry periods. Increased storage is needed to make more water available to some of the systems.

The Mirage Flats Project on the upper Niobrara River has experienced water shortages in most years since its completion in 1946. Box Butte Reservoir provides storage, but the water supply is not sufficient to provide the full project requirement. Although several wells have been drilled by individual project irrigators to supplement their project water, additional wells are needed to provide the system with a more dependable supply.

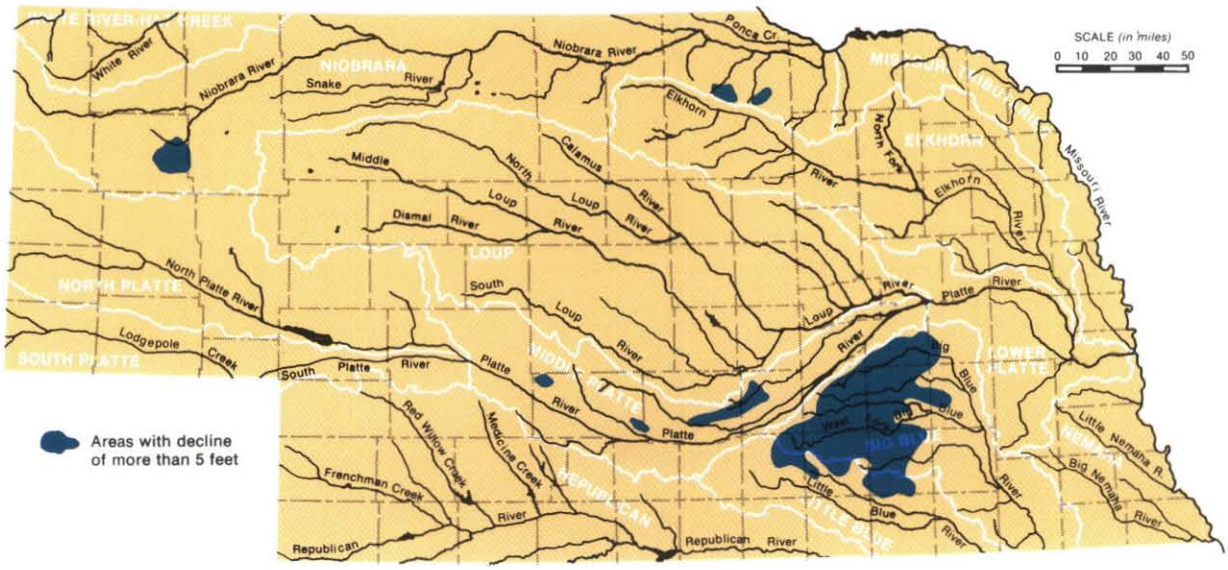
The North and Middle Loup Public Power and Irrigation Districts in the Loup River Basin have considered storage to supplement natural streamflow during low flow periods.

Lowering Water Table. Ground water withdrawals have caused a lowering of the water table in some areas of the State. This lowering has ranged from a few up to 20 feet in the O'Neill area of the Niobrara River Basin and in the Middle Platte and Big Blue River Basins to as much as 40 feet in Box Butte County. Areas with declines of more than five feet are shown on Figure 32. Some lowering of the water table is not generally of major importance, but where aquifer thickness is limited and recharge is slow it can signal the reduction of large scale pumping.

One way of stabilizing a lowering water table at economic levels is to provide surface water to augment the ground water supply. This "conjunctive use" has unintentionally been used successfully in the Middle Platte River Basin where losses from the Nebraska Public Power and Irrigation District and other canals recharge the ground water aquifer being used by pump irrigators. This type of conjunctive use could also prevent rising ground water levels such as are occurring in Adams, Kearney, Phelps, and Gosper Counties.

A large area in the upper Big and Little Blue River Basins and the central Big Blue River Basin has experienced a water table decline of ten feet or more. However, the water bearing material is quite extensive and pumping levels are still at economic depths for irrigation developments. Present problems are being solved by lowering pumps. Well deepening will follow in some areas. Continued intensive development of ground water will make supplemental surface water and conjunctive use necessary in the future to maintain the present irrigation economy.

FIG. 32 / AREAS OF GROUND WATER LEVEL DECLINE



Source: Conservation and Survey Division, University of Nebraska

Part of Box Butte County is irrigated from ground water and is experiencing a water table decline. The water table in the Alliance area has lowered 40 feet causing some decrease in well capacities and an increase in pumping costs. Although some of the area still is underlain with 250 to 300 feet of water bearing material, the geology is quite complex and adjacent areas could have significantly less saturated aquifer depth.

The water table decline has ranged from five to ten feet or more in an area near the northern edge of the proposed Mid-State Project in the Middle Platte River Basin. Some of the area is underlain with only 25 feet of saturated sand and gravel aquifer.

FUTURE NEEDS

Future needs will be partly dictated by the economic conditions prevalent when existing supplies of water are exhausted or severely reduced. The motivation for individuals to improve their water application efficiency is related directly to the associated costs and the anticipated gains.

Unit pricing of water studies similar to that discussed in the municipal and industrial water section are needed for irrigation water usage. These studies should also involve electrical demands created by irrigation.

Supplemental Water Supply. The areas described previously that are being irrigated from ground water in the Big Blue River Basin, Alliance area, O'Neill-Atkinson area, and the Middle Platte River Basin will eventually need a supplemental source of water to maintain current levels of irrigation. An area in Chase and Perkins Counties will also require a supplemental source of water if development continues at the present rate. The aquifers in these two counties are quite productive, but are limited in volume and amount of recharge.

A typical solution to a shortage of water supply for surface water systems is construction of a reservoir to store off-season surplus flows. However, good sites are rarely available and, on most interstate streams, the water is allocated by compact or decree. One need, therefore, is the lining of canals and laterals to conserve the water diverted and thus provide additional water to the lands served.

Research and Education. Nebraska has been a world leader in many areas of irrigation research and development. This has been demonstrated by development of the center pivot and other mechanized sprinkler systems. Overflowing crowds at both state and national irrigation educational meetings held throughout the State demonstrate an

eagerness by irrigators for new irrigation techniques. Although the practicing irrigator is generally willing to accept new programs and concepts, the problem is that he is oftentimes unable to implement these irrigation changes because of a lack of funds.

Many areas of irrigation research have, however, been lacking in the State. Research on irrigation practices, especially as they relate to efficiency, has been quite limited. Attention in Nebraska has been focused recently on moisture sensing devices and reuse systems.

Continued research efforts in the area of irrigation application methods are needed. Attention in Nebraska has been focused recently on moisture sensing devices, reuse systems and automation of distribution systems.

Improved canal sealing techniques and more efficient irrigation water distribution facilities developed through research could prevent many future drainage problems from developing.

OPPORTUNITIES FOR FURTHER DEVELOPMENT

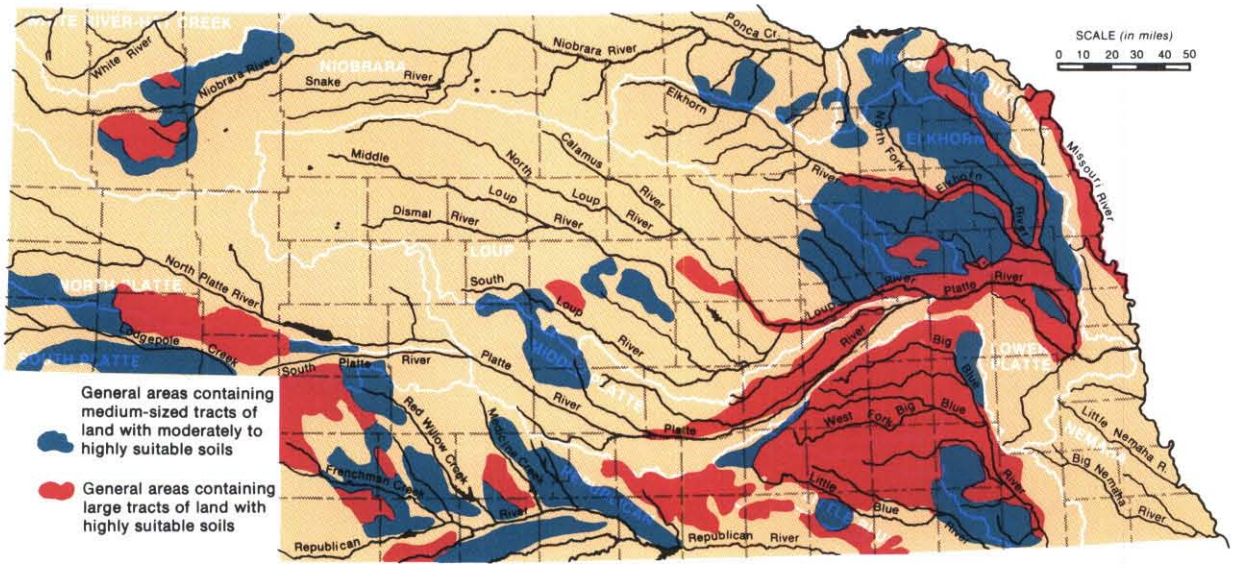
There are many large areas of irrigable land not presently irrigated. While water supplies are not available to all of these irrigable lands, most areas

have sufficient quantities for full irrigation development.

Land Available. Over 19 million acres of land are classified as suitable for irrigation in Appendix A to this report, *Land Inventory*. About 20 percent of this total is now being irrigated.

Large tracts of land suitable for irrigation occur in the Big and Little Blue River Basins, the lower Elkhorn River Basin, the upper and central Republican River Basin, portions of Cheyenne and Deuel Counties in the North and South Platte River Basins, the upper Niobrara River Basin, and the upper portion of the Lower Platte River Basin. Figure 33 shows lands suitable for project-type irrigation development. In addition, there are small tracts scattered throughout much of the State which could be irrigated. Some of this land shown is already being irrigated and some does not have a readily available source of water.

FIG. 33 / LANDS SUITABLE FOR PROJECT-TYPE IRRIGATION DEVELOPMENT



NOTE: Lands presently irrigated by surface water systems and lands requiring drainage or other major improvements are not shown

Water Available. Surface water is generally available for additional irrigation development in the Niobrara, Loup, Lower Platte, and Nemaha River Basins as well as the Missouri River mainstem.

Surface supplies are limited mostly to the lower end of the basin in the Elkhorn, Big Blue, and Little Blue River Basins. This largely limits the surface water irrigation development potential to those lands which are susceptible to service from reservoirs which might be constructed in the lower parts of the basins.

Surface water development in the remaining basins will be limited to the amounts which can be stored that are surplus to the existing demands of downstream rights and compacts. Those river basins having compacts or court decrees in effect are the Niobrara, North Platte, South Platte, and Republican.

Ground water supplies are generally abundant but quite variable across the State with the Loup, Middle Platte, and Big Blue River Basins having the greatest amounts available for use. However, local areas within general areas of abundant supply often have only limited supplies and some of the good water supplies are located under lands which are not considered suitable for irrigation.

Ground water supplies are scarce or nonexistent in most areas of the White River-Hat Creek and Nemaha River Basins. Other river basins with limited supplies are the Little Blue, Republican, Lower Platte, Elkhorn, South Platte, North Platte, and Missouri Tributaries.

Exceptions exist in all cases and some ground water development for irrigation may be possible for scattered areas of those basins where the supply is limited. However, large scale development will not be possible in river basins such as the Nemaha, White-Hat, South Platte, and Missouri Tributaries.

Withdrawals of ground water already exceed the recharge in some parts of the Big Blue, Middle Platte, Niobrara, and Little Blue River Basins. Additional development may require introduction of supplemental water supplies in order to maintain and protect the established economy in these areas.

Water Quality Control

The quality of Nebraska's surface and ground water is equally as important as its quantity. In their natural condition most of the state's water resources would have been suitable for present day uses. Man's development, however, sometimes alters the character of the water until it becomes less suitable or unfit for some uses.

Relatively complete information is available on municipal wastes because these wastes have been sampled rather extensively in some cases and their characteristics are quite consistent. Comparatively little is known about industrial wastes since very little sampling has been done and they vary greatly in composition depending on the manufacturing processes and the in-plant procedures used. A survey of 563 industrial firms made by the Nebraska Department of Health in 1968 provides the most complete information concerning industrial wastes.

Agriculture's effect on surface and ground water quality isn't fully understood. Livestock wastes from feedlots, increased chemical concentrations in irrigation return flows, and agricultural land runoff definitely degrade the physical, chemical, and biological quality of Nebraska waters, but the extent to which they contribute to water quality degradation is not known at this time.

NEBRASKA WATER QUALITY STANDARDS

Most of Nebraska's surface and ground waters are still suitable for most beneficial uses. With increased use and discharge of wastes by municipalities, industries and agriculture, some degradation of the state's water resources can be expected. However, in recent years steps have been taken to protect and enhance the quality of the state's waters.

In accordance with the Federal Water Quality Act of 1965, the Nebraska Water Pollution Control Council has developed water quality criteria, implementation plans, and enforcement procedures applicable to all Nebraska surface waters. These *Water Quality Standards,* which were approved by the Secretary of the Interior in December, 1968, and adopted by the Nebraska Water Pollution Control Council in January, 1969, include a policy statement, a classification of waters, a definition of water quality criteria, and a listing of known municipal and industrial sources of pollution and treatment needs on the interstate streams of Nebraska.

The *Water Quality Standards* provide in part that:

"All surface waters shall meet general aesthetic standards and shall be capable of sup-

porting desirable diversified aquatic life. These waters shall be free of substances attributable to discharges or wastes having materials that will form objectionable deposits, floating debris, oil scum and other matter producing objectionable color, odor, taste or turbidity—materials including radionuclides, in concentration or combinations which are toxic or which produce undesirable physiological responses in human, fish or other animal life or plants and substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life."

These standards declare that it is "...the public policy of this state to conserve the waters of the state and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for domestic, agricultural, industrial, recreational, and other legitimate beneficial uses...."

As part of these standards, it is required that "...all municipal wastes shall receive at least secondary treatment plus such additional treatment as is required to maintain Water Quality Criteria. All industrial wastes shall receive an equivalent degree of treatment or control consistent with waste characteristics, use and quality of receiving waters." Agricultural wastes must also receive "...the necessary treatment or other corrective action to protect the legitimate beneficial uses of...waters...."

FEEDLOT REGISTRATION

In 1968, the Nebraska Water Pollution Control Council adopted a regulation requiring registration of animal feedlots in order to determine their potential for pollution. Feedlots containing more than a specified number of animals, those located within 500 feet of any watercourse, and any other feedlot having a significant water pollution potential were required by this regulation to be registered with the Council.

PRESENT MUNICIPAL AND INDUSTRIAL SEWAGE TREATMENT

Municipal and industrial wastes have long been major stream pollutants. Before the first sewer systems, the wastes were hauled and dumped onto streambeds where high flows washed them away. The first sewage collection systems, in the 1890's, discharged untreated wastes directly into watercourses. Three towns in the State with a combined population of about 1,800 still use this means of waste disposal. There are also 78 communities in the State that do not have sewage collection systems.

In addition, extensive areas of Omaha and a few local areas in Lincoln are served by combination storm and sanitary sewers. As a result, heavy rainstorms or snowmelts cause considerable runoff, including sewage, to bypass the treatment plants and flow into streams untreated.

Forty-six communities with a combined population of about 429,000 provide only primary treatment of their wastes before discharging the effluent into watercourses.

Primary treatment consists of a settling basin often equipped with a skimming apparatus. Such treatment does little more than remove the most unsightly and objectionable pollutants. Primary treatment, at best, only lowers the Biochemical Oxygen Demand (BOD) by about 35 percent and removes about 60 percent of the suspended solids. As a result, downstream from these primary treatment plants, the natural oxidation process often reduces the dissolved oxygen (DO) in the water to a level fatal for fish and other desirable aquatic life.

Three hundred and forty communities, with a total population of 533,000, provide secondary treatment of their sewage. As with primary treatment, a settling basin is provided, but the BOD and suspended solids contained in the wastes are further reduced through biological action. Efficient plants incorporating secondary treatment remove about 85 percent of the original BOD and suspended solids. Presently no sewage treatment plants in Nebraska disinfect their effluent.

TABLE 24 / STATUS OF MUNICIPAL SEWAGE TREATMENT FACILITIES
(July 1, 1969)

River Basin	Communities Inventoried		Number of Communities				
				Type of Treatment			
	Number	Total 1960 Population	Without Sewer System	None	Primary	Secondary	Needing Improved Facilities
White River - Hat Creek	3	6,765	1	0	0	2	1
Niobrara	26	23,364	11	0	4	11	7
Missouri Tribs.	39 a/	347,253	7	2	5	23	9
North Platte	17	45,626	0	0	0	17	1
South Platte	13	22,463	0	0	0	13	3
Middle Platte	30 b/	63,584	1	0	2	28	2
Loup	47	42,775	8	0	5	34	7
Elkhorn	64	81,315	9	1	13	41	19
Lower Platte	42	150,610	5	0	2	35	4
Republican	50	42,014	17	0	6	27	10
Little Blue	35	42,300	6	0	3	26	6
Big Blue	62	61,180	4	0	2	56	7
Nemaha	40	38,567	9	0	4	27	5
STATE TOTAL	**468**	**967,816**	**78**	**3**	**46**	**340**	**81**

a/ South Sioux City and Ralston deliver sewage to Sioux City and Omaha respectively.
b/ Kearney has 2 plants.

Source: Nebraska Department of Health

Table 24 shows the status of municipal waste treatment facilities on July 1, 1969.

In addition to central systems serving municipalities, there are seventeen federal installations in the State with separate surface discharges. These plants process about 1.25 million gallons of sewage daily, an amount equal to that produced by a city of 20,000 people. All of these installations provide secondary treatment at present or are constructing additional facilities to provide such treatment.

Of the 563 industrial firms inventoried in 1968, which includes essentially all industries producing significant amounts of wastes, 408 used municipal facilities or had their own treatment plants. Seventeen other industrial plants had treatment facilities under construction. The remaining plants had inadequate waste treatment facilities at that time. However, many of the plants with inadequate waste treatment facilities have since made improvements. The status of industrial waste treatment facilities in 1968 is summarized in Table 25.

EXISTING PROBLEMS AND NEEDS

The quantity and variety of wastes produced by our growing, affluent society is increasing at an alarming rate. Even with modern primary treatment facilities, many communities discharge more harmful materials into streams today than they did a few decades ago when no treatment was provided. Also, the composition of wastes has changed drastically in recent years because of manufacturing's increasingly complex chemical processes, greater use of pesticides and fertilizers on farms and in municipalities, and the introduction of appliances such as automatic clothes washers, dishwashers, and garbage disposals, along with new household detergents high in phosphate content.

Municipal and Industrial Sewage Treatment. The present policy of the Nebraska Water Pollution Control Council requires a minimum of secondary treatment of all municipal sewage discharged into interstate streams by January 1, 1972, and secondary treatment of wastes discharged into the Missouri River by the end of 1975. As of July 1, 1969, 49 communities with a combined population of about 429,000 needed to install new facilities in order to comply with these standards (Table 24). In addition, 32 communities with a total population of about 183,000 had secondary treatment plants which needed improvement. Of these, five plants are badly overloaded and will require construction of additional facilities. Eight others are in such poor condition that replacement will be required. Improved treatment facilities are a major need in the Missouri Tributaries, Lower Platte, Elkhorn, and

TABLE 25 / STATUS OF INDUSTRIAL WASTE TREATMENT FACILITIES
(1968)

Status	Type of Industry							Total
	Meat Process.	Other Meat Products	Dairy Mfg.	Other Food	Hide Process.	Misc. Mfg.	Sand & Gravel Operations	
Adequate Treatment Provided	236	15	50	33	4	70	0	408
Need Treatment Facility or Connect to Municipal Sewer	8	1	0	0	0	0	0	9
Waste Treatment Facility Under Construction	15	1	0	0	1	0	0	17
Under Study by Nebraska Dept. of Health	4	8	1	4	0	10	102	129
STATE TOTAL	**263**	**25**	**51**	**37**	**5**	**80**	**102**	**563**

Source: Nebraska Department of Health

Nemaha River Basins. These basins have the greatest concentration of population which adds to the potential pollution problem.

State aid to municipalities for construction of waste treatment facilities would result in provision of more federal funds to the State. Under current law, water pollution control projects now receive either 30 or 33 percent federal funding and 67 or 70 percent local funding. The higher federal contribution is provided if comprehensive planning has been done. If the State would meet 25 percent of the cost, the federal portion would increase to 50 or 55 percent and the local portion would drop to 20 or 25 percent.

Sewage treatment plants of two federal installations are in need of remodeling or replacement.

Nine industries, including eight meat processors and one meat by-products processor, were discharging untreated wastes in 1968 (Table 25). They will be required to provide for treatment of their wastes either by constructing their own facilities or by connecting their sewers to a municipal sewage system. The waste treatment needs of another 129 plants were under study by the Nebraska Department of Health at that time. Most of the 129 plants under study will be required to treat their wastes, or in the case of sand and gravel producers, to manage their operations so wastes do not pollute streams.

Thermal Pollution. Little is known about the effects of thermal pollution on aquatic life. Some forms are very sensitive to temperature fluctuations and can tolerate only moderate rises in water temperature while other forms may benefit from the same changes.

Although thermal pollution is not presently a problem in Nebraska, it may become a problem if new thermal power generation plants are not located near abundant sources of water and if preventive measures, such as cooling towers, are not installed as some of these plants are constructed. More cooling towers will be needed as these plants become more numerous. However, blow-down wastes from recirculation cooled plants utilizing cooling towers can create their own pollution and aesthetic problems.

Studies are now in progress to investigate the effects on aquatic life of possible water temperature rises resulting from the operation of two nuclear-fueled power generating plants under construction adjacent to the Missouri River in Nebraska. Full investigation of thermal pollution and other potentially adverse ecological effects as well as possible benefits, utilizing the data from the two plants now being studied, is needed in the planning of all future thermal power generation plants in the State.

Agricultural Wastes. The water pollutants associated with agricultural operations are fertilizers, herbicides and insecticides, concentrations of salts in irrigation return flows due to water depletions, animal wastes, and silt from overland runoff. Excessive concentrations of these pollutants can and do change the water quality of both the streams, generally during periods of high runoff, and ground water, through seepage.

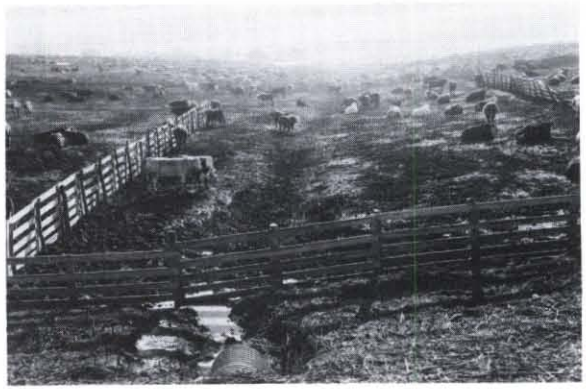
Modern agriculture has come to rely heavily on the use of chemicals. Commercial inorganic fertilizers are now used where barnyard wastes were once used to maintain soil fertility. Surface runoff and seepage to ground water leach some naturally available minerals from the soil, but heavy applications of commercial fertilizer, if not applied properly, can significantly increase the amounts of minerals leached or contained in runoff. These minerals affect surface water quality when washed into streams and the ground water when deep percolation takes place. Research and educational efforts are needed to develop methods to retain fertilizers and natural minerals on the land and to properly instruct people on the use of these methods.

The use of herbicides and insecticides has also increased drastically in recent years. Herbicides and insecticides are essential to high agricultural production, but they may find their way into surface and subsurface water supplies. Initially, they are generally in low concentrations and, therefore, cause little harm. However, as these concentrations increase by passage through the food chain, higher forms of animal life, including man, may be adversely affected. Effective controls on the use of herbicides and insecticides including more emphasis on the shift towards use of biodegradable forms are needed.

Plants take up very little of the dissolved minerals in irrigation water. Practically all of the original constituents of diverted waters are retained in the return flow plus addition of minerals that may be removed from soils through which the return flow passes, especially during the period of early irrigation. The minerals removed from the soil coupled with reduced streamflow due to the water depletions result in increased concentrations of minerals. The type and amount of dissolved minerals in the return flows depends largely on the initial quality of the water, but also to some extent on soil composition and characteristics and on agricultural and irrigation practices. Educational efforts are needed to acquaint irrigators with reuse methods to control or eliminate irrigation water return flows. Regulations may be necessary in the future if the problem persists or becomes worse.

Wastes produced from confined feeding of livestock in outdoor lots located near watercourses, particularly large cattle and swine operations, are a major stream pollutant. When waste materials are not properly handled, feedlot runoff carries large quantities of oxygen demanding organic matter, nitrates and other forms of salt, bacteria, and antibiotics into the receiving watercourses.

By June 15, 1969, 1,819 registrations had been received under the feedlot registration program. At



that time the registered feeding facilities had a total capacity of about 1,163,000 cattle, 226,000 swine, 76,000 sheep, and 1,000,000 poultry. About one-third of these facilities were within 500 feet of a watercourse. Cuming County had the greatest registered feedlot capacity with facilities for about 111,000 head of cattle. Dawson County followed with 90,000, then Scotts Bluff County with 66,000. Other counties with registered feedlot capacities in excess of 40,000 were Douglas, Hall, Polk, Sarpy, and Stanton.

Most feedlot wastes do not become stream pollutants. The Nebraska Water Pollution Control Council estimates that 10 percent of the feedlots contribute 90 percent of the feedlot wastes causing stream pollution. These major offenders generally straddle or are adjacent to streams or large drainageways. The Nebraska Water Pollution Control Council has brought legal action against one of the major offenders and as a result feedlot waste control facilities have been installed. Legal measures against other offenders may be necessary to reach the Council's goal of a fully effective program to control feedlot wastes by December 31, 1972.

Although many of the wastes do not pollute surface waters, some do pollute the ground water supply. No detailed information is available on the extent of this form of pollution, but local problems are likely in areas where the water table is near the land surface.

Sediment is the greatest pollutant of the state's surface water. Suspended sediments limit the uses of the water and increase the costs of treatment. In addition, sediment deposition reduces the capacities of stream channels, irrigation canals, farm ponds, and reservoirs.

Natural erosion caused by surface runoff produces some sediment. However, man's activities have accelerated the natural process. Overgrazed grasslands, inadequately protected cultivated lands, and poor agricultural practices in general contribute heavily to the high sediment load in

most Nebraska streams. Unprotected roadside cuts, building construction sites, drainage of marshes and other wetlands, and channel modification schemes also contribute significantly in some areas. Intensive application of good soil conservation practices, which is discussed in a later section, is needed to reduce the silt pollution of Nebraska waters. A side benefit of this conservation measure would be a reduction of flooding problems.

Eutrophication of Lakes and Reservoirs. Eutrophication is the natural maturation process of a lake from a nutrient-poor to a nutrient-rich body of water. Under natural conditions, most lakes are initially nutrient-poor, but as organic matter builds up over a period of centuries, they become nutrient rich. Decayed organic matter eventually fills the lake.

Some nutrients are very desirable in a body of water to support minute plant and animal life on which fish depend for their food supply. However, man's activities often add excessive nutrients to the water and shorten the enrichment period to only a few years, thus inducing eutrophication and drastically reducing the life and usefulness of such lakes.

Rapid eutrophication induced by man's activities is presently taking place in some Nebraska lakes, particularly the Salt Valley flood control reservoirs near Lincoln. Advanced stages of eutrophication can seriously reduce the recreational uses of reservoirs.

Although the amount of nutrients in the water is an influencing factor, there is no simple relationship between the amount of nutrients and the rate at which a lake or reservoir deteriorates. Essentially, all climatic, physical, chemical, and biological factors have an influence on the eutrophication process, but the concentrations of nitrogen and phosphorus are most commonly believed to be the critical determinants. Runoff from vegetated lands, feedlot runoff, irrigation return flows, and municipal and industrial wastes all contain nitrogen and phosphorus.

Unfortunately, the eutrophication process is practically irreversible. As the algae plants die, the nutrients are released and recycled to new algae growth while at the same time, additional nutrients are being supplied to the lake. Man can retard the eutrophication process and prolong the useful life of lakes by controlling the amount of nutrients entering the lakes.

Control of nutrient contribution to Nebraska's waters from the various sources mentioned previously is needed to retard eutrophication of lakes and reservoirs. This will, in some areas, require tertiary treatment of municipal and industrial wastes, regulation of feedlot location and operation to prevent waste runoff, more efficient use of irrigation water including adoption of reuse systems, and good land treatment practices to minimize nutrient leaching and runoff.

FUTURE NEEDS

As Nebraska's population and productivity increase, both surface and ground waters will be used more intensively, causing the compounding of water quality problems. Research, public education, cooperation between all levels of government, an effective regulation program, and above all, comprehensive planning are necessary to fully realize the goal of maintaining and improving the quality of Nebraska waters. Structural measures that may be needed in the future include elimination of combination sewers, regionalization of sewage collection and treatment systems, installation of sewage systems in small communities presently without systems, and disinfection of wastes.

Research and Education. Research is needed to evaluate the problems of organic and inorganic matter in surface runoff from metropolitan areas, agricultural lands, feedlots, and irrigation return flows. Even if a satisfactory method of reducing the nutrient level in surface water runoff can be found, eutrophication of future impoundments can only be retarded rather than prevented so additional research will be needed to develop methods of coping with eutrophication problems. It is important also that the adverse effects of eutrophication be considered in the planning and design of all future impoundments in the State, particularly when heavy recreation use is anticipated.

Since little is known about methods of treatment for many industrial wastes, research is needed to guide the development of adequate treatment facilities for some industrial wastes in the State.

The current focus on the causes and effects of all types of environmental pollution is expected to continue nationally and intensify at the state and local levels. All segments of society need to be aware of their individual contribution to the total pollution problem and be provided means whereby they can do their part in lessening the problem to achieve overall success. Farmers and urbanites alike need to be educated on the proper use of pesticides and fertilizers. Soil conservation and irrigation practices need improvement. Industries must be induced to use in-plant procedures and pre-treatment processes to reduce the strength and toxicity of their wastes to treatable limits.

Wastewater treatment plants must be operated at maximum efficiencies if the waters of the State are to be maintained at the highest possible level

of quality. Operator training will be required to realize this goal.

Regulation. Water quality criteria are of little value without an effective regulation program. Periodic monitoring of the effluent from all significant municipal and industrial waste treatment plants will be needed to assure adequate attention to treatment. The present limited program of monitoring, sampling, and surveillance of the quality of streams and other bodies of surface and ground water will require expansion to locate sources of pollution and assure compliance with the water quality standards. The *Nebraska Water Quality Standards* propose these measures, but expansion of the monitoring and sampling activities has been slow.

Cooperation. Effective regulation and improvement of the quality of Nebraska's waters will require cooperation between all levels of government. The improvement and construction of municipal waste treatment plants to comply with the water quality standards will require the expenditure of huge sums of money. It is important that federal, state, and local governments cooperate in financing the construction of these plants. Cooperation will continue to be needed between all levels of government in combating land erosion, monitoring the quality of streamflow, and carrying on other programs which serve to reduce water pollution. And finally, citizen cooperation is essential for an effective program to safeguard the quality of the state's water resources.

Comprehensive Planning. Because of the wide diversity and increasing complexity of water pollution problems, they can no longer be combated successfully on a local, piecemeal basis. Comprehensive basin planning is needed now to effectively control water pollution in the future. A thorough investigation program as well as the previously discussed elements of research, education, regulation, and cooperation are all important facets of a comprehensive water pollution control program.

Waste Collection Systems. Combination storm and sanitary sewers presently permit large quantities of wastes to bypass sewage treatment plants during periods of high storm runoff. These combination sewers are in use in Omaha and in local areas of Lincoln. Elimination of these combination sewers, which would be very costly, is needed in the future.

As of July 1, 1969, there were 78 communities in the State with a combined population of almost 14,000 people that had no sewage collection systems. All of these communities are small with populations of 350 people or less and many have populations of less than 100 people. However, as water use increases in some of these communities through community growth and higher per capita water use, those communities that continue to prosper will need to install sewage collection and treatment facilities in the future.

The existing trend is toward installation of individual sewage treatment facilities as suburbs develop and expand. This trend is particularly evident in the Omaha metropolitan area. Regional sewage collection systems and treatment facilities should be considered for areas of this type. Often low flows in small streams in the vicinity of newly developing suburbs are inadequate to assimilate the waste loads imposed on them, even when the wastes have received a high degree of treatment. Regional sewage treatment facilities can generally be located along larger watercourses with greater assimilative capacities for the treated wastes. In addition, larger waste treatment facilities can generally be designed to operate more economically and efficiently and personnel can be better trained to insure that the treatment plants are properly operated.

Waste Disinfection. As water associated recreation grows in the future, disinfection of waste discharges will be increasingly needed to prevent health problems. Disinfection will be particularly necessary for wastes discharged to streams used extensively for recreational purposes or where impoundments are located directly downstream.

Fish and Wildlife

Fish and wildlife resources are important not only to Nebraska and the nation's sportsmen, but also to a growing number of nonconsumptive users such as sightseers, outdoor photography enthusiasts, and science students. The indirect, but very real, economic benefits which accrue to trades and businesses associated with these consumptive and nonsconsumptive uses extend the importance of fish and wildlife to an even larger part of the populace.

Almost all of Nebraska is useful for fish and wildlife, but this use is generally subordinate to agriculture. Only about 380,000 acres, or less than 1 percent of the state's area, is devoted primarily to fish and wildlife purposes. The preponderance of this area is made up of wildlife refuges, multipurpose reservoir developments, and state recreation and special use areas. Also, the 340,000 acres included in the Nebraska National Forest and Oglala National Grasslands, while classified as primarily

agricultural, have significant fish and wildlife value.

EXISTING RESOURCES AND HABITAT

The fish and wildlife resources of the State have undergone a series of major changes since the arrival of the first settlers. An initial lack of concern for these resources in times of former abundance resulted in little regard being given to their conservation and propagation. Yet, even with intensive management, fish and wildlife often have been adversely affected by extensive changes in habitat resulting from agricultural pursuits. Conversion of grasslands and woodlands to cropland and increased human habitation have brought about the demise of some species of wildlife. Dewatering of streams for irrigation and power generation, and pollution, particularly by sediments, of Nebraska streams has had a deleterious effect on fishery resources. In addition, stream fisheries have suffered as a result of reductions in peak flows below reservoirs.

Some changes have been beneficial. Some species of wildlife have been able to adapt to environmental changes, and have benefited through increased availability of grain and forage foods, by the reduction of natural predators, and because of good soil conservation practices. Fishery resources have been benefited by increased fish production in reservoirs.

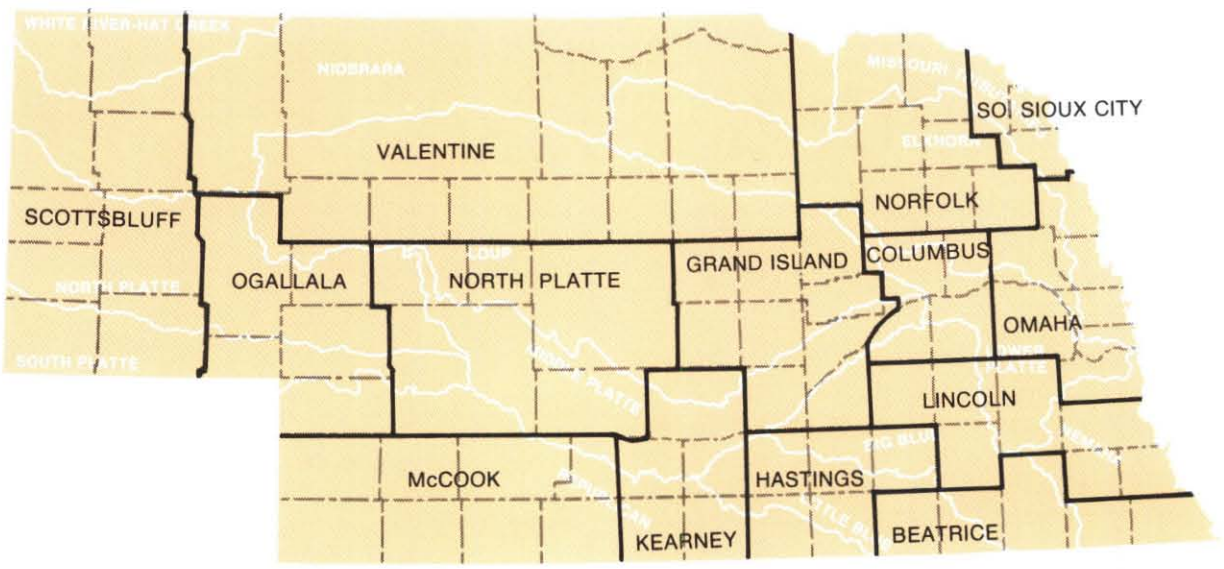
Fish. Most standing waters and perennial streams in the State have some sport fishery value. These include: reservoirs, natural lakes, streams, farm ponds, and gravel pits. While nearly all reservoirs and about half the natural lakes are open to the public, sportsman access to most of the state's water is privately controlled.

Most of the state's ponded waters support mixed populations of pike, bass, perch, catfish, bullheads, and carp. While some streams in the western and northern portions of the State support a trout fishery, the fish population of most Nebraska streams is predominantly made up of warm water fish.

The State was divided into 14 socio-economic areas (SEA's) as a basis for regional planning in the *Outdoor Recreation Plan* of the Nebraska Game and Parks Commission. The boundaries of these SEA's are shown in Figure 34.

A 1966 inventory of fishery resources conducted by the Nebraska Game and Parks Commission shows nearly 8,850 miles of streams and 136,800 acres of ponded water suitable for fish production. The inventory did not include gravel pits and small watershed project structures. The inventoried sup-

FIG. 34 / SOCIO-ECONOMIC AREAS



Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan,* Nebraska Game and Parks Commission

TABLE 26 / EXISTING SUPPLY OF SURFACE WATERS WITH FISHERY POTENTIAL

Socio – Economic Area	Stream Mileage by Class a/ (1967)					Surface Area of Standing Water b/ In Acres			
						Reservoirs			
	1	2	3	4	5	Over 1,000 Acres	Under 1,000 Acres	Farm Ponds	Natural Lakes
1. South Sioux City	0	36	39	233	0	0	500	421	0
2. Omaha	0	0	198	509	43	0	724	1,306	0
3. Lincoln	0	0	0	693	0	1,800	2,586	2,812	0
4. Beatrice	0	0	96	474	13	0	255	2,315	0
5. Norfolk	0	32	130	419	0	7,349	60	2,329	0
6. Columbus	0	0	18	257	2	0	1,114	522	0
7. Grand Island	0	0	0	737	0	2,680	175	1,398	0
8. Hastings	0	0	34	239	0	0	59	1,534	0
9. Kearney	0	0	0	238	0	13,468	364	806	0
10. McCook	0	0	0	807	0	10,085	120	313	0
11. North Platte	0	0	0	397	0	7,661	1,752	258	0
12. Ogallala	0	0	32	140	0	35,000	320	0	3,372
13. Valentine	0	0	166	1,860	0	2,700	370	1,913	22,775
14. Scottsbluff	0	0	193	808	9	3,758	1,192	636	0
STATE TOTAL	**0**	**68**	**906**	**7,811**	**67**	**84,501**	**9,591**	**16,563**	**26,147**

a/ *Class 1 – Streams with national as well as statewide value*
2 – Streams with statewide value
3 – Streams of value to large districts of the state
4 – Streams of value to smaller districts such as counties
5 – Streams of restricted local value

b/ *Surface area of private gravel pits and small watershed project structures not inventoried*

Source: *Outdoor Recreation for Nebraska – A Comprehensive Plan*, Nebraska Game and Parks Commission, 1968

ply of these waters by SEA is shown in Table 26. There is almost as much water surface area in the combined Valentine and Ogallala SEA's as in the remainder of the State.

Wildlife. Nebraska is known for a wide variety of upland game birds and mammals, several types of big game, and numerous species of waterfowl. Many of these birds and mammals are directly dependent on water as part of their habitat. The habitat of all wildlife is to some degree affected by land use and water development.

The most important upland game birds are the ringnecked pheasant, bobwhite quail, prairie chicken, and sharptailed grouse. Of these, the pheasant has the widest distribution and largest popularity with both residents and nonresidents. Both pheasant and quail find suitable habitat in developed cropland, readily adapting if some natural cover is available. Prairie chicken and grouse are adapted to range and grassland but also are found on the fringes of intensively cropped lands.

Upland game animals consist mainly of cottontail rabbits and fox squirrels. These species are found throughout the State, but are most abundant in the mixed cropland-woodland habitat commonly found along streams in the eastern and southern portions of the State.

Muskrat, mink, beaver, and raccoon are important fur species. These animals are dependent upon streams and adjacent cover for their habitat. In recent years, fox and coyotes have provided increased hunting opportunities during winter months.

Big game species available include mule and whitetailed deer, antelope, and wild turkey. Mule deer are found primarily in the western portion of the State. Whitetail deer are found throughout the entire State, but their population is highest along the more heavily forested stream reaches. Deer, particularly whitetails, have adapted remarkably well, in many cases benefiting from man's changes.

Antelope are most numerous in the Panhandle, but recent reintroduction programs in the Sandhills have increased their population in that region.

Wild turkeys were introduced to Nebraska only 10 years ago, and are already providing good hunting opportunity. The greatest turkey populations

are presently in the northern portion of the State, but they are becoming established in other areas where large tracts of forest cover are available.

Migratory Waterfowl. Waterfowl habitat is unevenly distributed across the State, as shown by the Waterfowl Range Map in Figure 35. Most natural wetlands are concentrated in the Sandhills and southcentral Nebraska. These wetland areas are valuable for duck production and serve important roles as resting areas along the migration route and as hunting areas.

There are few public areas for waterfowl hunting in the State. Most of the lands presently devoted to waterfowl are used for production and as refuges.

Sixty-two publicly owned areas in the State, containing about 160,000 acres, are managed primarily for waterfowl purposes. Of these, 21 areas containing 18,227 acres are managed by the Nebraska Game and Parks Commission and four areas containing about 128,000 acres are wildlife refuges managed by the U. S. Fish and Wildlife Service. The other 37 were recently acquired by the Fish and Wildlife Service in the rainwater basin area of southcentral Nebraska. These areas were obtained as a part of a program to purchase and manage selective waterfowl production areas and of the 12,274 acres devoted to waterfowl, 11,215 acres are currently open for hunting.

PRESENT PROBLEMS

Although the problems associated with fish and wildlife are numerous and varied, they center about the maintenance of enough favorable habitat to enable production of sufficient quantities of fish and game to meet sportsman demand and the provision of access to fishing and hunting areas.

Insufficient Production. Depletion of streamflow in combination with increasing degradation of water quality reduces fish and wildlife habitat and the potential for reproduction.

Many of the smaller streams and tributaries in cropland areas are overappropriated for irrigation, particularly in the upper portions of the Big Blue River Basin, the North Platte River Basin, and the Middle Platte River Basin. During periods of drought, stream appropriations are generally used to the fullest extent possible and as a result many streams are completely dried up. The total, or near total, absence of flow in such streams may essentially kill off existing fish and aquatic plant life, thus almost irreversibly damaging these resources in some instances unless extensive programs of restocking and management are undertaken. Historically, fish and wildlife have been given little consideration in water law and water development and are often affected adversely by water use patterns and provisions developed specifically for other purposes.

Public Access. The landowner-sportsman relationship is a major problem limiting use of the state's fish and wildlife resources, according to *Outdoor Recreation for Nebraska,* a comprehensive plan prepared in 1968 by the Nebraska Game and Parks Commission. Although fish and wildlife are public resources, access to these resources is largely at the discretion of individual farmers and ranchers. Poor landowner-sportsman relationships have long hindered hunting activity and, to a lesser degree, fishing activity near the metropolitan areas of eastern Nebraska. This problem is also manifesting itself in the west, far removed from metropolitan centers.

Access to hunting areas is particularly limited for waterfowl hunters along the Platte and Missouri Rivers and in some parts of the wetlands area of southcentral Nebraska. Most of the shortage is due to the lack of enough suitable land in comparison with the large demand for waterfowl hunting. Better hunting areas are often leased to individuals or groups of individuals and are not available to the general public.

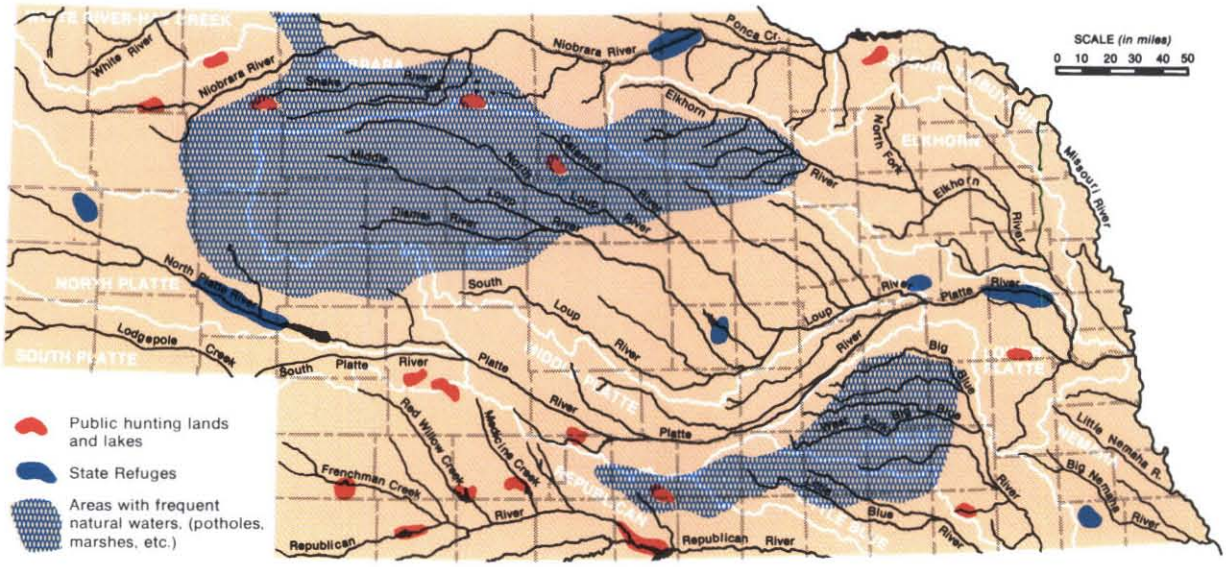
Water Quality. Fisheries production in many Nebraska streams is being reduced by degradation of water quality. In many waters, sediment is the most serious pollutant restricting sport fish production. Other major pollutants are municipal and industrial wastes, feedlot wastes, and runoff from agricultural lands containing excess concentrations of chemicals.

In addition to the effects of sediment and municipal and industrial wastes discussed in an earlier section, the detrimental effects of herbicides and insecticides on fish and wildlife populations has recently been recognized. Documentary evidence from other parts of the country substantiates the adverse effect on fish and wildlife by these chemicals, particularly by the long-lived chlorinated hydrocarbons such as DDT that were so freely used up until very recently. With almost 4 million acres of the state's lands treated with various insecticides and herbicides in 1964 and undoubtedly more treated now, it is obvious that Nebraska, along with the rest of the nation, must be concerned about the possible effects of the widespread use of these chemicals.

Habitat Preservation. Many farmers and ranchers apply good conservation measures to their lands which provide essential wildlife habitat, but the trend has been toward more intensive agricultural development and a general deterioration of wildlife habitat. Massive, but short-range, programs that diverted land from production for other reasons temporarily stemmed this decline by pro-

FIG. 35 / WATERFOWL RANGE MAP

(1967)



Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan*, Nebraska Game and Parks Commission

viding essential habitat for game production. However, since the lessening of emphasis on such programs, many idle lands have been returned to production. This effect on the habitat has been especially detrimental to pheasant populations.

A land conversion program presently providing wildlife habitat is the Cropland Adjustment Program (CAP). When authorized in 1965, the primary program objective was to convert cropland to protective conservation uses for which farmers received annual adjustment payments. The program also provided for enhancement of wildlife habitat by providing additional payments to farmers who performed recommended wildlife habitat work on land designated under agreement. These lands were contracted for periods between five and ten years in 1966 and 1967. Unfortunately, even though landowner interest was high, this program has not received further funding and will probably be phased out as the present contracts expire. If this occurs and the habitat provided by the program is destroyed, wildlife populations may be significantly reduced in some areas.

Other. A lack of wetlands is the major problem facing duck populations. Drainage of wetlands has taken a high toll of waterfowl habitat. About 85 to 90 percent of the original wetlands in southcentral Nebraska has been lost to drainage, land leveling, and siltation. Loss of wetlands in the Sandhills has been much slower, estimated at about 16 percent of their original area. However, the loss is continuing there and the supply of wetlands could eventually become critically short in that area unless their inherent values are considered in all water development programs, with measures for protection and retention.

FUTURE PROBLEMS AND NEEDS

Future problems will likely differ from present problems only in severity. As is the case presently, provision and conservation of adequate amounts of good quality fish and wildlife habitat will be the principal problem of the future and will be increased significantly in severity if appropriate steps are not taken as Nebraska's land and water resources are developed. Loss of habitat can be aggravated through further degradation of water quality, diminution of streamflow, and intensification of agricultural production without regard for wildlife habitat.

As Nebraska's water quality standards are enforced, the water quality downstream from municipalities and industries will improve and fishery resources in particular will benefit accordingly. However, water pollution due to agricultural operations will continue to be detrimental to fish and

wildlife in the future as irrigation development and water depletion continues, and as lands more susceptible to erosion are brought into production.

Probably the most important future need to improve water quality for fish and wildlife as well as for other purposes is a greatly accelerated land treatment program and comprehensive land use planning.

As irrigation development continues in the future, fish and wildlife will be even more detrimentally affected by streamflow depletions unless adequate precautions are taken. Fish and wildlife need to be considered in all future water development and adequate flows maintained for their survival and propagation. Consideration for fish and wildlife requirements is needed in Nebraska water law, as no provisions now exist to designate and reserve water for these purposes.

Efforts should be made to protect and preserve the habitat during future water resource developments. These efforts should include an accurate assessment of project impact based upon thorough ecological evaluation by all interested agencies, compensating project features to reduce habitat losses, and consideration of alternative project features in the event irretrievable damage may occur to the environment.

Production of sufficient quantities of game to meet consumptive and nonconsumptive demands will be largely dependent upon the management of private lands. This will require an intensive educational effort as well as economic incentives. Nebraskans need to be aware that wildlife is a valuable product of the land and a renewable natural resource and is thus subject to husbandry and stewardship through wise land use management. Every effort needs to be expended by all levels of government and the private sectors to retain and enhance habitat essential to the fish and wildlife resources of the State. Programs will be needed to inform the public of the values of these resources and to prevent future deterioration and destruction of wildlife habitat. Farmers in particular need to be cognizant of the value of windbreaks, woodlots, grassed waterways, farm ponds, etc. to their agricultural operations and the need for developing and preserving these forms of wildlife habitat.

Agricultural operations are becoming increasingly sensitive to economic considerations. This has in large part been responsible for the trend toward destruction of wildlife habitat in order to intensify agricultural use of the land. Nothing short of a redirecting of economic incentives will prevent future destruction of much of the remaining habitat.

The best potential for redirecting economic incentives rests in providing payments for certain agricultural and conservation practices of benefit to fish and wildlife as an integral part of federal and state programs. The present Cropland Adjustment Program is an excellent example of the type of measures that will be needed. Programs of this type, when instituted over large areas, have a highly significant impact on game populations. Additional programs will be needed to encourage a redirecting of economic incentives, such as payments for preservation of wetlands, if the status of wildlife, through habitat conservation, is to be maintained in the future.

Public access to lands will likely become a critical problem in the future. Some of the loss of public access will be due to the skyrocketing demand for water associated land, principally river and lake frontage. Individuals and groups of individuals will likely continue buying and leasing these lands as rapidly as they become available and generally totally restricting public access as they have done in the past.

Poor landowner-sportsman relationships have been responsible for much of the loss of sportsman access to lands. This is presently most evident in eastern Nebraska and if existing attitudes and trends continue, poor relations could become established across the remainder of the State. In order to preserve sportsman access to lands in the future, landowner-sportsman relations need to be improved and tools developed to provide greater public access and use of private waters.

Intensive efforts will be needed to obtain public access to streams, lakes, and marshes which have significant potential for fishing and hunting. Public access could be obtained through access easements or purchase of these areas in fee title where necessary. In addition to fishing and hunting, many of these areas would be a boon to other forms of outdoor recreation. They could be used for nature study, outdoor photography, hiking, and other outdoor activities. The need for this type of land will be particularly critical in eastern Nebraska near the Omaha and Lincoln metropolitan areas.

Outdoor Recreation [a/]

Outdoor recreational opportunities enable many people to more fully enjoy life. For this reason, ample outdoor recreational opportunities are an important segment of our total environment.

Recreation also contributes measurably toward the economic growth of the State. Continued outdoor recreational development is not only necessary to satisfy the growing needs and demands of Nebraskans, it is also a key to the state's tourist industry.

Water oriented activities historically have been among the most popular forms of recreation and their popularity is increasing at an even greater rate.

EXISTING SUPPLY OF WATER AREAS

Bodies of water larger than 40 acres and streams over 1/8 mile wide provide about 705 square miles of water surface area within the State.[b/] Major reservoirs used for recreation are located in the Republican River Basin in the southwest, in the Platte River Basin in the westcentral, and on the Missouri River in the northeast. Almost all of the natural lakes are located in the Sandhills area.

Major rivers in the State are the Missouri, Niobrara, Elkhorn, the Loup system, Platte, Republican, and the Little and Big Blue. There are also many smaller rivers and streams that are valuable

a/ *Much of the information contained in this section has been obtained from Outdoor Recreation for Nebraska—A Comprehensive Plan, published by the Nebraska Game and Parks Commission in 1968.*

b/ *Area Measurement Reports, Bureau of the Census, June, 1967*

TABLE 27 / ESTIMATED ANNUAL CAPACITY OF FISHERY RESOURCES EXPRESSED AS FISHERMAN DAYS
(1967)

Socio-Economic Area	Streams	Reservoirs Over 1000 Acres	Reservoirs and Public Gravel Pits Under 1000 Acres	Private Farm Ponds	Natural Lakes	Total a/
So. Sioux City	20,625	None	20,000	10,525	None	51,150
Omaha	43,375	None	28,960	32,650	None	104,985
Lincoln	17,325	45,000	103,440	70,300	None	236,065
Beatrice	26,250	None	10,200	57,875	None	94,325
Norfolk	37,975	183,725	2,400	58,225	None	282,325
Columbus	9,125	None	44,560	13,050	None	66,735
Grand Island	18,425	67,000	6,960	34,950	None	127,335
Hastings	10,975	None	2,320	38,350	None	51,645
Kearney	5,950	336,700	14,560	20,150	None	377,360
McCook	20,175	257,000	4,800	7,825	None	289,800
North Platte	10,800	191,525	53,800	6,450	None	262,575
Ogallala	8,300	875,000	12,800	1,650	202,320	1,100,070
Valentine	71,400	67,500	14,800	47,825	1,366,500	1,568,025
Scottsbluff	44,325	84,500	47,680	15,900	None	192,405
STATE TOTAL	**345,025**	**2,107,950**	**367,280**	**415,725**	**1,568,820**	**4,804,800**

a/ *Private gravel pits and watershed (PL 566) structures not included*

Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan,* Nebraska Game and Parks Commission, 1968

for recreation, particularly in the eastern and southern portions of the State.

Waters supporting sport fisheries include reservoirs, natural lakes, streams, farm ponds, and gravel pits. The state's waters, except for private gravel pits and small watershed project structures, were inventoried by the Nebraska Game and Parks Commission in 1966 and their fishing potential estimated. The estimated annual capacity of these fishery resources is shown in Table 27.

The distribution of fishery resources is as important as their magnitude. Over 55 percent of the total statewide capacity is in the Valentine and Ogallala SEA's. These western SEA's are so far from fishermen living in the more densely populated eastern portion of Nebraska that their use by eastern Nebraska fishermen on a daily basis (day use) is practically precluded. The combined Omaha and Lincoln SEA's contain only about 7 percent of the state's fishing capacity.

Data on boating and water skiing are combined because both activities use the same waters. With the exception of limited use of the Missouri River, practically all of the boating and water skiing activity is confined to standing water due to limited stream depths. Because of the distance between major bodies of standing water and population centers, much of the water area available is not convenient for day use. The rather sparsely populated Ogallala SEA alone contains more than one-third of the state's total available water surface suitable for boating and skiing.

The present supply of Nebraska's boating and water skiing waters, expressed in surface acres, is shown in Table 28.

PRESENT AND FUTURE RECREATION DEMAND

Outdoor recreation demand has been rapidly increasing in the past few years, both in Nebraska and the nation. All evidence indicates a continuation of this trend. Recreation demand depends in large part on total population, degree of urbanization, disposable family income, leisure time, and mobility. As the impact of these factors increases, the total demand for recreation is expected to swell dramatically.

Future demands for various outdoor recreation activities were estimated by the Nebraska Game and Parks Commission. Total statewide demand for outdoor recreation was projected to increase 21 percent from 1967 to 1972, 50 percent by 1980, and 160 percent by 2000.

These estimated demands for outdoor recreation activities are presented in Figure 36. Water oriented activities, outdoor sports, and camping are expected to increase considerably in popularity.

TABLE 28 / EXISTING BOATING AND WATER SKIING WATERS
(1967)

Socio-Economic Area	Surface Water Area (Acres)
So. Sioux City	30
Omaha	1,945
Lincoln	4,513
Beatrice	285
Norfolk	7,450
Columbus	946
Grand Island	3,083
Hastings	102
Kearney	13,188
McCook	12,255
North Platte	7,416
Ogallala	36,620
Valentine	14,914
Scottsbluff	3,898
STATE TOTAL	**106,645**

Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan*, Nebraska Game and Parks Commission, 1968

Of the many outdoor recreational pursuits dependent upon water, fishing, boating, and water skiing have by far the largest surface area requirements. Provisions for many other recreational activities such as camping, outdoor swimming, and picnicking are often made in connection with water bodies because of the attractiveness of the setting and the opportunity to combine activities, but the size of the water surface is not a prime requisite. Therefore, the enhancement needs of such activities primarily involve problems of quality, rather than quantity.

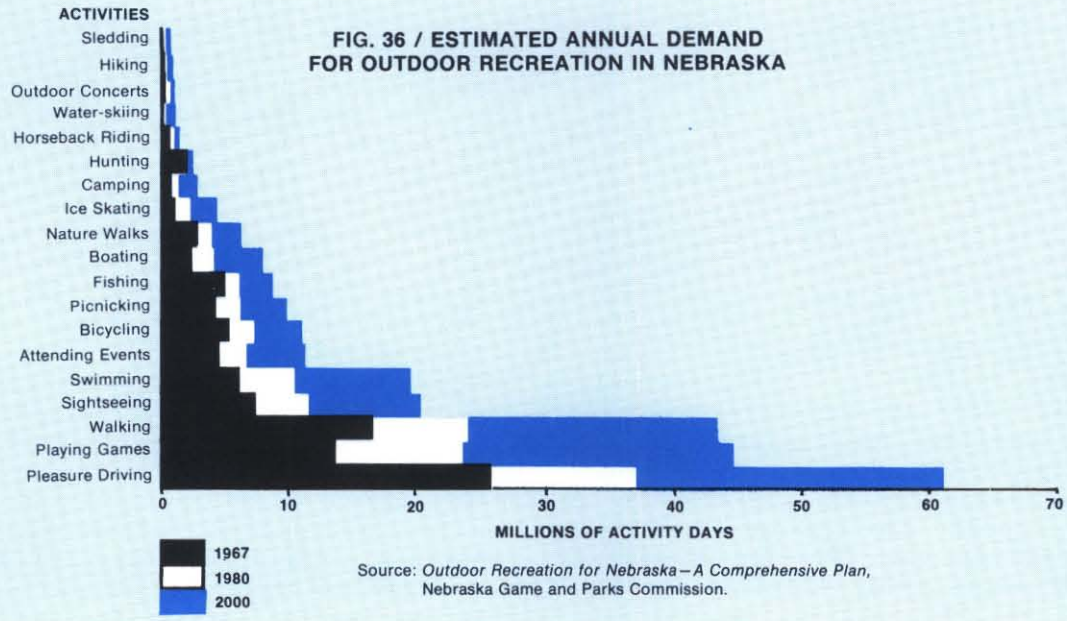
Fishing presently is the major recreational use of Nebraska waters in terms of surface area required and is expected to continue being the primary use into the 21st Century. By the year 2000, fishing demand is estimated to increase about two-thirds above the 1967 level of over five million fishermen days. Inspection of Table 29 shows that the distribution of demand for fishing will become even more unbalanced throughout the State than it is now. The demand generated in the Lincoln and Omaha SEA's will increase from slightly less than 50 percent to over 60 percent of the state total.

As rapid as the recent increase in demand for boating and water skiing has been, it appears that future demand will continue to increase at an even faster rate. The estimated future requirements for boating and water skiing waters are presented in Table 30.

The future demand for boating and water skiing waters is estimated to vary more across the State than the future demand for fishing waters. By the year 2000, the Omaha and Lincoln SEA's are expected to have over two and one-half times as much boating demand and almost four and one-half times as much water skiing demand as the remainder of the State combined.

Recreation activities such as camping, outdoor swimming, and picnicking are often complemen-

FIG. 36 / ESTIMATED ANNUAL DEMAND FOR OUTDOOR RECREATION IN NEBRASKA



Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan*, Nebraska Game and Parks Commission.

TABLE 29 / ESTIMATED PRESENT AND FUTURE DEMAND FOR FISHING

Socio-Economic Area	Demand in Fisherman Days			
	1967	1972	1980	2000
South Sioux City	103,300	104,800	111,500	131,300
Omaha	1,643,300	1,861,400	2,281,100	3,834,600
Lincoln	797,200	868,100	1,016,100	1,567,100
Beatrice	242,300	225,600	209,500	125,900
Norfolk	351,200	355,000	378,600	443,400
Columbus	192,200	198,400	219,200	289,700
Grand Island	339,700	347,400	376,500	464,800
Hastings	242,200	247,500	268,200	333,800
Kearney	207,300	214,000	235,000	306,600
McCook	143,800	138,300	143,100	123,400
North Platte	253,200	258,800	280,200	349,800
Ogallala	65,500	63,000	62,400	56,100
Valentine	169,800	92,600	147,800	93,100
Scottsbluff	328,700	342,000	383,000	542,000
STATE TOTAL	**5,079,700**	**5,316,900**	**6,112,200**	**8,661,600**

Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan*, Nebraska Game and Parks Commission, 1968

tary to the major activities of fishing, boating, and water skiing. These activities are all expected to become much more popular in the future.

EXISTING AND FUTURE NEEDS AND OPPORTUNITIES

Deficiencies in outdoor recreation opportunities were determined for each SEA on the basis of estimated present and future demands relative to the existing supply of water surface area. While opportunity exists for some recreation demand in water area deficient SEA's to be satisfied in nearby SEA's with a surplus of water area, no satisfaction of recreation demand across SEA boundaries was assumed in this analysis.

The greatest deficiency in water based outdoor recreational opportunity throughout the State is for fishing. On a statewide basis, the estimated 1970 fishing demand of about 5,200,000 fisherman days as compared to present capacity of about 4,800,000 fisherman days indicates demand is almost being met. However, a closer analysis of the demand-supply picture by SEA's qualifies this apparently favorable situation. As shown in Figure 37, some SEA's have large surpluses of fishing waters while others have gross deficiencies. For example, the Omaha and Lincoln SEA's presently have particularly severe deficiencies in fishing opportunity and these deficiencies are expected to become much more severe in the future. The South Sioux City, Beatrice, Norfolk, Columbus, Grand Island, Hastings, and Scottsbluff SEA's have moderate fishing water deficiencies. The remainder of the SEA's, all located in the westcentral portion of the State, have surplus fishing waters.

Future needs for fishing water in addition to that presently available, expressed in surface acres, are presented in Table 31. It appears that somewhere between about 80,000 and 130,000 surface acres of water are needed to satisfy the existing deficiency if they are well distributed in areas of need. By 2000, approximately 165,000 to 265,000 surface acres will be needed.

The existing supply of boating and skiing waters is compared with future demands in Figure 38. The eastern portion of the State, except for Norfolk SEA, is presently deficient in boating and water skiing opportunity, with the most critical problem in the Lincoln and Omaha SEA's. The remainder of the State presently has a surplus of boating and skiing waters.

Deficiencies in boating opportunity are about 45,000 acres presently and are expected to increase to about 150,000 acres by 2000. Deficiencies in water skiing opportunity are about 25,000 acres presently and are expected to increase to about 120,000 acres by 2000.

From these estimates it can be seen that the area of greatest present and future need for additional water based recreational opportunity is the eastern portion of the State. The Omaha and Lincoln SEA's have particularly severe opportunity limitations. The Scottsbluff SEA at the extreme western end of the State is also moderately deficient in water based recreational opportunity while the remaining SEA's have a surplus.

TABLE 30 / ESTIMATED FUTURE WATER SURFACE AREA REQUIREMENTS FOR BOATING AND WATER SKIING

Socio-Economic Area	Estimated Water Surface Area Requirements in Acres					
	Boating			Water Skiing		
	1972	1980	2000	1972	1980	2000
South Sioux City	1,080	1,300	2,080	370	470	1,120
Omaha	32,570	43,990	95,710	22,730	33,650	85,490
Lincoln	14,310	18,610	37,990	9,530	13,680	33,270
Beatrice	2,390	2,460	1,910	760	840	980
Norfolk	3,400	4,070	6,420	1,150	1,480	3,350
Columbus	2,090	2,590	4,620	660	830	2,320
Grand Island	3,660	4,460	7,420	1,170	1,530	3,810
Hastings	2,730	3,320	5,490	880	1,150	2,920
Kearney	2,330	2,880	5,030	760	1,000	2,670
McCook	1,280	1,480	1,690	470	580	910
North Platte	3,080	3,720	6,120	900	1,170	3,110
Ogallala	600	660	790	210	250	420
Valentine	1,330	1,390	1,170	500	550	600
Scottsbluff	4,080	5,040	9,630	1,180	1,560	4,830
STATE TOTAL	**74,930**	**95,970**	**186,070**	**41,270**	**58,740**	**145,800**

Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan*, Nebraska Game and Parks Commission, 1968

TABLE 31 / NEED FOR ADDITIONAL FISHING WATERS

Socio-Economic Area	Deficiency of Fishing Opportunity in Fisherman Days			Range of Additional Needs for Water Surface Area in Acres a/		
	1972	1980	2000	1972	1980	2000
South Sioux City	53,600	60,300	80,100	1,300 - 2,100	1,500 - 2,400	2,000 - 3,200
Omaha	1,756,400	2,176,100	3,729,600	43,900 - 70,300	54,400 - 87,000	93,200-149,200
Lincoln	632,000	780,000	1,331,000	15,800 - 25,300	19,500 - 31,200	33,300 - 53,200
Beatrice	131,300	115,200	31,600	3,300 - 5,200	2,900 - 4,600	800 - 1,300
Norfolk	72,700	96,300	161,100	1,800 - 2,900	2,400 - 3,800	4,000 - 6,400
Columbus	131,700	152,500	223,000	3,300 - 5,300	3,800 - 6,100	5,600 - 8,900
Grand Island	220,100	249,200	337,400	5,500 - 8,800	6,300 - 10,000	8,400 - 13,500
Hastings	195,900	216,600	282,100	4,900 - 7,800	5,400 - 8,700	7,100 - 11,300
Kearney	0	0	0	0	0	0
McCook	0	0	0	0	0	0
North Platte	0	17,600	87,200	0	400 - 700	2,200 - 3,500
Ogallala	0	0	0	0	0	0
Valentine	0	0	0	0	0	0
Scottsbluff	149,600	190,600	349,600	3,700 - 6,000	4,800 - 7,600	8,700 - 14,000
STATE TOTAL	**3,343,300**	**4,054,400**	**6,612,700**	**83,500-133,700**	**101,400-162,100**	**165,300-264,500**

a/ *The smaller acreage will be the water surface area needed if all future impoundments are less than 1000 surface acres (estimated on the basis of 40 fisherman days per acre annually) and the larger acreage is applicable if all future impoundments are greater than 1000 surface acres (25 fisherman days per acre annually).*

Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan*, Nebraska Game and Parks Commission, 1968

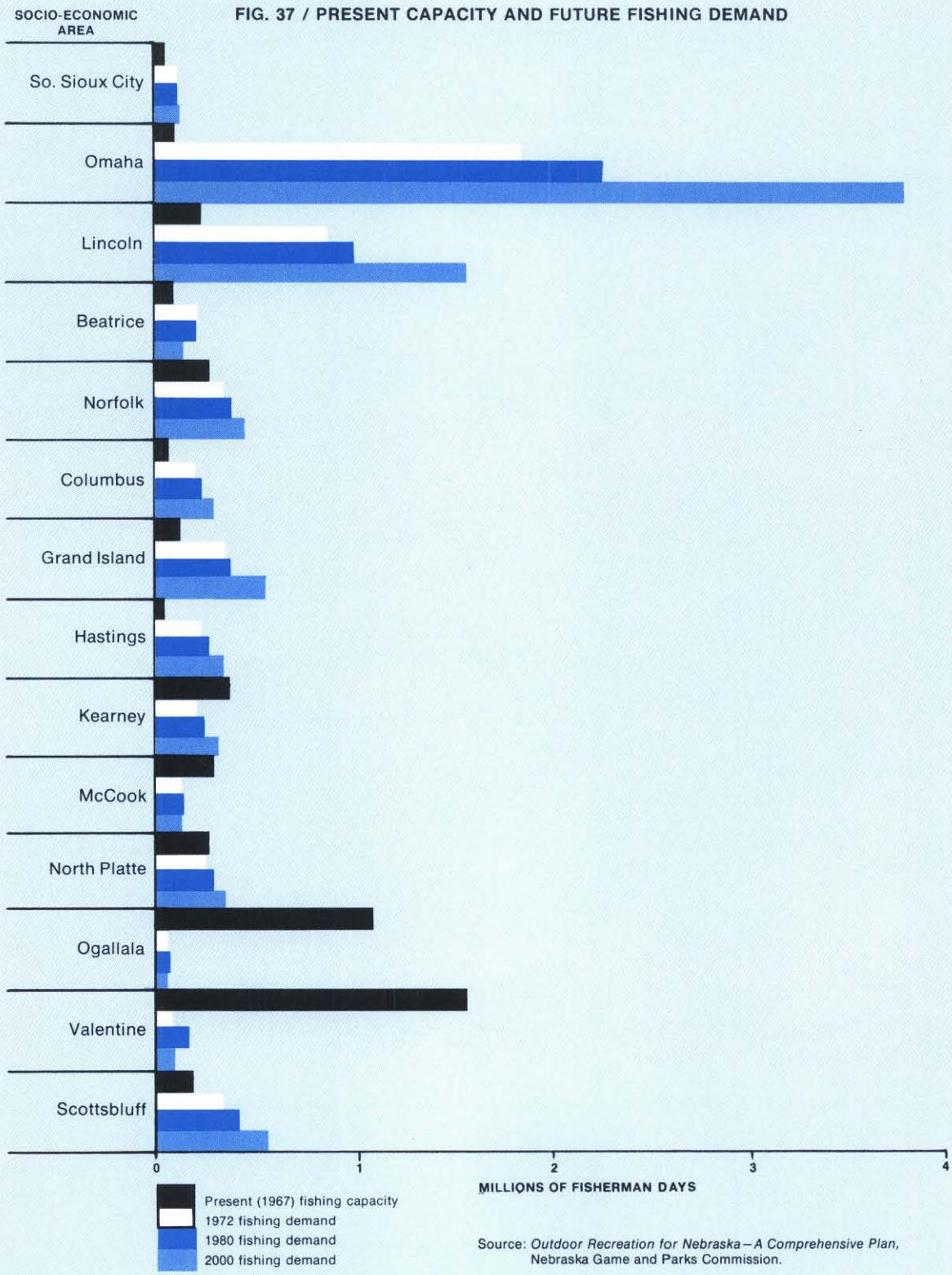


FIG. 37 / PRESENT CAPACITY AND FUTURE FISHING DEMAND

Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan,* Nebraska Game and Parks Commission.

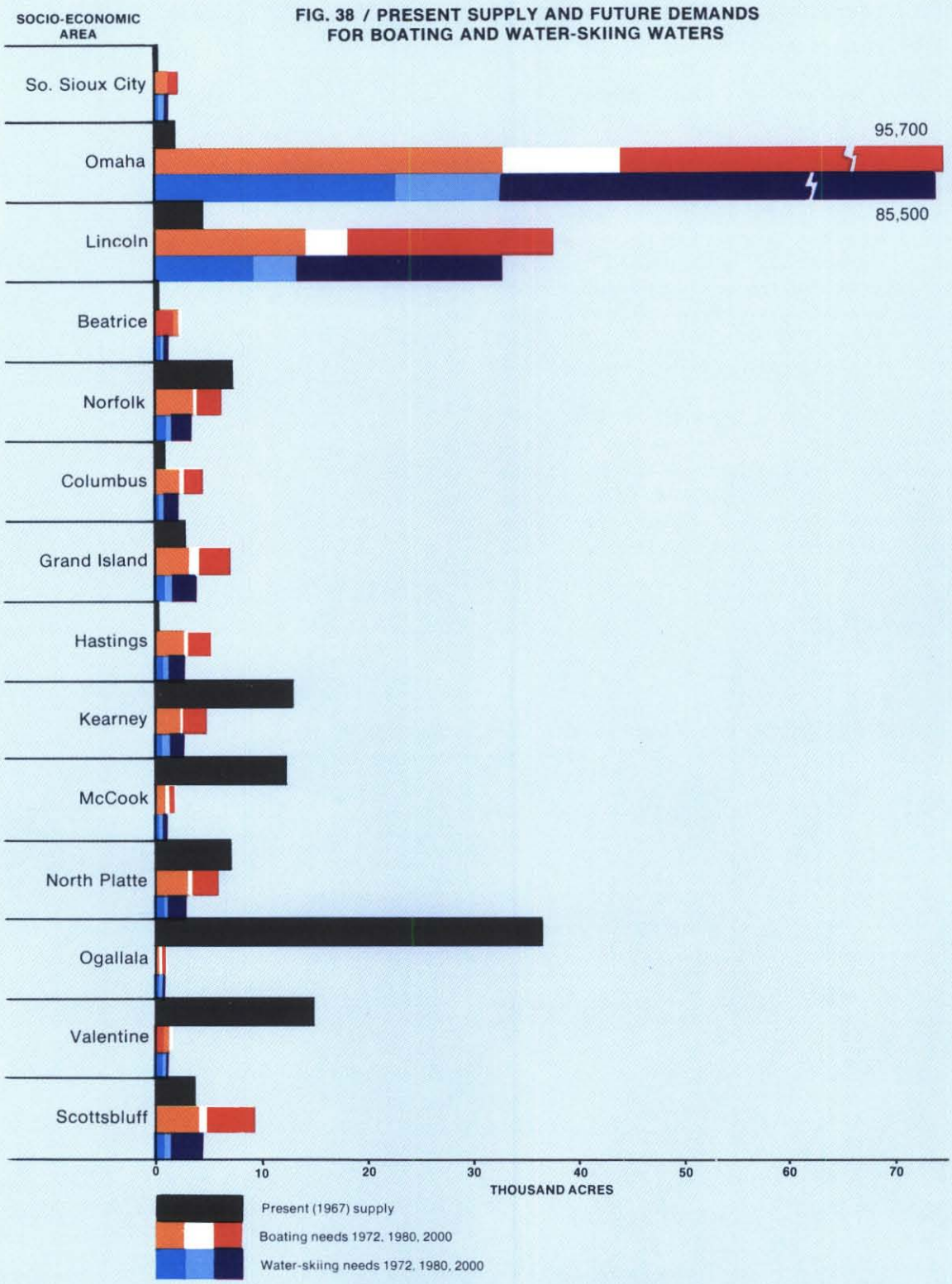


FIG. 38 / PRESENT SUPPLY AND FUTURE DEMANDS FOR BOATING AND WATER-SKIING WATERS

Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan,* Nebr. Game and Parks Commission, 1968

Areas with need for additional water based recreational development are shown in Figure 39.

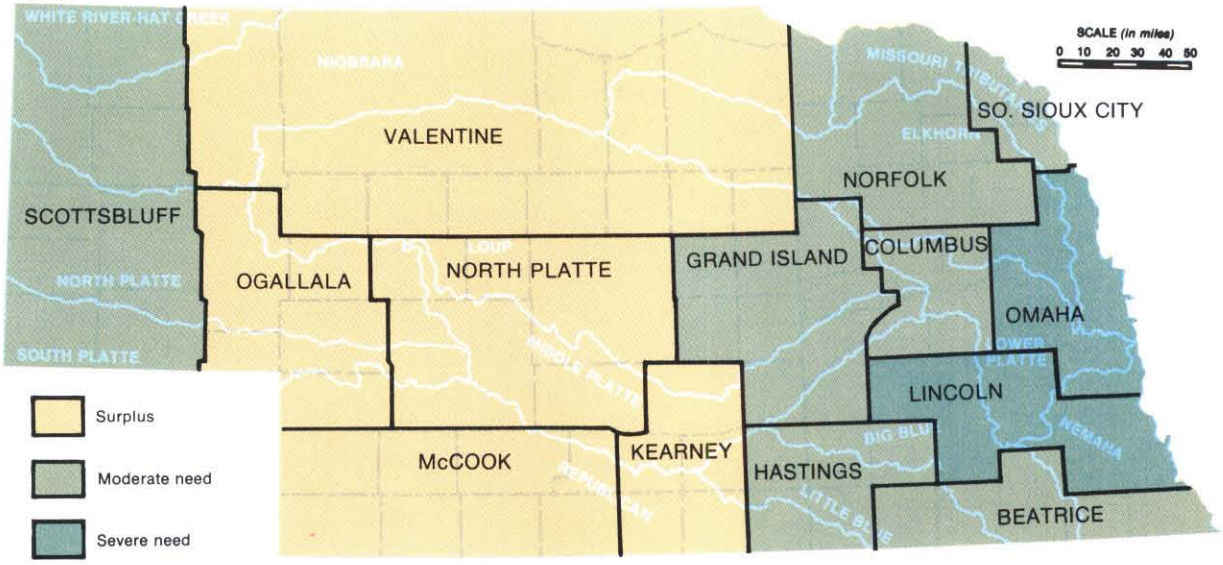
The fishing capacity of streams and natural lakes is not expected to increase significantly in the future. Therefore, the major potential for increasing opportunity for all forms of water based recreational opportunity, including fishing, lies in developing single purpose recreational reservoirs and in making recreation a purpose in multipurpose reservoirs wherever possible. Future multipurpose reservoirs have the potential of satisfying much of the deficiency in opportunity for recreational activities which require large bodies of water. This is particularly true in eastern Nebraska where the need is most critical.

In order to utilize the potential of these developments, recreational needs including adequate public access must be considered in design and management.

Adequate land and facilities will be required around these new developments not only to provide access, but to meet the needs of other water based recreational activities such as camping, outdoor swimming, and picnicking.

Many existing developments also need the addition of similar facilities.

FIG. 39 / ADDITIONAL WATER-BASED RECREATION DEVELOPMENT NEEDS
(Based on Socio-Economic Areas)



Source: *Outdoor Recreation for Nebraska—A Comprehensive Plan,* Nebraska Game and Parks Commission

Some recreation opportunity deficiency can be removed by making better use of the recreation potential of the Missouri River. Although channelization has adversely affected fish and wildlife and largely decreased the recreation potential of this resource, a significant unused potential exists and could be made available by increased access to the river. Adequate access sites are needed, particuarly within day use distance of Omaha and Lincoln. Some sites could be provided in conjunction with complete outdoor recreation developments utilizing oxbow lakes and scenic woodlands along the Missouri River valley and its adjacent bluffs.

A considerable, but underdeveloped, recreation potential presently exists at structures constructed under the Small Watershed Project Act (PL 566). The potential of many of these publicly financed developments is restricted by federal and state policies on public access.

Environmental Quality

The type and quality of the environment in the State is very important to Nebraskans. Without a quality of environment conducive to a healthy, productive society, the opportunity for future economic and social gain made possible through water and related land resource development will be of little avail.

Water resources development, itself, has a variety of positive and negative effects on the environmental quality objective.

Environmental benefits or positive effects stemming from water resources development can result from the management, preservation, or restoration of one or more of the environmental characteristics of an area. Such contributions generally enhance the quality of human life.

Environmental costs or negative effects are consequences of water resources development that result in deterioration or loss of relevant environmental characteristics. Examples are loss of open or green space, wilderness areas, alteration or inundation of wildlife habitat and irreparable land erosion. Such costs or adverse consequences generally detract from or diminish the quality of human life.

"The environmental quality objective is enhanced by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems in the area under study and elsewhere in the Nation."[a/] Nebraska has the opportunity to contribute measurably toward the total environmental quality objective by the (a) protection of unique or scenic rivers, (b) preservation and enhancement of outstanding biological and ecological systems, (c) enhancement of water quality, (d) prevention of erosion and restoration of eroded areas, and (e) avoidance of nonreversible decisions in future water resources development.

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a/ Standards for Planning Water and Land Resources, U. S. Water Resources Council, July, 1970.

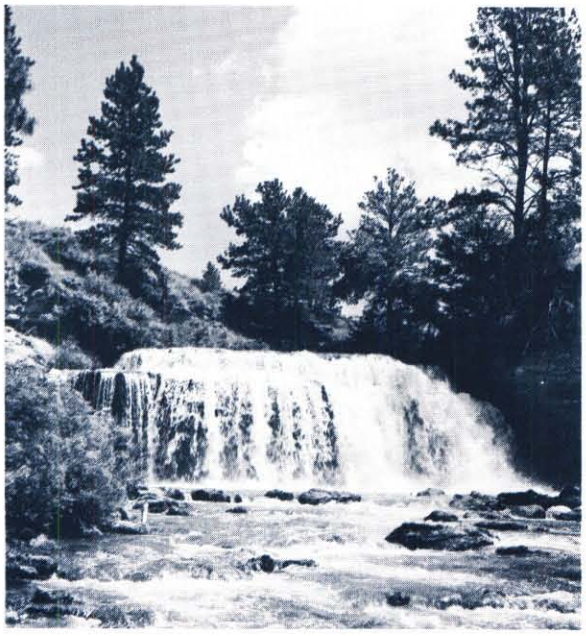
PROTECTION OF UNIQUE OR SCENIC RIVERS

A few rivers or portions of rivers within the State still retain to a large degree their historic flow and natural shoreline characteristics. These rivers have intrinsic values in their undeveloped and unaltered state, and these values increase as natural areas dwindle in number. Rivers of this type with particularly desirable or unique natural characteristics should be preserved in their existing free flowing, natural condition. This will provide the opportunity for present and future generations to see and explore a free flowing stream for the scientific, cultural, fish and wildlife, outdoor recreation and other environmental and aesthetic values it possesses. The following rivers or reaches of rivers, although all are not in a pristine condition, possess attributes which qualify them for consideration of preservation in their existing free flowing state:

1. Niobrara River—from its confluence with Antelope Creek downstream to the headwaters of the proposed Norden Reservoir, including the lower 8 miles of the Snake River tributary.
2. Snake River—from its headwaters to the headwaters of Merritt Reservoir.
3. North Loup River—from its headwaters to 18 miles west of the Taylor Diversion Dam.
4. Middle Loup River—from its headwaters to the Milburn Diversion Dam.
5. Dismal River—from its headwaters to its mouth.
6. Missouri River—from Lewis and Clark Reservoir west and north along the Nebraska border.
7. Missouri River—from Yankton to South Sioux City.
8. Platte River—from the mouth of the Loup River to the confluence of the Missouri River.
9. Big Blue River—from Crete to Beatrice.

These stream reaches are delineated on Figure 40. The reach of the Niobrara and lower Snake River listed previously is being reconsidered for classification as a wild river by the Federal Government under the Wild and Scenic Rivers Act of 1968.

Other Nebraska rivers with particularly valuable, natural characteristics may qualify for federal designation as wild, scenic, or recreation rivers. Investigation is needed to determine whether these selected stream reaches listed previously or others meet the minimum federal standards. But whether or not these stream reaches measure up to the federal standards, several need to be preserved in their existing free flowing condition. A system of state



scenic and recreation rivers requiring a minimum of land acquisition and using flood plain zoning or easements to preserve the existing riparian lands may be needed to control development on selected river reaches.

PRESERVATION OF OUTSTANDING ECOLOGICAL SYSTEMS

Islands created by meandering stream channels comprise one of the last reserves of undeveloped land remaining on the Great Plains. Many of our islands have already been lost through large scale channelization and reservoir construction.

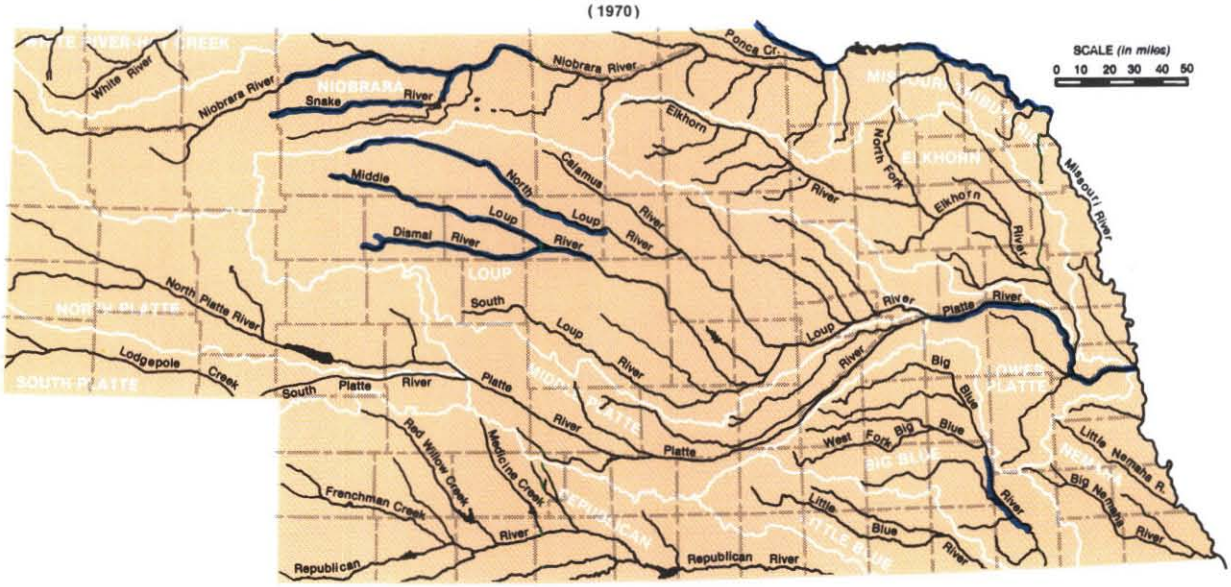
The Platte River islands between the mouths of the Platte and Loup Rivers have been studied by the Bureau of Outdoor Recreation, U.S. Department of Interior, and classified as outstanding islands that merit national recognition in the *Islands of America* report published in 1970. As the largest group of islands remaining on the Great Plains, they represent remnants of a vanishing land form associated with meandering alluvial rivers. The islands, with their vast and ecologically unique fauna and flora, stand in bright contrast to the agricultural, municipal, and industrial development which has taken place on the surrounding mainland.

This reach of the Platte River is prolifically studded with islands. In general, these islands are privately owned, relatively inaccessible, heavily wooded, and uninhabited. An abundance of the basic elements of food and cover make the islands a haven for numerous species of birds and animals.

The opportunity exists for preservation of the natural qualities of these islands through public

FIG. 40 / STREAM REACHES WITH POTENTIAL FOR DESIGNATION AS WILD, SCENIC OR RECREATION RIVERS

(1970)



Source: Nebraska Game and Parks Commission

acquisition and a system of easements on the adjoining mainland throughout this reach. Through this action and with limited development, the unique natural environmental qualities of these islands could be preserved and made accessible to present and future generations of Nebraskans and the nation.

ENHANCEMENT OF WATER QUALITY

Municipal, industrial, and agricultural wastes when discharged into watercourses untreated or only partially treated are often aesthetically unpleasant, harmful to fish and wildlife, and a health hazard to human beings. The incidence of untreated or only partially treated wastes reaching Nebraska streams is quite high.

Besides the deleterious effect on water quality through waste discharge, diminution of the quantity of water in many Nebraska streams through irrigation and power diversions represents an adverse effect on their environmental qualities. There are no provisions for fish, wildlife, and other environmental components in Nebraska water law. Irrigators and power districts are presently allowed to divert streamflow totally without regard for the environmental qualities, particularly fish and wildlife, of the affected stream reach.

Adequate treatment of all wastes discharged into Nebraska waters is needed to restore the environmental qualities of degraded stream reaches. As discussed previously, municipalities and industries will need to provide at least secondary treatment of all wastes, and farmers and ranchers will need to manage their operations so that feedlot wastes, fertilizers, pesticides, and silt do not reach streams in quantities detrimental to environmental aspects.

Consideration needs to be given in future water resources development to provision of adequate streamflows downstream from reservoirs and diversion dams to maintain the fishery resource and retain other environmental characteristics. Also, future water development schemes offer the potential to improve stream quality through maintenance of adequate low flows or dilution flows in streams which have already been adversely affected by water resource development or waste discharges.

PREVENTION OF EROSION

Erosion of the land surface by rainfall runoff lowers the productivity of the land. Streambank and gully erosion not only harm the land but they sometimes present poor aesthetic qualities. Besides the harmful effects on the land, the soils carried away through these erosion processes, seriously degrade the quality of Nebraska streams through sediment pollution.

The rougher areas in the eastern part of the State and other areas where the plains and tablelands break into the river valleys are the most erosion prone. Measures have been taken to reduce erosion in some parts of the State, particularly the Nemaha and Big Blue River Basins, but erosion is continuing unchecked in most other areas, particularly in the Missouri Tributaries River Basin.

Intensive application of good conservation measures is needed to reduce future land damage and stream pollution caused by erosion and to restore presently damaged areas.

Included with good conservation measures is the need to harmonize land use, in terms of its economic productivity for local and regional development, with preservation of natural characteristics of the landscape. Although not currently a major problem, this need may become more evident in the future as pressures increase for development of the Sandhills area as cropland.

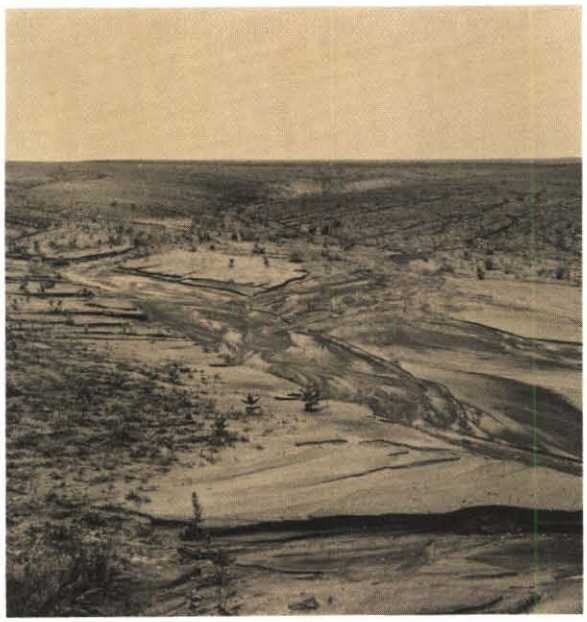
AVOIDING NONREVERSIBLE DECISIONS

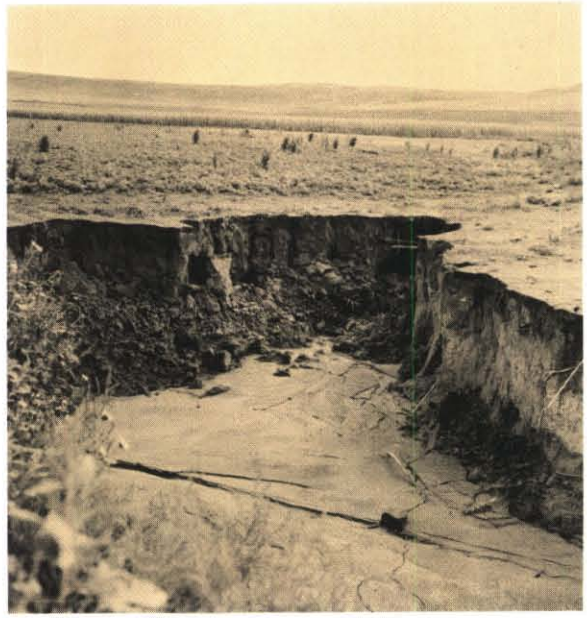
Nebraska currently possesses a relative abundance of natural resources. The water, air, and landscape of the State in general still retain elements of a quality environment.

However, man has a tremendous ability to alter, develop, and utilize these natural resources and at times in the past has shown a lack of comprehension and appreciation for the ramifications of his actions. Many of these ramifications have been undesirable and often difficult or impossible to correct. Destruction of the habitat necessary for preservation of rare or endangered species of birds and animals is an example of irreversible action which must be avoided.

In the planning and design of future water and related land resource developments, it is essential therefore that an ecological awareness be developed and man's position in this ecology become a factor in resource development projects. All environmental ramifications of future developments need to be assessed and alternatives sought and developed for all projects which threaten to affect unfavorably the quality of Nebraska's environmental resources. Decisions as to whether to proceed with future water and related land resource developments should then be based on a thorough comparison of needs for action with the dangers of undesirable changes in the environment and the virtue of retaining options for the future and avoiding irreversible decisions.

A realm of uncertainties as to the long range effects of major resource developments still exists. It is therefore important that research activities be aimed at improving our ability to predict and analyze these effects.





Soil Erosion

Water and wind erode the soils of the State, both naturally and as a result of man's activities. Water erosion is most severe in eastern Nebraska where rainfall is greater and more rolling land is cultivated. It generally takes the form of either sheet and rill erosion, gully erosion, or stream channel bottom and bank erosion. Wind erosion is generally most severe in central and western areas where soil moisture is generally low and ground cover sparse during the season when wind velocities are the highest.

Soil erosion is a potential hazard on about 36,000,000 acres, or over 75 percent of the state's agricultural land. Water erosion is the dominant problem on about 19,000,000 acres and wind erosion on about 17,000,000. Nearly 25 percent of the 13,800,000 acres of cropland and 45 percent of the 21,200,000 acres of pasture and rangeland with a wind and water erosion hazard are now being adequately protected. About 1,000,000 acres of land with an erosion hazard are in forest and other uses.

THE PROBLEM

Soil erosion not only damages the land surface but deposition of the sediment or dust often causes off-site problems.

Wind Erosion. Wind erosion is a potential hazard on dry soils, particularly sandy and sandy loam soils, with limited vegetative cover. This situation frequently occurs in central and western areas where plant cover may be sparse due to low amounts of rainfall during the growing season and where wind velocities are moderate to high during the seasons when the land is most exposed. Wind erosion is an ever-present hazard in the Sandhills Region where if vegetative cover is removed, severe blowouts of the loose sand occur.

Farming practices, such as clean tillage and fallow operations, and removal of top growth by harvesting or grazing, contribute to the wind erosion hazard. Damages result from lowered productivity due to removal of the fertile top soil, roughened land surfaces, smothered crops, covered fences and equipment and dust deposited in buildings and on roadways. Severe dust storms frequently contribute to traffic accidents in which property damage and, occasionally, loss of life occurs.

Sheet and Rill Erosion. Sheet and rill erosion gradually removes the thin cap of highly productive top soil. This soil loss has permanently reduced the productivity of many acres of land in the glacial till areas of the Lower Platte, Big Blue, and Nemaha River Basins. Erosion has been so severe in some of these areas that land can no longer be profitably cultivated.

Increased fertilizer applications are required in the loess hill areas of the Missouri Tributaries, Elkhorn and Lower Platte River Basins where six inches or more of top soil have been eroded from the moderately to steeply rolling fields during the last 50 years.

Erosion is greatest on clean tilled croplands, fields with row crops cultivated up and down the slopes, overgrazed grasslands and timberlands, and unprotected highway and building sites.

Economic losses result from reduced productivity, increased farm operation costs, and the deposition of sediments on flood plains and in streams and reservoirs. These deposits smother crops and pastures located on flood plains and reduce the capacities of streams and reservoirs.

Gully Erosion. Gully erosion is the process by which watercourses progressively deepen, widen, and extend headward. This type of erosion is most pronounced when through some change, additional waters are directed into unstabilized waterways or when stream velocities are increased. As a formerly stable channel deepens, tributary drains likewise deepen, spreading the effect of the channel lowering over a wide area. Economic loss occurs from loss of land as the gully grows, the extra time and care needed to perform cropping operations in gullied fields, and the costs of corrective measures. Frequently the channel enlargement destroys the footings and approaches of road bridges. In irrigated fields, gully development often is accentuated by lack of care in handling irrigation water return flows.

Small gullies can usually be controlled by individual land operators by application of land treatment measures.

Large gullies whose stabilization requires measures which an individual could probably not undertake were inventoried by the U.S. Soil Conservation Service in 1966. This study showed that 16 percent of the gully erosion problem areas has a high rate of soil loss from productive lands. An additional 23 percent has a moderate rate of soil loss, or was affecting the capability of lands whose productivity was already lowered by erosion. The remaining 61 percent has a low rate of soil loss affecting lands of moderate to low productivity.

Potential land damage by large gullies is shown by river basin in Table 32. Gully erosion is most severe in the Nemaha River Basin where without abatement it is estimated that about 8 percent of the land area will be affected in varying degrees from reduction in productivity to complete loss during the next 50 years. The next most susceptible area is the Missouri Tributaries River Basin where nearly 5 percent of the land area will be similarly affected. Other basins where more than 1 percent of the area could suffer damage include the Lower Platte and Republican River Basins.

Streambank Erosion. The rates at which streambanks are eroded is closely associated with floods. High flows frequently destroy the vegetation along streambanks and make them vulnerable to erosion even by low flows. In addition, debris is deposited in stream channels and deflects the current toward the banks, thus accelerating the erosion process.

Streambank erosion occurs in local areas along all major streams, but rates are generally moderate to mild. The nature of the hazard varies depending upon streamflow, channel characteristics, and the degree of development in the vulnerable areas. No estimates were made of the losses by streambank erosion.

Many of the present streambank erosion problems were caused by straightening channels to speed removal of flood flows. The higher velocity flows have caused major erosion problems on the Elkhorn River and tributaries, Big and Little Ne-

TABLE 32 / POTENTIAL LAND DAMAGE BY LARGE GULLIES
(1966)

River Basin	Drainage Area Above Existing Large Gullies in Acres	Area Subject to Damage in Acres a/ 50-Yr. Period	Average Annual
White River-Hat Creek	None Reported		
Niobrara	9,000	2,400	48
Missouri Tribs.	215,100	91,850	1,837
North Platte	10,000	300	6
South Plate	4,000	400	8
Middle Platte	None Reported		
Loup	29,600	4,800	96
Elkhorn	106,000	25,050	501
Lower Platte	122,500	45,120	903
Republican	224,000	63,350	1,267
Little Blue	27,300	6,960	139
Big Blue	87,500	31,350	627
Nemaha	311,300	140,900	2,818
STATE TOTAL	**1,146,300**	**412,480**	**8,250**

a/ Damaged acreage is only for areas considered to need project action for solution

Source: *1966 Watershed Needs Inventory*, U.S. Soil Conservation Service

maha River, Salt Creek, the short steep tributaries of the North Platte River, and many short stream channels directly tributary to the Missouri River. Streambank erosion on the Missouri River itself has been largely arrested through the comprehensive bank stabilization program which has been completed below Sioux City.

Bank erosion on Frenchman Creek has been aggravated by conveyance of irrigation water from upstream reservoirs to downstream diversion works through the natural stream channel. The USBR is now stabilizing the channel with erosion abatement works as part of the operation of the irrigation projects. The lower reaches of the Loup and Platte Rivers also have moderate to severe streambank erosion losses. The severity of these problems is increasing.

EROSION PREVENTION PROGRAMS

The greatest contribution in reducing soil erosion and its consequent production of sediment or dust can be made if individual land owners and operators use the land within its capability and treat it according to its needs. Assistance is available to landowners from state, county, and city governments, and from soil and water conservation districts and various agencies within the U. S. Dept. of Agriculture. Federal cost sharing assistance is available for application of many needed land treatment measures.

Major gully and streambank erosion problems usually require group action. The Federal Government furnishes local groups and organizations with technical and financial assistance to prevent and control these problems. However, few projects are economically justifiable under current evaluation criteria.

Major assistance for planning and construction of erosion control structures is normally provided through either the Soil Conservation Service (SCS), U. S. Army Corps of Engineers, or the Bureau of Reclamation.

The State of Nebraska, through the Soil and Water Conservation Commission, provides assistance to local groups in obtaining help in solving their soil erosion problems.

PRESENT AND FUTURE NEEDS

About 23,000,000 acres of agricultural land need protection against wind and/or water erosion. This is about 65 percent of the land with an erosion hazard and is nearly equal to half of the land area of the State. Some of this acreage is partially protected now by one or more land treatment measures, but to be fully protected, additional treatment is necessary.

Assistance programs designed to encourage the application of land treatment measures have been in existence for about 35 years. However, funding of these programs, particularly the Agricultural Conservation Program (ACP), is in jeopardy from year to year. If funding is continued and future rates of land treatment are comparable with the past, more than 100 years would pass before all land with an erosion hazard would be adequately treated. By this time, much of the land would be so seriously damaged that it probably would not be worth salvaging. Therefore, an accelerated rate of land treatment is needed, especially in the eastern part of the State.

About 14,000,000 acres of agricultural land in the State are not yet protected against water erosion. This is about 75 percent of the land with a potential water erosion hazard and equals nearly 30 percent of the land area in the State. Most of the serious water erosion hazards are on the glacial till and deep loess soils in the eastern one-third of the State. Treatment measures needed include crop residue management, cover crops, sod in rotation, contour farming, strip cropping, terraces, field diversions, and proper grazing.

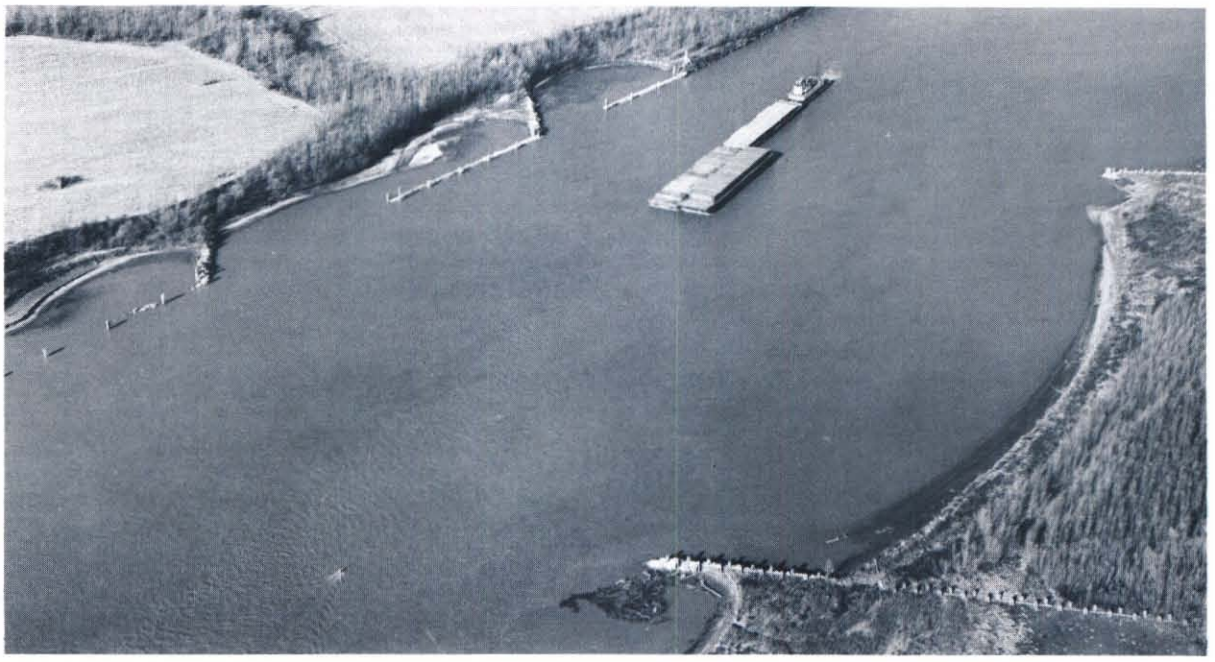
In the glacial till area of the Nemaha River Basin and in parts of the Lower Platte and the Big Blue River Basins, the virgin soils were naturally thin. Because of this, erosion of a few inches of top soils causes tremendous losses in productive capacity. Nearly 50 percent of the cultivated lands in this area is now adequately treated but most pastures are still being severely overgrazed.

The deep loess soils in northeastern Nebraska, most of the Missouri Tributaries River Basin, and parts of the Elkhorn and Lower Platte River Basins, are not severely harmed by even moderate erosion. They are, however, producing large amounts of sediment which are creating problems in downstream areas. The rate of application of land treatment measures in this area has been extremely slow because productive capacity of the land has not been seriously affected by loss of top soil and because many treatment measures would require changes in present farming practices.

About 9,000,000 acres of land need protection against wind erosion, including about 1,800,000 acres of cropland, 6,900,000 acres of pasture and rangeland and 300,000 acres in other uses. Treatment needs include crop residue management, cover cropping, sod crops in rotation and range management through proper grazing and other techniques of grass care.

About 70 percent of the land with a potential wind erosion hazard is in the Sandhills. About 95 percent is now in native grass, most of which is being properly grazed. Wind erosion will not become serious in this area as long as the land remains in permanent vegetation and is properly grazed and managed.

There is a statewide need for abatement of present land erosion and prevention of future erosion problems. Unless both individual and group action can be stimulated, the problems will become more acute in the future.



Navigation

The Missouri River is the only commercially navigable stream available to Nebraska. Shortly after Lewis and Clark explored the Missouri in 1804, steamboats began traveling the river from St. Louis to Fort Benton, Montana. The river served the pioneers as a natural communication route and principal artery of travel until the faster, more flexible and dependable railroads brought about a decline in steamboat traffic.

In its natural state, the Missouri River meandered between continually eroding banks in numerous shallow channels separated by low, shifting sandbars and islands. Improving the channel for navigation began in 1824 when federal funds were provided to remove snags. During the latter part of the nineteenth century, some bank stabilization and channel improvement for navigation was undertaken at scattered locations.

Navigation improvement of the Missouri River from Sioux City, Iowa, to its mouth was begun in earnest in the 1930's. Since that time, navigation has been improved through the integration of numerous shallow channels of the natural river into one stabilized, comparatively deep channel. A navigation channel from the mouth to Sioux City with a minimum depth of nine feet over a width of 300 feet has essentially been completed.

In addition, six multipurpose dams have been constructed by the Corps of Engineers on the Missouri River above Sioux City. One function of this series of dams is to regulate streamflow for the benefit of navigation. Since 1962, releases from the system of reservoirs have made navigation operations from Nebraska ports possible for about eight months of the year, usually April through November.

PRESENT SITUATION

Barge service on the Missouri River is being provided by three common carrier companies. Connective service is available to all parts of the federal waterways system by interline arrangements.

The annual tonnage moved by commercial navigation on the reach of the Missouri River between Sioux City and Kansas City has increased gradually from about 130,000 tons in 1955 to over 1,380,000 tons in 1969. During this period, the proportion of total Missouri River commercial tonnage moving into and out of the Sioux City to Kansas City reach increased from about 33 percent to about 67 percent. In 1969, about 50 percent of the Missouri River commercial tonnage was moved into or out of the ports in the Sioux City to Rulo reach.

For the 1966-69 period, grain made up 90 percent of the downstream shipments and 55 percent of the total commercial tonnage on the Missouri River system. For the Sioux City to Kansas City reach, grain made up nearly 40 percent of the total tonnage and about 80 percent of the freight moving downstream. The remainder of the downstream freight in this reach was nearly all foodstuffs and related products.

Upstream shipments in the Sioux City to Kansas City reach were 36 percent chemicals, 23 percent food and related products, 19 percent stone and clay products, 16 percent nonmetallic minerals, and smaller quantities of metals, fibers, and paper products. Commercial tonnage on the Missouri River by product and reach is shown in Table 33.

In addition to the common carrier operations, an undetermined amount of contract and private barging takes place.

Harbor and terminal facilities accessible to Nebraska shippers are located in or near Sioux City, Blair, Omaha, Council Bluffs, Bellevue, Plattsmouth, Nebraska City, Brownville, and Rulo. Most of these terminals, which are shown in Figure 41, have connections with railroads and all are ac-

TABLE 33 / MISSOURI RIVER COMMERCIAL SHIPPING

Product	Average Annual Commercial Tonnage In Thousands of Tons (Based on 1966-1969 Period)			
	Sioux City to Mouth		Sioux City to Kansas City	
	Upstream	Downstream	Upstream	Downstream
Farm Products (Grains including Soybeans)	12	1,285	0	516
Nonmetallic Minerals	148	a/	105	a/
Food and Kindred Products	167	139	164	138
Basic Textiles	1	1	a/	a/
Pulp Paper and Allied Products	9	0	9	0
Chemicals and Related Products	310	6	238	6
Petroleum Products	73	9	0	0
Stone, Clay and Glass Products	134	0	134	0
Metal Products	80	1	36	a/
Miscellaneous	a/	a/	a/	a/
Total Average Annual Tonnage	**934**	**1,441**	**686**	**660**

a/ *Less than 500 tons*

Source: U.S. Army Corps of Engineers, Missouri River Division

cessible to improved highways. In general, the available facilities are suitable for handling grain, sand and gravel, steel, cement and other low-cost bulk commodities.

FUTURE NEEDS AND OPPORTUNITIES

Nebraska shippers are expected to barge about the same commodities in the future as they do now. The increased quantities moved by commercial navigation will be somewhat less than the gross increase in crop production and the demand for bulk type goods. This is due to the anticipated increase in utilization and processing of farm produce near sources of production and greater use of bulk unit railroad and truck transport.

The chief requirements for the improvement of navigation service to Nebraska will continue to be grain storage facilities at terminals and the development of adequate land transportation facilities between terminals and production areas.

The Corps of Engineers has recently reported that extension of the navigation channel upstream from Sioux City to Gavins Point Dam is physically and economically feasible. However, the environmental impact of such development has not been fully evaluated by considering loss of values related to the natural unchanneled conditions.

FIG. 41 / HARBOR FACILITIES ACCESSIBLE TO NEBRASKA SHIPPERS

Source: *Missouri River Basin Comprehensive Framework Study*

Drainage

Drainage is a general term applied to the removal of surface waters or ground water wastes from an area. This process takes place naturally due to gravity and can be accelerated or induced by pumping or construction of channels, waterways, or subsurface interceptor systems. Soils drain to varying degrees and at different rates depending upon the condition and type of soil, topography, and subsurface geologic barriers. Natural drainage is poor at many locations in the State and, therefore, various measures have already been used to accelerate drainage of the land. Some poorly drained areas still remain. However, many of these remaining wetlands have existing value for wildlife purposes.

PRESENT DEVELOPMENT

Numerous drainage districts have been formed to construct and operate drainage channels in localized areas. These districts have been most popular in the Lower Platte, Missouri Tributaries, and Elkhorn River Basins where extensive drainage was needed, but at least one district exists in every river basin except the White-Hat. Most districts are small, involving only a few hundred acres each. Figure 42 locates all known drainage districts as of April, 1968.

The majority of the drainage development in the State has been accomplished by individuals. This type of development is generally simple, but usually serves the purpose well. Often, it merely involves cutting a channel from a depression into a drainageway.

EXISTING PROBLEMS

Both natural and man-made drainage problems currently exist in the State. The use of nearly 1,800,000 acres of agricultural land is restricted because of these problems of "wetness" in one degree or another. Not included in this acreage are the wetland types such as those found in the Sandhills area. About 900,000 acres of the statewide acreage would require project-type action for correction of the problem. Table 34 presents these acreages by river basin.

Natural drainage is normally poor along many of the major rivers whose broad, flat flood plains have little slope in any direction. This occurs in the valleys of the Platte, Elkhorn, Missouri and Nemaha

TABLE 34 / AGRICULTURAL DRAINAGE PROBLEM AREAS
(1966)

River Basin	Acreage With Drainage Problem a/	Acreage Requiring Project Action
White River - Hat Creek	3,600	0
Niobrara	56,800	29,000
Missouri Tributaries	84,600	37,300
North Platte	90,700	53,000
South Platte	100,900	28,200
Middle Platte	407,000	286,100
Loup	282,800	46,000
Elkhorn	290,000	207,900
Lower Platte	182,300	46,000
Republican	97,300	32,150
Little Blue	40,900	25,500
Big Blue	117,600	89,450
Nemaha	41,500	6,000
STATE TOTAL	**1,796,000**	**886,600**

a/ Excludes all wetland types as classified by the Fish and Wildlife Service
Source: *Watershed Inventory*, U.S. Soil Conservation Service

Rivers. Flooding often aggravates problems of wetness in these areas by causing rises in the water table.

Some water-filled depressions existing in the Sandhills area, and in other local areas, have developed water quality problems. Repeated evaporation of the ground water filling these depressions results in concentration of the minerals which were dissolved in the water. This can be injurious to plant and animal life, particularly when the process leads to highly alkaline soils.

The major man-made drainage problem results from seepage of surface water irrigation project canals and laterals. Many of the lands in irrigation districts in the North Platte River Basin are affected by this problem. The Central Nebraska Public Power and Irrigation District in southcentral Nebraska has drainage problems in much of the northern portion of its lands. Much of the water accumulations in areas like these is due to canal and lateral seepage but part is due to poor natural drainage which is aggravated somewhat by poor land development practices. Irrigation systems with existing or developing drainage problems are shown in Figure 43.

Problems caused by land development are becoming more prevalent, and they will continue to increase as more land development, including increased irrigation, occurs. Many times the effect of filling existing drains in land leveling or diverting them to roadside channels of inadequate capacity

FIG. 42 / LOCATION OF DRAINAGE DISTRICTS

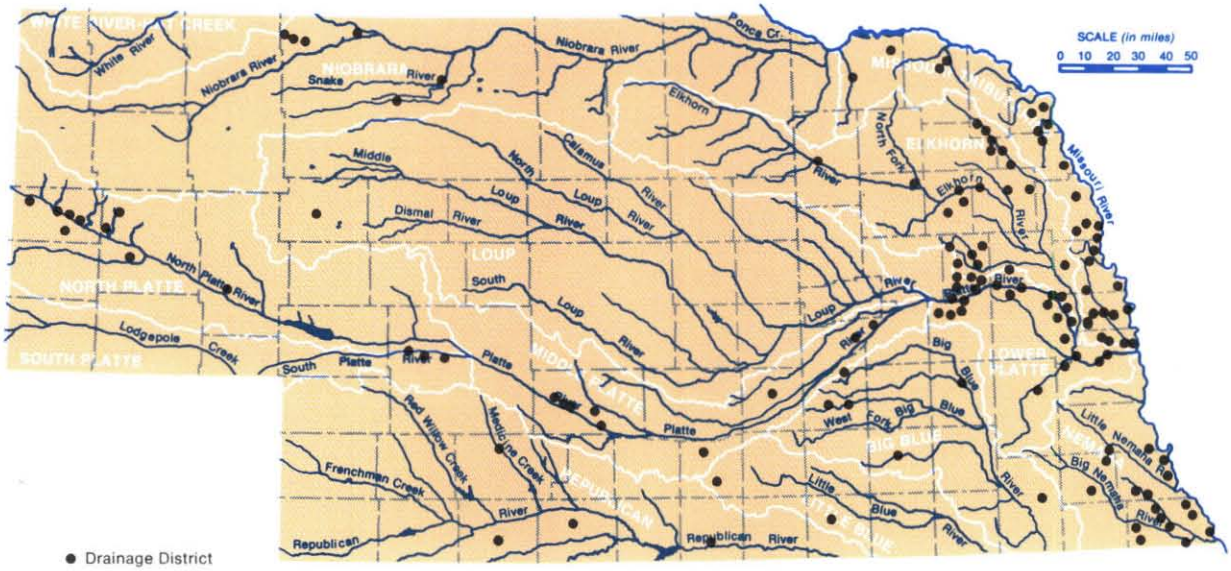
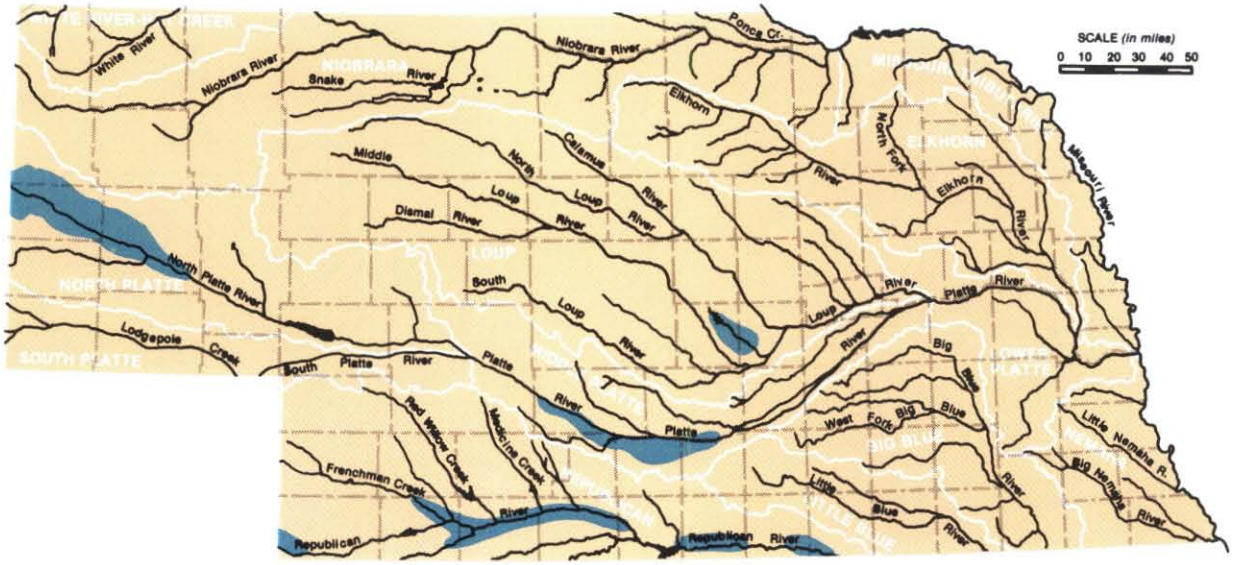


FIG. 43 / IRRIGATION SYSTEMS WITH HIGH OR RISING WATER TABLES
(1970)



Source: Missouri River Basin Problems and Needs Work Group

is not fully realized until periods of heavy rainfall make the inadequacy obvious. Cross drainage structures on road fills are not always large enough to carry increased flows and this results in flooding above the structures. Increased flows in roadway channels may create flooding and erosion problems in areas where channels formerly were relatively stable.

Drainage districts sometimes have been formed for the express purpose of channel straightening and shortening to speed runoff of floodwaters. This practice has been prevalent in the Elkhorn and Nemaha River Basins and invariably leads to channel degradation, bank erosion, and extension of tributaries upstream through gully erosion as discussed previously in the flood damage reduction section. These poorly planned practices result in production of large quantities of sediment, poor aesthetic qualities, and loss of land adjacent to the stream. In time this loss can be greater than the flood loss in the channel bends prior to straightening.

PRESENT AND FUTURE NEEDS

Some agricultural croplands need drainage at the present time, but other naturally wet areas are being used for wildlife purposes which can best utilize the wet conditions. Only general statements of drainage needs are presented here. Determination of actual drainage requirements must be made considering specific needs for drainage in each individual area.

Improvement by Drainage. An efficient method of removing excess water from some types of areas has not been found and continued research is needed.

Future developers need to increase their cognizance of the possibility of excess water build-up through changed drainage patterns and transfer of water into other areas. Developers also need to make necessary provisions for adequate surface and subsurface drainage in all project plans such as the USBR is presently doing.

Continued Use of Wetlands for Wildlife Purposes. Many areas which are periodically wet are valuable for wildlife purposes. Areas which have been historically wet because of poor natural drainage probably can best be utilized for wildlife purposes. Several areas in the upper Big and Little Blue River Basins and much of the Sandhills area are in this category. Many of these areas have been used by waterfowl for many years, and need to be preserved for this type of use.

Maintenance of Existing Systems. Many existing drainage systems are in need of channel maintenance. Often no provision was made by drainage

districts for maintenance of facilities following their initial construction. In fact, it is difficult to determine which districts are active, inactive, or abandoned. Two reasons for this are the lack of uniformity in organization, and inadequate provisions for financing. The Nebraska Natural Resources District Act prevents the formation of new drainage districts after January 1, 1972, but many of those presently in existence need a more adequate financial program for maintenance.

Electric Power

An adequate supply of electricity at reasonable rates has become a necessity. Without it, the high standard of living enjoyed in the State and the nation would be impossible. Because of its many uses, electricity is being used increasingly by more people, resulting in ever increasing demands on the power industry. Power production is already a major industry in the United States and is one of the fastest growing of all industries.

Water is important to the production of electricity. Falling water is used for hydroelectric generation and in thermal plants water is used for condensing the steam which drives the turbines before it is returned to the boilers.

PRESENT SITUATION

Nebraska's power industry is entirely publicly owned. The Omaha Public Power District (OPPD) and the Nebraska Public Power District (NPPD) provide nearly 75 percent of the total generating capacity of 1730 megawatts within the State. They retail part of the energy generated to their customers and wholesale the remainder to other power distributors.

The Central Nebraska Public Power and Irrigation District and the Loup River Public Power District provide another 12 percent of the generating capacity, of which about one-half is supplied by the Canaday thermal electric plant. Most of the remaining 13 percent is provided by municipal plants.

The generating capacity of power plants within the State is presently not sufficient to supply all of Nebraska's power needs, particularly peaking power requirements. Most of the deficit is made up through power imported from the Missouri River Basin Project power system, consisting of hydropower generated at the six dams on the Missouri River. In 1969, nearly 740,000 megawatts of the state's peak power requirements were purchased from this system.

In 1970, there were 20 operative hydroelectric plants in Nebraska, excluding the federal installation at Gavins Point Dam on the Missouri River which is intertied with the Missouri River Basin Project power and transmission system. The individual capacity of ten of these plants was less than one megawatt each. Their combined output totalled only 3.3 megawatts. Four other plants had capacities from one to five megawatts, totalling 10.1 megawatts of capacity. The other six plants had capacities from 8.25 to 40 megawatts, producing a combined total of about 128 megawatts.

These 20 plants have individual rights to divert streamflow ranging from 35 to 3,500 cubic feet per second (cfs). Total rights for diversion amount to 16,070 cfs, including 68 cfs for two small plants that are inoperative. The locations of existing hydroelectric plants and some of the plant characteristics are shown in Figure 44 and the accompanying chart.

Slightly over two-thirds of Nebraska's total present electrical energy requirements are provided by fossil fueled plants located within the State. These plants all use water for cooling and for steam to drive their turbines. Large quantities of water are required for cooling, but little is consumed. The location and more significant characteristics of the larger thermal plants are also shown in Figure 44 and the accompanying table.

In addition to the existing fossil fueled plants, there are two nuclear fueled power generation plants under construction along the Missouri River. The larger of the two plants, Cooper, is located near Brownville and will have a generation capacity of 778 megawatts when completed in 1972. The other plant, Fort Calhoun, is located north of Omaha. It is scheduled for operation in 1973 with a capacity of 475 megawatts.

The existing fossil fueled plants use over 620,000 acre-feet of cooling water annualy of which about 10 percent comes from ground water. Less than 10,000 acre-feet of the cooling water is consumed quantity-wise.

PROBLEMS AND NEEDS

The present problems and future needs of the electric power industry, as they relate to the availability and use of water in Nebraska, are discussed in this section.

Present Problems. Water problems presently related to power development in Nebraska appear to be minor; two, however, merit discussion.

KEY TO HYDROELECTRIC POWER PLANTS SHOWN ON FIGURE 44

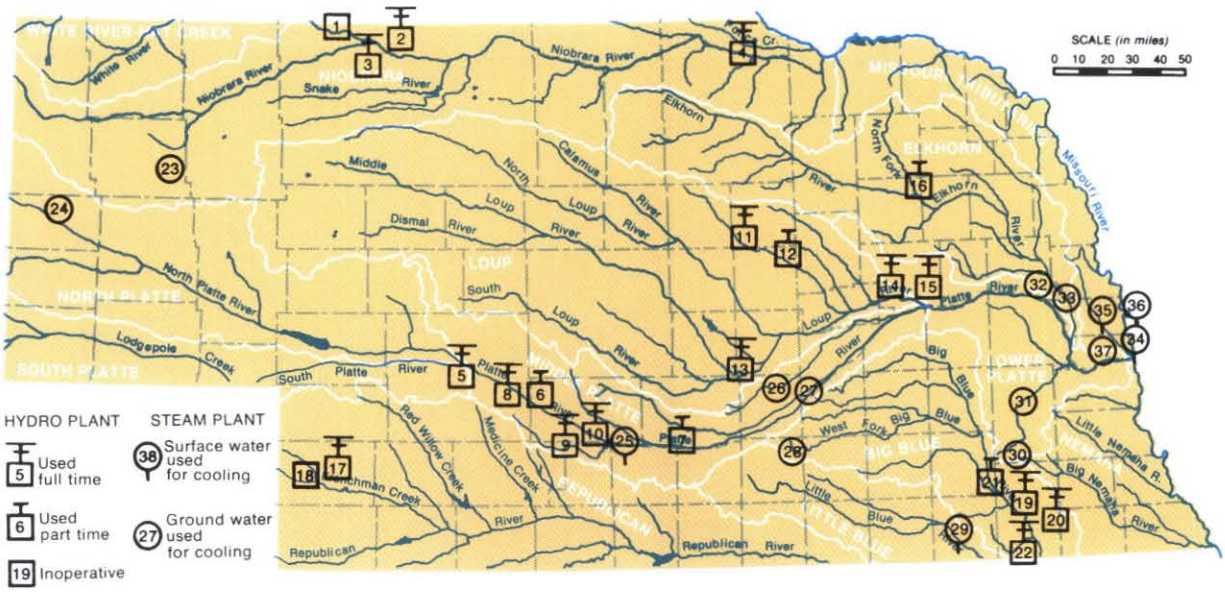
Map Index No.	Name of Plant	Name of Owner	Capacity in Megawatts	Surface Water Rights in cfs	Water Source
1.	Valentine #1	City of Valentine	Not Used	40.0	Minnechaduza Creek
2.	Valentine #2	Consumers PPD	0.25	35.0	Minnechaduza Creek
3.	Valentine #3	Consumers PPD	1.85	2,150.0	Niobrara River
4.	Spencer	Consumers PPD	3.9	1,450.0	Niobrara River
5.	North Platte	Nebraska PPD	26.0	2,550.0	North & South Platte R.
6.	Gothenburg	Nebraska PPD	0.5	188.0	Platte River
7.	Kearney	Consumers PPD	1.88	625.0	Platte River
8.	Jeffrey	Central Nebr. PP&ID	18.0	2,200.0	North & South Platte R.
9.	Johnson #1	Central Nebr. PP&ID	18.0	2,200.0	North & South Platte R.
10.	Johnson #2	Central Nebr. PP&ID	18.0	2,200.0	North & South Platte R.
11.	Ericson	Consumers PPD	0.44	175.0	Cedar River
12.	Spalding	Village of Spalding	0.15	290.0	Cedar River
13.	Boelus	Consumers PPD	2.5	1,000.0	Middle Loup River
14.	Monroe	Loup River PPD	8.25	3,500.0	Loup River
15.	Columbus	Loup River PPD	39.9	3,500.0	Loup River
16.	Norfolk	Norfolk Feed Mills Co.	0.08	100.0	N.F. Elkhorn River
17.	Imperial	City of Imperial	0.14	55.0	Frenchman Creek
18.	Champion Mills	Carl Hill	Not Used	28.3	Frenchman Creek
19.	Holmesville	Consumers PPD	0.35	500.0	Big Blue River
20.	Blue Springs	Consumers PPD	0.42	450.0	Big Blue River
21.	DeWitt	Fred Zwonecheck Estate	0.24	200.0	Big Blue River
22.	Barneston	Norris PPD	0.72	500.0	Big Blue River

KEY TO STEAM ELECTRIC POWER PLANTS 10 MW AND OVER SHOWN ON FIGURE 44

Map Index No.	Name of Plant	Name of Owner	Capacity in Megawatts	Source of Cooling Water
23.	Alliance	Alliance	16	Ground Water
24.	Scottsbluff	Nebraska PPD	44	Ground Water
25.	Canaday	Central Nebr. PP&ID	108	Platte River
26.	Burdick C.W.	Grand Island	42	Ground Water
27.	Pine Street	Grand Island	18	Ground Water
28.	Hastings	Hastings	59	Ground Water
29.	Fairbury	Fairbury	21	Little Blue River [b/]
30.	Sheldon	Nebraska PPD	225	Ground Water
31.	Lincoln K St. [a/]	Nebraska PPD	30	Ground Water
32.	Fremont No. 1	Fremont	44	Ground Water
33.	Fremont No. 2	Fremont	21	Ground Water
34.	Omaha Jones St.	Omaha PPD	180	Missouri River
35.	Omaha Kramer	Nebraska PPD	113	Missouri River
36.	North Omaha	Omaha PPD	647	Missouri River
37.	South Omaha	Omaha PPD	23	Ground Water

a/ Leased to Nebraska PPD
b/ Partially from ground water

FIG. 44 / HYDRO AND STEAM ELECTRIC POWER PLANTS



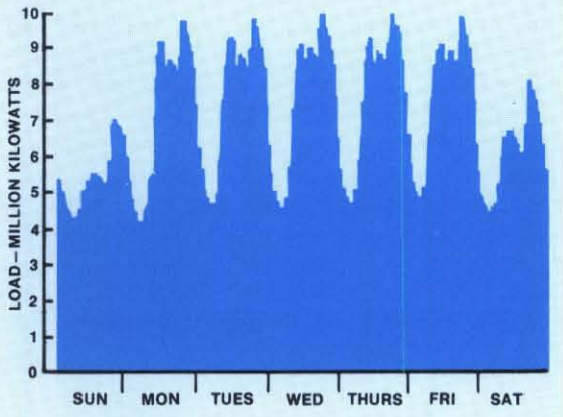
Based on 1970 data

Power is an industry, and as an industry it has third preference in the use of water supplies—domestic and agricultural uses having higher preference. This has caused a conflict in the recent past when applications for the storage and use upstream of water presently being used for downstream hydroelectric power generation have been made for a higher preference use. Water reserved for hydropower generation downstream cannot be taken and used consumptively for irrigation and other agricultural and domestic purposes upstream unless the hydropower producers are reimbursed for damage suffered through loss of power production. As the development of water resources continues, problems concerning present power rights will likely increase.

The demand for electrical energy is not constant. The typical weekly load curve presented in Figure 45 shows sharp daily peaks. These peak demands are satisfied most easily with energy generated by hydroelectric power plants that can rapidly vary their energy output. However, existing plants in Nebraska are unable to meet present peaks and virtually no additional suitable sites remain in the State for economical hydroelectric power production under current economic criteria.

Future Needs. Electricity can now be transferred long distances with relative efficiency. Interconnections with adjacent areas make projections of future generation requirements within the State difficult. For the Framework Study, water requirements have been determined for facility development sufficient to meet Nebraska's power needs after sometime in the 1980's, including peaking requirements, without power importation. During the

FIG. 45 / TYPICAL WEEKLY POWER DEMAND

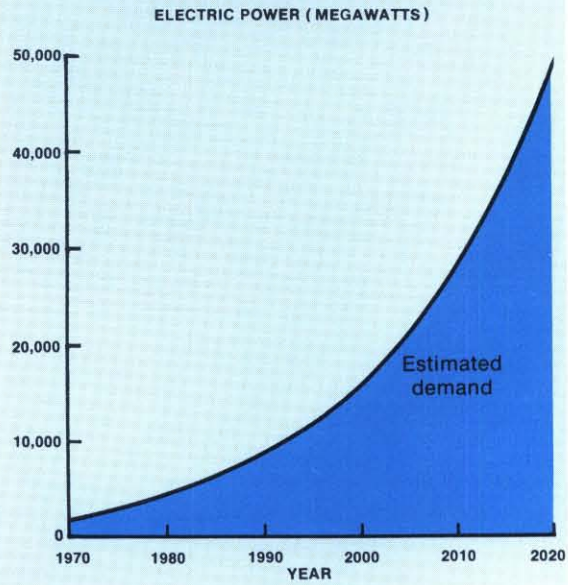


Source: National Power Survey, F.P.C., 1964

interim period till the 1980's, continued importation of power at about the present net (import minus export) rate was assumed.

In the past the national use of electric power has roughly doubled every ten years, and it is expected to continue doubling for several more decades. Nebraska's needs are expected to grow similarly. Estimates of future demand for power in Nebraska are shown in Figure 46.

FIG. 46 / NEBRASKA'S ESTIMATED FUTURE PEAK POWER DEMAND



Source: Nebraska Power Industry Committee

Hydroelectric power generation in the State is being replaced by other methods. In recent years the cost of generating electricity at large thermal and nuclear plants has declined, while the cost of generating electricity at hydroelectric plants has increased. Obsolescence and the cost of operating and maintaining hydroelectric plants has also increased, resulting in the phasing out of a number of small plants.

No new hydroelectric plants have been built in the State since 1941 because of the lack of feasible sites and increased costs. Dams and power plants more recently have been built on the Missouri River where high flows were available and where power was only one purpose of the overall project.

The importance of hydroelectric generation within Nebraska is likely to continue to decline. The Nebraska Power Industry Committee (NPIC), composed of representatives of many of the state's subdivisions which supply power recently established a committee to study the industry and investigate generation and transmission facilities which might be needed in the future. The construction of new hydroelectric plants was not assigned any consideration in these studies, and of the existing hydroelectric facilities, none were mentioned beyond the 1980's in future plans.

The six largest hydroelectric power plants in the State are licensed by the Federal Power Commission and have a total generating capacity of only 128 megawatts. No plans were proposed for their expansion. The NPIC has estimated that the statewide demand for power will reach 8,950 megawatts by 1990, when these six plants will be about 50 years old and the Federal Power Commission licenses will expire. Their output will be only 1.4 percent of the estimated 1990 demand, declining to 0.8 percent of the demand by the end of the century. Repairs and replacement will probably be uneconomical and the plants will likely be phased out.

The cooling facilities of present thermal electric plants use either recirculating or flow-through process. The flow-through process takes water from some source, such as a stream, circulates it through the cooling apparatus once, and then discharges it, generally back to the source. This is generally the least expensive method, but it requires steady supplies of large volumes of water from the source and the right to increase the temperature in the stream or ponded area to which it is discharged.

Plants using flow-through processes require large quantities of water, but only small quantities are consumed. The loss of water in this process is from stream evaporation due to the water temperature increase. Therefore, sites for plants using this method may be limited in some instances by the availability of water and by restrictions on allowable temperature increases in the receiving water. If the temperature increase is large enough to create a problem, it can become a form of pollution as previously discussed.

When the supplies of water are not sufficient, or the temperature rise is too great, it is necessary to use the recirculating process. This process cools the water by recirculating it through a cooling pond or tower.

The disposal of blow-down wastes from the recirculating systems which are generally rather saline and possess toxic constituents, may be a substantial problem. Also, the discharge of these wastes into the atmosphere in the form of steam can have adverse aesthetic and localized meteorological effects.

The flow-through process takes greater amounts of water from the point of origin than does the re-

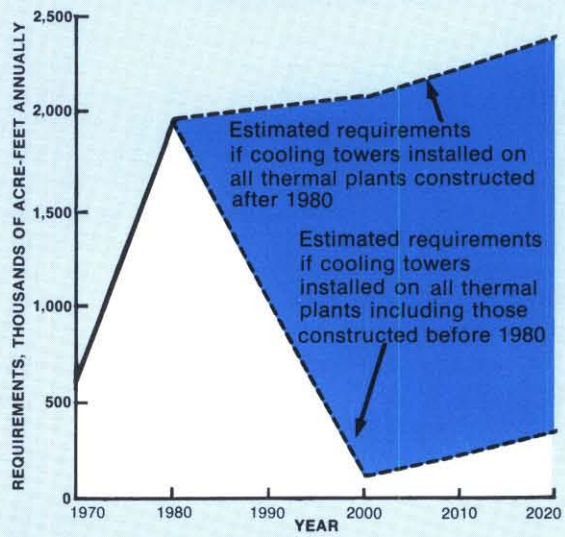
circulating process, but the water losses of the recirculating process are greater because of wind spray and blow-down. In cases where ground water is used for flow-through cooling, streamflows can be increased by water discharged from the plants.

The NPIC has estimated that the peak power demand in Nebraska will increase from about 2,400 megawatts in 1970 to approximately 15,600 megawatts by 2000, and to almost 48,000 megawatts by 2020. To meet this demand with thermal electric power plants located within Nebraska, it would be necessary to divert about eight million acre-feet of water annually for cooling purposes by 2000, and 24 million acre-feet annually by 2020 if flow-through systems are used exclusively. Except for the Missouri River, these large quantities of water are not available in the State.

If all the plants have recirculating systems with cooling towers, only about 117,000 acre-feet of cooling water will be needed by 2000, but the total amount will be consumed. By 2020, about 360,000 acre-feet of water will be required for recirculating systems. Disposal of large amounts of blow-down with its many attendant problems will be necessary if recirculating systems are predominant.

Future water diversion requirements for both methods of cooling are shown in Figure 47. Some intermediate requirement will be the most likely development.

FIG. 47 / ESTIMATED COOLING WATER REQUIREMENTS FOR THERMAL POWER GENERATION



Note: Includes an allowance for blow-down losses in recirculating systems

Source: Nebraska Power Industry Committee

Summary

The preceding description of water related resources development in Nebraska reveals:

...Existing and anticipated future problems requiring individual or community action,

...Needs for additional resource development, and

...Opportunities for further resource development.

These problems, needs, and opportunities along with existing water and associated resources development are summarized in the following section. The purpose is to accentuate the needs and opportunities for future development of Nebraska's water and related land resources.

WATER SUPPLY (M&I, RURAL DOMESTIC, AND LIVESTOCK)

The present water use for municipal, industrial, rural domestic, and livestock purposes is estimated to be about 403,000 afa. About 46 percent is used by municipal systems, 22 percent by private industrial systems, 7 percent for rural domestic use, and 25 percent for livestock purpose. The vast majority of the present supply is derived from ground water. When used for these purposes, water is lowered in quality, but only small amounts are actually consumed quantity-wise.

Future water requirements are expected to reach about 1,000,000 afa by 2020. This includes an increase of about 205 percent for municipal systems, 60 percent for private industrial systems, 35 percent for rural domestic use, and 175 percent for livestock purposes.

Good quality ground water is generally plentiful across the State. However, adequate quantities for some uses are not available in parts of the following river basins: White River-Hat Creek, lower portion of the Niobrara, Missouri Tributaries, Nemaha, portions of the Lower Platte, and southern portion of the Republican. In addition, many municipalities in other areas of the State experience water quality problems to some degree although the quantity of ground water available is more than adequate. Excess sodium, iron, and manganese are the most prevalent chemical elements degrading the quality of the state's ground water.

Assuming fertilizers and insecticides are used prudently and other sources of pollution are regulated effectively, the future supply of water for municipal, industrial, rural domestic, and livestock

purposes should be more than adequate except in areas where quantity and quality problems now exist. Where such local problems exist, rural water distribution systems or additional raw water treatment facilities are needed to insure adequate supplies of good quality water.

FLOOD DAMAGE REDUCTION

Flooding is one of the most severe and widespread water resource problems in the State. The existing structural improvements to control flooding include 404 flood control structures with a total floodwater storage capacity of almost one million acre-feet, about 185 miles of channel improvement, and almost 70 miles of levees. In spite of these structural flood control measures, flood damages have been increasing because investments in flood plain development are being made at an increasing pace.

In 1967, a flood plain regulation program was initiated to supplement the structural measures by regulating flood plain development. Since enactment of the act, several municipalities and counties have adopted flood plain zoning ordinances.

About 6 percent of the State is still subject to flooding. The average annual damage caused directly by this flooding was estimated to be about 21 million dollars in the early 1960's. Average annual losses are even greater now because of more costly and intensive development in many flood plains. About two-thirds of the total average annual loss is damage to crops and pasture, nearly one-fourth is damage to other rural property, and about one-tenth is damage to urban areas.

Additional structural measures and intensive implementation of a nonstructural program which includes flood plain regulation, flood forecasting and warning systems, flood insurance, and flood fighting and emergency relief measures are needed.

IRRIGATION

An average acreage of about 1.1 million acres is irrigated from surface water annually in Nebraska. Lands in federal irrigation projects make up over 35 percent of the total, with another 25 percent served by public power and irrigation districts, and the remainder included in irrigation districts and private systems. Most of the acreage irrigated by surface water is in the North Platte, Middle Platte, Loup, and Republican River Basins. Annual diversion rates vary from one to over three acre-feet per acre irrigated.

Many of the older surface water distribution systems are in need of repair, are inefficient, and use excessive amounts of water. Water shortages and drainage problems, such as those presently being experienced in northern Phelps and Kearney Counties and throughout the North Platte River Basin, are often experienced by these older systems. Distribution system rehabilitation including consolidation of some existing districts is needed.

The delivery schedules maintained by some districts encourage overwatering during periods of adequate supply. Losses to deep percolation, leaching of plant nutrients, and drainage problems often result from this practice. Additional reservoir storage is needed in some basins, e.g. in the Middle Platte River Basin, to permit better scheduling of water deliveries and to increase irrigation efficiencies.

Approximately 2,600,000 acres of land are irrigated annually in Nebraska from ground water. Areas that are the most extensively developed include the western and central portion of the Big Blue River Basin and northern part of the Little Blue River Basin, the Middle Platte River Basin, the Republican River Basin, and the lower portion of the Loup River Basin. The statewide average annual consumptive use is about one acre-foot per acre irrigated.

Ground water pumping has caused significant lowering of the water table in some areas. This lowering ranges from a few up to 20 feet in the Middle Platte and Big Blue River Basins and in the O'Neill area to as much as 40 feet in Box Butte County. An area in Chase and Perkins Counties will soon experience problems if ground water development continues. Conjunctive use of ground and surface waters is needed in these areas to stabilize ground water levels.

About 70 percent, or 19,200,000 acres, of Nebraska's arable land is classified as suitable for irrigation. Only about 20 percent of this total, or some three and three-fourths million acres, is now being irrigated.

Relatively large tracts of land suitable for irrigation are located in the Big and Little Blue River Basins, the Lower Elkhorn River Basin, the upper and central Republican River Basin, portions of Cheyenne and Deuel Counties in the North and South Platte River Basins, the upper Niobrara River Basin, and the western part of the Lower Platte River Basin. Adequate quantities of ground or surface water are available locally for additional irrigation development in these areas with the exception of the upper portions of the Big and Little Blue River Basins, the Cheyenne and Deuel Counties area, and the upper Niobrara River Basin.

WATER QUALITY CONTROL

In general, water quality problems are not severe except in local areas. The problem is largely

one of preventing further general degradation and correcting specific problems.

Three towns in the State with a total population of about 1,800 discharge untreated sewage into streams, 46 communities with a combined population of about 429,000 remove only the readily floatable and settleable materials, and 340 communities with a total population of 533,000 provide additional but sometimes inadequate biological treatment of their wastes before discharge. In addition, 78 small communities have no sewerage systems.

All totaled, there are 81 Nebraska municipalities that need to improve their facilities or construct new facilities in order to comply with the minimum treatment facility requirements of the *Nebraska Water Quality Standards*. These standards require a minimum of secondary treatment of all municipal sewage discharged into interstate waters by January 1, 1972, and secondary treatment of all wastes discharged into the Missouri River by the end of 1975. Higher forms of treatment may be required of the wastes of these or other municipalities to maintain water quality consistent with stream classification. State aid to municipalities would result in more federal funds for construction of these much needed facilities.

Of 563 industries inventoried in 1968, 408 were served by municipal facilities or had their own treatment plants, 17 others had facilities under construction, nine were in need of treatment facilities, and the needs of the remaining 129 were under study by the Nebraska Department of Health. In the future, all industries will be required to provide waste treatment consistent with the characteristics of the wastes, quality of the receiving waters, and nature of downstream water uses in order to comply with the water quality standards.

Sediment, primarily produced from agricultural lands, is the greatest contributor to degradation of the physical quality of Nebraska surface waters. Other increasingly common pollutants derived principally from agricultural operations are fertilizers, pesticides, salts concentrated in irrigation return flows, and feedlot wastes. Of these, feedlot wastes are presently the most serious pollutant. According to the *Water Quality Standards,* all agricultural wastes will be required to be treated or receive other corrective action to protect the legitimate beneficial uses of the state's waters.

A large scale, comprehensive approach will be necessary to control the various pollution problems of the State. Research, public education, regulation, cooperation, and comprehensive planning are all important elements of the total effort needed. Structural measures which will be necessary include elimination of combination sewers, installation of sewerage systems in some towns presently without collection systems, regionalization of waste collection and treatment systems where practicable, and disinfection for the residual of treated wastes.

FISH AND WILDLIFE

Less than one percent of the area of the State is primarily devoted to fish and wildlife purposes. Most of the State, however, is useful as either fish or wildlife habitat.

Practically all of the state's ponded waters and perennial streams support a fishery. Altogether, there are about 8,850 miles of streams and 136,800 acres of standing water that are suitable for fishery purposes. Most of the standing waters are located in the central part of the State.

Four species of upland game birds, of which the ringnecked pheasant is the most abundant, are found in Nebraska. Three species of big game, two species of upland game animals, many species of non-game animals, and numerous species of waterfowl are also common in the State.

Present problems associated with fish and wildlife center around the production of sufficient quantities of fish and game. Some of the most important water problems concerned in these two issues are water quality, diminution of streamflow, and retention of habitat. A greatly accelerated land treatment program, consideration of fish and wildlife in Nebraska water law, and the application of good habitat conservation practices are needed to preserve the status of fish and wildlife in the State.

Future problems are expected to differ from present problems mostly in severity. Future land development practices and water use will affect both habitat and water quality and quantity, and largely determine the severity of future problems. Adequate precautions will be necessary in future land development and water use programs to insure that fish and wildlife resources are maintained.

OUTDOOR RECREATION

Water oriented activities are among the most popular forms of outdoor recreation in the State, and their popularity is increasing at an ever greater rate. Of the many forms of water oriented activities, fishing, boating, and water skiing have by far the largest water surface area requirements.

Nebraska waters have an existing fishing capacity of about 4,800,000 fisherman days annually. However, their distribution is a serious problem, with practically all of the supply located in the central and western portions of the State.

Boaters and water skiers can generally utilize the same water surface area. As with fishing waters,

boating and water skiing waters are poorly distributed with very little of the total supply of almost 107,000 acres located in eastern Nebraska.

The demand for outdoor recreation, particularly for water oriented forms, is increasing rapidly. The total statewide demand for outdoor recreation is projected to increase 21 percent from 1966 to 1972, 50 percent by 1980, and 160 percent by the turn of the century.

The annual demand for fishing is expected to increase about two-thirds above the present level of about 5,200,000 fisherman days by 2000. About 60 percent of the 2000 demand will be generated in the Omaha and Lincoln SEA's.

The estimated future demand for boating waters indicates an increase of almost 150 percent above the 1972 estimated statewide demand of about 75,000 acres by 2000. Water skiing is expected to record an even greater increase in popularity, increasing 250 percent over the 1972 estimated statewide demand of about 41,000 acres during the same period.

The SEA's in the eastern portion of the State are deficient in fishing, boating, and water skiing opportunity. The Omaha and Lincoln SEA's have particularly large deficiencies which will increase in the future. The remainder of the SEA's in the State, with the exception of a small fishing opportunity deficiency in the Scottsbluff SEA, have a surplus of recreation water surface area.

It appears that somewhere between 80,000 and 130,000 surface acres of water are needed to satisfy the existing fishing opportunity deficiency if they are well distributed in SEA's of need. By 2000, about 165,000 to 265,000 surface acres will be needed. Deficiencies in boating waters are about 45,000 acres presently and are expected to increase to about 150,000 acres by 2000. The existing deficiency in water skiing opportunity is about 25,000 acres, and it is expected to increase to about 120,000 acres by 2000.

The major opportunity for satisfying existing and future recreation water needs lies in development of multipurpose reservoirs and watershed structures in eastern Nebraska. Provision of public access to all impoundments where practicable and adequate land and facilities around the developments will be needed to insure full utilization of their recreation potential.

An opportunity exists to satisfy some of the recreation demand in eastern Nebraska through additional development of the scarcely tapped potential of the Missouri River. Adequate access sites and facilities are needed to capitalize on this potential.

ENVIRONMENTAL QUALITY

Water resources development has a variety of both positive and negative effects on the environment. The environment can be enhanced through future water resources development by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

A few rivers or portions of rivers within the State still retain to a large degree their historic flow and natural shoreline characteristics. One river and portions of seven others have been selected as possessing particularly valuable natural characteristics. Investigation is needed to determine whether these stream reaches or others qualify for designation as wild, scenic, or recreation rivers. Several of these stream reaches are of statewide importance and need to be preserved in their existing free flowing condition.

The Platte River islands between the mouth of the Platte and Loup Rivers are the largest group of islands remaining on the Great Plains. In general, these islands are privately owned, relatively inaccessible, heavily wooded, uninhabited, and possess ecologically unique combinations of flora and fauna. An opportunity exists for preservation of the natural qualities of these islands for present and future generations as outlined in the *Islands of America* report.

The quality of water and land resources affects the quality of the environment. Wastes discharged into Nebraska waters and silt produced through the erosion processes which scar Nebraska lands are aesthetically unpleasant and cause a great deal of harm.

Adequate treatment of all wastes reaching streams and intensive application of good conservation measures are needed to improve water quality and reduce erosion scarring of the land. Also, consideration needs to be given in future water resources development to maintaining adequate environmental flows in all streams, including streams which have already been adversely affected by streamflow depletions.

Man has a tremendous capability to alter, develop, and utilize natural resources. It is essential that an ecological awareness be developed, and that man's position in this ecology becomes a factor in future water resource development decisions.

SOIL EROSION

The soils of the State are generally erodible and, when unprotected, are damaged by wind and water

erosion. Wind erosion is generally most severe in central and western Nebraska. Because of heavier rainfall, water erosion problems are most severe in the east. However, anywhere steep slopes or sparse cover occur, erosion is a serious problem.

Soil erosion is a potential hazard on nearly 36,000,000 acres or over 75 percent of the state's agricultural land. Water erosion is the dominant problem on 19,000,000 acres and wind erosion on about 17,000,000 acres.

Wind erosion is a potential hazard on dry soils, particularly sandy and sandy loam soils, with limited vegetative cover. The wind erosion problem is most acute in the Sandhills area of the State.

Sheet and rill erosion is a particularly severe problem in the southeastern part of the State where there is only a thin cap of top soil. Gully erosion is most severe in the Nemaha River Basin where, if unabated, it will affect approximately 8 percent of the land during the next 50 years. However, the problem is also severe in the Missouri Tributaries and Republican River Basins and in other more local areas. Streambank erosion occurs in local areas along most major streams and has caused problems on the Elkhorn River, Big and Little Nemaha Rivers, and on short, steep tributaries of the North Platte and Missouri Rivers.

About 14,000,000 acres of agricultural land in the State presently need protection against water erosion, mostly in the eastern one-third. About 9,000,000 acres need protection against wind erosion, about two-thirds of which is in the Sandhills.

Both individuals and groups are presently combating the problem using technical assistance provided by federal, state and local agencies. Continued investment at an increased rate and improved measures for control are needed.

NAVIGATION

The Missouri River is the only commercially navigable stream available to Nebraska. The river has been improved from its mouth to Sioux City and is presently used to transport commodities to and from nine ports to Nebraska shippers.

The bulk of commercial tonnage presently shipped from Nebraska is farm products. This pattern is expected to continue in the future. Upstream shipments consist mostly of chemicals, food and related products, stone and clay products, and nonmetallic minerals.

Improvement of existing transport can best be accomplished through increased grain storage facilities at terminals and development of adequate land transportation facilities between terminals and production areas.

DRAINAGE

Nebraska has both natural and man-made agricultural drainage problems which affect about 1,800,000 acres. Drainage of many of these lands can, and probably will, be accomplished by individuals. However, about 900,000 acres will require some type of project development. Care must be exercised in drainage programs because the concentration of collected waters frequently results in erosion and various other problems downstream.

Many existing drainage systems need substantial rehabilitation and/or maintenance. In addition, many of the areas with inadequate drainage, especially those that historically have been wetlands, have high value for wildlife. Decisions to drain such areas should be made only after due consideration of probable consequences.

Areas of particular need for drainage include the northern portion of the Central Nebraska Public Power & Irrigation District service area, parts of the North Platte River Valley, and numerous smaller areas associated with other irrigation projects.

ELECTRIC POWER

Nebraska presently has enough generation capacity to satisfy almost three-fourths of the state's peak electric energy requirements. The remaining one-fourth of the state's requirements are satisfied through power importation, primarily from the Missouri River Basin Project power system.

About 92 percent of the state's electric power generation capacity is contained in thermal electric power plants. These consume less than 10,000 acre-feet of cooling water annually. Twenty small hydropower plants using large quantities of water supply the remaining 8 percent of the state's power generation capacity.

The capacity of hydroelectric plants is small in relation to total power production. While energy demands will continue to rise, the importance of hydroelectric power is expected to decline as it becomes a smaller part of total power production. It is anticipated that most of the existing hydro plants will gradually be phased out. There appear to be few opportunities for additional hydroelectric installations.

Many existing hydroelectric plants are faced with reduced amounts of water available for generation because of upstream appropriations by higher preference users and a lack of adequate storage capability to regulate and utilize the higher flows.

Thermal plants will have greater cooling water needs in the future. The exact amounts will depend on the extent of use of various types of cooling processes now available.

Chapter 4 / THE BASIC FRAMEWORK

Nebraska's physical features, natural resources, people, and economy were described in Chapter 2. The State is rich in water, land, and environmental amenities. Its physical features suit Nebraska to agriculture and its size provides ample space for the moderate population. The economy is, has been, and likely will continue to be oriented to agriculture and industries associated with agriculture. Its people are industrious, conservative, and accustomed to a high quality of life.

Chapter 3 summarized the existing development of land and water resources, existing resource problems, and future needs and opportunities for further development of these resources.

Agriculture, of course, dominates all other economic development, but industry is becoming increasingly prominent.

Control of flooding and erosion are among the most urgent needs. Major irrigation water needs, for the present and the future, are additional water supplies and the reduction of waste and inefficient use of existing supplies.

Municipal, industrial, and rural water supplies can be met from ground water development throughout most of the State.

Waste disposal and various other forms of stream pollution have created localized water quality problems and could become a major problem in the future.

The distribution of water oriented recreation and fishery resources throughout the State is poor as related to the population distribution, with severe shortages of recreation waters in the east and a surplus in western Nebraska. The physical environment in the State is varied and, on the whole, makes a substantial contribution to the quality of life.

The Basic Framework presented in this chapter includes only the development of in-basin water resources required to satisfy needs within the basin of origin. The concepts for interbasin water transfer discussed in Chapter 5 are not part of the Basic Framework. The Basic Framework is intended to be a flexible guide for the future development of the state's water and water related resources. It includes all developments of in-basin water resources which appear to be reasonable and necessary in the foreseeable future to meet the needs outlined in Chapter 3.

The Basic Framework is designed to be flexible. More detailed investigations may disclose more desirable alternatives to meet some needs. Some projects may require modification due to unanticipated future conditions and other projects may need to be added, but development essentially in the manner described herein should effectively and efficiently meet most future needs.

The Basic Framework does not include maximum utilization of the resources in all areas. More complete use of the resources will be possible should the need arise.

Two types of structural development are included in the Basic Framework.

The first, "independent local development," is that undertaken to satisfy individual or localized needs. Examples of this are individual development of ground water for irrigation and for other rural uses; further development and expansion of municipal supplies by cities; water supplies developed by individual industrial plants; and individual erosion control efforts. Independent local development is not susceptible to explicit planning, but development that is likely to take place was made a part of the plan.

The second type, "public project development," requires group action and generally involves several levels of government to both plan and finance. Examples are large irrigation projects, watershed protection projects, and flood control projects of substantial size, serving many associated purposes.

In addition to these two types of structural development, nonstructural measures such as flood plain regulation and protection of unique or scenic rivers are also included.

Possibilities for modification of existing or proposed projects to provide for more efficient use of water, enhance fish and wildlife values, and increase recreation opportunities are also included in the Basic Framework.

In this chapter, the Basic Framework is first summarized and then outlined basin by basin in separate sections. The chapter concludes with an evaluation of the extent to which water related problems and needs would be fulfilled by the Basic Framework.

Planning Guides and Restrictions

General planning guidelines for the Framework Study were presented in Chapter 1. The Basic Framework, developed as a principal part of the Study, follows those guidelines. Because of their importance, the guidelines particularly applicable to the Basic Framework are briefly reiterated.

(1) The general welfare of the people and the quality of their life, both now and in the future, shall be the overriding consideration in planning for water resource development.

(2) The Study shall encompass the entire State and give attention to all reasonable uses for water.

(3) The Study will include and be built around presently proposed feasible projects.

(4) The Study shall accord first priority to use of water resources within their basins of origin.

(5) Wherever possible, development will include provisions for multipurpose use of resources.

(6) Development should provide for the reasonably full use of resources to meet the major needs anticipated through the early decades of the 21st Century.

(7) Long range water resource development is subject only to constraints external to the State, present private investments and established water rights.

(8) Attention shall be given to the environmental effects of development and the benefits of non-development or protection of environmental values to the greatest extent practicable with development.

Summary of The Basic Framework

The Basic Framework for future development of Nebraska's in-basin water resources includes allowance for both independent local development and public project development. The public project development included provides the skeletal structure and is shown on a statewide basis on Figure 48. Independent local development cannot be adequately depicted on the same map, so it is shown, where possible, on separate figures in the following sections. The combination of "independent" and "public" development make up the Basic Framework. Table 35 summarizes the potential of the major developments included.

INDEPENDENT LOCAL DEVELOPMENT

Independent local developments, because of their cumulative effect within a river basin, must be considered in projections of future resource availability and use, even though in many cases their separate effects would be very small. It is beyond the scope of this Study to specifically predict and account for all future independent developments. However, where such development in the aggregate was anticipated to have significant statewide impact, assumptions concerning amount and location of development were made based on the best technical judgement available. The assumptions made are broad and methodologies used were generalized, but the results are of an accuracy appropriate to a framework level study.

The independent local development included as part of the Basic Framework is described, by type, in the following sections. The general techniques of analysis are also discussed.

Water Supply. Criteria established for state water planning provide per capita daily use rates for municipal supply varying from 80 to 200 gallons depending on community size and location. In addition, 80 gpcd was added to provide for industrial development and water use from a community's central supply system.

Future community populations were based on projections of total State population made by the Bureau of Business Research at the University of Nebraska.

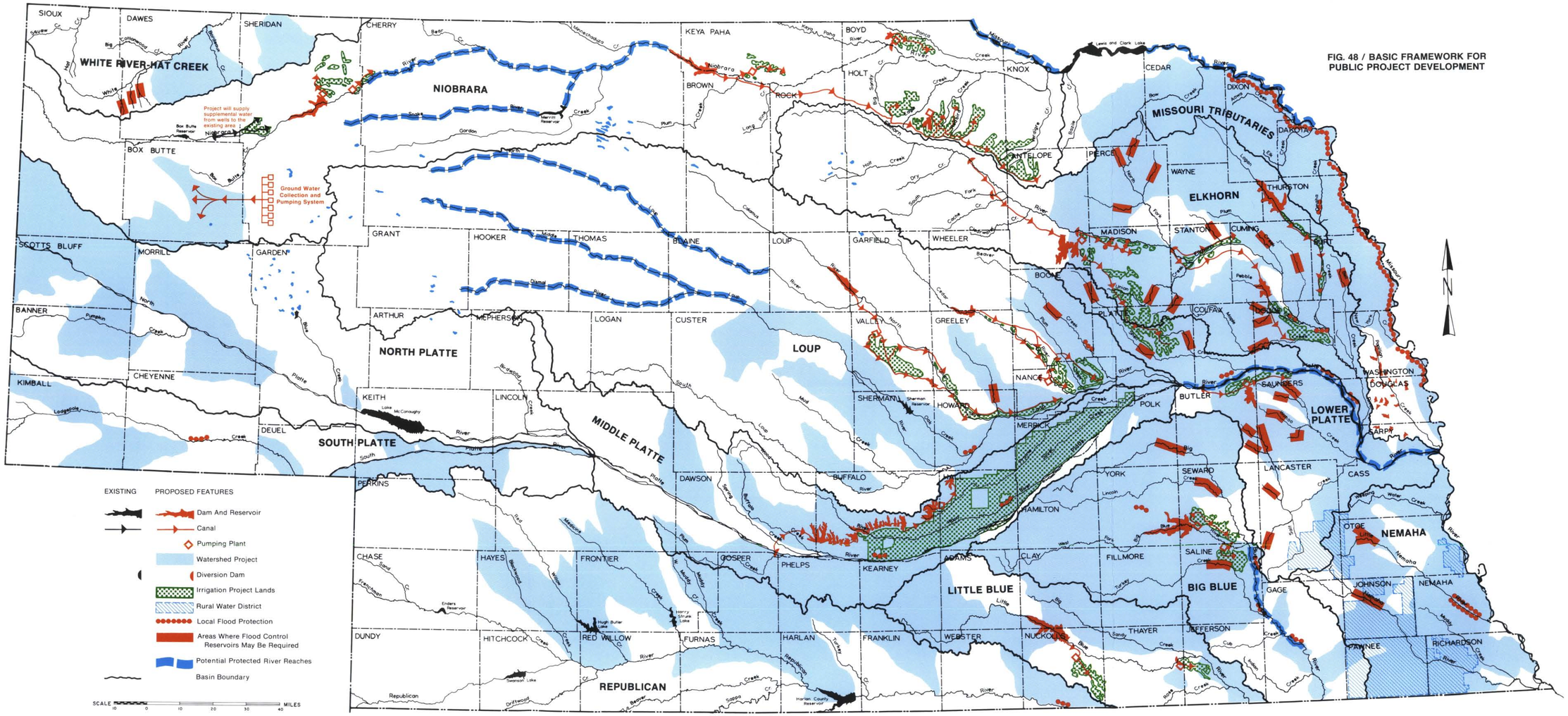


FIG. 48 / BASIC FRAMEWORK FOR PUBLIC PROJECT DEVELOPMENT

TABLE 35 / SUMMARY OF BASIC FRAMEWORK DEVELOPMENT POTENTIAL

Item	Present Development	Basic Framework Development Potential	Total Development
Independent Local Development			
Municipal and Industrial Water (afa)	270,000	430,000	700,000
Rural Domestic and Livestock Water (afa)	130,000	190,000	320,000
Ground Water Irrigation (Acres)	2,600,000	2,100,000	4,700,000
Public Project Development			
Surface Water Irrigation (Acres)	1,100,000	520,000	1,620,000
Flood Water Storage (AF)	1,000,000	2,270,000	3,270,000
Water Surface Area for Recreation and Fishery (Acres)	90,000	160,000	250,000
Land Treatment (associated with projects) (Acres)	400,000	2,000,000	2,400,000

Future demands, estimated by use of these population projections and per capita use rates, were compared to the adequacy of present water sources. It appears that ground water sources presently utilized by nearly all Nebraska communities are more than adequate to meet future needs for the foreseeable future, with minor exceptions.

Some communities in the lower Niobrara, White-Hat, Nemaha, and southern Republican River Basins are having difficulties in locating adequate supplies of suitable quality ground water. In the future, if communities in these areas require substantially larger amounts of water and continued use of ground water is desired, public projects to provide central water supply and regional distribution systems may be necessary. In most of these areas, ample surface water supplies and reservoir sites exist if development of surface water is desired; public projects would probably be necessary in most cases for economical development.

Omaha and Lincoln, as major metropolitan centers, will have rapidly expanding water needs in the future and simple expansion of facilities at existing supply sources may not be sufficient to meet their needs. Both cities have their own planning underway to provide for future supplies. It will be necessary to maintain substantial flows in the lower Platte River to rechrage the alluviums in which they have their well fields.

Other than as noted above, municipal and industrial water supply problems forecast are local in nature and within the capability of individual entities to resolve. The water needs for all municipal and industrial uses are shown together in this section.

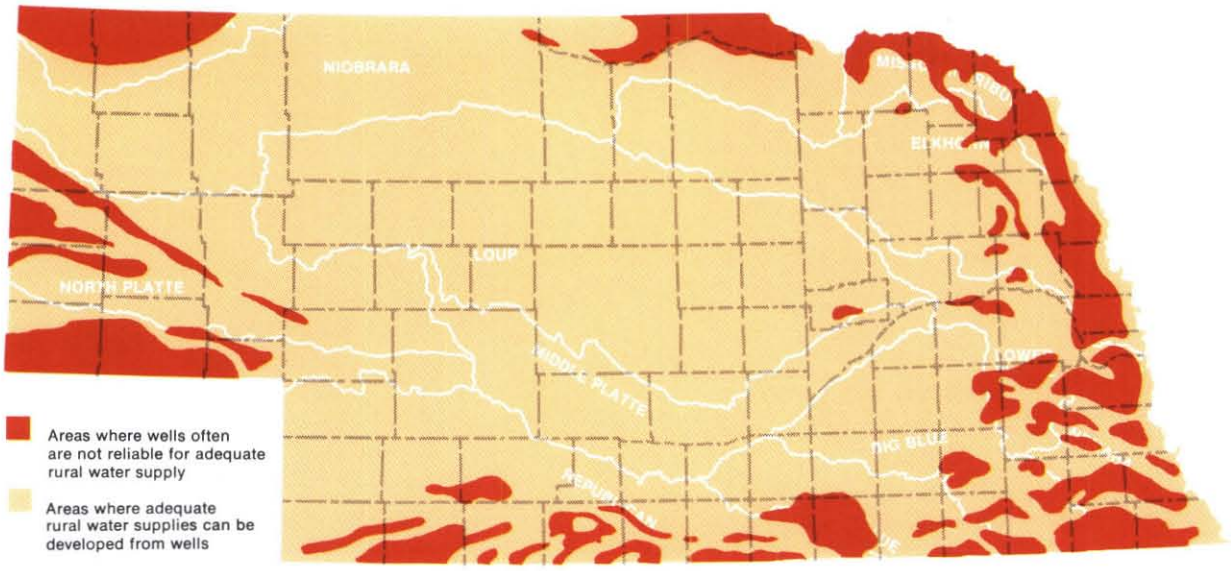
A statewide water withdrawal of about 700,000 afa for municipal and industrial purposes has been projected for 2020. This is approximately 430,000 afa above present use. Only a portion of the water withdrawn will be consumed. Since ground waters are largely used as a source and wastes are mostly discharged to streams, municipal and industrial water withdrawals can augment surface supplies.

Estimates of future rural domestic water use were based on a declining farm population but an anticipated increase in per capita use rates. Use rates varied with location from 80 to 120 gpcd. Total rural domestic water use is projected to increase from the present 27,000 afa to about 36,000 afa by 2020. Almost all private rural supplies are from ground water. With the exception of the areas shown in Figure 49 where wells generally are not reliable for adequate rural water supplies, individuals are not expected to have difficulties finding suitable water supplies.

Future requirements for livestock water will be distributed throughout the State. Total statewide use will approach 285,000 afa in 2020 compared to the present use of 103,000 afa. This is based on future projections of livestock numbers prepared for the Missouri River Basin Comprehensive Framework Study. About 80 percent will be supplied from ground water and the remaining 20 percent will be provided from streams, lakes, and small farm ponds impounding surface waters on minor drainages.

Farm ponds have only a moderate effect on water availability because of their widespread distribution and small amounts impounded. Total water consumed from farm ponds, including evaporation, is projected to be approximately 130,000 afa in 2020.

FIG. 49 / ADEQUACY OF GROUND WATER FOR RURAL WATER SUPPLY



Source: Conservation and Survey Division, University of Nebraska

Irrigation. The largest single use of Nebraska's water resources is for irrigation. At the present level of development it is estimated that about 2.6 million acres are being irrigated from ground water and about 1.1 million acres from surface water. Ground water development is all private, but a large amount of the surface water development is through public projects.

Projections of future private irrigation development are vital to a determination of water supplies which will remain available for public project development.

It was assumed the total amount of private development of irrigation from surface water sources would remain at current levels, since essentially all natural streamflow has been appropriated in areas where lands adjacent to the streams are suitable for irrigation development. It is anticipated that future new diversions of streamflow for private irrigation development will generally reflect replacement of more marginal land being dropped from irrigated production.

Additional private development of ground water for irrigation was projected to occur wherever suitable land is underlain by ground water supplies deemed adequate to sustain the development over a considerable period of time.

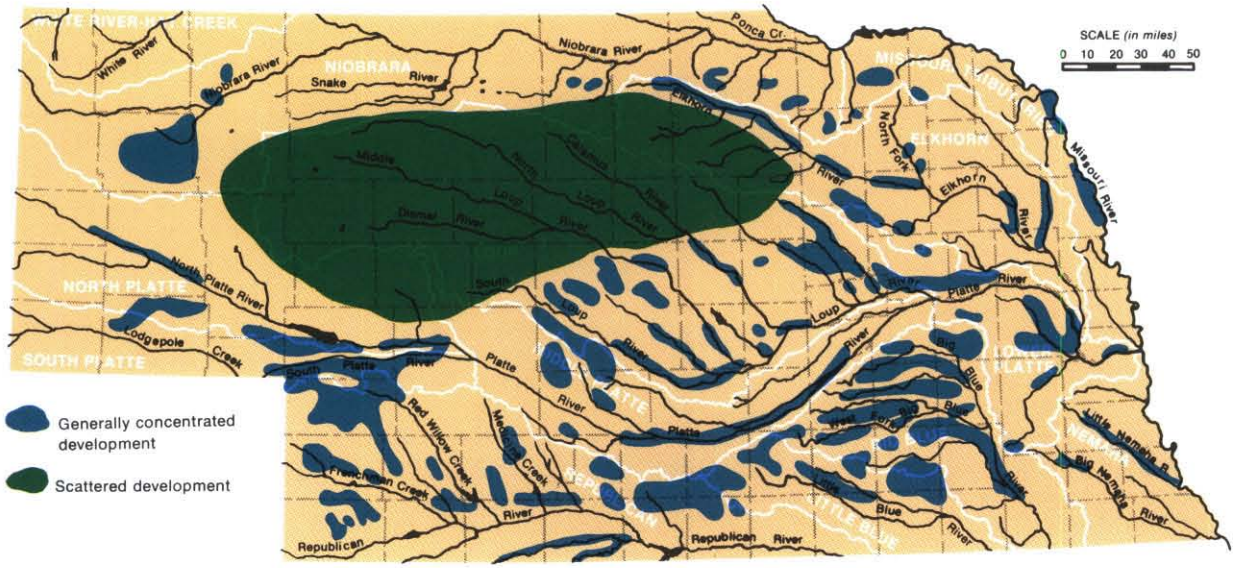
The suitability of land was determined by surveys made by the USBR and the availability of water supplies was estimated from data compiled by the Conservation and Survey Division of the University of Nebraska.

Recent trends in ground water development for irrigation were also taken into account. Some lands not presently classified as suitable for irrigation development by the USDA standards adopted for the State Water Plan are in fact being developed in the Sandhills area. This development by independent local initiative is expected to continue until many of the better Sandhills lands, about 300,000 acres, are under irrigation. The extension of irrigation beyond that to more marginal Sandhills lands may occur, but only at great risk of severe wind erosion problems unless adequate control technology is developed and carefully followed.

Ground water irrigation development in several other areas of the State has resulted in withdrawal rates in excess of natural recharge. It was assumed that development in these areas would continue until further development becomes uneconomical.

In general, no large new areas of private ground water irrigation are expected to develop. Future increases in well irrigation will result mostly from extension of development from the present periphery

FIG. 50 / PROJECTED GROUND WATER IRRIGATION AREAS



and an intensification of development in presently irrigated areas.

Altogether, it is projected that approximately 2.1 million additional acres of land will be irrigated from ground water by the early decades of the 21st Century. The general areas of future development are shown on Figure 50.

Land Treatment. Treatment of land to prevent soil erosion is one of the most widespread needs in Nebraska. Treatment varies from proper range management to structural works such as terraces, waterways, and gully stabilization.

About 36,000,000 acres of the State are potentially susceptible to water and wind erosion. About 23,000,000 acres are not adequately treated and need added protection from erosion. Of this, about 14,000,000 acres are subject to water erosion hazards and the remaining 9,000,000 acres have wind erosion hazards.

About 11,000,000 acres are included in watershed project areas (public project development) that have flood control storage structures. Of this total area, nearly 50% or about 5,000,000 acres would contribute to drainage behind structures and 75% (3,500,000 acres) of that area must be adequately treated by landowners as one of the watershed project requirements. Since a portion of this total area is adequately treated at the present time, it can be assumed that about 2,000,000 acres would receive treatment under projects included in the Basic Framework.

PUBLIC PROJECT DEVELOPMENT

Resource development by individuals and small groups is necessarily limited to projects of small size and generally produce benefits over a limited area.

Major resource developments usually require costly facilities, detailed technical study, and extensive institutional arrangements.

Because of economic considerations, public projects tend to be both large in scale and multipurpose in nature. Their conception, design, construction, and successful operation requires close collaboration between the private sector and all levels of government.

The development of in-basin water resources through public projects is the central feature of the Basic Framework. The analysis of water supplies available for development of these projects and water available after project development indicates that projects included are compatible with anticipated future downstream development.

Because the Basic Framework includes several types of projects and because most developments are multipurpose in nature, no single method of display adequately treats all developments.

Figure 48 shows, on one map, the public projects included in the Basic Framework. Descriptions of the projects are included in the following sections on individual River Basins.

Surface Water Irrigation Developments. Surface water irrigation projects incorporated in the Basic Framework and the estimated amount of land which would be irrigated are shown in Table 36.

All of these projects have been previously studied to some extent. No additional potential for major irrigation projects using surface waters within the basin of origin was found during the Framework Study.

In addition to the 520,000 acres which would be provided irrigation water by these projects, several other purposes would be served.

They would, in total, provide nearly 90,000 surface acres of water in reservoirs for fish and wildlife and recreational purposes. Lands adjacent to the reservoirs could be used for recreation.

The reservoirs would, in many cases, have space available for flood control. Slightly over 1,000,000 AF of space could be specifically devoted to that purpose. Additional storage, amounting to about 500,000 AF, would trap and store sediment moving downstream. Releases from water stored in the reservoirs could maintain flows downstream during drought periods to insure the survival of fish and wildlife as well as the aquatic flora.

Percolation of surface irrigation waters not consumptively used by crops would add to the ground water reservoir. In certain areas this method of stabilizing falling ground water levels can be an essential benefit from the project. This concept is already being implemented in planning for the Nebraska Mid-State Division in the Middle Platte River Basin.

TABLE 36 / BASIC FRAMEWORK SURFACE WATER IRRIGATION PROJECTS

River Basin	Project Name	Irrigation Service Area in Acres
White R.-Hat Cr.	No Project	--
Niobrara	Mirage Flats Supp.	Supplemental water for existing area
	Lavaca Flats Unit	2,300
	Gordon Area	20,000
	O'Neill Unit	77,000
	Page Area	25,000
	Keya Paha Area	15,000
Missouri Tributaries	No Project	--
North Platte	No Project	--
South Platte	No Project	--
Middle Platte	Nebr. Mid-State Div.	140,000
Loup	North Loup Division	52,600
	Cedar Rapids Div.	26,800
Elkhorn	Highland Unit [a/]	42,600
	Norfolk Unit	33,000
	Logan Unit	11,700
Lower Platte	Linwood Unit	10,600
	Highland Unit [a/]	12,900
Republican	No Project	--
Little Blue	Little Blue Unit	20,000
Big Blue	Sunbeam Unit	30,000
Nemaha	No Project	--
STATE TOTAL		**519,500**

a/ Highland Unit irrigation service area lies in both Elkhorn and Lower Platte River Basins.

TABLE 37 / BASIC FRAMEWORK SMALL WATERSHED PROJECTS

River Basin	Number of Watersheds Included	Total Watershed Area in Acres	Number of Watersheds With Reservoir Storage	Flood Control Storage in 1000 Acre-Feet	Area of Permanent Pool Water Surface	Miles of Channel Improvement
White R.-Hat Cr.	3	365,000	3	15	2,200	0
Niobrara	2	335,000	0	0	0	34
Missouri Tributaries	15	1,244,000	12	66	6,500	120
North Platte	13	1,233,000	11	45	3,600	336
South Platte	6	869,000	4	22	1,300	77
Middle Platte	12	2,074,000	3	31	2,400	842
Loup	14	1,775,000	8	59	4,500	258
Elkhorn	21	2,641,000	15	122	10,200	457
Lower Platte	14	1,453,000	11	70	5,400	213
Republican	12	2,100,000	6	49	2,300	115
Little Blue	7	1,113,000	2	8	800	88
Big Blue	19	2,291,000	5	44	2,900	255
Nemaha	16	1,436,000	14	116	7,800	10
STATE TOTAL	**154**	**18,929,000**	**94**	**647**	**49,900**	**2,805**

Ground Water Irrigation Development. Public project development of ground water may be required to provide supplemental water to existing irrigators in Box Butte County. A possible project including a well field in southwestern Sheridan County to provide water for pumping into the Alliance area has been included in the Basic Framework. No estimates of the amount of water needed or the time of need were made.

From cursory examination, this appears to be the only reasonable source of supplemental water supply. However, detailed investigation of possible induced ecological effects would be required before serious consideration could be given to the project.

Small Watershed Projects. One of the most popular programs of resource conservation and development in Nebraska has been accomplished under the Watershed Protection and Flood Prevention Act, PL 566. Developments carried out under this program emphasize flood and erosion control but often include other purposes such as recreation, fish and wildlife, and irrigation.

While numerous watershed projects are now being planned for construction, it appears that many additional projects are needed and are either economically feasible at the present time or will become so in the foreseeable future.

The program is particularly well adapted to eastern Nebraska where both flooding and erosion are serious problems. Numerous projects also appear feasible in the central and western part of the State in the rough lands along tributaries to major rivers.

Table 37 provides a summary of information on those watersheds included in the Basic Framework for development. Locations of the watersheds are shown on Figure 48.

These watersheds provide a total of about 650,000 AF of storage for flood control. In addition, they will provide about 50,000 acres of water surface which could be utilized for recreation and fish and wildlife. The recreational use of these moderately sized structures is particularly important in eastern Nebraska.

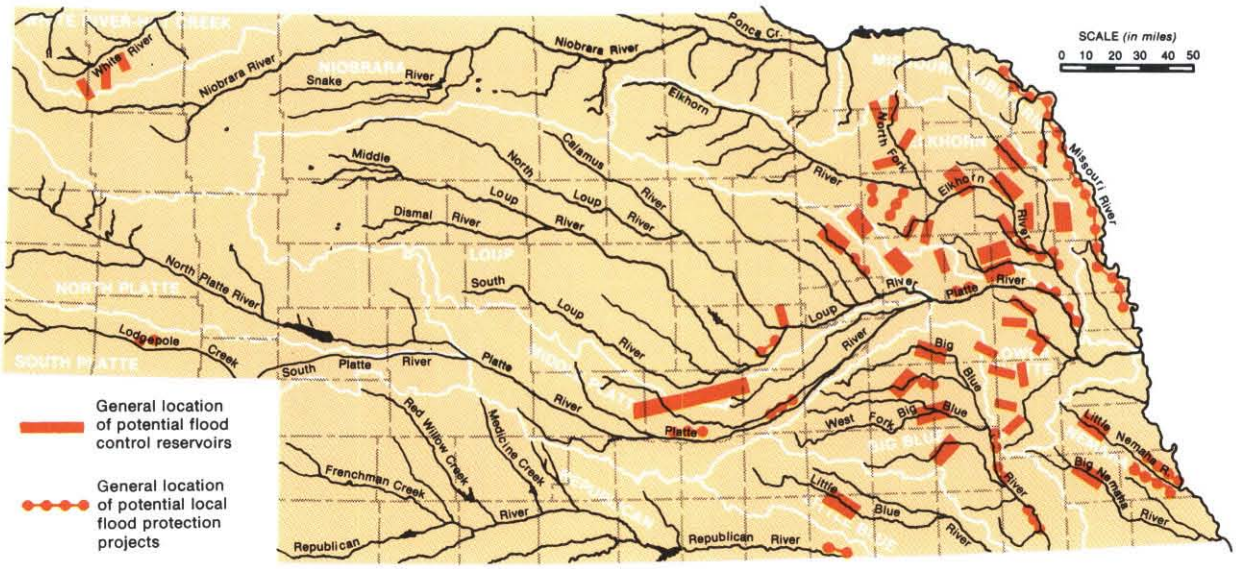
Flood Control. Control of floods and reduction of damages may be achieved in a variety of ways. Often a combination of structural and nonstructural programs is necessary to obtain satisfactory results. Developments included in the Basic Framework are primarily for the purpose of reducing flood damages but again, through multiple purpose development, they serve a variety of public needs.

Structural Development. Figure 51 shows approximate locations where flood control storage would be desirable and where levee projects are being considered. Levees are included in the Basic Framework as specific public projects at several locations, primarily in eastern Nebraska.

Although specific locations are not noted in the Basic Framework, stream channel improvements such as bank stabilization and selected channel clearing and straightening are needed in some areas.

Major flood control reservoirs provide a high level of flood protection for immediate downstream areas and their influence is measurable, although decreasing with distance, over extensive areas.

FIG. 51 / BASIC FRAMEWORK
MAJOR FLOOD CONTROL FEATURES



The Basic Framework for development includes four projects that have multipurpose reservoirs which include flood control as a major purpose. In addition, 35 approximate locations have been noted where major flood storage is needed. These 39 locations are shown on Figure 51. Estimated total storage capacity required is about 600,000 acre-feet. This would provide about 20,000 acres of water surface at permanent pool level. It can be seen from the map that most of the locations are within day use recreation distance of either Omaha or Lincoln.

In several basins, the plans for providing the required storage have been coordinated between several federal agencies, but in most instances considerable refinement of plans is required to determine the optimum combination of flood control facilities required to provide the desired degree of protection.

Flood control reservoirs may also provide considerable enhancement to streams during drought periods by a gradual release of stored water. These releases enhance water quality, maintain fish and wildlife habitat, and sustain other environmental values of streams.

Land Use Regulation. Land use regulation for the prevention of flood damage is the practice of designating areas which are susceptible to flooding, and in those areas, allowing only use and development that will not be seriously damaged or present a hazard to life if flooded.

A program presently exists in Nebraska for such regulation. For the Framework Study, it was assumed this program would be continued and fully implemented, thus reducing further increases in flood damage due to investments in flood prone areas.

Six municipalities and two counties have adopted flood plain zoning ordinances, but the program of regulation will require many years for full implementation. Attention should continue to be given first to those communities with the most urgent needs. Table 38 lists those communities where the regulatory program should be emphasized. The communities listed are in the general order of need, but local circumstances and availability of necessary information may require adjustments in the order of implementation.

Land use regulations are necessary in all areas where projects having flood control as either a major or minor purpose are contemplated to insure that the reductions in flood losses achieved by the projects will not be negated by increasing development of the flood plain.

TABLE 38 / COMMUNITIES NEEDING EARLY FLOOD PLAIN REGULATION

1. Columbus	8. Lexington
2. Sidney [a/]	9. Cozad
3. Valley	10. York
4. Scottsbluff	11. Norfolk
5. Wahoo [a/]	12. Schuyler
6. Fairbury [a/]	13. South Sioux City
7. Fremont	14. North Platte [a/]

a/ Flood plain information studies are being made for these communities.

TABLE 39 / COMMUNITIES NEEDING FLOOD EMERGENCY PLANS

1. Omaha	9. Columbus
2. Bellevue	10. Norfolk
3. Millard	11. Fremont
4. Ralston	12. Valley
5. Papillion	13. West Point
6. Lincoln	14. North Platte
7. Grand Island	15. Scottsbluff
8. Beatrice	

The program of land use regulation, undertaken to minimize flood damages, often provides an opportunity for highly desirable public uses of the flood plain. Suitable uses include hiking, bicycling, and bridle paths, parklands, parking lots, golf courses, wildlife management and other similar uses not subject to severe flood damage. As cities grow, such open space, particularly near central urban areas, will become increasingly valuable.

Flood Warning. Floods are often sudden and frequently disastrous. Effective emergency action in providing timely warnings and a rapid response to those warnings can save lives and greatly reduce damages to both public and private property. However, the time available between recognition of an impending flood and the onset of flooding is generally too short to make adequate preparations. Advance planning is required on a local basis.

The warning phase of flood fighting requires expert technical knowledge and extensive communications beyond the capacity of most communities and is properly the role of the State and Federal Governments. A special recommendation and report titled *Flood Warning and Community Action* dealing with needed state action in this area has already been prepared and made available as part of the State Water Plan activity.

The preparation of plans to guide reaction to flood emergencies is, however, a local responsibility. While all communities subject to flooding should prepare plans commensurate with the local flood hazard, assistance given by the State in leading this program should be directed to those communities with the more urgent problems.

Table 39 lists, in a general order of need, those communities which particularly need flood emergency plans.

Environmental, Outdoor Recreation, and Fish and Wildlife Measures. The Basic Framework contains provisions specifically for outdoor recreation, fish and wildlife resources and for preservation and enhancement of the physical environment.

In Nebraska there are numerous rivers having unique or exceptionally high value because of their scenic beauty, recreation potential or fishery resources. These rivers serve a high purpose in their present relatively undeveloped state and should be protected to assure their availability into the future. The rivers and reaches of rivers identified by the Nebraska Game and Parks Commission as suitable for protection are not required for development to meet foreseeable needs and their protection should not conflict with other needed development. Locations of the river reaches, listed in Table 40, were shown earlier on Figures 40 and 48.

Maintenance of historic streamflow characteristics and protection of water quality are crucial for fish, wildlife, and environmental values in the areas designated for protection and must be weighed in future considerations for development.

TABLE 40 / RIVER REACHES SUITABLE FOR PROTECTION

River	Reach	Principal Value	Approximate Length (Miles)
Niobrara	Middle	Scenic	120
Snake	All	Scenic	50
North Loup	Upper	Scenic	100
Middle Loup	Upper	Scenic	100
Dismal	All	Scenic	70
Missouri	Above Lewis & Clark Lake, north & west along Nebraska border	Recreation	30
	Yankton to South Sioux City	Recreation	70
Platte	Lower	Recreation	110
Big Blue	Lower	Recreation	30

In a framework level study, it is impossible to specifically identify the wetlands which have historically served as nesting and feeding areas for waterfowl. However, the general areas shown on Figure 52 contain most of the state's wetlands, many of which have high value for waterfowl production and hunting and fishing opportunities. While further studies will be necessary to completely identify all such wetlands, those with obvious wildlife values require immediate protection from drainage.

Future demand for catchable size fish will exceed the natural supply. At least one additional hatchery, centrally located to reduce handling and travel time, will be required. This development has not been specifically located but should probably be undertaken in conjunction with some other major water resource development as the opportunity arises. From a water use standpoint its location is unimportant since the hatchery's use of water will be largely nonconsumptive.

The amount and general location of surface water area that will be provided for recreation use from Basic Framework multipurpose reservoir development is shown on Figure 53.

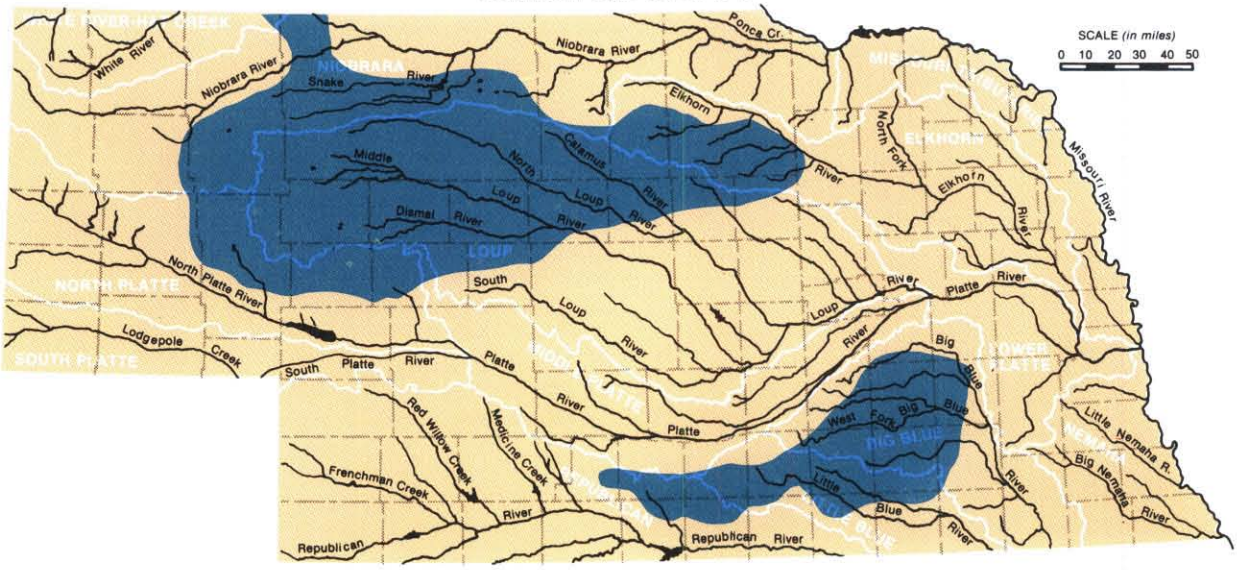
However, the demand for recreational waters may still exceed the capacity provided either by inclusion of recreation as a specific purpose in multipurpose projects or incidentally by water development projects for other purposes.

Reservoirs built specifically for recreation purposes can be much more intensively used than similarly sized bodies of water serving several purposes because of the greater control over site selection, water level stability, and other such factors. Single purpose recreational reservoirs may eventually be required in the Omaha-Lincoln area if demands are to be met. While no specific locations have been determined, numerous sites are available in both the Elkhorn and Lower Platte River Basins which could be utilized. Whenever needed, development of such sites should probably take place near the lower end of either or both basins to avoid conflict with other uses.

Power. Relatively small quantities of water are actually consumed during the production of electric power in thermal plants. In some areas, future in-basin development of water resources will reduce the water available at present plant locations, but will not seriously affect thermal power production.

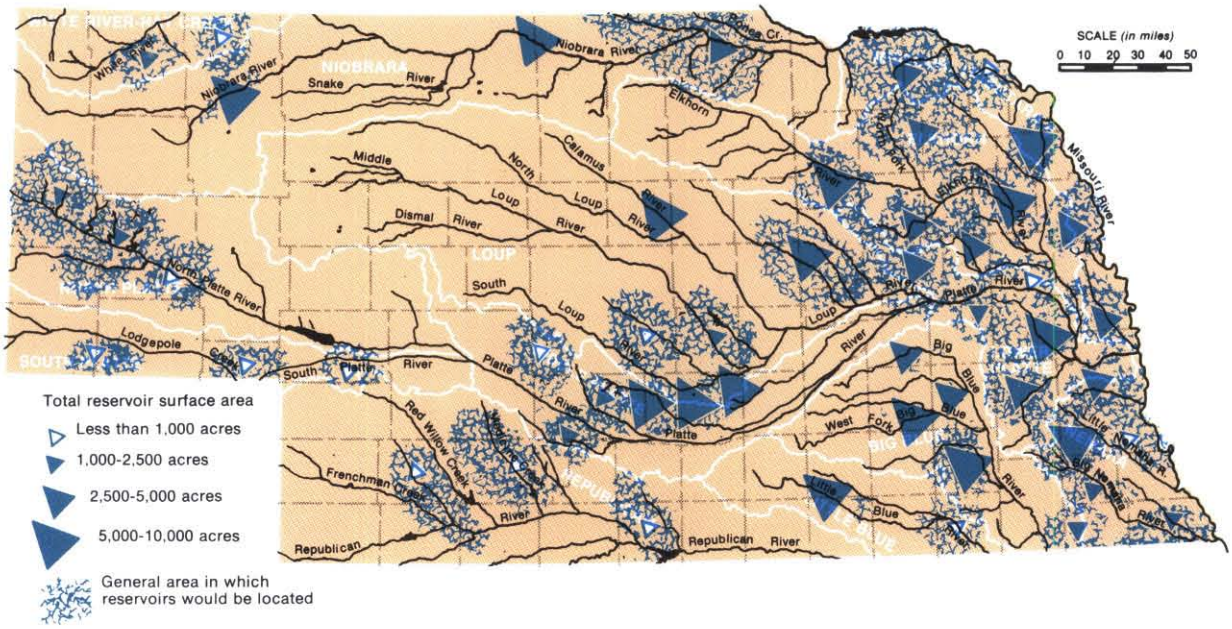
Hydroelectric power production, however, depends on the use of large quantities of water, even though it is used nonconsumptively. As in-basin development reduces water availability, the pro-

FIG. 52 / AREAS CONTAINING NATURAL WETLANDS VALUABLE FOR FISH AND WILDLIFE



Source: *Outdoor Recreation for Nebraska*, Nebr. Game and Parks Commission

FIG. 53 / POTENTIAL MULTIPURPOSE RESERVOIR WATER SURFACE AVAILABLE FOR RECREATION



ductive capability of downstream hydroelectric plants will be progressively reduced. However, losses of power production as a result of in-basin water development will be negligible compared to total future power requirements in the State.

Future thermal electric plants are expected to locate primarily along the Missouri River where adequate water for cooling will be available and thus not be affected by projected development in the various Nebraska River Basins. If additional plants are eventually required in the central or western parts of Nebraska, the relative ease with which power may be transmitted will allow sufficient flexibility for such plants to locate where adequate cooling waters are available.

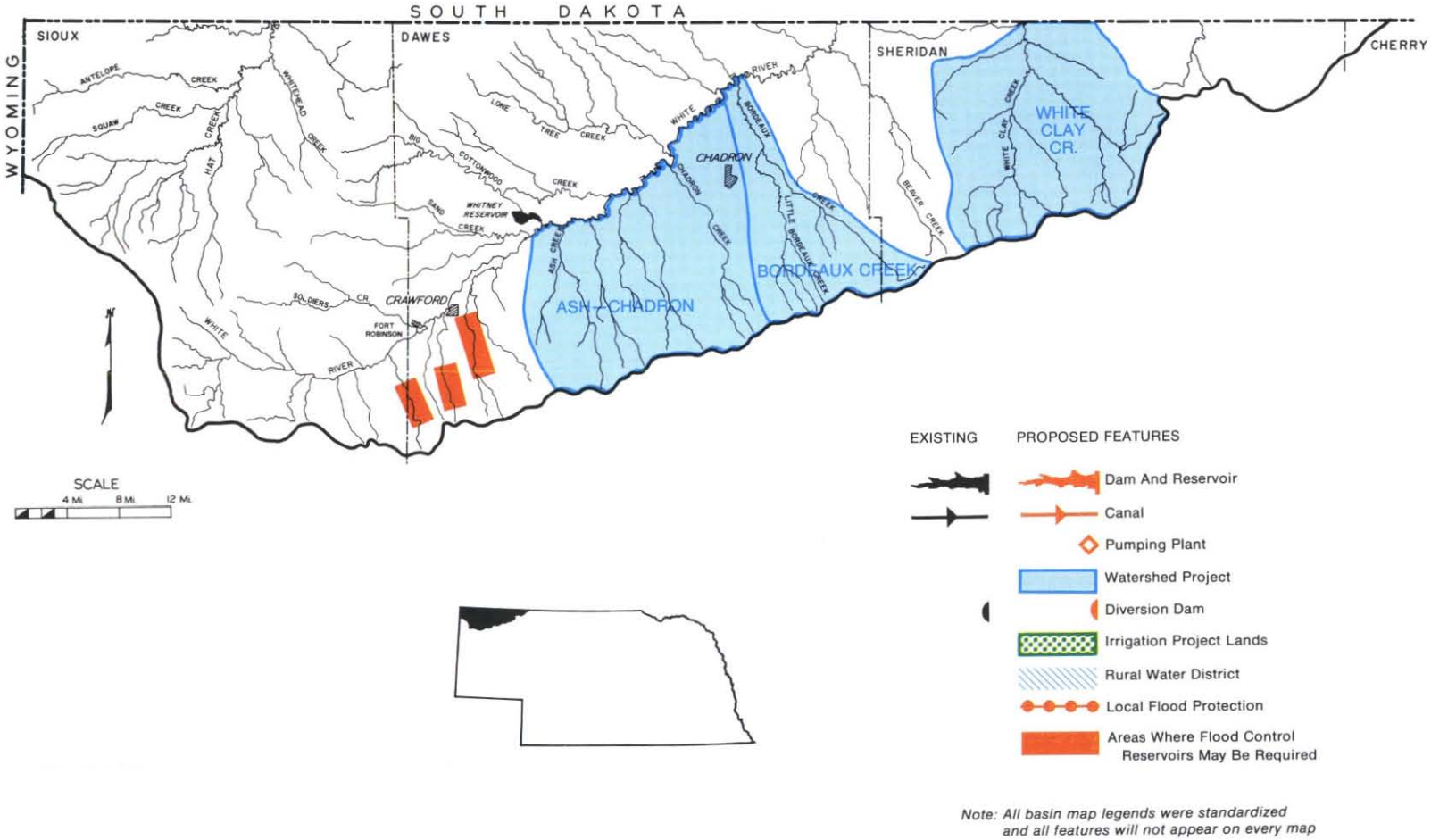
White River-Hat Creek Basin

GENERAL DESCRIPTION

This Basin is located in the extreme northwestern corner of the State. The White River with its many tributaries drains the major portion of the Basin. It begins in northern Sioux County, near the Nebraska-Wyoming state line, flows northeast into South Dakota and finally empties into the Missouri River above Fort Randall Dam. Hat Creek, which drains the remainder of the Basin, rises in the northwestern part of Sioux County and flows northward into the Cheyenne River in South Dakota.

Topographically, this is one of the roughest basins in the State. The southern tributaries of the White River and Hat Creek head in the Pine Ridge, a massive sandstone escarpment which forms part of the northern boundary of the high plains. In their upper reaches in the Pine Ridge, most of these streams are well entrenched forming an area of rough lands. Tributaries from the north and west cross a gently sloping area marked with clay hills and occasional badlands. Here these streams form narrow bottomlands with well defined terraces. Throughout the entire Basin, the streams have cut deeply into the surrounding land and formed narrow valleys.

FIG. 54 / BASIC FRAMEWORK DEVELOPMENT
WHITE RIVER-HAT CREEK BASIN



Note: All basin map legends were standardized and all features will not appear on every map

The rugged, steep slopes of the sandstone escarpment forming the Pine Ridge are clad with coniferous trees. Elsewhere, much of the Basin, including the badlands area in the northwest, is covered with native grasses which are used for livestock grazing. Less than 10 percent of the land in the Basin is cultivated.

Basin Resources. Most of the land is not suited to cultivation because of the poor, clayey soils and rugged topography throughout much of the Basin. A strip of land lying south of the White River in Dawes County and some local tracts scattered throughout the Basin are suitable for cultivation provided intensive conservation practices are used.

Of a total land area of 1,360,000 acres in the Basin, about 1,270,000 acres are classified as agricultural land, but only about 500,000 are classified as arable and about 225,000 acres, mostly in small scattered tracts, are classified as suitable for irrigation.

The average annual precipitation across the Basin is about 16 inches per year. Most of it is received as rainfall during the spring and summer months.

The Basin's only dependable source of water is from the spring fed tributaries which head in the Pine Ridge in the southern and eastern part of the Basin. Streams flowing from the west and north drain the badlands area and are usually dry except when carrying direct runoff from precipitation. Runoff is usually rapid because of the steep slopes and the impermeable soils.

The Indians and the U. S. Government claim and hold in abeyance rights to water flowing into or through Indian Reservations for use on Reservation lands. The right could possibly be quantified by fixing the amount of water required to serve the Reservations' needs, but in the absence of quantification, the streamflow on the White River is reserved for use on downstream Indian Reservations in South Dakota.

Good quality ground water is scarce in the Basin. Only meager supplies can be obtained from the fine textured clays and shales underlying most of the Basin. Even the alluvial deposits in the valleys produce only small yields. Only in the high lands where the spring fed streams begin can moderate quantities of good quality ground water be found. Larger supplies are available in deeply buried sandstone underlying the entire Basin, but this water generally is highly mineralized.

The Pine Ridge area is the largest forested area in the State. Its forest contains primarily coniferous trees which are used to some extent for pulp wood, lumber, and posts.

The fish and wildlife resources of the Basin are abundant. Deer, antelope, and wild turkey are found in large numbers. Many spring fed streams originating in the Pine Ridge offer excellent trout fishing.

Existing Development. Irrigation began in this Basin in the early 1880's and has developed gradually during the ensuing years. Presently, there are about 28,000 acres of irrigated land in the Basin of which only about 1,400 acres are irrigated from ground water. Of the 26,600 acres irrigated from surface water, about 9,800 acres are in the Whitney Irrigation District, the only irrigation district in the Basin. Water storage for the District is provided by Whitney Lake, an off-stream 11,000 AF impoundment storing water diverted from the White River. Water for the remaining acreage is diverted on an individual basis.

The economy of the Basin is presently linked most closely to agriculture but recreation and tourism are rapidly gaining a foothold. Ranching is the main agricultural activity. Chadron, with a population of about 5,000, is the business hub of the Basin.

A plentiful supply of wildlife, excellent fishery resources, beautiful scenery, and a rich historical heritage provide an attraction for thousands of hunters, fishermen, and tourists each year. The Nebraska National Forest in the Pine Ridge area south of Chadron, Oglala National Grasslands, and Chadron and Fort Robinson State Parks are the principal attractions to tourists. Many working ranches are now providing services to hunters as a secondary source of income. Guest ranch development has gained impetus in the area and several are providing diversified services to the tourist trade.

PROBLEMS AND NEEDS

The clayey soils prevailing throughout much of the Basin promote rapid runoff of rainfall. However, flood damage problems are minor because many of the streams are deeply entrenched with only narrow flood plains and because only limited development has taken place on the flood plains.

Sheet and rill erosion is significant in the Basin because of the steep slopes and poor cover conditions. Only about one-fifth of the cropland and one-third of the rangeland are now adequately treated by soil conservation measures.

Gully and streambank erosion damages in the Basin have been quite minor. Many local areas in the Pine Ridge and badlands area are subject to gully erosion, but the damage is low due to present types of land use.

Good conservation measures are needed to prevent erosion damage to lands in the Basin. Both individual and group action will be required for a total program.

Ground water is quite limited in the Basin and even rural domestic, municipal and livestock water supplies are difficult to develop. Crawford is the only municipality in the State entirely dependent on surface water for its needs. Chadron used surface water for its municipal supply until 1969 when a system was constructed to pump ground water across the Pine Ridge from the Niobrara River Basin to the south.

Six rural water distribution systems have been installed to alleviate dependence on surface water supplies in parts of the Basin, but additional systems are needed.

The fact that Indian Reservations in South Dakota claim superior rights to the streamflow of the White River and other streams in the Basin under the Federal Reservation Doctrine, which applies to all federally owned land, creates an obstacle to surface water development. Without firm water rights, development in Nebraska is effectively stymied.

Many of the diversion, storage, and distribution structures of the Whitney Irrigation District have deteriorated, creating an inefficient supply and distribution system. Improvement of these facilities is needed to conserve the limited supply of water available.

The communities in the Basin were inventoried in 1969 to determine the adequacy of their waste treatment. Crawford, with a population of about 1,600 people, provides secondary treatment but its facilities are in need of improvement. The facilities of the other two municipalities were found to be adequate.

Many opportunities for recreation and tourist development exist in the Basin. However, continued development and promotion are needed if the full potential of the area is to be attained.

BASIC FRAMEWORK DEVELOPMENT

Development projected for the White River-Hat Creek Basin includes independent and project developments which appear reasonable or feasible within the planning period.

Independent Local Development. The independent portion of the development is particularly difficult to quantify, but allowances have been made for developments which appear reasonable and likely to occur as the result of independent action. The limited supply of both ground and surface water makes any extensive water development unlikely in the future. Future private development will consist mainly of additional domestic water supply facilities and livestock ponds. It was assumed that land treatment for soil conservation would follow established trends.

Municipal and Industrial. The urban population of the Basin is expected to increase from a present level of about 6,670 people to about 10,500 people in 2020. Municipal water use is expected to increase substantially from the present 1,580 afa to about 3,100 afa by 2020 as shown in Table 41. However, this municipal and associated industrial use will still be relatively small. No development of separate private industrial water systems is anticipated. The increase in use for municipal systems can probably be met from ground water sources but locating adequate well fields will be difficult and it may be necessary to transport water over long distances.

Rural Domestic and Livestock. Rural domestic water use is expected to increase only slightly from the present 240 afa to about 300 afa by 2020. Livestock requirements are expected to almost triple from a present requirement of about 1,100 afa to about 3,000 afa in 2020.

Rural water distribution systems will continue to be installed in the future to provide for rural domestic and livestock water needs. Locations, however, are not known and are not shown on the map in this section. An increase in the number of farm ponds will supply part of the livestock requirement.

Irrigation. No significant amount of future private irrigation development from either ground or surface water is expected because of the limited supply of available water.

Public Project Development. The project-type development foreseen for the Basin consists primarily of multipurpose small watershed projects. No new major irrigation development is probable because of the limited water supply and the unknown effect of the Federal Reservation Doctrine.

Small Watershed Projects. Three small watershed projects are potentially feasible for development, probably late in the planning period. More detailed study of their feasibility is required.

These multipurpose projects are located in the lower half of the Basin, as shown in Figure 54, and are known as Ash-Chadron, Bordeaux Creek, and White Clay Creek. The major purpose of the projects is to provide flood control. Proper land treatment to prevent soil erosion is also a requirement of these projects.

The combined flood control storage of the three projects will be about 15,000 AF with about 2,150 acres of water surface area available for recreation as shown in Table 42. Some irrigation water storage could also be included in all three projects if a satisfactory arrangement can be made with those holding downstream water rights.

TABLE 41 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
White River-Hat Creek Basin

Subbasin	Municipal Systems: People Served Present	Municipal Systems: People Served 2020	Municipal Systems: afa Present	Municipal Systems: afa 2020 a/	Private Industrial Systems: afa Present	Private Industrial Systems: afa 2020
Hat Creek above State Line	0	0	0	0	0	0
White River						
Above Crawford	0	0	0	0	0	0
Crawford to State Line	6,670	10,500	1,580	3,100	0	0
BASIN TOTAL	**6,670**	**10,500**	**1,580**	**3,100**	**0**	**0**

a/ *Includes projected industrial reserve*

Nonstructural Measures. Flood plain management through land use regulation, building codes, and structural flood proofing can be used in this Basin where conventional structural measures, such as dams, are not feasible to reduce the damage done by floods. Implementation of flood plain zoning under the existing program would provide for the best uses of flood prone areas to minimize damage to public and private property.

Careful planning of development on streams which are highly valued cold water fisheries is needed to maintain or enhance the fishery resource.

Modification of Existing Development. Past irrigation development in this Basin has been minor and existing facilities are relatively old. Deterioration of the original structures is allowing water loss and low efficiency of use.

Improvement of the facilities of the Whitney Irrigation District is desirable to conserve the limited supply of water available. Financing of rehabilitation may require state or federal loans to supplement the limited financial capability of the District.

Potential Effects. Reduction of flood damages will help stabilize the economy of the Basin, particularly in its already distressed agricultural areas. The installation of additional rural water distribution systems and construction of farm ponds will allow increased livestock production, thereby increasing and stabilizing the economy. Rehabilitation of the Whitney Irrigation District facilities will also have beneficial effects on the economy.

The environmental quality of the Basin will be enhanced by planned development. Land treatment measures provided through individual initiative and construction of small watershed projects will lessen erosion disfigurement of the land surface and reduce the silt load, thereby benefitting fish, wildlife, and recreationists.

Reduction of flooding through small watershed project development in conjunction with flood plain management will prevent blighted areas from developing in areas frequently damaged by floods.

The environmental qualities of the Basin will be greatly enhanced by controlled development along stream reaches with particularly valuable scenic,

TABLE 42 / POTENTIAL SMALL WATERSHED PROJECTS
White River-Hat Creek Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible for Construction a/					
None					
Potentially Feasible					
Ash-Chadron, Bordeaux Creek, White Clay Creek	571	Not Known	15,300	2,150	None

a/ *Based on completed Work Plans or Preliminary Investigations*

fish and wildlife, recreational, and other environmental qualities. Present and future generations will benefit from this action as these natural areas dwindle in number.

Within the limitations of available water supplies, the construction of watershed project reservoirs, flood and sediment control reservoirs, and farm ponds will enhance the fish and wildlife resources of the Basin and provide additional water surface area for recreationists.

The Basin's already limited surface water supply will be further reduced by additional flood water detention reservoirs, land treatment measures, and livestock use. Table 43 shows the average annual flow under 1970 conditions of development, estimated depletions due to in-basin development during the planning period, and streamflow remaining after in-basin development.

The depletions shown for the White River are accumulated totals and reflect the estimated net use of water within each subreach analyzed.

REMAINING PROBLEMS AND OPPORTUNITIES

Additional development that may be needed includes the construction of moderate sized reservoirs primarily for flood control and reduction of the total sediment load in high flows. The clay soils in the area are easily eroded by high intensity storms and once eroded, the clay particles remain suspended for extensive periods of time. This damages the fishery resources of the streams and detracts from the excellent recreational qualities of the Basin. Continued application of land treatment measures and proper conservation treatment by individual land owners will be needed to reduce the sheet and rill erosion problems.

Little opportunity exists for additional irrigation development in the Basin unless an adequate supply of water can be located. Almost 200,000 acres, mostly in small scattered tracts, are suitable for irrigation but cannot be developed for lack of water supply.

Rural and urban water supply problems of a local nature will continue in the Basin. Continued exploration will be needed to locate suitable ground water supplies to satisfy these needs.

The remaining streamflow shown in the last column in Table 43 is the average amount of water which would annually pass the points listed during the period analyzed (1954-63), adjusted for both the development that has taken place since that time and the in-basin development projected. Although this table shows water leaving the Basin, much of it cannot be stored and used because of the superior right to the water held for Indian Reservation uses downstream.

TABLE 43 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT

White River-Hat Creek Basin

Stream Location	1,000 Acre-Feet Annually		
	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Hat Creek @ State Line	4.5	0.6	3.9
White R. @ Crawford	12.9	1.1	11.8
White R. @ State Line	17.6	6.8	10.8

Note: Estimates based on average annual streamflow of period 1954-63

Niobrara River Basin

GENERAL DESCRIPTION

The Niobrara River begins as a small trout stream in the tablelands of eastern Wyoming and flows eastward across the northern part of Nebraska to the Missouri River. In the central and eastern portions of the Basin, the steep, fast flowing river has formed a narrow valley with precipitous walls rising hundreds of feet to meet the adjoining uplands.

The western part of the Basin is characterized by flat tablelands bordered on the north by the Pine Ridge, a rough, scenic area of coniferous trees and rock outcrop. The Sandhills Region also extends into this and the central part of the Basin.

The river tumbles through several sparkling waterfalls in Cherry, Brown, and Holt Counties and throughout its length the valley provides beautiful

scenic vistas. In the Basin's central and lower sections the valley walls along the Niobrara River and its major tributaries are covered with a mixed forest of eastern hardwoods and western pines.

The population of the Basin is sparse, development slight and large portions of the area remain in practically a pristine condition.

Basin Resources. Soils range from the coarse sands of the Sandhills to the silts and clays of the tablelands. The eastern section of the Basin is steep and severely eroded with soils mostly of poor quality. Good quality soils exist on the tablelands of Box Butte County and the Mirage Flats area at the upper western end of the Basin.

About 40 percent of the agricultural land in the Basin is classified as arable. Almost 2.2 million acres of these lands, mostly in the western part of the Basin, are suitable for irrigation.

The average annual precipitation varies from about 16 inches in the west to about 23 inches at the Basin's eastern end.

In the high plains area of western Nebraska, the Niobrara's flow is variable, and undependable. Farther downstream, the steady flows of the Snake River, Plum Creek, Long Pine Creek, and other Sandhills streams exert a moderating influence on the Niobrara's flow. Surface water quality is generally excellent for most beneficial uses throughout the Basin.

The Upper Niobrara River Compact between Wyoming and Nebraska gives Wyoming use of the surface flow of the river except for restrictions imposed by Wyoming law. There are also certain limitations regarding the period of use and size of future reservoirs. The compact also makes provision for collection of data to be used in the event apportionment of ground water becomes necessary.

The proposed Lower Niobrara River and Ponca Creek Compact between South Dakota and Nebraska has been accepted by the two states but is awaiting congressional approval. This compact would apportion surface water in those streams common to the two states.

Ground water is plentiful throughout most of the Basin. Sandstone aquifers in the west and the porous Sandhills area in the central part of the Basin contain excellent quality ground water. The ground water supply varies in the lower Basin and sizable water supplies are generally not available in the rough, rolling hills between the upland and the river terraces.

Many of the valley walls in the central and eastern portions of the Basin are covered with trees. However, little commercial use is made of the timber resources.

The fish and wildlife resources of the Basin are extensive. Trout abound in the cold water fishery provided by some of the ground water fed streams. The timber and terrain provide habitat for deer, antelope, small game, waterfowl, and upland birds.

Environmental aspects of the Basin are excellent. Consideration of the central portion of the Niobrara River for inclusion under the U. S. Wild and Scenic Rivers Act is indicative of its quality and the nationwide significance attached to it.

Existing Development. Land and water resource development in the Basin includes irrigation, land treatment, small watershed project construction, hydroelectric power production, and establishment of wildlife refuges and recreation areas.

The Mirage Flats Irrigation Project began operation in 1946. This project consists of Box Butte Reservoir on the upper Niobrara River, a diversion dam, and distribution canals to serve 11,660 acres of land in Sheridan County.

The Ainsworth Unit is capable of supplying water to irrigate about 34,000 acres in Brown and Rock Counties, but this area has not yet been fully developed. Merritt Reservoir on the Snake River provides storage for project water. This water is conveyed across the Sandhills to the project lands through the 50 mile-long Ainsworth Canal.

Small tracts of land are also irrigated from surface water by individuals, mostly in the upper Basin.

Ground water irrigation began in Box Butte County in 1938 and has spread throughout the Basin. Extensive areas are now irrigated from ground water in the Alliance and O'Neill-Atkinson areas.

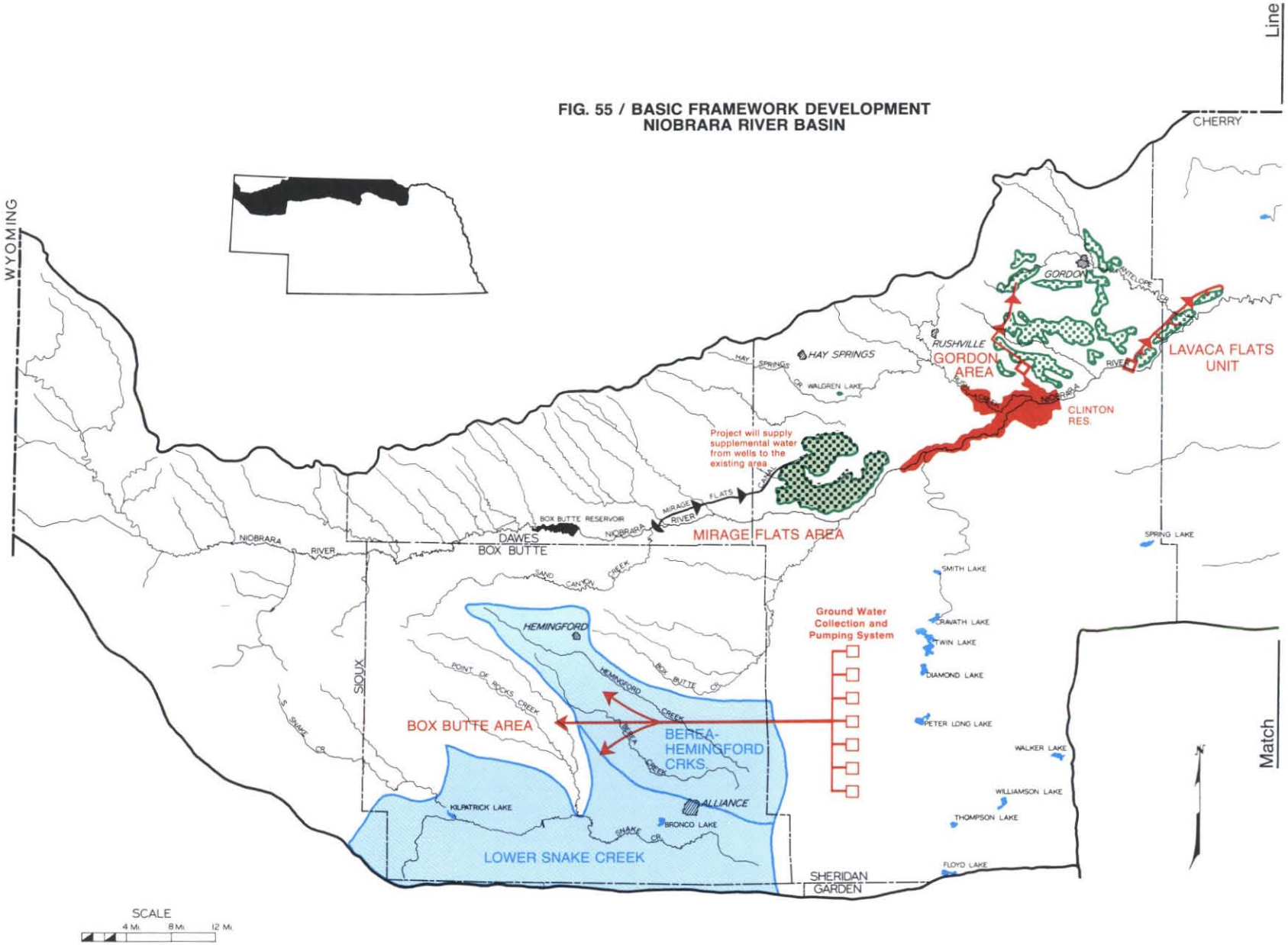
Only 155,000 acres have so far been developed for irrigation. This is only 7 percent of the total land suitable for irrigation in the Basin.

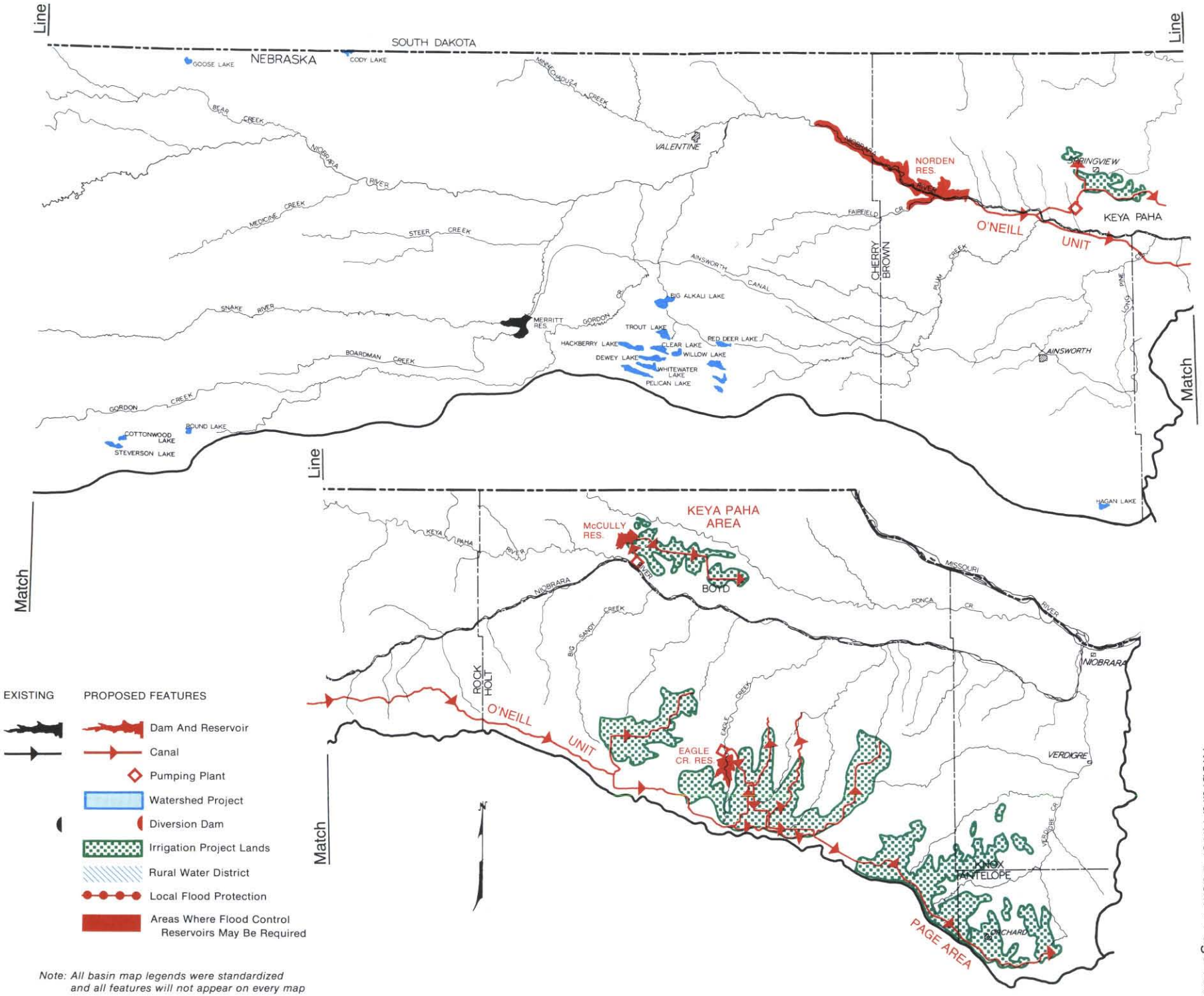
Antelope Creek Watershed Project, one of the first in the State, has been constructed above Gordon. It provides flood protection for the city of Gordon as well as the adjacent agricultural community.

Boyd County Rural Water District #1 has been organized to provide domestic and livestock water supplies in the eastern end of the Basin where adequate ground water supplies are difficult to find. The district's distribution system, now under construction, will supply water to homes in rural areas.

The majority of the Basin is rangeland, particularly in the western tablelands and the Sandhills areas. Intensively cultivated croplands under irrigation in Box Butte County, Holt County, and in the Ainsworth area are the major exceptions. In the eastern part of the Basin, the loess uplands bordering the steep valleys are cultivated.

FIG. 55 / BASIC FRAMEWORK DEVELOPMENT
NIOBRARA RIVER BASIN





Note: All basin map legends were standardized and all features will not appear on every map

The economy of the Basin is almost entirely dependent on agriculture. The towns are small and few in number. Alliance, Valentine, and Ainsworth are the three largest with 1960 populations of 7,845, 2,875, and 1,982 respectively. The limited industry within the Basin is generally confined to manufacturing goods supporting agriculture or processing agricultural products.

Two national wildlife refuges, Fort Niobrara and Valentine, are located in the Basin. There are also many Sandhills lakes which provide habitat for fish and wildlife.

Recreation development in the Basin includes state parks located at Chadron and Niobrara. The scenic qualities of the area provide recreational opportunities throughout most of the Basin.

PROBLEMS AND NEEDS

Flood damage in the Basin is minor because of the infrequent high flows and the lack of development on the flood plain.

Since the Basin lands are largely grass covered, erosion damage is not of major consequence. Streambank erosion damage is very low except along some tributaries in the lower part of the Basin. All inventoried gullies requiring project action are in the Ponca Creek drainage, located at the lower end of the Basin.

Future needs for the Basin include provision of supplemental water for irrigation in the Box Butte County and O'Neill-Atkinson areas where the water table is presently declining, and increasing the irrigated acreage throughout the Basin to stabilize the agricultural economy at higher and more profitable levels.

Mirage Flats Irrigation Project in the upper part of the Basin has had insufficient water supply since attaining full development.

Location of adequate water supplies for municipal, industrial, and rural domestic water use is a problem in the lower lying lands of Keya Paha, Boyd, and Knox Counties where little or no good quality ground water is available.

Some municipalities in the Basin lack adequate waste treatment facilities. Altogether, seven municipalities with almost 40 percent of the Basin's urban population need improved facilities.

Because of their unique characteristics, parts of the Niobrara River and its tributaries have statewide and even national significance and should be protected from adverse development. These areas are shown on Figure 48.

BASIC FRAMEWORK DEVELOPMENT

Independent local and public project development included in the Basic Framework for the Niobrara River Basin is generally that expected to occur in direct response to existing needs or that which appears likely to take place through the early decades of the next century.

Independent Local Development. Projected independent local development in the Niobrara Basin includes a continued increase in ground water irrigation, additional installation of wells for rural domestic and livestock waters, and increasing municipal and industrial water use. Individual land treatment for prevention of soil erosion must be continued in the Basin. Proper range management is essential in this predominantly rangeland area and is encouraged and provided for in this Basic Framework.

TABLE 44 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Niobrara River Basin

	Municipal Systems				Private Industrial Systems a/	
	People Served		afa		afa	
Subbasin	Present	2020	Present	2020 b/	Present	2020
Niobrara River						
State Line to Gordon	11,225	11,370	2,405	3,500	60	200
Gordon to Sparks	5,955	6,220	1,020	1,700	0	0
Sparks to Spencer	2,845	2,320	425	600	0	0
Spencer to Mouth	1,288	1,140	210	200	0	0
Ponca Creek						
State Line to Mouth	1,950	1,150	280	300	0	0
BASIN TOTAL	**23,263**	**22,200**	**4,340**	**6,300**	**60**	**200**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

TABLE 45 / POTENTIAL PUBLIC IRRIGATION PROJECTS
Niobrara River Basin

Project or Unit	Name of Reservoir(s)	Purposes a/	Flood Control Storage (AF)	Area Irrigated (Acres)	Reservoir Capacity b/ (1000 AF)	Water Surface Area c/ (Acres)
Mirage Flats Extension	None	I, R, FW	0	d/	0	0
Gordon	Clinton	I, R, FC, FW	13,000	20,000	250.0	5,700
Lavaca Flats	None	I	0	2,300	0	0
O'Neill	Norden	I, R, FW	0	77,000	411.0	6,300
Page	Eagle Creek	I, R, FW	0	25,000	120.0	3,700
	Norden				411.0	6,300
Keya Paha	McCully	I, R, FW	0	14,800	5.4	400
BASIN TOTAL			**13,000**	**139,100**	**786.4**	**16,100**

a/ I–Irrigation, FC–Flood Control, R–Recreation, FW–Fish and Wildlife
b/ Total initial capacity excluding surcharge
c/ Area at top of conservation pool
d/ Supplemental ground water supply for existing project

Municipal and Industrial. By 2020 municipal and industrial water requirements are expected to be almost 50 percent above the present annual use of about 4,400 AF. Table 44 shows present and projected municipal and industrial water requirements by subbasin. These future requirements can generally be met from ground water by expanding present developments.

Rural Domestic and Livestock Water. Livestock water requirements are expected to increase considerably during the planning period from the present use of about 9,000 afa to a future annual requirement of almost 25,000 afa by 2020. Requirements in most of the western and central parts of the Basin can be met on an individual basis. Additional rural water districts may be necessary in the eastern part of the Basin.

Irrigation. An increase in irrigation development from ground water is the major consumptive water use among private development anticipated in the Basin during the planning period.

Additional development of ground water for irrigation will probably take place in Box Butte County although the water table has dropped about 40 feet in some areas. Extensive blocks of land suitable for irrigation still remain in this area that could be developed with ground water. The expected additional development will increase the rate of decline and at some time early in the planning period a supplemental water supply will be required if the irrigated economy is to be sustained on a permanent basis.

Additional development is expected in Sheridan County adjacent to the Mirage Flats Project. More development is also expected adjacent to and interspersed with the lands of the proposed O'Neill Unit in Holt County. Both of these areas have inadequate water supplies to support the current irrigated acreage on a sustained basis and anticipated additional development will intensify the problem and accelerate the need for a supplemental supply.

The total private irrigation development from ground water expected within the Basin during the planning period and provided for in the Basic Framework totals about 150,000 acres.

Public Project Development. Six multipurpose irrigation projects in the Basin appear feasible during the planning period. Pertinent project information is presented in Table 45 and project locations are shown on Figure 55. Although the primary purpose of these projects would be irrigation, they would also provide substantial benefits for flood control, fish and wildlife, and recreation.

Mirage Flats Project. The existing Mirage Flats Project provides water for irrigation of about 11,660 acres south of Hay Springs in Sheridan County. However, the water supply has been inadequate in most years since attaining full development. The present water supply comes from natural river flows, as available, and from Box Butte Reservoir on the Niobrara River.

Feasibility studies of the USBR indicate that the water supply could be economically augmented by installing 17 deep wells along the canals and laterals to pump into them. In addition to the principal benefit to irrigation, substantial benefits to recreation, fish and wildlife would result from concurrent work on Box Butte Reservoir if the project

were undertaken. Additional lands which would be acquired for the project improvement and added recreation facilities would be available for public use.

Gordon Area. The primary purpose of this potential project would be to supply irrigation water to approximately 20,000 acres of land in the vicinity of Gordon, Nebraska. Other project purposes would be flood control, recreation, and the enhancement of fish and wildlife in the project area.

Principal features of the project include Clinton Dam and Reservoir, Clinton Pumping Plant and Canal, and the distribution system necessary to deliver the water to the project lands. Clinton Dam would be located on the Niobrara River immediately downstream from the junction of Rush Creek with the Niobrara River. The project lands which would be irrigated lie above the river and a pumping plant would be necessary to lift reservoir water to the Clinton Canal.

The project could adversely affect the portion of the Niobrara River included in the Basic Framework as a protected area. The upstream limit of the designated protected area is the confluence of Antelope Creek and the Niobrara River, 20 miles downstream from the proposed Clinton Dam. The method of reservoir operation must be carefully selected to harmonize with the downstream scenic, recreational, and other environmental values.

This project has been given only limited study at reconnaissance or lesser level. Full provision has been made within the Basic Framework, however, to accommodate its eventual implementation if it is found to be feasible and desirable and if environmental values downstream can be adequately preserved.

Lavaca Flats Unit. This potential project is located along the north side of the Niobrara River southeast of Gordon. It was under investigation by the U. S. Bureau of Reclamation (USBR) for a number of years. A feasibility report completed in 1956 indicated a wide margin of favorable economic feasibility.

As presently formulated, the project includes a pumping plant to lift water from the Niobrara River, a main supply canal, distribution laterals and a drainage system. About 2,300 acres would be irrigated.

O'Neill Unit. The potential O'Neill Unit is located in the central part of the Niobrara River Basin. The USBR has completed a feasibility investigation and a favorable report has been submitted to the Congress for authorization of the project. Field hearings were held by a congressional subcommittee in July, 1970.

Major features of the O'Neill Unit would include Norden Dam and Reservoir on the Niobrara River, O'Neill Canal, Springview Canal and Pumping Plant, and associated distribution systems. The primary project purpose would be the irrigation of 77,000 acres of land with major benefits also accruing to recreation, fish and wildlife. Some flood control benefits, incidental to the operation of Norden Reservoir for the other purposes, would accrue downstream.

The Springview Canal and Pumping Plant would serve 8,000 acres mostly on the high tablelands above the Niobrara River south of Springview in Keya Paha County.

The O'Neill Canal would serve 69,000 acres on the uplands just north of the Basin boundary in Holt County about 60 miles downstream from the reservoir.

Approximately 4,700 acres would be acquired and managed for fish and wildlife purposes at Norden Reservoir.

Page Area. This project would extend the proposed O'Neill Unit. Water for irrigation of approximately 25,000 acres would come from Niobrara River flows excess to the needs of the O'Neill Unit. These excess flows would be conveyed through the O'Neill Canal and the O'Neill sub-canal and stored as necessary in Eagle Creek Reservoir located on the east branch of Eagle Creek. A pumping plant would lift water from Eagle Creek Reservoir into the Page Canal for distribution to the irrigable area in the vicinity of Page and Orchard, Nebraska.

The project would also provide an opportunity for fish and wildlife and recreational development. However, a present excess of recreational waters exists in the area.

The project has been studied at reconnaissance or lower level and additional studies will be required to determine specific project value. However, provision has been made within the Basic Framework for eventual implementation of the project.

Keya Paha Area. This project would provide Niobrara River water for irrigation of nearly 15,000 acres of land near Butte and Spencer in Boyd County. Water from the Niobrara River would be pumped and stored in McCully Reservoir located on an intermittent tributary of Ponca Creek near Naper, Nebraska. From the reservoir, water would be conveyed by gravity through the Keya Paha Canal to the irrigable area.

There would be potential benefits to recreation and to fish and wildlife from this project. However, there are already ample waters for these purposes in this and nearby areas.

Only reconnaissance or lesser level studies have been completed for the Keya Paha Area and addi-

TABLE 46 / POTENTIAL SMALL WATERSHED PROJECTS
Niobrara River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/] **for Construction**					
None					
Potentially Feasible					
Berea-Hemingford Creeks, Lower Snake Creek	524	None	None	None	34

a/ Based on completed Work Plans or Preliminary Investigations

tional studies would be required. However, the Basic Framework incorporates the project and the hydrologic analyses make allowance for the implementation of the project when and if it is found to be desirable and feasible.

Box Butte Area. Within the Niobrara River Basin, one major problem is the rapid depletion of the ground water in the vicinity of Alliance. The cumulative effect of individual decisions to irrigate has already caused significant depletions to the aquifer and additional development will accelerate its depletion. In the absence of control over development a supplemental source of water will be required if general and progressive deterioration of the existing economy based on irrigation production is to be avoided.

During this study several sources of supplemental water supply for the Box Butte Area were given cursory examination. Potential sources included: (1) the North Platte River upstream from Nebraska, (2) the upper Niobrara River in Nebraska, (3) development of small streams in northwestern Box Butte County, and (4) ground water supplies in the Sandhills area. Sufficient water was not available in the first three areas to supply the Box Butte area with the quantities which will be required in the future.

Ground water in storage in the western edge of the Sandhills in southwestern Sheridan County appears to offer an adequate supply to meet future needs. Although extensive investigation would be required, it appears that a well field or other type of collection system could be developed to pump ground water from this area 20 to 40 miles westward to the area of decline around Alliance.

No estimates are available that would indicate the amount of water required or the approximate time of need.

Detailed investigation of possible induced ecological effects caused by altering the high ground water table exposed in numerous lakes would be required before serious consideration could be given to the project.

Small Watershed Projects. Two multipurpose small watershed projects, shown in Figure 55, are included in the Basic Framework. These watershed projects, located in the upper part of the Basin, are primarily for surface water disposal systems in irrigated areas. General information concerning them is shown in Table 46.

Nonstructural Measures. A reach of the Niobrara River between Antelope Creek confluence and the headwaters of the proposed Norden Reservoir along with the Snake River should be protected from development because of both the natural beauty of the area and because the area is unique in Nebraska as a transition between eastern and western species of both plants and animals. Most of this area is being considered for inclusion as part of a national program to protect unique river reaches under the Wild and Scenic Rivers Act.

No physical development is proposed for these stream reaches in the Basic Framework. Their protection does not conflict with projected in-basin development, with the possible exception of the diminished flows which would result from development of the Gordon Unit irrigation project.

Potential Effects. Full implementation of projects and programs included in the Basic Framework would, to a high degree, meet the needs which now exist or are exptected to exist in the Basin.

TABLE 47 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT

Niobrara River Basin

Stream Location	1000 Acre-Feet Annually		
	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Niobrara R. nr. Gordon	74.9	42.1	32.8
Niobrara R. nr. Sparks	493.4	40.7	452.7
Niobrara R. nr. Spencer	1027.6	232.0	795.6
Niobrara R. @ Mouth	1292.3	204.7	1087.6
Ponca Creek @ Mouth	68.4	−5.3 [a/]	73.7

a/ Net accretions to steamflow of irrigation return flow from imported water

Note: Estimates based on average annual streamflow of period 1954-63

The Basic Framework provides for full satisfaction of independent private development. Where a substantial problem is arising from that type of development in the Box Butte area, a source of supplemental water has been tentatively located and a potential public project included to alleviate the problem.

The 139,000 acres of additional land to be irrigated from public projects would produce economic benefits both directly in additional dollar income and by stabilization of the economy. The effect of these major projects and private development of ground waters will boost the local economies of small communities thus contributing toward their continued existence and growth. Stabilization of ground water levels will permit the continued use of ground water as anticipated in the Basic Framework to proceed without serious or immediate danger of exhaustion of the available water supply and consequent deterioration of the irrigated economy.

While certain areas of environmental impact have been identified for further study, environmental analysis of the specific changes which would occur in the Basin is not possible or warranted in a framework level study.

The scenic beauty of the Niobrara River and its adjacent areas immediately upstream of the proposed Norden Reservoir has been nationally recognized. Development of the reservoir and its contiguous lands for recreation, adjacent to the scenic areas to be preserved upstream, will provide outstanding recreational opportunities for residents of the Basin and the State and is expected to result in an inflow of tourists to the area.

The Basic Framework includes sufficient reservoir surface area distributed throughout the Basin to completely meet recreational and fish and wildlife needs of the area and to provide considerable surpluses for regional use.

Estimates of water use and future water availability were made to assess the adequacy of the supply for in-basin development and to provide a basis for estimating what additional use might be made of these waters. Table 47 shows the average annual streamflow under 1970 conditions of development, estimated depletions expected from in-basin development during the planning period, and streamflow available for additional development.

The depletions shown are accumulated totals except for Ponca Creek. The major depletion for the Basin is for surface water irrigation.

REMAINING PROBLEMS AND OPPORTUNITIES

After full allowance for the effect of individual private development on the available water supply and for development of all public projects, large quantities of water would remain unused in the lower Basin. Also, large blocks of land highly suitable for irrigation will remain undeveloped in the upper Basin. However, the opportunity to join these waters and lands for irrigation is limited by economics, engineering problems, and environmental considerations. Under current economic criteria, the cost of bringing the available waters of the eastern Niobrara 150 miles upstream to the western lands would be prohibitive.

Some opportunity remains to increase the regional recreational value of the area by acquisition of additional lands to connect the Norden Reservoir lands with the existing Fort Niobrara National Wildlife Refuge.

With these exceptions, it appears that the major water related needs of the Niobrara River Basin can be met by the development contained within the Basic Framework.

Missouri Tributaries River Basin

GENERAL DESCRIPTION

The Missouri Tributaries River Basin occupies a narrow strip of land along the eastern and northeastern borders of the State between the mouths of the Niobrara and Platte Rivers. The Basin is composed of the drainage areas of a number of small streams directly tributary to the Missouri River and the portions of the Missouri River flood plain which interconnect these drainage areas.

The major topographic features of this Basin are steeply rolling hills, accentuated by large, steep bluffs dropping rather sharply to a broad, flat flood plain adjacent to the Missouri River. The location of the bluffs with regard to the river varies greatly throughout the Basin. In some locations, especially in the upper part of the Basin, the bluffs are adjacent to the river. Farther downstream these bluffs may be as far as ten miles from the river. The drainage pattern is very well defined in the bluff and hill areas but poorly defined in many locations on the flat flood plain.

Most of the rolling, loess covered hills are devoted primarily to cropland and pastures. Woodlands are common along the many stream courses and in the steeply rolling areas. The flat, terraced bottom lands between the wooded bluffs and the Missouri River consist of alluvial soils which are mainly utilized for cropland. Some areas of the flood plain remain in a native, wooded state.

Basin Resources. Most of the bottom land in the Missouri River valley is good quality cropland except in areas where the drainage is poor. Most of the hills and bluffs adjoining the Missouri River valley are too rough to be used for cropland without intensive conservation practices and are generally best suited for permanent vegetation.

About 80 percent of the 1,697,000 acres of agricultural land in the Basin is classified as arable and almost 800,000 acres are suited for irrigation.

The average annual precipitation varies from 23 inches in the northern part of the Basin to 29 inches in the southern part. The majority of the precipitation falls during the late spring and summer months.

The mainstem of the Missouri River is an integral part of this Basin. Construction of mainstem reservoirs upstream from Nebraska and Gavins Point Dam at the upper end of the Basin has firmed and enhanced low flows and decreased flood flows in the Basin. Streamflow is generally maintained slightly in excess of 30,000 cfs for navigation purposes during the spring, summer, and fall months.

The base flows of the many small tributary streams entering the Missouri River in this Basin are small. Most streamflow originates from direct rainfall runoff and because streams are steep and topography is rugged, runoff is rapid. This causes very high flood flows in relation to the size of the drainage area.

The supply of ground water is variable throughout the Basin but generally low in quantity and quality. Wells in the sand and gravel deposits of the Missouri River valley generally yield large amounts of good quality water. The remainder of the Basin is largely underlain with glacial till which yields small amounts of often highly mineralized water. Moderate quantities of good quality water are available from local pockets of sand and gravel found interspersed throughout the glacial till area.

The mineral resources of the Basin are quite limited. Limestone, sand, and gravel are produced in commercial quantities at a few scattered locations, mostly in the northern part of the Basin.

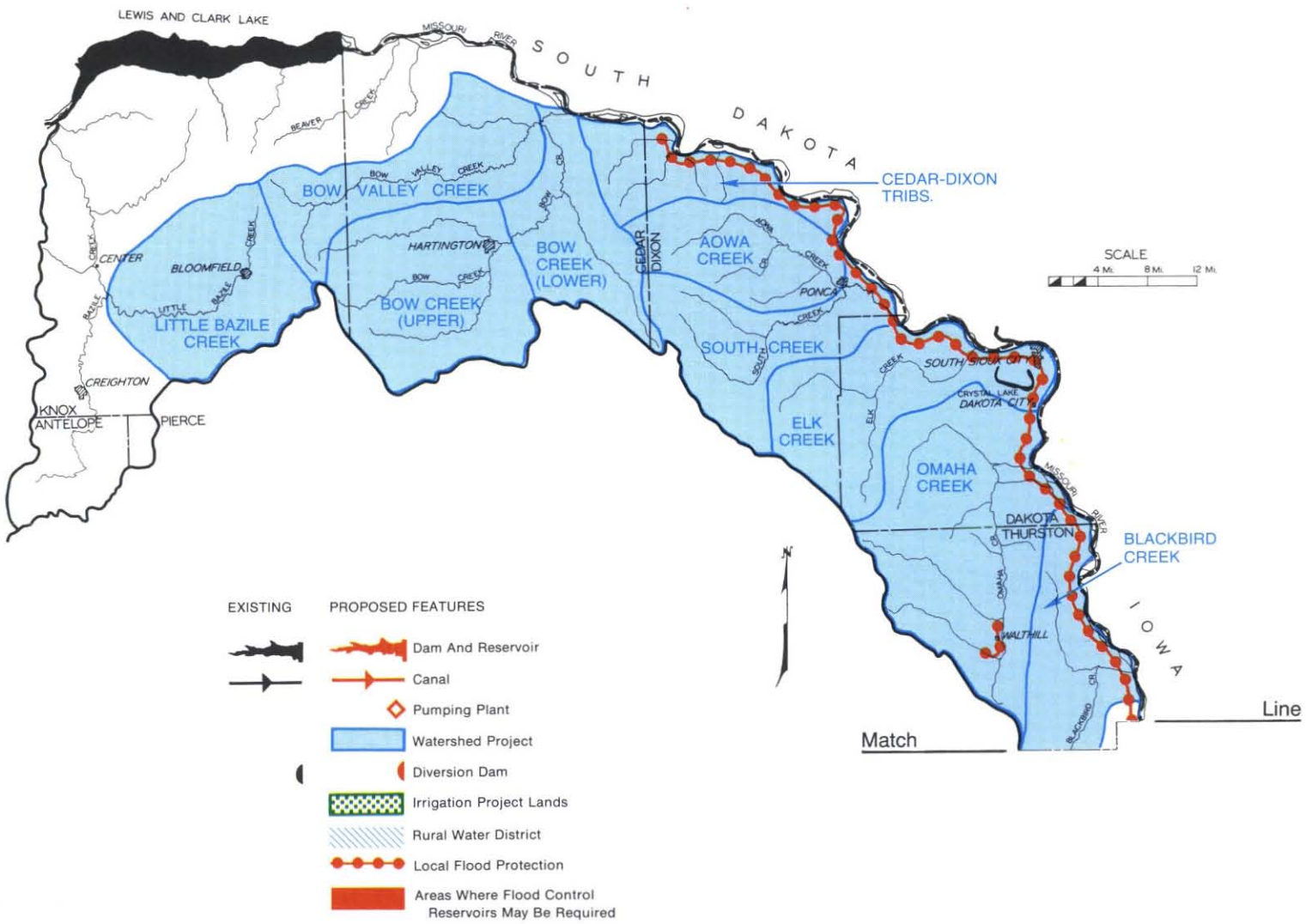
At one time, woodlands were common in the Missouri River valley and on the adjacent bluffs. However, more intensive agricultural development in the valley was made possible through stabilization of the channel of the Missouri River and has resulted in destruction of many of these woodlands. Woodlands remaining along the bluffs and in other areas are harvested to a limited extent by local sawmills.

Lewis and Clark Reservoir, with a water surface area of 33,000 acres, and the Missouri River are the most significant fishery resources in the Basin. In addition, the Missouri River historically has been an important migration route for ducks and geese. Many parts of the Basin also provide good habitat for upland game birds and animals, including whitetail deer.

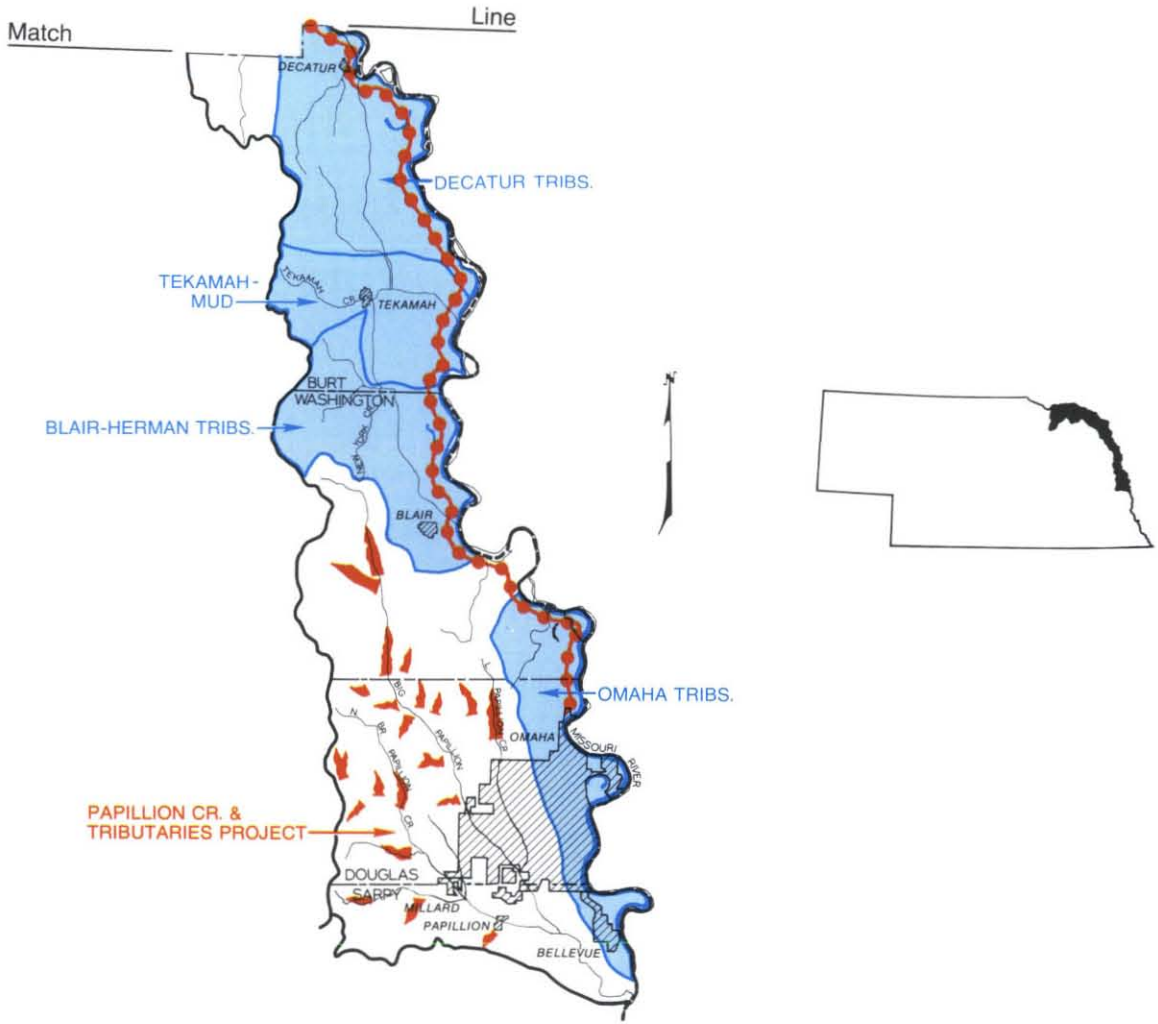
Existing Development. Adoption of land treatment and conservation measures has lagged badly in the Basin. Only 20 percent of the cropland, 11 percent of the pasture land and 2 percent of the grazed forest land is presently receiving adequate soil conservation treatment.

No watershed projects for flood control or grade stabilization have been constructed in the Basin other than the Papillion Creek Watershed Project near Omaha which is under construction at the present time. This project, which includes 52 grade stabilization structures for erosion control, has been coordinated with the plans of the Corps of

FIG. 56 / BASIC FRAMEWORK DEVELOPMENT
MISSOURI TRIBUTARIES RIVER BASIN



Note: All basin map legends were standardized and all features will not appear on every map


Match
Line
DECATUR
DECATUR TRIBS.
TEKAMAH-
MUD
TEKAMAH
BURT
WASHINGTON
BLAIR-HERMAN TRIBS.
BLAIR
OMAHA TRIBS.
OMAHA
MISSOURI
RIVER
PAPILLION CR. &
TRIBUTARIES PROJECT
DOUGLAS
SARPY
MILLARD
PAPILLION
BELLEVUE

Engineers for flood control reservoirs in the same watershed.

In addition to bank stabilization and levees along the Missouri River, approximately 6.5 miles of channel in the Basin have been improved and about 16 miles of levees have been constructed.

Several large reservoirs have been constructed upstream on the Missouri River including Lewis and Clark Lake impounded by Gavins Point Dam near the upper end of this Basin. In addition, the Missouri River below Sioux City has been channelized and the banks stabilized. The reservoirs and channelization projects provide flood control and improve the channel for navigation.

Drainage is poor on the flat valley floor and construction of drainage facilities has been required in the middle and lower parts of the Basin. As of 1968, 28 drainage districts had been formed. Many miles of drainage channels have been constructed by these districts.

Irrigation development in the Basin has been quite limited. Of the 800,000 acres of land that have been classified as suitable for irrigation, only about 23,000 acres have been developed. About 17,000 acres are irrigated from ground water and the remainder from surface water. Almost all of the irrigated acreage is in the Missouri River valley. The small amount of irrigation development can probably be attributed to a number of factors including a relative abundance of rainfall, a lack of high quality irrigable lands, and the shortage of ground and surface water supplies in some areas.

The Omaha metropolitan area at the lower end of the Basin has a population of about 350,000 and a wide diversity of industry, much of which is agriculturally oriented. The economy of the remainder of the Basin is oriented mainly toward farming with some large recreation development beginning in the vicinity of Lewis and Clark Lake.

The major crops grown are corn and oats with Cedar and Knox Counties the two leading producers of oats in the State. Cedar County is also a leader in the dairy industry, producing more milk than any other county.

Two developments associated with improvement of navigation on the Missouri River below Sioux City, Lewis and Clark Lake and Desoto Bend National Wildlife Refuge, have benefited fish and wildlife. Work associated with channelization has increased public access to the river. In general, however, channelization of the river has destroyed fish and wildlife habitat, changed the scenic attractiveness, and reduced the area available for many forms of recreation.

Lewis and Clark Lake is the largest development providing water oriented recreation opportunities in the Basin. About 30,000 acres of water surface area are available for recreation uses. Ponca State Park and several other public areas also serve recreation needs.

Large private recreation development in the Basin was initiated with beginning of construction on the Devil's Nest project along the tree studded bluffs bordering Lewis and Clark Lake. When completed, this $100,000,000 private development will provide a wide spectrum of recreation activities and, in addition, will include summer homes.

PROBLEMS AND NEEDS

Floods are common along many of the tributaries because of rapid runoff from the steep hills, making this one of the most severely damaged areas in the State. The Papillion Creek Watershed, which includes west Omaha, accounts for 25 percent of the two million dollars annual flood damages in the Basin. There are also occasional floods along the mainstem of the Missouri River. Upstream reservoirs and some local levees have significantly reduced but not eliminated the flood hazard. More structural and nonstructural measures are needed.

The Missouri Tributaries River Basin ranks high among the thirteen basins in potential land damage by erosion. The steep stream channels and the loess soils are conducive to extensive erosion of the hills and bluffs with resultant deposition of sediment on the broad valley floor. Rapid runoff from the steep hills also causes sheet and rill erosion. Flood flows cause severe streambank erosion and moderately severe gully erosion on many of the tributary streams. Streambank erosion is no longer a serious problem on those portions of the Missouri River mainstem where the banks have been stabilized.

Intensive application of land treatment for soil conservation, both on an individual and project basis, would reduce the erosion damages now being experienced in the Basin.

Several municipalities in the Basin are creating water pollution problems. Five, including Omaha, discharge their wastes into the Missouri River or its tributaries after only primary treatment, while two municipalities provide no treatment whatsoever. Improvement of secondary treatment is needed at 3 other locations. Similar problems are created at some locations within this Basin where municipal wastes from combined sewers and industrial wastes are discharged untreated into the river.

Drainage is poor across much of the Missouri River bottom lands because the valley is flat. The drainage problem is compounded by the fact that

TABLE 48 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Missouri Tributaries River Basin

Subbasin	Municipal Systems People Served Present	Municipal Systems People Served 2020	Municipal Systems afa Present	Municipal Systems afa 2020 b/	Private a/ Industrial Systems afa Present	Private a/ Industrial Systems afa 2020
Bazile Creek	3,240	2,210	400	500	0	0
Bow Valley Creek	2,525	1,880	260	400	0	0
Aowa Creek	1,620	1,080	220	250	0	0
Omaha Creek	1,960	1,910	210	400	0	0
Missouri River						
Niobrara R. to Douglas Co. Line	19,520	34,740	2,320	10,350	2,600	3,000
Omaha Metro. Area	325,715	850,000	69,130	266,700	287,000	297,470
BASIN TOTAL	**354,580**	**891,820**	**72,540**	**278,600**	**289,600**	**300,470**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

sediment from the upland areas has filled the existing outlet channels so they are not large enough to convey the floodwaters from the upland tributaries. Some channel clearing and construction of drainage ditches is needed to facilitate removal of runoff. Good conservation practices and watershed development in the uplands, as discussed previously, are needed to reduce the flood flows that aggravate the drainage problem on the bottom lands.

The lower portion of the Basin, including the Omaha metropolitan area, lies within the Omaha SEA. This SEA has the most severe water associated recreational deficiency in the State because of its high population density. The Norfolk and South Sioux City SEA's, which encompass the remainder of the Basin, are also deficient in recreation water surface area. These deficiencies, particularly in the Omaha SEA, are expected to increase in severity in the future.

BASIC FRAMEWORK DEVELOPMENT

Independent Local Development. Growth of municipalities and industries, an increase in ground water irrigation development, and operation of new thermal power generation plants will create the greatest future increase in need for water in the Basin. Land treatment for soil conservation, both on an individual basis and in conjunction with watershed projects, should be considerably accelerated in this Basin.

Municipal and Industrial. Municipal and industrial water requirements are expected to increase in the future, primarily because of greater future populations and increased industrialization in the Omaha metropolitan areas. The total M&I requirements, including thermal cooling, are expected to increase from a present use of about 360,000 afa to about 580,000 afa by 2020. Table 48 shows present and projected municipal and industrial water requirements for the Basin. These additional requirements can be developed from ground water, though generally at some distance from point of need, or if more economical, from the Missouri River.

The municipalities discharging their wastes into the Missouri River are required to provide secondary treatment by December 31, 1975. In order to comply with the requirements, two municipalities must construct treatment plants; five municipalities, including Omaha, must add secondary treatment; and three others must improve their secondary treatment plants. Some industries will also be required to either provide or improve treatment.

Because of the abundance of water, large thermal power generation plants are locating along the Missouri River. The two plants under construction are the flow-through type with large water requirements. Very little water will be consumed and the remainder will be returned to the Missouri River but at higher temperature.

Rural Domestic and Livestock. This is the only Basin in the State in which future rural domestic water use is expected to decrease. In spite of greater per capita water use in the future, the use will decline from a present level of about 3,750 afa to about 1,800 afa in 2020 because of rural population decreases.

Livestock numbers are expected to increase substantially. Livestock water use is expected to increase from about 8,100 afa presently to almost

21,000 afa in 2020. Ground water along with a small increase in farm ponds will meet the future requirements.

Irrigation. Future irrigation development will be almost entirely from ground water. Because of the lack of suitable land and an inadequate supply of ground water for irrigation in the uplands, practically all of the 50,000 acres of projected development will be confined to the Missouri River bottom lands in Dakota and Burt Counties.

Public Project Development. Future public project development in the Basin will mainly be limited to multipurpose flood and erosion control projects. One single purpose local flood control project also appears feasible. Project area locations are shown on Figure 56.

Flood Control Projects. The major multipurpose flood control project is the Papillion Creek and Tributaries Project of the Corps of Engineers. The principal purpose of the project is to provide flood control to the Omaha urban area but water quality and recreation benefits are also included. Features of the project include 21 reservoirs with a total flood control storage capacity of 76,600 acre-feet. The total conservation storage is 47,000 acre-feet and the conservation pool surface area totals 4,400 acres. The project has been authorized for construction by Congress but has not been funded.

Small Watershed Projects. Two small watershed projects, Aowa Creek and Tekamaha-Mud Creek, have been investigated in detail and are feasible for construction. Some general information on these projects is given in Table 49.

Twelve other watershed projects appear to have potential for development during the planning period. Some preliminary information on possible project features taken from the MRB Study is given in Table 49. Further investigation will be required to obtain more detailed information on these projects before feasibility can be determined.

Local Flood Protection. One single-purpose project for local flood protection has been studied by the Corps of Engineers. It appears that a levee project may be feasible at Walthill to protect about 100 acres in that community from floodwaters.

Other. The Corps of Engineers has studied the feasibility of extending the channelized portion of the Missouri River from Sioux City to Gavins Point Dam for navigation. The project appears economically justified and is awaiting congressional action. However, the significant natural beauty, unique wildlife habitat and recreation opportunities of this reach of the river warrant consideration of preservation in its present state. The project has not been included in the Basic Framework pending further investigation.

TABLE 49 / POTENTIAL SMALL WATERSHED PROJECTS
Missouri River Tributaries Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/] **for Construction**					
Aowa Creek	86	53	5,230	466	None
Tekamah-Mud Creek	30	19	3,110	275	None
Potentially Feasible					
Little Bazile Cr., Bow Valley Cr., Bow Cr. (Upper), Bow Cr. (Lower), Cedar-Dixon Tribs, Omaha Cr., Decatur Tribs, Blair-Herman Tribs, Omaha Tribs	1,372	Not Known	57,920	5,780	120
South Cr., Elk Cr., Blackbird Cr.	455	Grade stabilization structures only			

a/ *Based on completed Work Plans or Preliminary Investigations*

TABLE 50 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT
Missouri Tributaries River Basin

Stream Location	1000 Acre-Feet Annually		
	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Bazile Cr. @ Mouth	75.4	3.9	71.5
Bow Valley Cr. @ Mouth	80.6	5.2	75.4
Aowa Cr. @ Mouth	33.4	1.4	32.0
Omaha Cr. @ Homer	25.2	2.4	22.8
Papillion Cr. @ Mouth	80.7	8.8	71.9

Note: Estimated from average annual streamflow during the period 1954-63

The Corps of Engineers also has a continuing program of constructing levees along the Missouri River for protection of land from flooding. Additional sections of levee under study between Sioux City and Omaha have been included in the Basic Framework. Study and construction of these levees should be continued until all feasible protection is provided.

Nonstructural Measures. Measures are often available to control or reduce flood damage without actual physical construction. One such measure, flood plain regulation, is being used in this Basin.

Flood plain zoning ordinances have been enacted in six municipalities, including Omaha, and two counties in the Basin. Control of encroachment onto the flood plain through flood plain regulation should be considered in many of the outlying portions of the Omaha urban area and in several other localities in the Basin.

The Missouri River between Sioux City and Yankton, South Dakota, has not been improved for navigation. The natural beauty and unique wildlife characteristics of this reach warrant consideration of keeping this river reach in its present state. This requires early study, since the proposal for channelization of the river for navigation is awaiting congressional approval.

Access along the Missouri River for recreation purposes throughout the Nebraska reach should be provided by both private individuals and public groups.

Potential Effects. Development included in this Basic Framework will produce varied and significant effects on several areas of the Basin.

Increased irrigation from ground water will provide some stabilization of the economy in local areas. Structural and nonstructural flood control measures will prevent considerable damage in recurrently flooded areas. Potential small watershed projects to provide flood and erosion control cover all but the northern end of the Basin.

Control of flooding and erosion will enhance the environment in the protected tributary flood plains. Many of the environmental qualities of the Missouri River, particularly fish and wildlife habitat, have been destroyed by channelization and the associated increases in agricultural development of the flood plain. Preservation of existing natural river reaches would prevent further damage of the type incurred in the past.

Recreation opportunities in the severely recreation deficient Omaha SEA will be significantly enhanced by construction of the nearby Papillion Creek and Tributaries Project and watershed projects within day use distance of the Omaha area. Improved Missouri River access will also add recreational opportunities to the area.

Secondary treatment of municipal and industrial waste discharges into the Missouri River will significantly improve the quality of water in the affected downstream reaches. Effects of heated water to be discharged into the Missouri River from thermal power plants are being studied by the Nebraska Game and Parks Commission.

Estimates were made of remaining surface water resources after allowance for in-basin development. Table 50 shows the estimated average annual streamflow at the 1970 level of development, estimated streamflow depletions due to expected development during the planning period, and the remaining streamflow.

Estimated depletions of these small streams are relatively small because development is expected to be minor. The largest depletion shown is from Papillion Creek. It reflects the evaporation losses expected from the flood control reservoirs.

REMAINING PROBLEMS AND OPPORTUNITIES

An evaluation of the degree of satisfaction provided by the Basic Framework development indicates that both problems and further opportunities for development will remain.

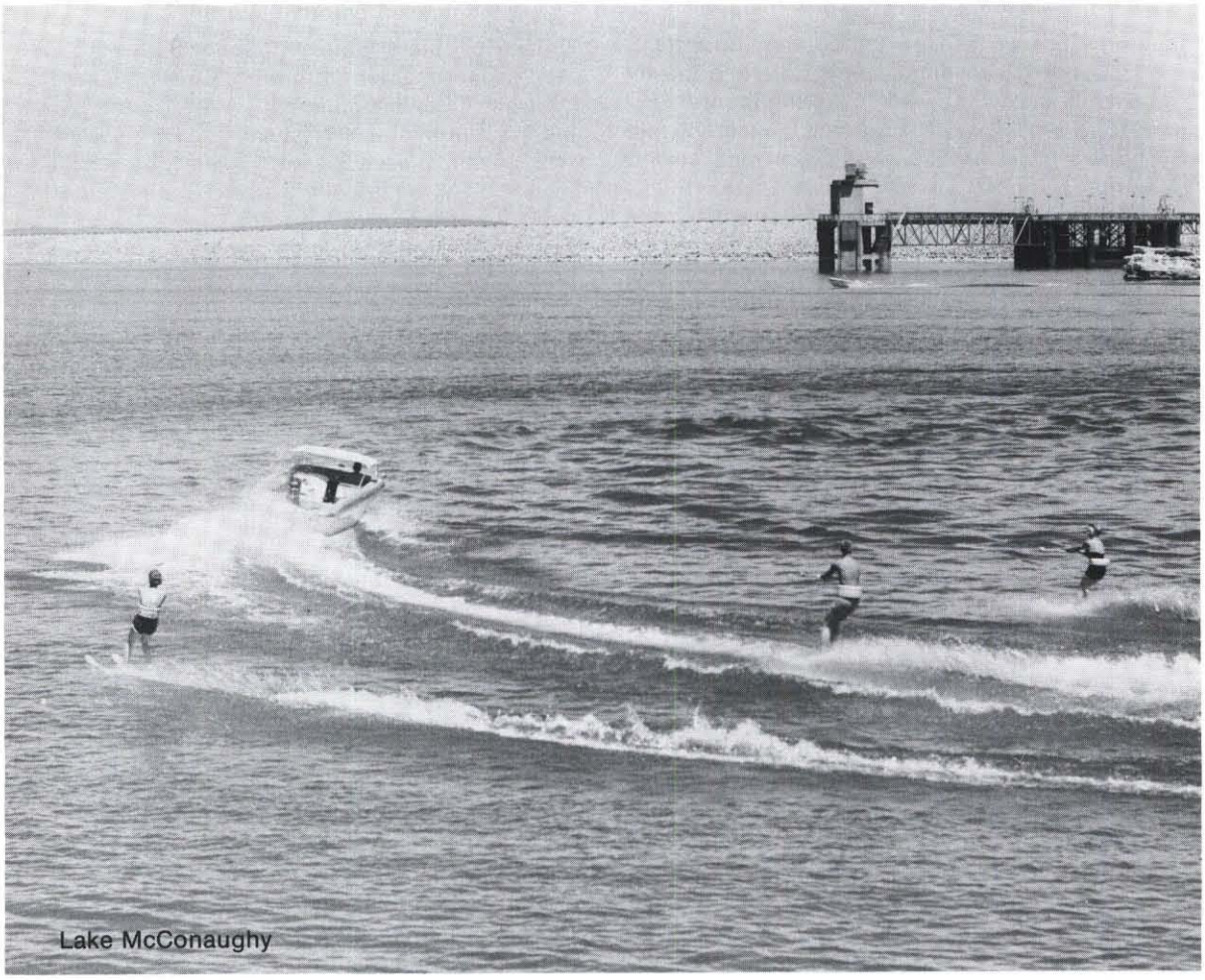
The flood hazard can never be entirely eliminated. Additional structural and nonstructural measures should be evaluated on a continuing basis. The need will be particularly evident in urban areas where increased development and runoff will continue to compound flood damages.

There are large blocks of moderately suitable land in Knox, Cedar, and Dixon Counties which have no ground water or local surface water supply available for irrigation development except the Missouri River.

The paramount need in the Basin will continue to be for water associated recreation opportunities. Even with the development expected during the planning period, a severe lack of recreation water surface area will exist in the Omaha area. Opportunities for developing the recreation potential of the Missouri River and adjacent land areas by additional access sites and outdoor recreation developments, possibly utilizing oxbow lakes and wooded valley and adjacent bluff lands, should be given further study and consideration.

Although Table 50 shows significant amounts of water remaining at the various points, the sustained flow of the tributary streams is small with much of the average annual flow occurring during high flow periods. Therefore, most of the present supply is potentially available for additional use, but due to the variability of flow, the relatively small amount, and difficulty in storing and transporting the supply to areas of need, it is doubtful whether the surplus could be economically developed.

This is not the total amount of water which would be available but only that from those streams which were gaged or for which estimates of runoff were made. This represents slightly over half of the total drainage area of the Basin.



Lake McConaughy

North Platte River Basin

GENERAL DESCRIPTION

This Basin is located in the western portion of the State near the central part of the Panhandle. It extends from the Wyoming-Nebraska state line to the confluence of the North and South Platte Rivers near North Platte.

The North Platte River, which heads in Colorado and flows through Wyoming before entering Nebraska, has cut a valley as much as 1,000 feet deep through Nebraska's high plains. Distinct terraces remaining after stream erosion are evident on the north side of the North Platte River and the south side of Pumpkin Creek in the upper Basin. However, the area between the two streams, known as Wildcat Ridge, resisted erosion and produced spectacular bluffs and buttes such as Scotts Bluff and Chimney Rock.

The valley is broad in the upper and lower sections but narrows through the middle reach around Lake McConaughy. The Sandhills border the valley on the north side in all but the upper one-fourth of the Basin.

Broad tablelands several hundred feet above the river valley drop sharply through an escarpment area which is mostly native grass. Extensive timber growth covers several of the canyons in the escarpment and creates a scenic setting.

Basin Resources. Much of the land in the North Platte River Basin is not suitable for cultivation because of topography or limited depth of soil. In the upper valley, however, soils are very productive and extensively irrigated.

Only about 32 percent, or 1,527,000 acres, of the agricultural land in the Basin is classified as arable. About 1.3 million acres of the arable lands are suited for irrigation.

The average annual precipitation varies from about 14 inches in the upper Basin to 19 inches in the lower Basin. Most precipitation falls during the growing season.

Streamflow characteristics in the Basin vary from those of the stable spring-fed Sandhills streams north of the river to those sporadic flows from excess precipitation runoff on the steeper escarpment areas of the terraces. Much of the runoff of the North Platte River upstream from Nebraska is snowmelt from the higher elevations in Colorado and Wyoming. The flow is regulated by reservoirs in Wyoming as well as Lake McConaughy in Nebraska. Irrigation development in the upper Basin has tended to stabilize the streamflow in many of the smaller tributary streams. Part of the flood flows is diverted for irrigation and return flows increase streamflow during dry periods, thereby enhancing the fishery resource.

A U.S. Supreme Court decree apportioned the flow of the North Platte River between Colorado, Wyoming, and Nebraska. This decree limits the amount of water divertible in Colorado and Wyoming. It also established priorities for appropriations and storage between Wyoming and Nebraska and allocated the natural flow of the stream below the storage reservoirs.

The ground water resources of this Basin are quite varied. The plains and terraces on both sides of the river in the upper Basin are underlain by formations which do not yield sufficient quantities of water for irrigation wells. The Sandhills area is underlain by deep, permeable formations which yield large quantities of water. Some of the water bearing material below the tablelands on the north side of the river are at too great a depth for economical development. Aquifers in the main river valley and Pumpkin Creek valley yield sufficient quantities of water for irrigation development, although those in Pumpkin Creek are somewhat localized.

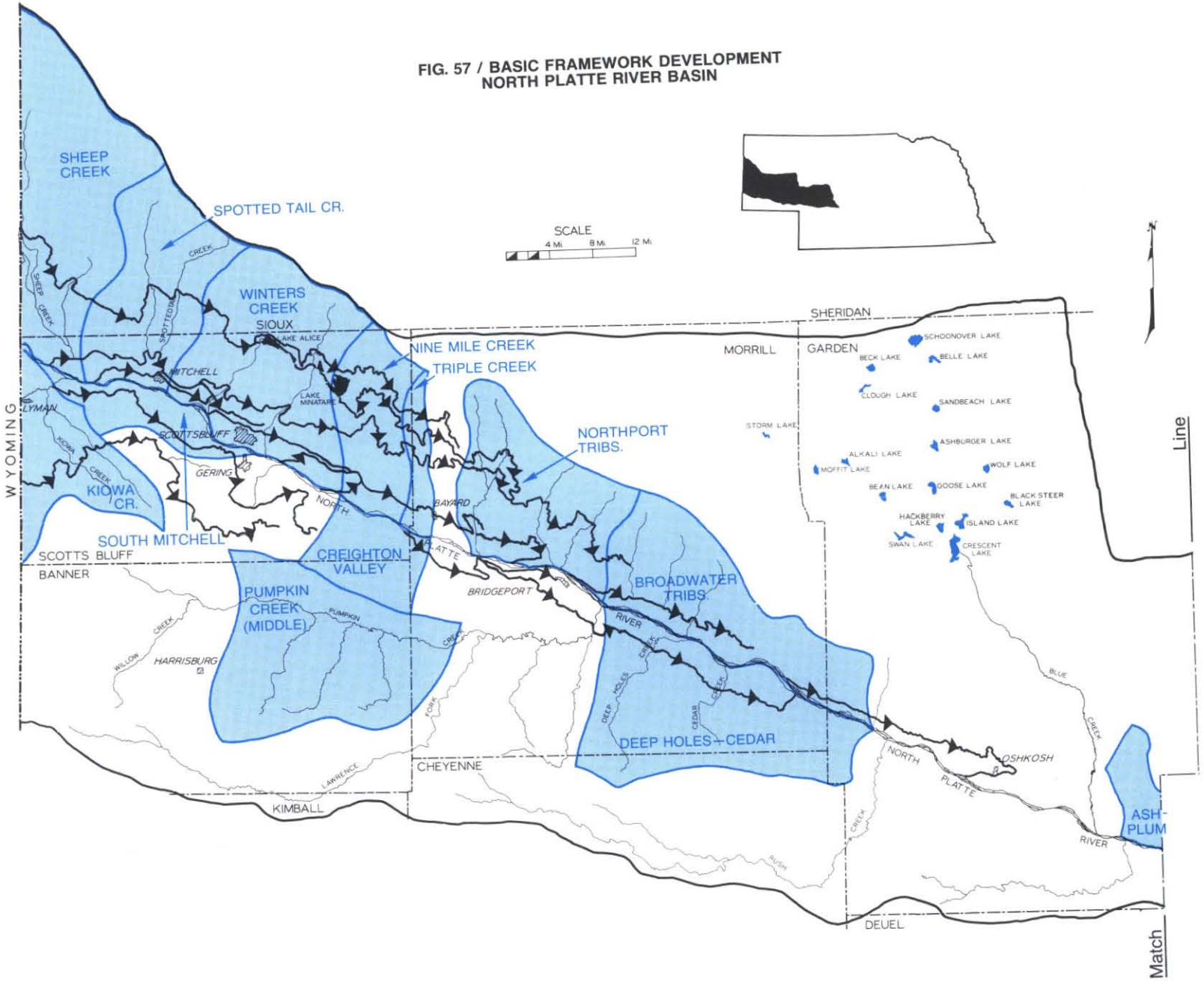
The largest reservoir in the State, Lake McConaughy, is located in this Basin and provides 35,000 acres of surface area for recreation and fishery uses. In addition, several of the tributaries in the upper Basin along the north side of the river provide vital trout spawning and rearing habitat essential to the Lake McConaughy fishery.

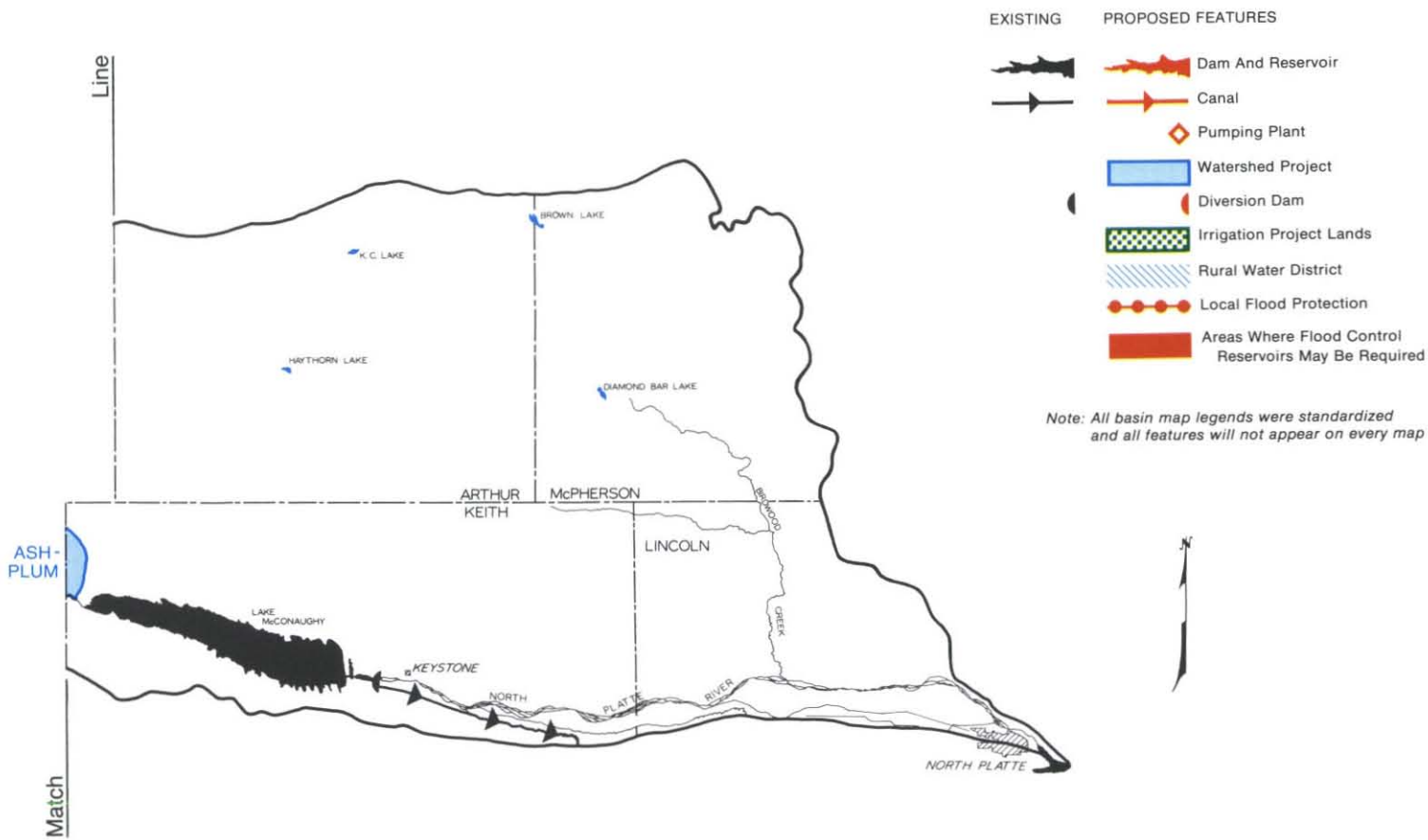
Oil resources in this Basin are significant. Banner County has several producing fields and Morrill County produces a limited amount. The only oil refinery in the State is located at Scottsbluff.

Existing Development. Lake McConaughy was constructed in the early 1940's by the Central Nebraska Public Power and Irrigation District to store North Platte River water for irrigation and hydroelectric power production. It is the largest reservoir in the State with a storage capacity of 1,948,000 acre-feet. About 130,000 acres of land in the Middle Platte River Basin are irrigated with water stored in this impoundment.

The North Platte Project was constructed by the U. S. Reclamation Service, the forerunner of the U.S. Bureau of Reclamation, during the first part of the Twentieth Century. About 170,000 acres of land in Nebraska are irrigated with water developed by this project. Several thousand additional acres in this Basin above Lake McConaughy are provided supplemental storage water from project reservoirs

FIG. 57 / BASIC FRAMEWORK DEVELOPMENT
NORTH PLATTE RIVER BASIN




EXISTING
PROPOSED FEATURES
Dam And Reservoir
Canal
Pumping Plant
Watershed Project
Diversion Dam
Irrigation Project Lands
Rural Water District
Local Flood Protection
Areas Where Flood Control Reservoirs May Be Required
Note: All basin map legends were standardized and all features will not appear on every map
Line
Match
ASH-PLUM
BROWN LAKE
K.C. LAKE
HAYTHORN LAKE
DIAMOND BAR LAKE
ARTHUR
KEITH
McPHERSON
LINCOLN
BIG MOOD
CREEK
LAKE McCONAUGHY
KEYSTONE
NORTH
PLATTE
RIVER
NORTH PLATTE
N

located in Wyoming.

Development of surface water for irrigation began in this Basin in the 1860's, but it did not reach a sizable amount until about 1890. Since that beginning several irrigation districts and ditch companies, both large and small, have developed facilities to irrigate about 250,000 acres in the Basin.

The Gering Valley Project, a combination of flood storage and channelization, was one of the first measures of that type initiated to control extensive erosion of the escarpment area along the valley of the North Platte River. Wildhorse Watershed Project has also been constructed near Bayard on the north side of the valley to control erosion and flooding.

Most of the valley lands and those terraces paralleling the river upstream from Lake McConaughy are irrigated. The higher plains on each side are dry farmed or grassland while the Sandhills are predominantly rangeland.

Irrigation is practiced intensively in the upper part of the Basin. Scotts Bluff County is the state's leading producer of sugar beets, potatoes and dry beans. The acreage irrigated in Scotts Bluff County is the second largest county total in the State.

The total area irrigated in the Basin is about 420,000 acres. This is about 31 percent of the land classified as suitable for irrigation.

The Basin's economy, like most of the State, is based primarily on agriculture. Scotts Bluff County leads the State in sheep feeding and is one of the leaders in cattle feeding.

Scottsbluff and North Platte, located at the upper and lower ends of the Basin, respectively, are the two largest cities and trade centers in the Basin. Recreation oriented industries are of major importance because of Lake McConaughy, the Wildcat Ridge area, numerous Sandhills lakes, and various historical sites.

There are two national wildlife refuges in the Basin, Crescent Lake Refuge in Garden County and North Platte Refuge in Scotts Bluff County. In addition, there are several state special use and wayside areas which are available for recreational uses.

PROBLEMS AND NEEDS

The flow of the North Platte River is well controlled so that flooding on the mainstem is infrequent. However, damaging floods occur periodically on some of the tributaries. Many of the escarpment areas between the plains and the valley are steep and concentrate runoff from high intensity storms onto the irrigated lands below. The distribution systems serving these lands are thus subject to damage. Gering Valley, on the south side of the river, has experienced extensive damage in the past. Although the Gering Valley Project now controls severe flooding in the area, erosion and channel degradation are still experienced. Pumpkin Creek valley also experiences damaging floods, the most recent being in June, 1965, when the discharge of Pumpkin Creek near Bridgeport was the maximum of record.

The North Platte River between Lake McConaughy and North Platte has become overgrown with trees and brush since the construction of Kingsley Dam which impounds floodwaters in Lake McConaughy. Releases from the reservoir have been mainly for irrigation and power purposes and bypass the natural channel below the dam. If design flood releases are necessary in the future to protect the structure, the area along the channel would be flooded and many individuals would suffer damages.

Construction by several large ditch companies and federal project development on the North Platte Project has resulted in irrigation canal systems which parallel each other in many areas. The canal and distribution systems of many districts are old and in need of repair. High seepage losses are creating some wetted areas below the canals. Some areas are short of water partly as a result of high diversion rates on the upper systems made necessary because of excessive water losses. There is a real need in this Basin, especially the upper part, for consolidation and rehabilitation of the irrigation distribution systems.

Some surface water is reused several times for irrigation, but any quality impairment has not yet caused problems. Return flows are eventually stored in Lake McConaughy and no evidence of eutrophication or poor quality water has been observed.

BASIC FRAMEWORK DEVELOPMENT

There appears to be potential for both public and private development during the planning period. Local independent development is difficult to quantify but allowances have been made for that which appears reasonable and likely to occur. Public project development has been included in the Basic Framework to satisfy particular needs or take advantage of opportunities for further development.

Independent Local Development. Additional independent development of the soil and water resources will depend largely upon the need for agricultural products and the economic capability of land owners. Growth of municipalities and industrial development will also create a demand for additional water and land. Rural water use for do-

mestic and livestock purposes will increase slightly in this Basin. Treatment of cropland and range management for soil conservation should be continued and encouraged throughout the Basin.

Municipal and Industrial. It is estimated that the urban population of the North Platte River Basin will be about 65,000 people in 2020. Adequate additional water supplies can and will be obtained from ground water. The present municipal and industrial water use in the Basin is about 53,000 afa and is expected to increase to just over 70,000 afa by 2020. Table 51 shows the present and estimated future municipal and industrial water requirements for the Basin.

Rural Domestic and Livestock. Future rural domestic water use is expected to nearly double despite a projected loss of rural population. The increase will be caused by increased per capita requirements to meet the demands of additional water using equipment and appliances. Generally, ground water supplies are adequate to meet this demand throughout the Basin.

The MRB Study estimated that livestock numbers will nearly triple by 2020 with a resultant increase in water requirements. Presently, the main source of livestock supplies is ground water and it should be adequate to meet future demands. Additional construction of livestock water ponds will take place in the upper plains area of the Basin.

Irrigation. Most of the Basin's irrigable land with a water supply which can be economically developed has already been developed. Future irrigation development will be mostly from ground water. Only about 30,000 additional acres are expected to be developed during the planning period. This development will take place mainly below Lisco on the tablelands away from the stream. Some development of scattered tracts in the valley interspersed among the existing irrigated parcels is also anticipated.

Public Project Development. The public project development includes several multipurpose small watershed projects providing flood control, recreation opportunities, fish and wildlife enhancement, and drainage facilities. No local flood protection or single purpose projects appear to have potential for development under present or anticipated future economic criteria.

Small Watershed Projects. There are three small watershed projects in this Basin which have been investigated in detail and are feasible for construction in the immediate future. These projects, Winters Creek, Ash-Plum, and Creighton Valley, are proposed primarily for flood control. Winters Creek will provide protection for the city of Scottsbluff. Some general information concerning these watershed projects is shown in Table 52.

Several other watershed projects appear to have potential for development later in the planning period. More detailed analysis will be required to determine the merits of each of these projects. Some preliminary information based on MRB Study reconnaissance estimates is shown in Table 52.

These small watershed projects will provide a total of approximately 45,000 AF of flood control storage. Locations of the watershed areas are shown on Figure 57. Recreation and fish and wildlife features can be provided in most of the projects. The total surface area of the reservoirs available for recreational uses will be about 3,600 acres. Two projects will provide drainage and flood control for agricultural lands by construction of 40 miles of channels and/or levees. Requirements for adequate soil conservation treatment on at least 75 percent of the area above storage structures will reduce flood flows and erosion.

Nonstructural Measures. Flood plain management can be a useful tool in preventing and reducing future flood damages in the North Platte River Basin. Several areas in this Basin are subject to

TABLE 51 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
North Platte River Basin

Subbasin	Municipal Systems				Private Industrial Systems a/	
	People Served		afa		afa	
	Present	2020	Present	2020 b/	Present	2020
State Line to Lisco	26,885	41,980	5,420	13,300	43,190	50,550
Lisco to Lewellen	1,775	1,010	320	300	0	0
Lewellen to Mouth	18,500	22,000	3,650	6,900	490	950
BASIN TOTAL	**47,160**	**64,990**	**9,390**	**20,500**	**43,680**	**51,500**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

TABLE 52 / POTENTIAL SMALL WATERSHED PROJECTS
North Platte River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
Winters Creek	140	70	3,600	595	7
Creighton Valley	50	13	720	80	2
Ash-Plum	30	11	720	33	3
Potentially Feasible					
Kiowa Cr., Spotted Tail Cr., South Mitchell, Nine Mile, Northport Tribs, Middle Pumpkin Creek, Broadwater Tribs, Deep Holes-Cedar	1,430	Not Known	39,900	2,870	254
Sheep Cr., Triple	277	None	None	None	40

a/ Based on completed Work Plans or Preliminary Investigations

overflow from tributary streams as well as the North Platte River itself. Encroachment on the flood plain below Lake McConaughy is already taking place and will cause problems when design flood releases are required.

The two largest cities in the Basin, North Platte and Scottsbluff, would benefit from enactment of flood plain regulation ordinances. North Platte has initiated a preliminary survey to determine the flood flow elevations for zoning purposes.

Many short tributaries of the North Platte River provide a good quality cold water fishery. Provisions should be made to protect or enhance these fishery values in all future development schemes.

Modification of Existing Development. Water distribution facilities of several irrigation systems in this Basin are old or outdated and need renovation in order to use the available water more efficiently.

There are 35 canal systems having a total distribution system length of over 1,000 miles. Reorganization to combine canals of some of these systems and canal lining to prevent leakage could increase the water supply available to the crops by as much as 20 percent. Some of the existing drainage problems caused by canal leakage and excess water use could be alleviated by this system rehabilitation.

Consideration should be given to channel clearing and maintenance along with regulation of flood plain development along the reach of the North Platte River between Lake McConaughy and the North Platte Diversion Dam. This would alleviate the channel constriction problem described earlier.

Potential Effects. The development outlined in this Framework Study will provide varied and significant effects on several areas of the Basin.

The local development will stabilize the existing economy and allow for orderly and continued growth of the urban areas.

The small watershed projects will provide short range economic effects to the local community during construction. However, the flood control aspects of the projects will provide long range effects and economic relief for the urban and agricultural areas protected.

The recreation features will enhance the existing recreational facilities, especially in the upper Basin. Enactment of flood plain regulations will reduce future flood damages. Reduction of seeped areas below canals will reduce the amount of marshy lands with their associated phreatophyte growth and mosquito problems. Some undesirable effects may also be expected because waterfowl and pheasants using marsh habitats will no longer be accommodated.

The 1970 depleted streamflow, estimated streamflow reduction because of in-basin development and the remaining streamflow available are shown in Table 53.

The table shows the effects of present diversion

TABLE 53 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT
North Platte River Basin

Stream Location	1000 Acre-Feet Annually		
	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
North Platte River at Lisco	647.8	14.0	633.8
North Platte River at Lewellen	713.5	15.4	698.1
North Platte River at North Platte	332.2	16.6	315.6

Note: Based on average annual streamflow during the period 1954-63

below Lake McConaughy for operations of the existing Nebraska Public Power District and Central Nebraska Public Power and Irrigation District on the flow of the North Platte River at North Platte.

The depletions shown are accumulated totals and reflect the estimated net use of water within each subbasin analyzed. The quantity included in the subbasin above Lisco is mainly for additional municipal and industrial use and evaporation losses from small watershed project reservoirs.

Although the "Remaining Streamflow" shown in Table 53 appears to be available for development, this reflects historic regulation and operation and the remaining water is largely committed to existing rights downstream. The storage and appropriation rights of the many districts downstream are somewhat interrelated and complex. Any extensive use of this water will have to be on a replacement or exchange basis.

REMAINING PROBLEMS AND OPPORTUNITIES

Soil erosion will be a continuing problem although several erosion and flood control projects were included in the Basic Framework. Degradation of the channels on the steep escarpment areas will continue, but individual land treatment practices can help alleviate potential damages.

A large tract of land suitable for irrigation lies in Cheyenne and Deuel Counties on the divide between the North and South Platte Rivers. This area offers the opportunity for development but a source of water is not available within the Basin.

There will be opportunities for communities to develop recreational facilities at many of the small watershed project reservoir sites included in the Basic Framework.

South Platte River Basin

GENERAL DESCRIPTION

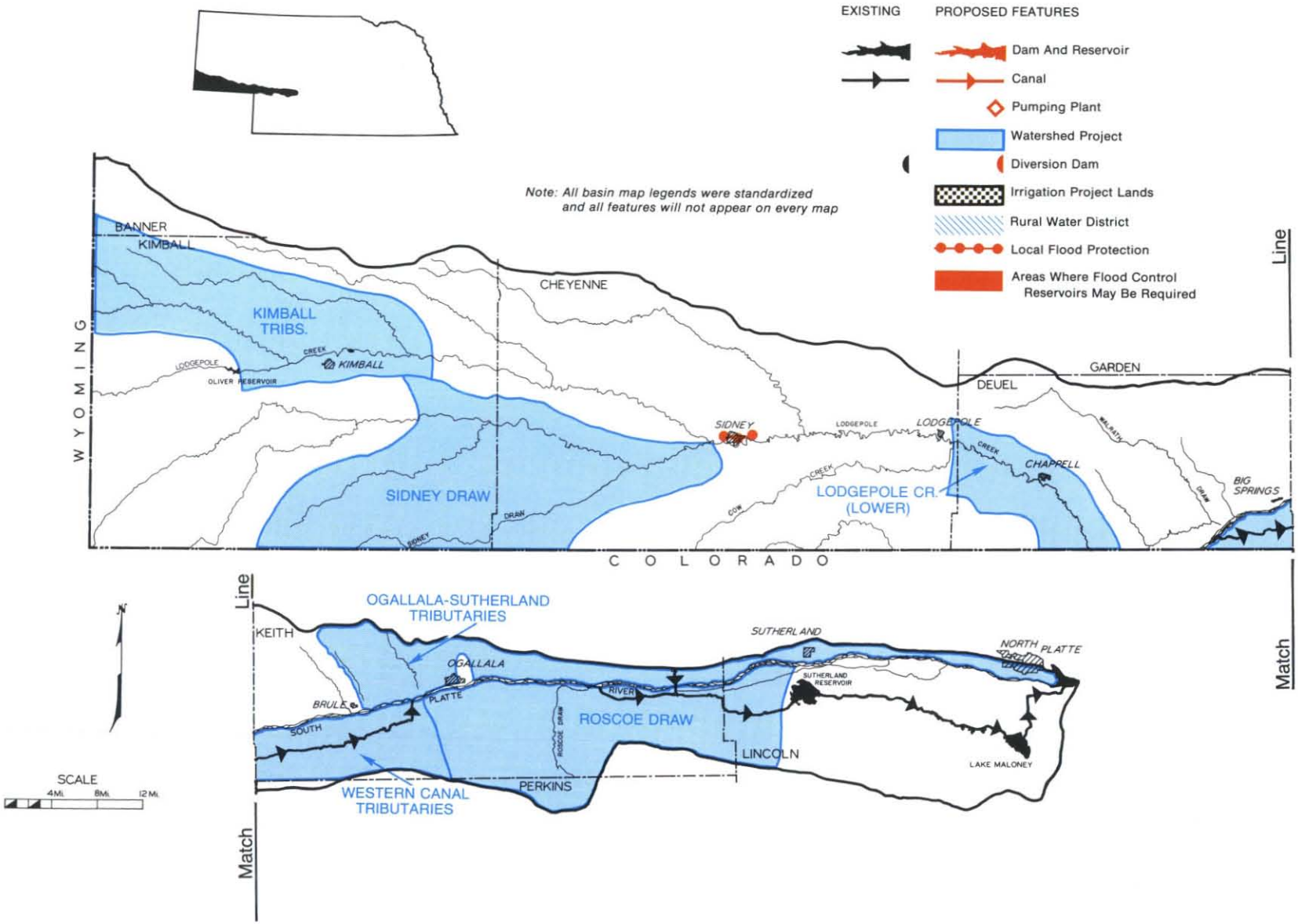
The South Platte River Basin covers a narrow strip along the southern Panhandle extending from the Wyoming-Nebraska state line to North Platte, Nebraska. Lodgepole Creek is the principal Nebraska tributary to the South Platte River which heads in Colorado.

The Basin is divided into high plains and stream valleys. In the west, the plains are gently rolling with low rounded knolls and broad swales, or basins, and the surface drainage pattern is incompletely developed. In the eastern part, the drainage pattern is better developed and canyons dissecting the plains are more pronounced. The South Platte River valley is broad and flat in the eastern part of the Basin and has poor surface drainage toward the river.

The steeper rolling areas are mostly native grass while the broader plains and tablelands are cultivated. Trees are limited mainly to the stream valleys and villages although farmstead and field windbreaks are numerous.

Basin Resources. Soils in the Basin vary from sandy in the western rolling plains to loess mantled tablelands in the central and eastern portions. There are large acreages of good quality lands with deep loess soils in Cheyenne and Deuel Counties.

FIG. 58 / BASIC FRAMEWORK DEVELOPMENT
SOUTH PLATTE RIVER BASIN



There are about 2,000,000 acres of agricultural land in the Basin of which about 75 percent has been classified as arable. About 1.2 million acres of the arable lands are suitable for irrigation.

Average annual precipitation varies from just under 16 inches in the west to about 19 inches in the east. About six inches of the annual amount occur during two months, May and June. Nearly all tributaries to the main streams dry up during the late summer months.

Streamflow in this Basin is greatly affected by development upstream in Colorado. Transmountain diversions for municipal and irrigation use in Colorado and development within the Basin alter the natural runoff conditions. Return flows from areas upstream and from in-basin uses significantly degrade the water quality.

Flood flows occur infrequently on the South Platte River, generally as the result of intensive rainfall on the eastern Colorado plains below the foothill reservoirs. Flash floods occur occasionally on Lodgepole Creek partly because of the relatively narrow flood plain and limited channel capacity. Most of the runoff from within the Basin in Nebraska is produced by high intensity storms.

There is some ground water discharge to the South Platte River which sustains base flow. However, most of the ground water in the alluvium of the valley is developed extensively for irrigation and the ground water level is generally drawn down below the river bed elevation.

There is an interstate compact between Colorado and Nebraska which apportions the flows of Lodgepole Creek and the South Platte River between the two states. Under this compact, Nebraska has essentially the full use of waters of Lodgepole Creek within the State. The division of the South Platte water is somewhat more complicated, but a minimum mean daily flow at the state line station of 120 cfs is established, provided the flow is being used beneficially in Nebraska. One section of the compact provides for the future diversion of water in Colorado for the irrigation of lands in Nebraska. This diversion is limited to 500 cfs for the period from October 15 to April 1 and is subject to prior reservation of storage in Colorado.

Ground water supplies vary across the Basin. The alluvium in the South Platte valley generally yields large amounts of water. However, the ground water aquifers of the Lodgepole Creek valley are quite limited and low yielding.

The high plains area of the eastern part of the Basin is underlain by the Ogallala formation which yields sufficient quantities of water for irrigation, but it must be pumped from considerable depths. The Brule Clay formation underlying the Lodgepole Creek area in the western portion of the Basin yields water only in scattered locations and usually in small quantities.

Oil and gas resources of the Basin are significant. Production began in the late 1940's and reached boom proportions during the 1950's. Although production has tapered off in recent years, Kimball and Cheyenne Counties have produced nearly one half of the state's total output.

The fish and wildlife resources of the Basin are limited. Streamflow is too variable to support a high quality fishery. Two reservoirs, Sutherland and Maloney, provide opportunity for fishing and limited water based recreation.

Wildlife species are mainly composed of furbearing animals, upland game birds, and small game. Deer are found in the valleys along the streams.

Existing Development. Early water resource development in the Basin was for surface water irrigation. The Western Canal diverts South Platte River water to lands in the South Platte valley. The Kimball Irrigation District develops and distributes Lodgepole Creek water. About 17,000 acres are irrigated by these two systems with some supplemental supply provided from ground water pumping. An additional 17,000 acres are irrigated from surface water in the Basin as a part of smaller irrigation districts or private systems.

The Sutherland Canal, which diverts water from the North Platte River below Lake McConaughy, also diverts water from the South Platte River. These waters are stored in Sutherland and Maloney Reservoirs before they are used to generate power at the North Platte plant of the Nebraska Public Power District. They are then returned to the river and diverted again farther downstream to irrigate lands in the Middle Platte River Basin.

There are about 54,000 acres irrigated from ground water in the South Platte River Basin. Together with the surface water irrigated acreage, this makes for a total of about 88,000 acres currently irrigated in the Basin which is only about 7 percent of the land classified as suitable for irrigation.

Soil and water conservation measures such as terracing and strip cropping are more common in the upper part of the Basin than the eastern areas.

Small watershed projects have been constructed recently near Brule and Ogallala. The Brule Watershed Project provides flood protection for the village of Brule and Cure Creek Watershed Project provides protection for the city of Ogallala.

With the exception of irrigated lands along Lodgepole Creek and the South Platte River, the land in this Basin is mainly devoted to dry farming.

Wheat is the major crop, and Cheyenne County is the leading county in the State in the number of acres harvested. Some of the rougher areas are devoted to rangeland.

The economy of the Basin is primarily dependent upon agriculture and agriculturally oriented industry. Excluding North Platte, which is partly within the Basin, there are only three towns with 1960 populations greater than 4,000. The largest of these is Sidney with 8,000. Ogallala, near Lake McConaughy, serves as a recreation and tourist center for those visiting the reservoir. The population boom experienced by Kimball and Sidney during the oil development period of the 1950's has subsided and both towns lost population during the 1960's. Industry is limited to small manufacturing plants and agricultural processing facilities.

PROBLEMS AND NEEDS

Water and wind erosion have been a constant problem in this Basin and the threat will continue in the future. The soil cover is quite thin on some of the plains area and sheet erosion from high intensity rain storms causes significant soil losses. Strip cropping has been practiced extensively in the past and will continue to be a prime land treatment requirement to combat both wind and water erosion.

Flooding is also a problem. The most damaging storms are thunderstorms which create flash flooding on the tributaries and result in large soil losses and property damage. Occasionally flood flows originating on the South Platte River in Colorado cause damages in Nebraska. The most recent, in June, 1965, caused extensive damage from the state line to beyond North Platte.

Sediment deposits in the Kimball Irrigation District's storage reservoirs have significantly reduced the water supply available for district lands. Since the distribution facilities are in need of extensive repair, the district has considered abandoning the surface water system and using wells to supply their irrigation water requirements from ground water. Some difficulty may be encountered, however, in obtaining adequate supplies of ground water in the local area.

The type of agricultural economy existing in the area has developed by necessity because of the distribution and small amounts of precipitation. Many areas are cropped only every other year to conserve moisture. There are large tracts of land which could be developed for irrigation if a water supply was available.

A need exists in the Basin for a reliable means of hail suppression. This area suffers more from hail losses than any other in the State and some parts of the Basin are damaged nearly every year. The occurrence is so regular and predictable that an area in southwest Nebraska and northeast Colorado has often been called "Hailstone Alley." Research is currently underway to determine the cause of this storm activity.

The South Platte River contains a higher concentration of dissolved solids than any other major stream in the State. Concentrations up to 1,700 mg/l have been recorded at Julesburg, Colorado, near the state line. Degradation of water quality is caused by the low flows and extensive use and reuse of the water upstream by municipalities and irrigation districts.

An inventory of sewage treatment facilities in Nebraska taken in July, 1969, showed that of 13 communities inventoried in the Basin, all were providing secondary treatment of their discharged wastes. However, treatment plants in three communities needed improvement to meet state water quality standards.

BASIC FRAMEWORK DEVELOPMENT

The projects and programs included in this Basic Framework for the South Platte River Basin consist of those independent local and public projects which appear reasonable or necessary for development from in-basin water resources.

Independent Local Development. Future development by local individuals, groups, and municipalities will be dependent upon the needs and the economic justification of the development. Predictions of independent development are difficult but allowances have been made for that which appears likely to occur during the planning period.

Land treatment to prevent soil erosion by both wind and water must be continued by individual landowners.

Municipal and Industrial. The urban population of the South Platte River Basin is expected to decrease to less than 20,000 people by 2020. However, the water which will be required for municipal and industrial purposes, as shown in Table 54, is more than present use because of the expected future increase in per capita use and provision of an industrial reserve. Supplies for the additional use can be developed from ground water sources.

Rural Domestic and Livestock. Rural domestic water use will increase despite a loss of population because of additional water using facilities and pressurized systems being installed in rural households. The demands can generally be met by individual wells but in some areas of the Basin where present supplies are limited, construction of rural water distribution systems may be required.

TABLE 54 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
South Platte River Basin

Subbasin	Municipal Systems				Private a/ Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020 b/	Present	2020
Lodgepole Creek						
State Line to Mouth	17,220	12,270	2,990	3,500	7,100	7,600
South Platte River						
State Line to Mouth	7,345	7,360	930	1,800	3,580	3,970
BASIN TOTAL	**24,565**	**19,630**	**3,920**	**5,300**	**10,680**	**11,570**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

Livestock numbers are estimated to increase with an accompanying increase in water demands. Increased demand can generally be met by ground water development and some additional farm pond construction.

Irrigation. The surface water supply available for irrigation is fully developed. Future irrigation development will be from ground water. About 110,000 additional acres could become irrigated during the planning period and have been included in estimates for Basic Framework development. Much of this acreage is located in Keith and Lincoln Counties in the South Platte River valley and on the broad plains along the valley. Although there are large additional acreages of land suitable for irrigation, the 110,000 acres included is a conservative estimate of the amount which would have a dependable water supply.

Public Project Development. Structural development which is part of the Basic Framework includes several multiple purpose small watershed projects and a local flood protection project for one community. The locations of the various projects are shown on Figure 58.

Small Watershed Projects. Potential small watershed projects in this Basin were investigated during the MRB Study. It appears that at least six have potential for construction during the planning period. Increased local interest or flood damage losses may accelerate the development of these projects.

Four of the projects include flood control structures which would provide about 21,900 AF of flood control storage. Two of these four projects will provide both urban and rural protection. The surface area available for recreation use will be about 1,300 acres. Opportunities for fish and wildlife enhancement and recreation development would also be provided.

Two additional watershed projects will provide drainage and flood control through construction of channels and/or levees.

The locations of these potential projects are shown on Figure 58 and pertinent information from reconnaissance estimates is shown in Table 55.

Local Flood Protection. A single purpose flood control project is included for the city of Sidney. Damages from flood flows of Lodgepole Creek and a local tributary stream have been severe in the past. A levee to protect the city from floodwaters has been considered and is included as part of the Basic Framework. Protection of other cities on Lodgepole Creek and on the South Platte River may be warranted after further investigation.

Nonstructural Measures. Flood plain management through land use regulation, building codes, and structural flood proofing can reduce future potential flood damages. Although the future growth of most cities in the Basin is expected to be small, zoning and subdivision regulations should be used to insure wise use and development of flood prone areas.

The city of Sidney has indicated an interest in flood plain regulation and preliminary hydrologic surveys are now underway. Implementation of a flood plain zoning program will prevent the increase of flood damages and lessen the structural flood control requirements.

Modification of Existing Development. Development that has taken place both in Colorado and in Nebraska has reduced not only flood flows but the normal flow of the South Platte River. Consequently, the channel capacity of some sections of the lower reaches of the river has been reduced by an accumulation of sediment, debris, and brush. No specific sections have been proposed for channel clearing but consideration should be given to this method of increasing flood carrying capacity.

TABLE 55 / POTENTIAL SMALL WATERSHED PROJECTS
South Platte River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
None					
Potentially Feasible					
Sidney Draw, Lower Lodgepole Cr., Ogallala-Sutherland Tribs, Roscoe Draw	925	Not Known	21,870	1,320	16
Kimball Tribs, Western Canal Tribs	433	None	None	None	61

a/ *Based on completed Work Plans or Preliminary Investigations*

Potential Effects. The Basic Framework contains projects and programs that would favorably affect several areas of the Basin.

The additional irrigation expected to be developed by individuals will help stabilize the economy and assist in maintaining the Basin's rural population.

The small watershed projects outlined will provide flood control for several areas. These projects, along with those presently constructed, will provide flood protection for most cities in the Basin and considerable areas of agricultural land.

The flood control features will also help stabilize the local agricultural economy and provide economic relief to those towns which have suffered flood damages in the past. Control of flooding and the resultant erosion and silt accumulation will improve the appearance of the area. Regulation of the flood plains and control of the development thereon should remove the blighted type development now present in such areas.

There will be opportunity for development of recreation facilities in conjunction with watershed projects, especially in the western part of the Basin.

Depletions from streamflow due to the development included in the Basic Framework were estimated for several subbasins. Table 56 shows the average annual streamflow reduced for 1970 conditions, estimated depletions due to in-basin development, and the streamflow remaining. The depletions shown are accumulated totals and reflect the net use of water in each subbasin analyzed.

The table shows little surface water remaining after the development projected. The large flow remaining at the mouth of the South Platte River is comprised mostly of North Platte River flows diverted through the Nebraska Public Power District hydroelectric power plant and back to the river.

TABLE 56 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT
South Platte River Basin

Stream Location	1000 Acre-Feet Annually		
	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Lodgepole Creek at Bushnell	7.6	4.3	3.3
Lodgepole Creek at Ralton	5.1	4.8	0.3
South Platte River at North Platte	74.5	20.7	53.8
South Platte River at Mouth [a/]	617.7	24.2	593.5

a/ *Includes power returns from the NPPD hydroelectric power plant*
Note: Based on average annual streamflow during the period 1954-63

These flows, like the flows of North Platte River mentioned previously, are largely committed to downstream rights.

REMAINING PROBLEMS AND OPPORTUNITIES

The projects included in the Basic Framework will provide significant flood and erosion protection, but additional and continued conservation action by individual landowners will be necessary to fully control water and wind erosion.

Out-of-state conditions pose a flood threat on the South Platte River. Further opportunity for flood reduction lies in construction of the proposed Narrows Reservoir in Colorado and completion of Chatfield Reservoir near Denver.

The large tract of land suitable for irrigation in the Cheyenne and Deuel Counties tableland area has no available in-basin water supply. The lands lie on the high plains between the North and South Platte Rivers over limited ground water aquifers.

Water quality of the South Platte River will continue to be a problem with additional development decreasing the total streamflow. Regulation of irrigation return flows by the proposed Narrows Reservoir may improve water quality below the reservoir but additional studies and measures for quality control will be required.

Middle Platte River Basin

GENERAL DESCRIPTION

The Middle Platte River Basin lies in the south-central part of the State. It occupies a narrow strip on each side of the Platte River extending from the confluence of the North and South Platte Rivers to the mouth of the Loup River.

The Basin includes broad Platte River valley lowlands, loess hills and dissected plains, and Sandhills. In the western part, the Sandhills merge into the rolling loess hills which in turn lead into the flat lowlands of the valley. These lowlands normally consist of several flat terraces with relatively steep slopes between the terraces.

The dissected plains and loess hills have a well developed drainage pattern which discharges onto the poorly drained flat valley lands. The valley is quite broad through the central portion and the drainage pattern becomes less well developed toward the eastern end of the Basin.

The Sandhills and rougher loess hills are mainly covered with native grass. The valley lands and high plains are mostly cultivated, except for those poorly drained areas adjacent to the Platte River which often have a high water table and are covered with grass, cattails, and brush.

Basin Resources. The soils in the Basin vary from the sands of the valley alluvium along the river and in the Sandhills to the fertile alluvium of the valley terraces and the loess soils of the plains and tablelands. About two-thirds, or 1,843,000 acres, of the agricultural land in the Basin has been classified as arable. Of these lands, 1.4 million acres are classified as suitable for irrigation.

Average annual precipitation varies from 19 inches in the western end to 25 inches in the eastern end of the Basin. Although distribution of the annual total during the growing season is generally good, over 50 percent of this amount may occur in one month.

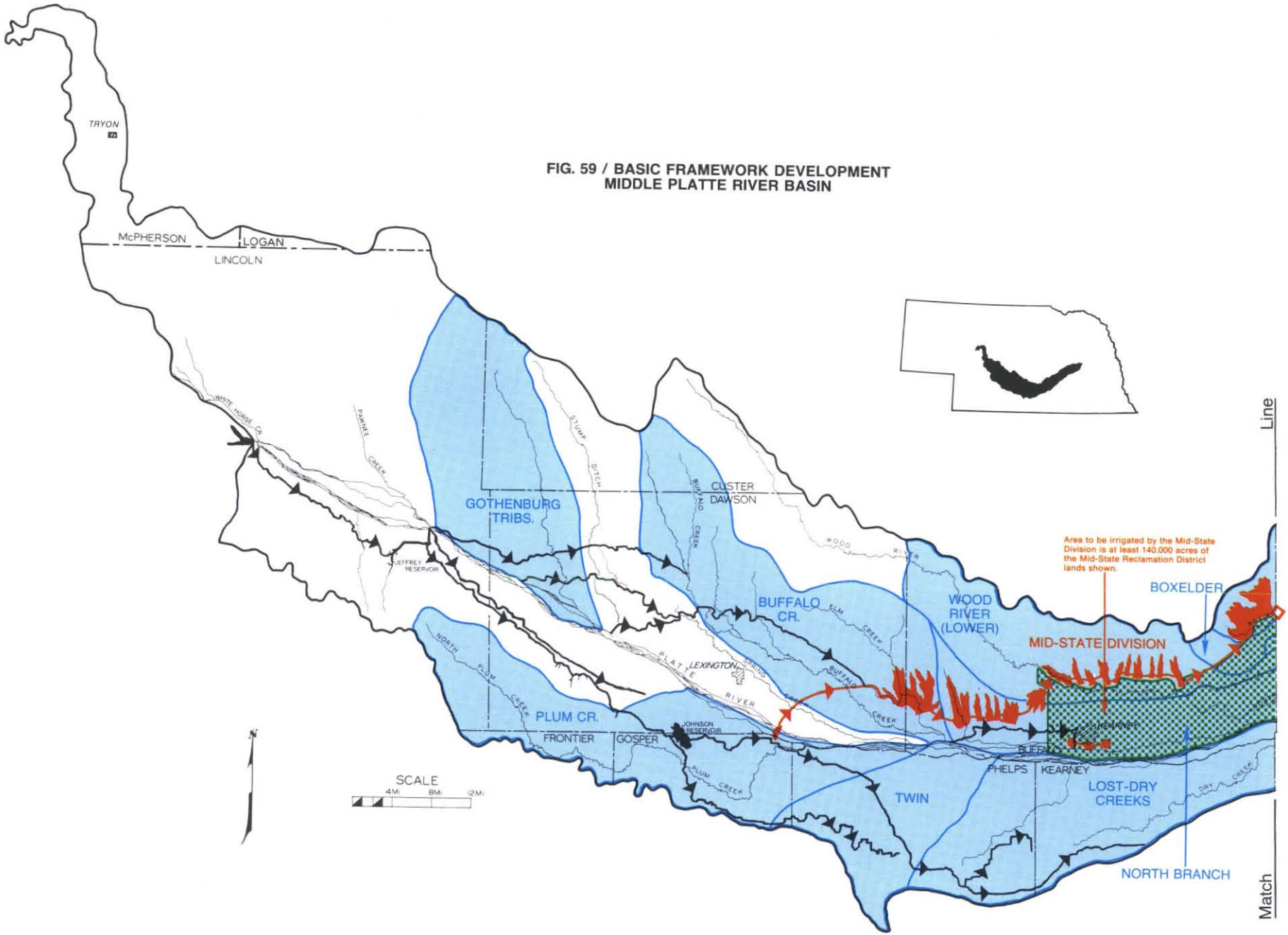
Platte River flow is regulated by upstream development and storage and further altered by development and diversion within the Basin. Lake McConaughy, on the North Platte River above the Basin, and storage reservoirs in Wyoming control most flood flows from that branch of the Platte. The South Platte is not so well controlled and infrequently causes some flood damage in this Basin. Major storage projects in Colorado, under construction or authorized at the present time, will greatly alleviate this problem.

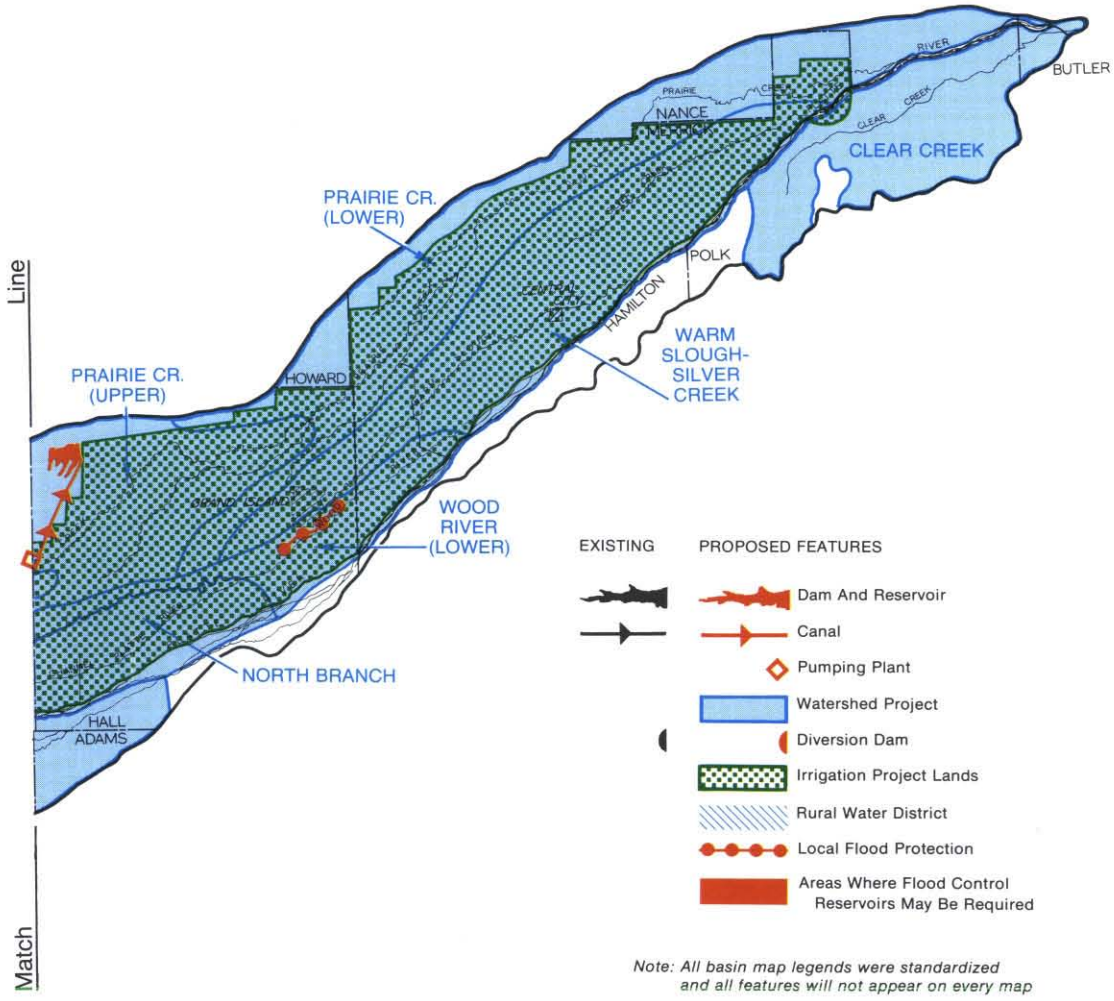
The variation in Platte River flow shows the effects of regulation. The flow during the irrigation season drops to essentially zero in the eastern portion of the Basin nearly every year. Nearly all tributaries in the Basin flow mainly as a result of surface water runoff from excess precipitation.

Good ground water aquifers underlie most of the Basin, with ample supplies available for irrigation development in most areas. The higher yielding aquifers are located in the Sandhills and in the valley alluvium. Aquifers in the valley are thick and the ground water level usually is at depths ranging from 5 to 40 feet below the surface.

Extensive sand and gravel deposits located adjacent to the Platte River have been developed for various uses such as concrete aggregate and road surfacing.

FIG. 59 / BASIC FRAMEWORK DEVELOPMENT
MIDDLE PLATTE RIVER BASIN




Match Line
PRAIRIE CR. (UPPER)
PRAIRIE CR. (LOWER)
HOWARD
NANCE
MERRICK
POLK
BUTLER
HAMILTON
CENTRAL CITY
GRAND ISLAND
CLEAR CREEK
WARM SLOUGH-SILVER CREEK
WOOD RIVER (LOWER)
NORTH BRANCH
HALL
ADAMS
EXISTING
PROPOSED FEATURES
Dam And Reservoir
Canal
Pumping Plant
Watershed Project
Diversion Dam
Irrigation Project Lands
Rural Water District
Local Flood Protection
Areas Where Flood Control Reservoirs May Be Required
Note: All basin map legends were standardized and all features will not appear on every map

Fish and wildlife resources consist mainly of warm-water fish, upland game birds and small game. Deer have become more numerous in recent years, mainly along the streams. The flat topography and standing water along the Platte River provide excellent habitat for migrating ducks, geese, and sandhill cranes.

Existing Development. Extensive development of ground water for irrigation in Nebraska began in the Middle Platte River Basin. Hall, Merrick, and Dawson Counties now lead all others in the number of irrigation wells registered with the Nebraska Department of Water Resources.

The Central Nebraska Public Power and Irrigation District completed construction of a surface water irrigation and hydroelectric project in the Basin during the early 1940's that now provides irrigation water to about 130,000 acres on the south side of the Platte River in Gosper, Phelps, and Kearney Counties. Three hydroelectric power plants with a combined installed capacity of 54 megawatts and one thermal power plant with 108 megawatts capacity have been constructed as a part of the project.

The Nebraska Public Power District, formerly Platte Valley Public Power and Irrigation District, provides surface water for irrigation of about 100,000 acres on both sides of the Platte River in Dawson, Lincoln, and Buffalo Counties. A 26 megawatt hydroelectric power plant located in the South Platte River Basin is operated by the District with the same water.

The total acreage irrigated in the Basin from both surface and ground water is about 900,000 acres, or approximately 65 percent of the total land suitable for irrigation.

Two small watershed projects are currently under construction. The Spring Creek (Dawson) Watershed project will provide flood protection for the city of Lexington and agricultural lands in the vicinity. The Jones Creek project will provide flood protection for agricultural lands in the eastern end of the Basin.

Most of the land in this Basin is cultivated except for the Sandhills and some of the rougher, broken lands which are grassland. Most of the valley lands and many of the upper plains are irrigated. Corn and alfalfa are the major crops with Dawson County being the state's leading producer of alfalfa hay. Buffalo and Hall Counties are the two leading producers of irrigated soybeans.

The economy of the Basin is agriculturally oriented but diversification by new industries has occurred in recent years. There were five communities in the Basin with populations over 3,000 and a combined total population of over 50,000 in 1960. The largest city in the Basin is Grand Island which had a population of 25,700 in 1960. Major industries in the Basin include farm equipment assemblage, munitions manufacturing, auto equipment assembly, irrigation distribution system construction, mobile home manufacturing, alfalfa processing, and meat packing.

Fish and wildlife enhancement and recreation development have been mostly associated with reservoir development undertaken for irrigation and hydropower purposes. Jeffrey and Johnson Reservoirs, two regulating reservoirs of the Central Nebraska Public Power and Irrigation District, provide significant recreation and fishery opportunities for persons in and adjacent to the Basin.

The "Chain of Lakes," created by ground water filling pits after excavation of materials for U.S. Interstate Highway 80, have been stocked with fish and provide recreation for both travelers and local residents.

PROBLEMS AND NEEDS

Flooding is a problem in this Basin. Most flooding results from rapid runoff of steep tributaries draining the higher lands on both sides of the valley. These flows are slowed considerably when they reach the flat transverse slope of the Platte River valley lands, causing floodwaters to spread across the valley floor. Flooding usually occurs on the tributaries running parallel to the mainstem although some flooding has occurred on the Platte River. The destructive flood of 1967, the worst recorded at Grand Island, was caused by tributary overflow, not mainstem flooding.

Some irrigation systems are short of water during the high use part of the irrigation season. This is partially due to the poor condition of the distribution systems which cause high seepage losses.

An area along the north side of the river valley from Kearney to Central City has been experiencing a ground water level decline. Aquifer storage in this area is limited and pumping for irrigation is depleting the storage faster than recharge can replace it.

A 1969 inventory of the sewage treatment facilities of the Basin showed only one community without a sewer system and two communities with primary treatment plants that need improvement to comply with the Nebraska Water Quality Standards. Besides poorly treated waste discharges from the primary treatment plants, upstream irrigation return flows also contribute to degradation of water quality of the Platte River.

Drainage needs are evident on many of the valley lands adjacent to the river. A portion of the Central Nebraska Public Power and Irrigation District

on the south side of the river in Phelps, Gosper, and Kearney Counties is in serious need of drainage. Canal seepage losses, excessive irrigation water application, and poor surface drainage have combined to increase ground water storage and raise the water table as much as 90 feet in the past 25 years. In some areas the ground water level is above the ground surface and is creating marshes.

There is a need for additional water oriented recreation opportunities in the Basin. Existing reservoirs in the area are becoming crowded during peak use periods and opportunity for additional development at these sites is limited.

BASIC FRAMEWORK DEVELOPMENT

The development included in the Basic Framework is that independent and public project development that appears reasonable and possible during the planning period. Developments included utilize only in-basin water and related land resources.

Independent Local Development. Additional development of the soil and water resources by individuals, municipalities, and industries will depend upon future needs and economic potentials. Allowances were made in water supply estimates for additional industrial use and increased usage by individuals in both the urban and rural areas. Land treatment for soil conservation must be continued on an individual basis and is included as part of the Basic Framework.

Municipal and Industrial. The urban population of this Basin is projected to increase from 63,600 in 1960 to 111,500 in 2020. Additional water supplies to meet increased municipal and industrial needs can be developed from ground water. The present municipal and industrial use in the Basin is about 80,000 afa and is estimated to increase to about 120,000 afa by 2020. The present and projected municipal and industrial uses by subbasin are shown in Table 57.

Rural Domestic and Livestock. Rural domestic water use in the Basin is expected to increase to slightly more than twice the present use. Although rural population is expected to decline, increased water use will result from installation of additional pressurized systems and new water using facilities. The additional water requirements can be met from ground water.

Livestock numbers are expected to increase with a resultant increase in water requirements. Water will come primarily from ground water sources with some livestock pond construction accounting for the remainder.

Irrigation. Future private independent irrigation development will be from ground water. About 120,000 additional acres are expected to be developed for irrigation during the planning period. Most of these lands will be on the upper terraces of the valley and the tablelands.

Public Project Development. Public project development included consists of several multipurpose projects providing flood control, recreation, irrigation, and fish and wildlife benefits. In addition, at least two single purpose local flood control projects appear to be feasible and are included in the Basic Framework. The location of these projects is shown on Figure 59.

Mid-State Division. The Mid-State Division of the Missouri River Basin Project in the central part of this Basin has been authorized for construction by the U.S. Congress, but contracts for the water have not yet been completed, and the project has not been funded by Congress. This multipurpose project will provide irrigation water for 140,000 acres in Buffalo, Hall, and Merrick Counties, flood control for rural and urban areas, recreation opportunities for residents of the area and region, and

TABLE 57 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Middle Platte River Basin

Subbasin	Municipal Systems				Private a/ Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020 b/	Present	2020
Platte River						
North Platte to Overton	7,220	19,220	845	6,300	800	1,200
Overton to Duncan	56,086	92,140	12,335	31,980	67,740	78,000
Duncan to Loup River	300	120	20	20	0	0
BASIN TOTAL	**63,606**	**111,480**	**13,200**	**38,300**	**68,540**	**79,200**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

fish and wildlife values. The U.S. Bureau of Reclamation has been authorized to construct the project and is partially funded for the advanced planning which must precede construction.

The original plan was developed by consultants for the Mid-State Reclamation District to provide a balanced and integrated system of irrigation, using both surface and ground water. The present plan includes a diversion dam on the Platte River near Lexington to divert water into a long series of storage reservoirs in the hills north of the river. Reservoir storage would be provided for irrigation and flood control and the water surface would be used for recreation and fish and wildlife. In addition, three floodways would be provided to assist in moving floodwater to the Platte River.

During the reservoir site selection phase of final project planning, a lesser number of reservoirs should be considered. Otherwise, evaporation and seepage from the large number of reservoirs will reduce the water supply available and may cause severely seeped areas below some storage sites.

Changes in irrigation techniques and a greater knowledge of conjunctive surface and ground water use systems gained since the project's conception also offer an opportunity to modify the original location and number of reservoirs planned for this project.

Small Watershed Projects. Potential small watershed projects in this Basin were investigated at reconnaissance level during the MRB Study. Those which appear feasible for construction during the planning period are shown in Table 58 along with general information concerning them. Three of these projects are primarily for flood control with associated recreation included. Nine additional projects will provide drainage and channel improvement measures. One, Warm Slough-Silver Creek, will also provide flood protection for the city of Grand Island. Additional investigation will be required to determine the merits of these projects.

Local Flood Protection. Single purpose flood control projects are included for the cities of Grand Island and Kearney. Grand Island has suffered extensive damages recently from flood flows of the Wood River and several other smaller tributaries of the Platte. The Corps of Engineers is presently investigating alternative methods of providing flood protection for Grand Island.

Nonstructural Measures. The flood potential of much of the valley land makes flood plain management essential in this Basin. A delineation of the flood plain area has been completed for Grand Island. Zoning and regulation should be implemented by the city as soon as possible to prevent escalation of flood damages. The other cities in this Basin should employ flood plain management as a tool in preventing future encroachment on the flood plain.

Modification of Existing Developments. Modification or improvement of existing projects through measures such as channel clearing, irrigation system rehabilitation, and improved drainage are often necessary to enable the facility to operate as initially envisioned.

TABLE 58 / POTENTIAL SMALL WATERSHED PROJECTS
Middle Platte River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
None					
Potentially Feasible					
Gothenburg Tribs, Plum Cr., Buffalo Cr.	1,023	Not Known	30,600	2,400	151
Twin Cr., North Branch, Lost-Dry Cr., Lower Wood River, Box Elder, Warm Slough-Silver Cr., Upper Prairie Cr., Lower Prairie Cr., Clear Cr.	2,217	None	None	None	691

a/ Based on completed Work Plans or Preliminary Investigations

TABLE 59 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT

Middle Platte River Basin

1000 Acre-Feet Annually

Stream Location	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Platte River at Overton	437.8	276.1	161.7
Platte River at Duncan	370.5	228.8	141.7
Platte River at Loup River	370.5	229.4	141.1

Note: Based on average annual streamflow for the period 1954-63

The flooding problem in the Basin has been aggravated by losses in stream channel capacity. Several streams have become partly choked with dead trees, debris, and heavy brush undergrowth. A project is currently underway to clear a section of the channel on the lower reaches of Wood River. Similar programs should be implemented on other streams in the Basin which have had substantial capacity reductions.

Many valley lands naturally have poor surface and subsurface drainage because of flat slopes and tight soils. Poor drainage conditions have often been aggravated by land leveling for irrigation which reduced the capacities of existing drainage channels by filling or rerouting. Modification and improvement of existing irrigation surface water removal systems will alleviate some existing drainage problems but future development should provide for adequate drainage.

The Central Nebraska Public Power and Irrigation District has experienced difficulty in supplying water to all their project lands during hot, dry periods. As a result, the system is operated over a longer period and at a higher canal capacity than would be necessary if regulatory storage were available. Seepage losses from the unlined distribution system have aggravated an existing problem of poor drainage. Canal lining, drainage channel construction, and regulatory storage are needed to improve the system's efficiency and make water available for irrigating additional land.

There are several smaller irrigation systems in the Basin which also have high canal losses and could benefit from canal lining. Over much of the area, however, the unreliable surface water supply has caused many irrigators to drill wells for a supplemental supply. This has resulted in a desirable system of conjunctive use which has farily well stabilized the ground water table in most surface water irrigated areas making it unnecessary to improve the efficiencies of these smaller surface water irrigation systems.

Potential Effects. The development included in the Basic Framework will meet most of the needs identified in previous sections.

The economic effects of the development outlined will be both local and regional. Construction associated with the project type developments will provide short range economic benefits. The flood control features will stabilize the agricultural and industrial economy of the Basin and provide relief to the urban areas. Irrigation will stabilize and augment the agricultural economy of both rural and urban areas. Recreation features of multipurpose projects will provide local and regional benefits.

Development of the land projected for irrigation will result in a total irrigated acreage of 1.2 million acres in the Middle Platte River Basin. This is 85 percent of the total land in the Basin classified as suitable for irrigation.

An estimate was made of the amount of depletion due to the projected Basic Framework development. Table 59 shows average annual streamflow depleted for 1970 conditions, estimated reduction by projected in-basin development, including the Mid-State Division, and the remaining streamflow.

The depletions shown are accumulated totals and reflect the total net use of water above the points listed. This includes the depletions from the basins above the Middle Platte (South and North Platte) to the extent that these depletions do not exceed the historic streamflow. The decrease in total Platte River depletions from Overton to Duncan is partly due to this limitation and partly due to anticipated return flows from the Mid-State Division irrigation project included in Basic Framework development.

The remaining streamflow in this Basin appears significant but is not dependable since it is generally composed of irrigation return flows and flood runoff. Large storage reservoirs would be needed to utilize this remaining flow to any appreciable extent.

REMAINING PROBLEMS AND OPPORTUNITIES

Although the flood hazard in the Middle Platte River Basin will be greatly reduced by implementation of structural and nonstructural measures included in this Basic Framework, some problem areas will remain. Continued evaluation of additional measures required to control future flooding in these areas will be needed.

Nearly all remaining land suitable for irrigation in this Basin has been included in this Basic Framework, but there may still be scattered tracts with opportunity for development by individual landowners. Ground water resources are generally ample in most areas of the Basin for additional irrigation development.

Quality of both ground and surface waters may become a problem because of the high proportion of irrigation return flows contained in the low summer flow of the Platte River. Several communities obtain their water supply from aquifers extending under or lying adjacent to the river and these aquifers may be subject to quality impairment by surface flows.

This Basin has an opportunity to develop industrially. Its central location within the State, good transportation network, bountiful ground water resource, and fairly large population all combine to provide a very favorable climate for future industrial development.

Loup River Basin

GENERAL DESCRIPTION

This Basin is located in the center of Nebraska and contains about one-fifth of the state's total area. It extends from the Sandhills of southern Cherry and Sheridan Counties to the Platte River valley near Columbus.

The Basin is comprised largely of rolling hills except for the stream valleys and a few scattered plains remnants. Large expanses of rolling sand hills in the upper end of the Basin gradually change into the loess plains and rolling hills found at the lower end. In the Sandhills area, the surface drainage is poorly defined and sometimes nonexistent. The sand hills are separated by broad flat valleys dotted with marshes and lakes. The drainage pattern improves in the central and lower parts of the Basin, and is well defined in the loess soils.

The rolling Sandhills are a "sea of grass" and form an area that is unique to the State and nation in composition and appearance.

Basin Resources. Soils in the Basin vary from the clean sand of the Sandhills where little soil formation is evident to the loess hills and plains where deep, good quality soils exist. Soils in the stream valleys are suitable for irrigation and are quite productive.

Only about one-third, or three million acres, of the agricultural lands in the Loup River Basin are classified as arable, or suitable for cultivation. About two million acres of these arable lands are classified as suitable for irrigation.

The average annual precipitation varies from about 17 inches in the western end of the Basin to 24 inches in the east. Most of the cultivated area receives 21 inches or more, but the distribution during the growing season is not always conducive to good crop production.

The surface water resources of this Basin are quite extensive. All the principal streams originate in the Sandhills where they are fed by a vast ground water reservoir. The streams in the upper Basin are among the steadiest flowing in the world. However, runoff in the lower reaches of the Basin is affected by the hardland characteristics. High intensity rainfall coupled with low soil permeability and steep slopes produce high flood flows in this portion of the Basin.

Natural streamflow is altered by diversions for irrigation and for hydropower developments.

Sandhills streams carry large quantities of sand as bedload. This bedload is accompanied by suspended loads of silt in the lower stream reaches.

The amount of ground water in storage in the Loup River Basin surpasses any other basin in the State. The Sandhills Region is underlain by permeable, saturated deposits as much as 700 feet thick. These aquifers yield large quantities of water to wells and to the major streams that tap them.

The eastern portion of the Basin is underlain by water bearing deposits which grow thinner in an eastward direction. Most of these aquifers, except those in some of the plains and valleys in the southeast corner of the Basin, yield water in sufficient quantities for all uses.

Sand and gravel deposits are widespread throughout the Basin and some have been developed for use in construction and road surfacing.

Timber resources are scattered and relatively minor in the Basin. The Bessey Division of the Nebraska National Forest is located near Halsey, but a significant portion was gutted by fire in 1965 and sustained considerable damage.

Fish and wildlife resources are of major importance in the Basin. The steady flowing streams in the upper reaches of the Sandhills provide a good cold water fishery. The extensive areas of lakes and marshes provide important habitat for ducks and geese, and deer are found in most of the stream valleys. Prairie grouse are abundant in the Sandhills area while other species of upland game birds and small game are widespread throughout the transition area between the lower Sandhills and the loess plains and hills.

Existing Development. Surface water irrigation has been practiced by individuals and groups in the Basin for several decades.

Surface water irrigation projects were first constructed by two local districts. The North Loup River Public Power and Irrigation District irrigates about 30,000 acres from three canals diverting at three different locations on the North Loup River. The Middle Loup Public Power and Irrigation District supplies water for about 25,000 acres served by four canals diverting from the Middle Loup River at two locations.

Federal irrigation projects in the Basin are the Sargent and Farwell Units of the Missouri River Basin Project. The Sargent Unit utilizes water diverted from the Middle Loup River near Milburn to irrigate about 13,000 acres on the north side of the river in Custer County. Water for the Farwell Unit is diverted from the Middle Loup River near Arcadia and stored in Sherman Reservoir, an off-stream structure with a capacity of 66,000 AF. Three canals then convey water to 48,000 acres in Howard and Sherman Counties.

The northwestern two-thirds of the Basin is rolling Sandhills rangeland used for pasture and native hay. The lower portion is mostly cultivated, particularly in the flat stream valleys and loess plains. Irrigation practiced in the lower one-third of the Basin is gradually spreading to the valleys of the upper Sandhills portion. Altogether, about 390,000 acres are presently irrigated in this Basin.

The economy of the Basin is closely linked to agriculture. Most industry is agriculturally oriented and is primarily located in Columbus. The city of Columbus has long been a leader in the development of small to medium sized industries contributing towards mechanized agriculture. Columbus, with a population of 12,500 in 1960, is the largest city in the Basin. Only one other community, Broken Bow, has more than 3,000 people.

Livestock production is the biggest industry in the Basin. Custer County is the second largest calf producing county in the State.

The Loup River Public Power District diverts Loup River water near Genoa through a canal to two hydroelectric plants located near Monroe and Columbus. After being used to produce power, this water flows into the Platte River just below Columbus. The combined capacity of the two power plants is 48 megawatts.

Several state special use and wayside areas have been developed at scenic locations within the Basin. Other recreational opportunities are available at Sherman Reservoir, Milburn and Arcadia Diversion Dams, along the Loup River Public Power District canal, and along scenic reaches of several streams.

PROBLEMS AND NEEDS

Flooding is a problem in the lower portions of the Basin. The shape and location of the Basin, with the hardland tributaries at the narrow end, tend to concentrate the high runoff flows near the lower end of the Basin. Flooding in the upper Basin is practically nonexistent because of the permeable properties of the Sandhills.

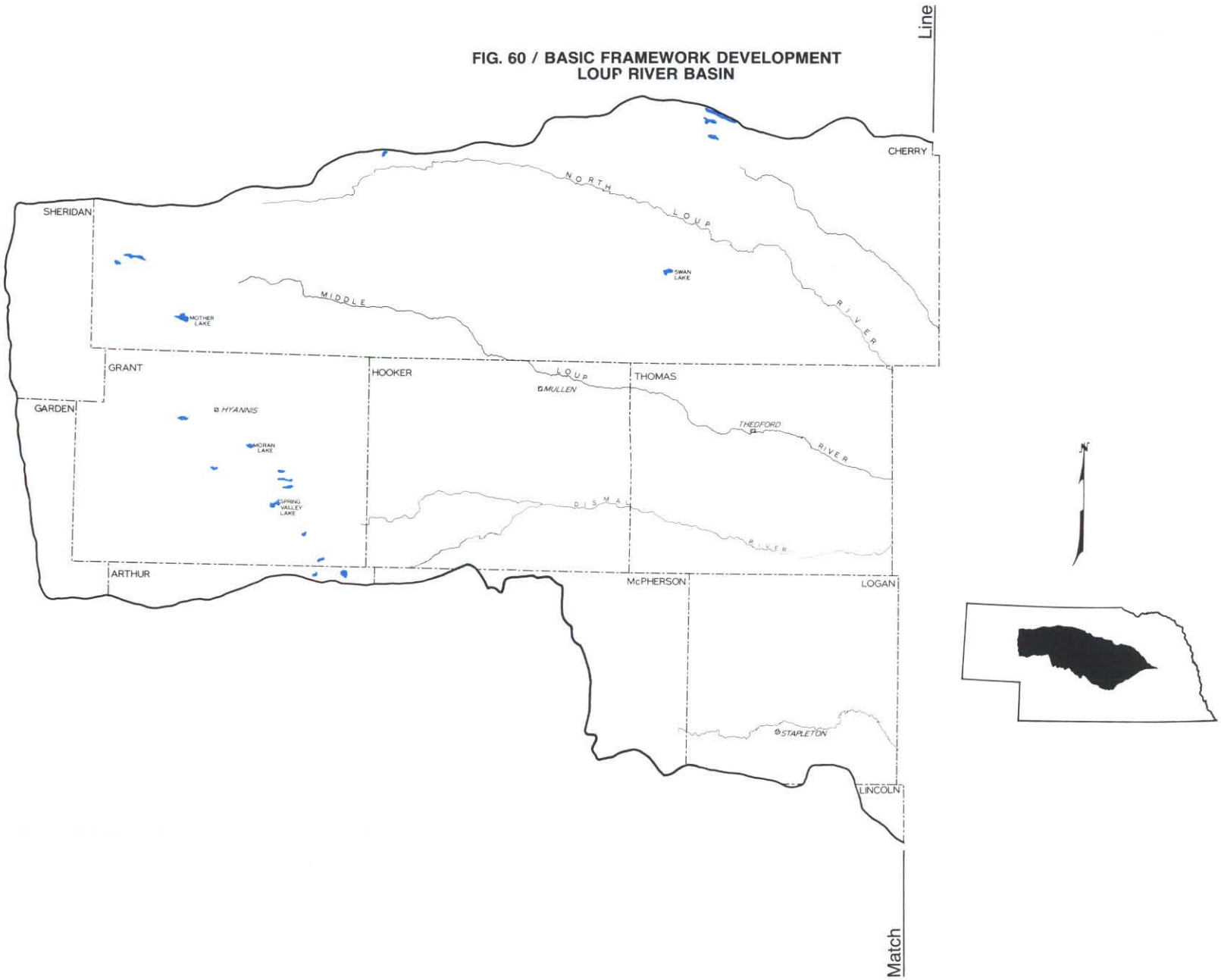
The Basin's most damaging flood occurred in August, 1966. Agricultural cultural damage was widespread and the communities of Fullerton, Columbus, St. Edward, Cedar Rapids, and Wolbach were extensively damaged. Columbus has suffered extensive damage at other times in the past.

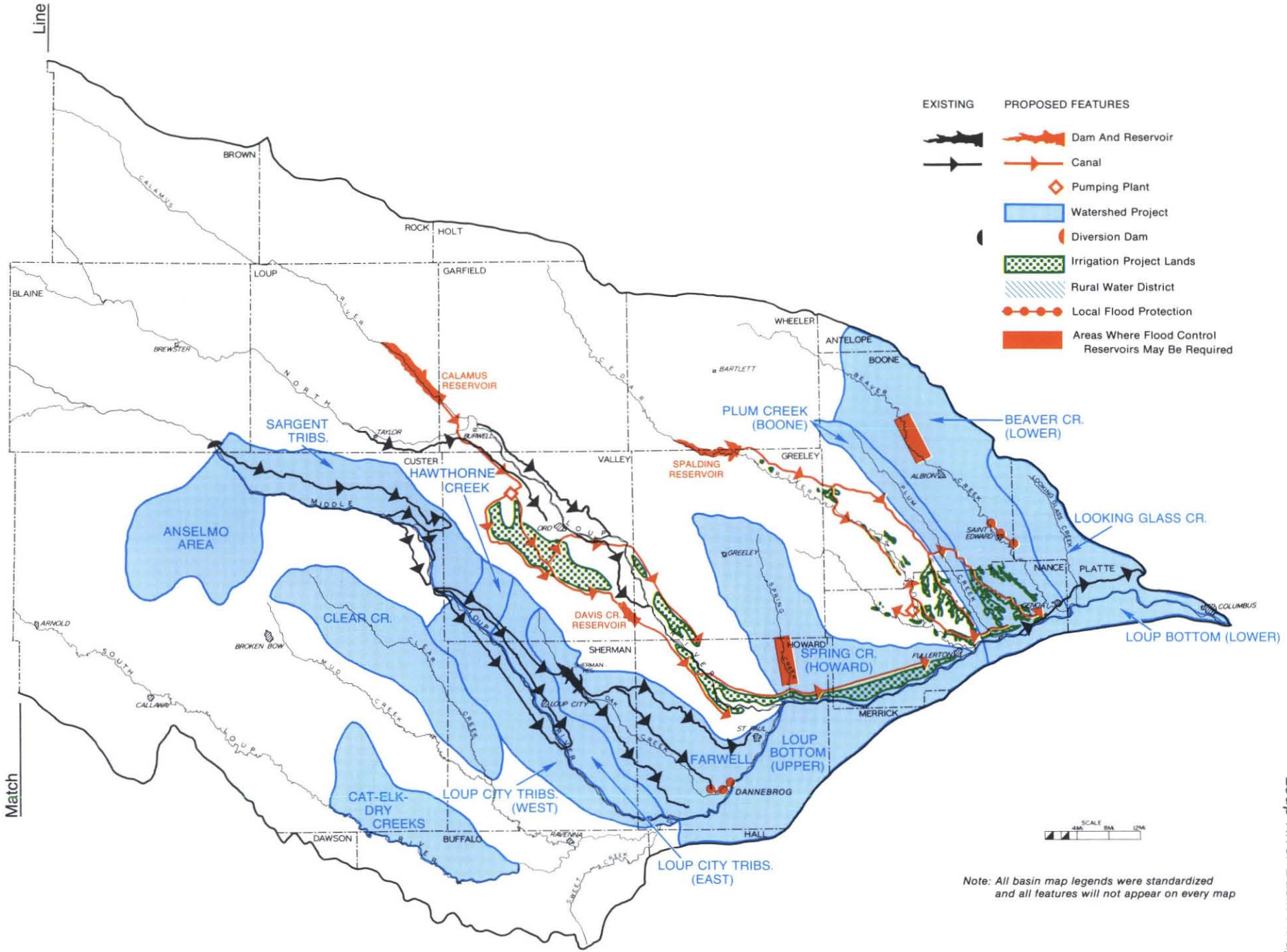
Wind erosion is a potentially serious problem in the Sandhills. As long as adequate grass cover is maintained, wind erosion presents little problem, but when the grass cover is removed blowouts can cause widespread, practically irreparable damage to large areas. As sprinkler irrigation systems move deeper into the Sandhills, extreme caution will be required to insure that adequate soil cover is provided at all times.

The need for drainage in some areas in the Farwell Unit is now becoming more readily apparent. In these areas the ground water table has been rising significantly in the past few years.

An inventory in July, 1969, showed there were eight communities in the Basin without sewer systems and five others which had only primary treatment plants. Four of these communities must provide secondary treatment of their waste discharges in order to comply with the water quality

FIG. 60 / BASIC FRAMEWORK DEVELOPMENT
LOUP RIVER BASIN





Note: All basin map legends were standardized and all features will not appear on every map

standards adopted by the Water Pollution Control Council. Three communities now providing secondary treatment must improve their facilities to meet the standards.

Estimates made by the Nebraska Game and Parks Commission show that there will be need for additional recreation water surface area in the lower part of the Basin to satisfy future demands created by Grand Island and Columbus.

BASIC FRAMEWORK DEVELOPMENT

The development projected for this Basin will aid in meeting the needs identified earlier and appears to present reasonably full development during the planning period.

Independent Local Development. The amount of future independent local development will depend upon the needs which arise and the economic conditions prevailing. Water supply estimates include provision for projected increases in rural and municipal water use. Livestock numbers are projected to increase with a resultant increase in water requirements. Additional land treatment measures were anticipated to meet the need for soil conservation.

Municipal and Industrial. The Basin's urban population is expected to increase by about 15 percent to nearly 50,000 by 2020. The amount of water required to meet the demands of this population is shown in Table 60. The estimate of increased municipal requirements is based on the population increase, an increase in the per capita use rate and an industrial reserve of 80 gpcd. The water requirement for private industrial systems is also shown in Table 60. Both municipal and private industrial requirements can and probably will be supplied by expansion of existing ground water development.

Rural Domestic and Livestock. An increase in rural domestic use is expected because of additional household water using facilities. The ground water resource is ample to provide for this additional demand.

Increased livestock numbers will cause livestock water requirements to nearly triple and total about 46,000 acre-feet by 2020. This is the largest amount included for livestock water use in any basin in the State. The demand will be met mainly from ground water with some additional construction of livestock watering ponds.

Irrigation. Privately developed irrigated acreage is expected to increase by about 540,000 acres during the planning period. All is expected to be irrigated with ground water pumped from individually developed wells. Much of this land is located on the tablelands between the streams in the lower portion of the Basin, but some lands scattered throughout the valleys are included in the projected total. Also, a substantial part of this area, 150,000 acres, was projected to be developed for ground water irrigation within the Sandhills. This development has just begun and no conclusive results of the effects are available, so it is difficult to predict how widespread this practice will become.

TABLE 60 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Loup River Basin

Subbasin	Municipal Systems				Private a/ Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020 b/	Present	2020
North Loup River						
Burwell to Mouth	4,890	3,550	490	800	0	0
Middle Loup River						
Above Dunning	1,580	1,000	230	300	0	0
Dunning to Arcadia	1,535	890	160	200	0	0
Arcadia to St. Paul	2,685	1,530	440	400	0	0
South Loup River	8,480	9,190	1,420	2,600	120	600
Loup River						
St. Paul to Genoa	4,600	3,170	580	700	0	0
Cedar River	1,740	1,165	200	300	0	0
Genoa to Mouth	17,290	29,100	2,370	5,300	290	3,600
BASIN TOTAL	**42,800**	**49,595**	**5,890**	**10,600**	**410**	**4,200**

a/ *Includes cooling water requirements for existing thermal electric plants*
b/ *Includes projected industrial reserve*

TABLE 61 / PROPOSED MULTIPURPOSE PROJECTS
Loup River Basin

Project	Purposes a/	Reservoir	Initial Capacity (1000 AF)	Surface Area b/ (Acres)	Area Irrigated (Acres)
North Loup Division	I, R, FW	Calamus	108.6	4,600	52,570
		Davis Creek	22.4	800	
Cedar Rapids Division	I, R, FW, FC	Spalding	81.4	3,600	26,800

a/ *I—Irrigation, R—Recreation, FW—Fish and Wildlife, FC—Flood Control*
b/ *Area at top of conservation pool*

Public Project Development. Several multipurpose public projects are expected to be developed in this Basin. Two large projects providing irrigation, recreation, and fish and wildlife benefits are included in the Basic Framework along with several small watershed projects with flood control, recreation, and fish and wildlife functions. Two single purpose local flood protection projects are also expected to be constructed. The locations of these various projects are shown on Figure 60. Two general locations on Spring and Beaver Creeks where additional flood storage reservoirs may be required are also shown. There has been no recent investigation of these areas, but reservoirs may be necessary in the future to control flood flows from these streams currently causing considerable damage.

North Loup Division. The North Loup Division of the Missouri River Basin Project has been proposed for irrigation of areas along the North Loup and Loup Rivers in Valley, Greeley, Howard, and Nance Counties. The project includes two storage reservoirs with combined capacity of about 130,000 AF, pumping plants, and canal distribution systems to supply irrigation water to 52,570 acres. Calamus Reservoir, on the Calamus River northwest of Burwell, and Davis Creek Reservoir, an off-stream storage facility south of the town of North Loup, together will provide about 5,400 acres of water surface area that can be developed for recreation and fish and wildlife values. Project investigations have progressed through feasibility studies and the project is now awaiting Congressional authorization for construction. Field hearings were conducted by a Congressional subcommittee in July, 1970.

Cedar Rapids Division. This proposed project would develop waters of the Cedar River, a tributary of the Loup River, for irrigation of land in Greeley, Boone, and Nance Counties. Project features include a storage reservoir on the Cedar River near Spalding, a diversion dam near Belgrade, and the necessary distribution system to serve 26,800 acres in the Cedar River valley and on tablelands on both sides of Plum Creek.

The capacity of Spalding Reservoir will be about 46,000 AF. The reservoir surface area, about 3,600 acres, will provide opportunities for recreation and fish and wildlife development. Small amounts of flood benefits can also be obtained by incidental storage of floodwaters. Investigation of the project has progressed through the preparation of a favorable feasibility report.

Table 61 provides information about these two projects.

Small Watershed Projects. Fourteen small watershed projects appear to have potential for development in the planning period. These projects will provide a total of 58,500 AF of flood control storage. All of the projects would provide flood protection to rural areas and three will also provide urban flood control benefits. The surface area available for recreation opportunities will be about 4,500 acres. One project has been investigated in detail and the rest were investigated during the MRB Study at reconnaissance level. Some general information relative to these projects is shown in Table 62.

Local Flood Protection. Single purpose local flood protection projects have been included for two communities, St. Edward and Dannebrog. St. Edward has been damaged by the flows of Beaver Creek, most recently in August, 1966. Damage to Dannebrog has occurred from flood flows of Oak Creek.

Nonstructural Measures. Flood plain management can be a useful tool in preventing and reducing future flood damages in this River Basin.

Flood plain delineation studies and development regulations are needed especially in the lower part of the Basin. Upstream floodwater storage sites are severely limited and far removed from the flooded areas. Regulation of development in the flood plain to provide for uses which are least susceptible to flood damage offers the most logical

TABLE 62 / POTENTIAL SMALL WATERSHED PROJECTS
Loup River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
Hawthorne Creek	31	18	3,300	530	8
Potentially Feasible					
Cat-Elk-Dry Crs., Clear Cr., Loup City Tribs (East), Farwell, Plum Cr. (Boone), Beaver Cr. (Lower), Lookingglass Cr.	1,478	Not Known	55,200	4,000	72
Anselmo Area, Sargent Tribs, Loup Bottom (Upper), Spring Cr. (Howard), Loup Bottom (Lower), Loup City Tribs (West)	1,265	None	None	None	178

a/ *Based on completed Work Plans or Preliminary Investigations*

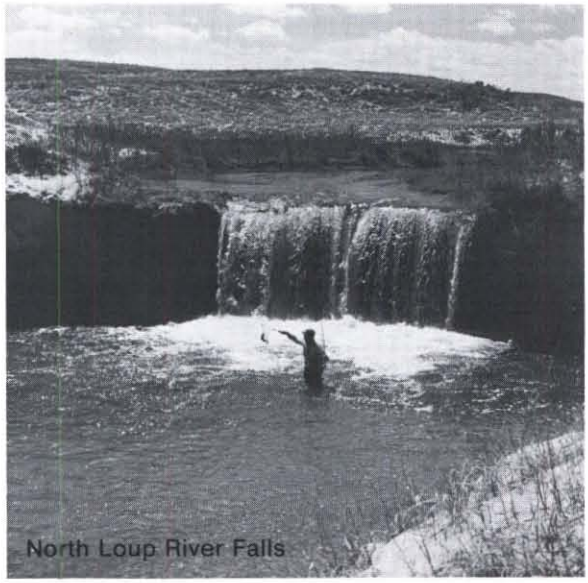
method of reducing future flood damages.

A local flood protection project at the city of Columbus is presently under construction. The city also has a flood plain delineation report available and through implementation of flood plain zoning could ensure proper development of the flood plain in the future, thereby reducing potential future damages.

Broken Bow is also constructing a local flood protection project. Completion of a flood plain delineation study and implementation of a flood plain management program should be undertaken there as soon as possible.

Considerable interest has been expressed in protecting certain river reaches in the upper tributaries of the Loup River Basin to preserve the natural qualities of the streams and prevent any action which would tend to alter or despoil them. These areas in the upper reaches of the North Loup, Middle Loup, and Dismal Rivers should be given further consideration for inclusion in a system of state or national protected rivers. The areas to be considered for inclusion are shown on Figure 48.

Modification of Existing Development. The Middle Loup and North Loup River Public Power and Irrigation Districts have indicated a need for canal lining to reduce seepage. The seepage is not particularly detrimental but the loss creates a water shortage during hot, dry periods. They have also considered storage to supplement low flows and, although not included in the Basic Framework, it could be incorporated if required at some future time.


North Loup River Falls

Some stream channels in this Basin have become partially clogged with trees, brush, and debris. One factor contributing to this problem is the development of water storage and diversion structures upstream which can greatly change the channel regime by reducing flows which would normally scour the channel downstream. One reach of stream which is particularly in need of clearing is the Loup River from the power diversion dam near Genoa to the mouth.

Potential Effects. Water resources development, both independent and public project, included in this Basic Framework will satisfy local needs and provide varied benefits. Some of these benefits in the form of economic boosts may be only temporary and eventually adverse, however, if future consequences of farming development in the Sandhills are not carefully considered beforehand.

Increased utilization of the water resources of the Basin will help boost local economies. The large amount of irrigation development anticipated and increased livestock production will require additional manufacturing and services to provide the necessary commodities for this increased production and to process the greater abundance of farm produce made possible. Irrigation development and the many structural and nonstructural flood control measures planned will tend to stabilize economies at a higher level by preventing periodic losses associated with droughts and floods.

The flood protection provided by small watershed structures, local flood protection projects, and flood plain regulation will improve the environment of the Basin by preventing blighted areas from developing in periodically damaged urban areas, by reducing erosion of the land surface and streambanks in rural areas, and by decreasing the sediment content in streams. Improved treatment of municipal wastes will further improve the quality of streams for fish and wildlife and for recreational purposes. Preservation of the scenic and unique qualities of the major Sandhills rivers through a system of protected rivers will have a particularly favorable influence on the environment and the quality of life, both on local and national levels, and provide recreational opportunity to satisfy increasing demands.

Table 63 shows the streamflow reduced for 1970 conditions, estimated net depletion due to potential in-basin development, and the streamflow remaining.

REMAINING PROBLEMS AND OPPORTUNITIES

Construction of the flood prevention projects under the small watershed program will not eliminate all flooding problems. Additional flood storage reservoirs on tributaries such as Spring and Beaver Creeks should be investigated.

Sediment deposition around and in water control structures has been and will continue to be a problem. The large bedloads carried by streams in this Basin make sediment deposition difficult to control. Additional erosion prevention measures to reduce the silt and sands produced in the lower Basin would reduce the total amount of sediment entering future water storage structures.

Even after in-basin development included in the Basic Framework is completed, there will be considerable amounts of surface water in lower reaches of the Loup River and its tributaries that is not developed for consumptive use, as shown in Table 63. Additional lands are also available for irrigation development in these lower reaches though there is little interest currently in such development. The opportunity will exist in the future to develop this water for irrigation, but economic conditions and needs will undoubtedly determine the extent to which this development takes place.

TABLE 63 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT

Stream Location	Loup River Basin 1000 Acre-Feet Annually: Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Middle Loup River at Dunning	285.9	1.0	284.9
Dismal River at Dunning	236.5	0.8	235.7
Middle Loup River at Arcadia	470.1	16.8	453.3
South Loup River at St. Michael	161.8	71.9	89.9
Middle Loup River at St. Paul	563.9	96.1	557.8
Calamus River at Burwell	227.6	95.7	131.9
North Loup River at Taylor	348.1	0.9	347.2
North Loup River nr. St. Paul	677.5	90.9	586.6
Loup River nr. Genoa [a/]	325.2	232.8	92.4
Loup River at Columbus [a/]	424.8	256.5	168.3

a/ *Does not include Loup Power diversions of approximately 1 to 1.25 million afa*

Note: Based on average annual streamflow during the period 1954-63

Elkhorn River Basin

GENERAL DESCRIPTION

The Elkhorn River rises in the northern part of the eastern Sandhills and flows southeastward through the rolling loess hills to join the Platte River about 30 miles upstream from its confluence with the Missouri River. The basin formed by the Elkhorn River drainage encompasses about 10 percent of the state's area.

Its topography varies from the Sandhills on the west to the dissected loess plains and rolling hills occupying much of the central and eastern portions of the Basin. The drainage pattern is well defined except in the Sandhills and in the flat Elkhorn River valley in the eastern portion of the Basin.

The Sandhills are mostly covered with native grass except for those areas in the valleys and swales which are cultivated. The remainder of the Basin is productive cropland under intense cultivation.

Basin Resources. Over 75 percent of the agricultural land in the Basin is classified as arable. The soils are deep and fertile throughout much of the eastern portion of the Basin. About 2.3 million acres, or 68 percent of the arable lands, are classed as suitable for irrigation. These figures do not include lands in the Sandhills area which were classified as not suitable for irrigation but are now being developed with sprinkler systems.

Average annual precipitation varies from about 20 inches in the upper Basin to 28 inches in the lower Basin. In the lower Basin, rainfall is generally adequate for most crops grown, but in many years supplemental irrigation supplies would improve yields and insure against crop failure.

Streamflow in the upper Basin originates partially from ground water which provides a steady base flow to the stream. In the lower part of the Basin, streamflow varies considerably because of more rugged topography and tighter soils which produce more rapid runoff and less infiltration to ground water.

Ground water supplies vary across the Basin. In the west, the Sandhills and dissected plains are underlain with permeable deposits that yield moderate to large amounts of water adequate for irrigation. In the east, wells in the glacial drift yield small supplies and it is often necessary to drill deep to the Dakota Sandstone or find buried valleys filled with water-bearing sand and gravel in order to develop satisfactory wells.

The fishery resources of the Basin consist of warm water species. The Basin possesses almost all types of game birds and animals because of the wide diversity of habitat available. Lakes and marshes provide habitat for waterfowl while stream valleys with their timber cover offer habitat for small game and deer. The cultivated valleys and uplands abound with upland game birds while the Sandhills offer grouse.

Existing Development. Water resource development in the Basin has consisted mostly of individual efforts in the areas of land treatment, irrigation, and drainage.

Flood protection projects have been completed at Norfolk, Waterloo, West Point, Clarkson, Madison, Hooper, and Pierce. Most of these include levees with some associated channel improvement.

One small watershed project has been constructed near Pilger to provide flood protection for the community and a small adjacent area of agricultural lands.

The upper portion of the Basin is Sandhills rangeland, mostly covered with native grasses. The central portion is a transition area where the dune-sand intermingles with the loess found in the east. The land use here is divided between grassland and cultivated cropland. The lower part of the Basin, containing mostly loess soils, is almost entirely devoted to cultivated cropland with some woodlands along the streams where drainage is poor.

The major crops grown are corn, sorghum, and soybeans. Extensive livestock feeding is carried on in the lower portion of the Basin. Cuming County is the leading cattle feeding county in the State with nearly 10 percent of the total number of cattle fed. It also leads the State in the number of hogs raised.

Irrigation is not practiced extensively in this Basin because of the usually favorable precipitation in the lower portion of the Basin. However, irrigation has been developing rapidly in the Sandhills area. About 150,000 acres, or about 7 percent of the total lands classified as suitable for irrigation, are irrigated in the Basin.

The economy of the Basin is mainly dependent upon agriculture. There is one city in the Basin, Norfolk, with a population over 10,000. Fremont, which also has a population over 10,000, is located on the Basin boundary. Norfolk, near the center of the Basin, is the transportation hub and the main trade and commercial center. Industry in the Basin is generally confined to manufacturing items needed by agriculture and processing agricultural products.

Existing recreation development is generally limited to the local community parks and state wayside and special use areas.

PROBLEMS AND NEEDS

Floods are always a threat in the Elkhorn River Basin. A damaging flood occurs somewhere in the Basin nearly every year. The estimated average annual damage of 3.4 million dollars is the largest for any basin in Nebraska. The most damaging flood occurred in 1944, when approximately 125,000 acres were flooded, numerous roads and railroads were washed out, and 17 communities were flooded. The total damage in that flood was $6,800,000. A flood in 1940 was less damaging to property than the one in 1944, but it took an even heavier toll in lives, when five persons died.

Ice jams during spring breakup periods are quite prevalent and contribute heavily to the flooding problems in the Basin.

Streambank erosion is a serious and continuing problem along some reaches of the Elkhorn River, Logan Creek, and Union Creek. In some instances, this problem has been increased by local attempts to straighten the stream channels. On Logan and Union Creeks, such projects have started an erosion process that has destroyed bridges and adjacent farm land.

The surface water supply for irrigation is often limited in the late summer months because of a lack of precipitation and resultant low runoff. This has not yet caused any serious problems but with the increase in irrigation expected, regulation storage may be needed in the future.

In 1969, the sewage treatment facilities of 64 communities in the Basin with a combined 1960 census population of over 80,000 were surveyed by the Nebraska Department of Health. Nine of these 64 communities, with populations varying from 26 to 378, had no sewer systems. Of the remaining 55 communities, one provided no treatment of wastes and 13 others provided only primary treatment. Nineteen systems, serving 60 percent of the Basin population, need improvement to meet state standards for water quality and waste treatment.

Runoff from large confined feedlots is becoming a source of serious water pollution in this Basin. Continued research to determine the measures required to control pollution from feedlot runoff is needed.

At the present time, the total fisheries capacity in the Basin just about equals the total use; but the lower Basin near Omaha is crowded beyond capacity, whereas resources in the upper Basin are not used to capacity. This problem is expected to intensify in the future as the demand in the lower Basin increases. The same problem exists for other types of water based outdoor recreation activity.

The Elkhorn River from the mouth of Clearwater Creek to Bell Creek has special significance for fisheries, wildlife, and outdoor recreation. A special effort is needed to preserve and enhance its value for these purposes.

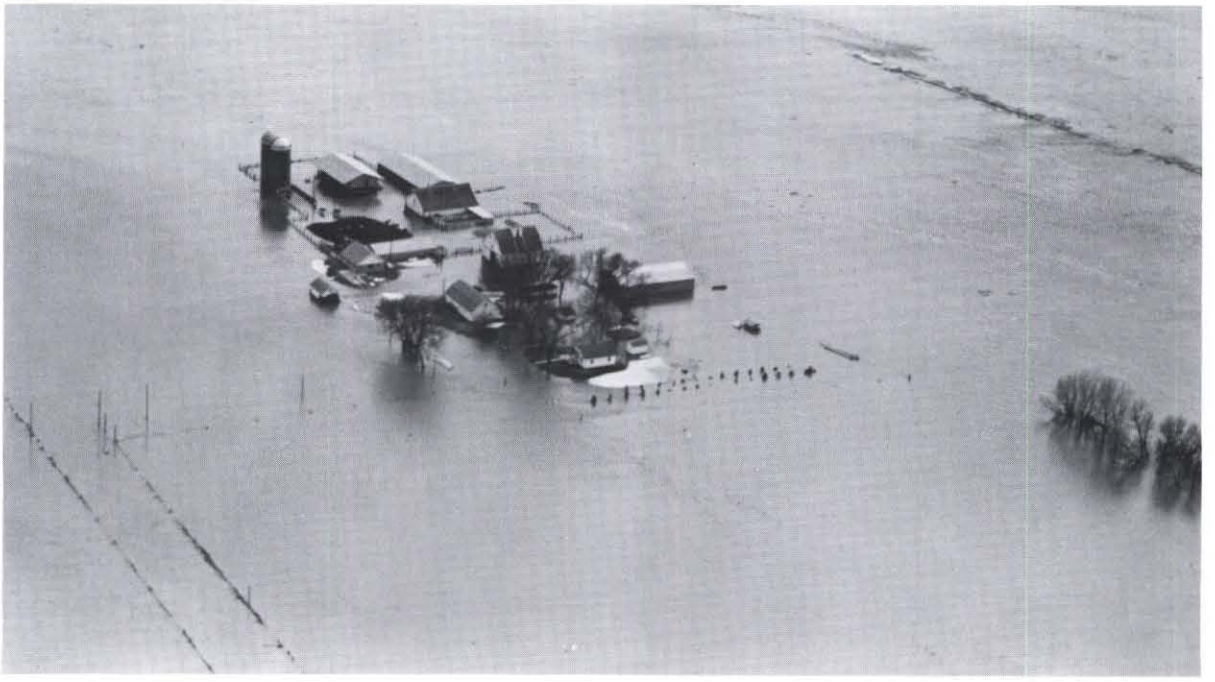
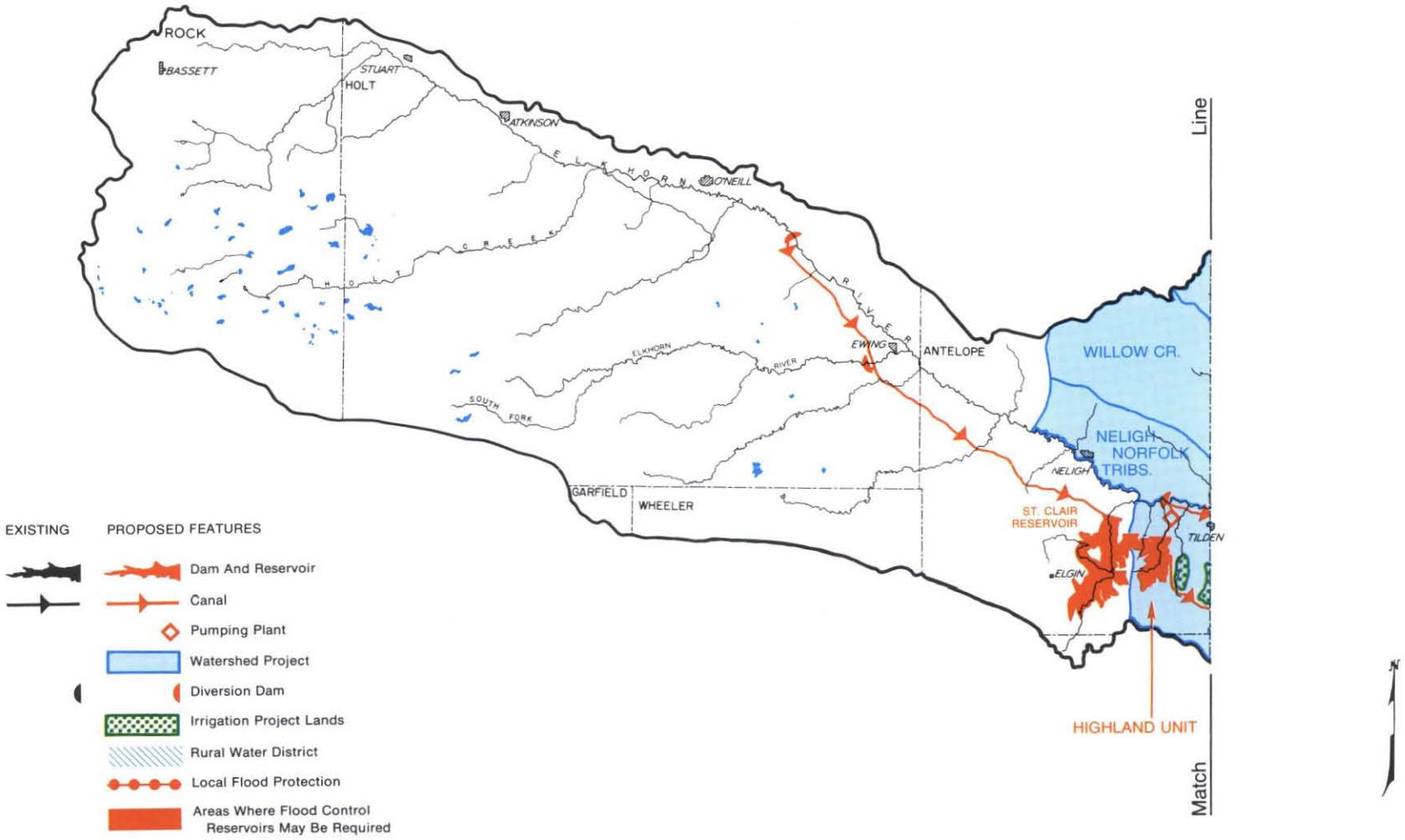
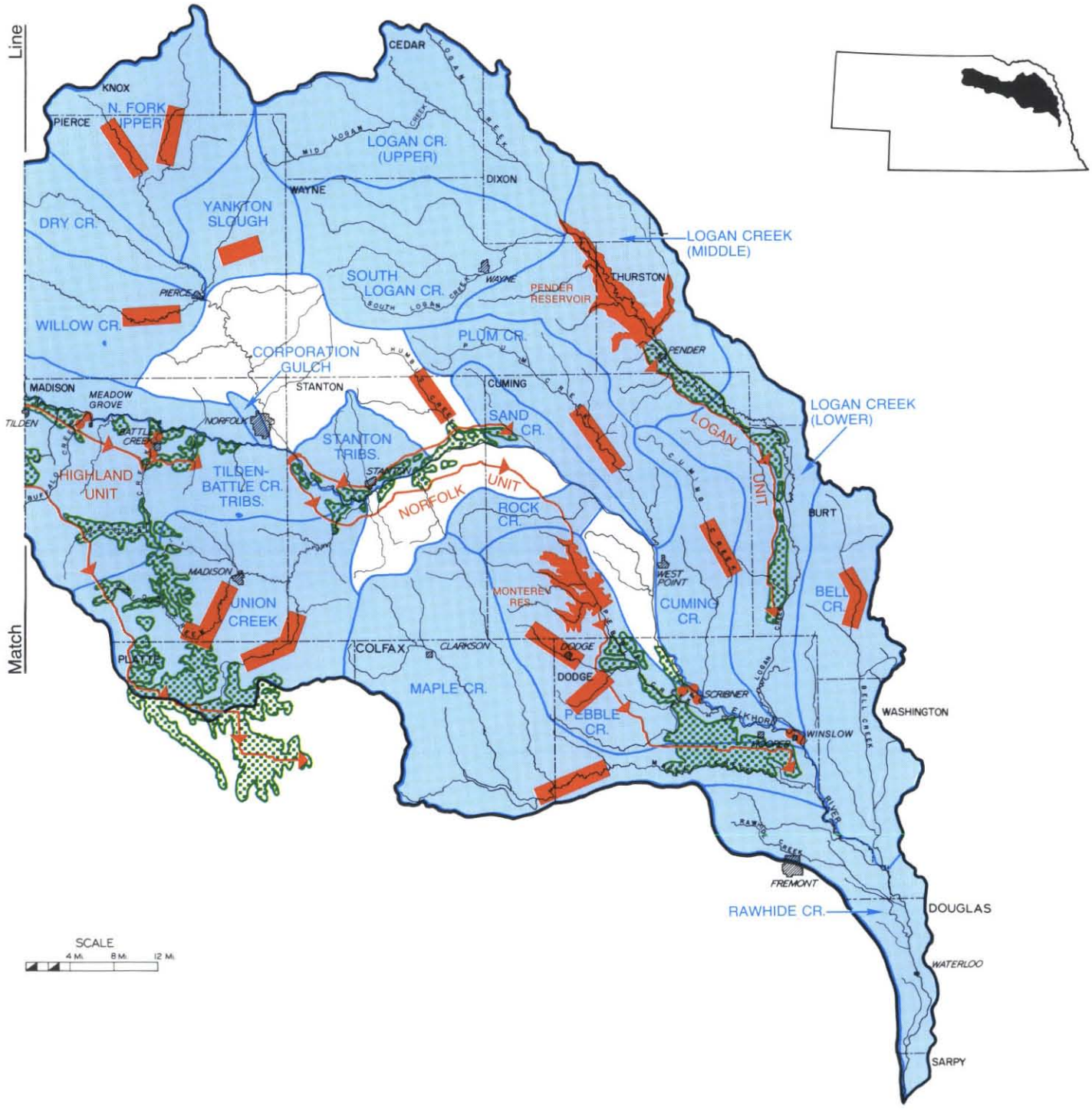


FIG. 61 / BASIC FRAMEWORK DEVELOPMENT
ELKHORN RIVER BASIN



Note: All basin map legends were standardized and all features will not appear on every map


Line
Match
CEDAR
KNOX
PIERCE
N. FORK UPPER
LOGAN CR. (UPPER)
DIXON
WAYNE
YANKTON SLOUGH
DRY CR.
LOGAN CREEK (MIDDLE)
SOUTH LOGAN CR.
THURSTON
PENDER RESERVOIR
PIERCE
WILLOW CR.
PLUM CR.
PENDER
CORPORATION GULCH
MADISON
MEADOW GROVE
STANTON
CUMING
TILDEN
NORFOLK
SAND CR.
LOGAN CREEK (LOWER)
LOGAN
STANTON TRIBS.
HIGHLAND UNIT
TILDEN-BATTLE CR. TRIBS.
NORFOLK
UNIT
ROCK CR.
BURT
WEST POINT
MONTEREY RES.
CUMING CR.
BELL CR.
MADISON
UNION CREEK
COLFAX
CLARKSON
DODGE
PLATTE
MAPLE CR.
SCRIBNER
PEBBLE CR.
WINSLOW
WASHINGTON
FREMONT
RAWHIDE CR.
DOUGLAS
WATERLOO
SARPY
SCALE
4 Mi. 8 Mi. 12 Mi.

BASIC FRAMEWORK DEVELOPMENT

The development outlined in the Basic Framework is that which appears likely and reasonable during the planning period to meet the needs identified.

Independent Local Development. Projected independent local development includes municipal, industrial and rural development of water resources and other developments, such as land treatment for conservation of soil, which indirectly affect the amount of water available for other uses. The extent of development will depend on future needs and the economic climate prevailing.

Municipal and Industrial. The urban population of the Elkhorn River Basin is expected to increase from 83,000 in 1960 to 120,000 in 2020. Additional municipal water supplies can and will be developed from ground water. Present estimated municipal and industrial use in the Basin is 20,000 afa and is expected to increase to about 49,000 afa by 2020. Table 64 shows projected municipal and industrial water requirements for the Basin.

Rural Domestic and Livestock. Rural domestic water use in the Basin will increase from almost 3,700 afa presently to about 4,800 afa in 2020 as more pressure systems and modern water using facilities are introduced into farm homes. This increased use can be supplied by ground water development. Livestock water use is expected to increase to about 45,000 afa by 2020 as compared to a present use of slightly more than 16,000 afa. Additional livestock water demands can be met from ground water.

Irrigation. Future private irrigation development is expected to be mainly from ground water. Ground water irrigation development for 300,000 acres of additional land is projected for the planning period. About half of these lands are in the stream valleys and the other half are scattered through the Sandhills. The latter fall into the same category as those in the Loup Basin and close surveillance of the effects of irrigation will be required.

Additional individual development of surface water for irrigation will be quite minor. New surface water irrigation appropriations are expected to be minimal with most new permits to divert water replacing abandoned or cancelled rights.

Public Project Development. The U.S. Bureau of Reclamation, Corps of Engineers, and Soil Conservation Service have studied this Basin in varying degrees for water development and control projects. It appears that there is adequate in-basin surface water supply for development of three multipurpose projects investigated by the USBR. An integrated flood control and watershed protection program was partially formulated by the SCS and Corps of Engineers as a result of the MRB Study. In addition, local flood protection projects appear to be feasible for three communities. The locations of the various projects are shown on Figure 61.

Highland Unit. This potential project would provide water to irrigate 55,500 acres in Platte, Madison, and Antelope Counties. Water would be diverted from the Elkhorn River near Emmet and South Fork Elkhorn River near Ewing and stored in

TABLE 64 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Elkhorn River Basin

Subbasin	Municipal Systems				Private a/ Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020 b/	Present	2020
Elkhorn River						
Above Ewing	6,725	8,370	930	2,200	0	0
Ewing to Norfolk	5,885	4,160	995	1,000	0	0
North Folk Elkhorn River	19,535	27,080	2,970	8,300	1,260	3,430
Logan Creek						
Above Pender	9,770	12,410	1,380	2,900	120	400
Pender to Mouth	3,435	2,100	570	600	0	0
Elkhorn River						
Norfolk to Mouth	37,627	4,730	6,070	19,200	5,190	11,170
BASIN TOTAL	**82,977**	**58,850**	**12,915**	**34,200**	**6,570**	**15,000**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

TABLE 65 / PROPOSED MULTIPURPOSE PROJECTS
Elkhorn River Basin

Unit	Reservoir	Purposes a/	Total Initial Cap. (1000 AF)	Surface Area b/ (Acres)	Flood Control Storage (1000 AF)	Area Irrigated (Acres)
Highland	St. Clair	I, R, FW	310.0	9,600	0	55,500
Norfolk	Monterey	I, R, FW	211.1	7,300	0	33,000
Logan	Pender	I, R, FC, FW	246.1	7,750	136.0	11,700

a/ I—Irrigation, FC—Flood Control, R—Recreation, FW—Fish and Wildlife
b/ Surface area at the top of conservation pool

an off-stream reservoir, St. Clair, near Neligh. Water from this reservoir would be supplemented by water diverted from the Elkhorn River near Tilden and distributed to the irrigable lands in the valley above Norfolk and on the tablelands near Madison and Humphrey. Besides irrigation, benefits would be derived from recreation development and fish and wildlife enhancement. The surface area and water volume available for recreation and fish and wildlife uses are shown in Table 65.

A reconnaissance study of the Basin has been completed by the Bureau of Reclamation and this project was identified as potentially feasible. Additional investigation will be necessary to determine the economic feasibility of the project.

Norfolk Unit. This potential project would include features for the purposes of irrigation, recreation, and fish and wildlife enhancement. Water would be diverted from the Elkhorn River below Norfolk and stored in Monterey Reservoir on Pebble Creek. Release from the reservoir and diversions from the river would supply water for 33,000 acres of land located along the Elkhorn River in Stanton and Cuming Counties and on the uplands between Pebble and Maple Creeks in Dodge County. Additional information about the project is shown in Table 65.

As with the Highland Unit, the USBR reconnaissance study of the Basin identified this project as potentially feasible. Additional investigation will be required to determine the economic feasibility of the project.

Logan Unit. This potential project would include features for the purposes of irrigation, recreation, flood control, and fish and wildlife enhancement. Unlike the other two projects already discussed, this project would include specific flood control storage.

Water would be stored in Pender Reservoir on Logan Creek where about 7,500 acres of water surface area would be available for recreation and fish and wildlife uses. Water developed would be used for irrigation of 11,700 acres in Logan Creek valley in Cumming and Burt Counties. Additional information about the project is shown in Table 65.

This project was also identified during the USBR reconnaissance study of the Basin. Additional study will be required to determine economic feasibility of the project.

Small Watershed and Flood Control Projects. Additional multipurpose development has been proposed to control runoff from the small watershed areas in the Basin. An integrated flood and erosion control plan partially developed by the Corps of Engineers and the Soil Conservation Service during the MRB Study will provide about 250,000 AF of flood control storage by means of a combination of small watershed type structures and flood control reservoirs. The locations of 21 small watershed project areas and 13 locations where additional flood control reservoirs may be required are shown on Figure 61. The total surface area available for recreation and fish and wildlife uses would be about 15,000 acres.

One of these watershed projects, Corporation Gulch near Norfolk, is ready for construction upon completion of the final design. A reservoir will provide flood protection for Norfolk and recreational opportunities for residents of the area. The important characteristics of this small watershed project along with information about the other 20 potential small watershed projects included in the Basic Framework are shown in Table 66.

The flood control reservoirs which are being considered by the Corps of Engineers are the result of an initial blending of small watershed projects and larger flood control storage reservoirs. The combined storage of the Corps structures would be about equal to that of the small watershed reservoirs. Additional study may show that additional sites are required or may eliminate some of those shown on Figure 61.

TABLE 66 / POTENTIAL SMALL WATERSHED PROJECTS
Elkhorn River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
Corporation Gulch	5	2	530	49	--
Potentially Feasible					
North Fork (Upper), Yankton Slough, Union Cr., Sand Cr., Rock Cr., Plum Cr., Cuming Cr., Pebble Cr., Logan Cr. (Upper), South Logan Cr., Logan Cr. (Middle), Maple Cr., Bell Cr., Rawhide Cr.	2,945	Not Known	121,690	10,145	286
Neligh-Norfolk Tribs, Tilden-Battle Creek Tribs, Dry Cr., Willow Cr., Stanton Tribs, Logan Cr. (Lower)	1,177	None	None	None	171

a/ Based on completed Work Plans or Preliminary Investigations

Local Flood Protection. Single purpose flood protection projects have been studied and appear to be feasible for four communities; Scribner, Winslow, Meadow Grove, and Battle Creek. The topography and streamflow characteristics of the Elkhorn River Basin make local flood protection projects the most effective way to control flooding in those communities.

Nonstructural Measures. Flood plain management must be an integral part of, and play an active role in, flood damage prevention in this Basin. Management and regulation of the flood plain in both urban and rural areas will be required for a total flood control and damage prevention program.

No communities in the Basin have flood plain delineation studies completed or in progress, but several should consider initiating studies to aid in future development. Valley, Fremont, and Norfolk are in need of early flood plain regulation.

Modification of Existing Development. In general, deterioration of original development features necessitates rehabilitation or renovation as they grow older. This is presently the case with much of the drainage district development in the Basin. Many of the channels of these older developments should be cleared where silt has clogged them or stabilized where erosion has created degradation and bank sloughing problems.

Although not directly connected to existing developments, several reaches of stream are in need of clearing. Fallen trees, debris, and underbrush severely curtail flood flows in some areas and compound flood damages. No specific reaches have been selected for clearing and investigation is needed to determine areas most in need of future action.

Potential Effects. The development included in the Basic Framework will produce varied and multiple effects. Allowance has been made for increased industrialization and irrigation development and the resulting increase in water use. Needs for recreation and flood control have been considered and will be satisfied to a significant extent by the development included.

Major economic effects from development included in the Basic Framework will occur in local project areas. Project construction contracts will have short range impact and stabilization of the agricultural economy through additional irrigation and flood control will have long range effects. Recreation areas provided around project reservoirs can introduce recreation as a new major industry to the area. More jobs and additional income will tend to lessen the population flow from the Basin.

Development will have both positive and negative effects upon the environment. More intensive development will bring more people and attendant problems to the area, but on the other hand, control of flooding and erosion and water associ-

ated recreation development will considerably enhance the existing environment.

An estimate was made to determine the amount of water which would be utilized by the development included in the Basic Framework. Surface water irrigation by the three proposed projects would use the greatest amount of water, some 110,000 afa.

Table 67 shows streamflow depleted for 1970 conditions, estimated net streamflow reduction due to projected in-basin development, and remaining streamflow. The estimated depletions shown are cumulative for all depletions above the stream location shown.

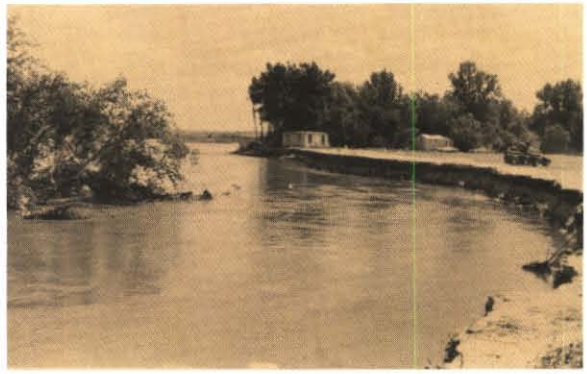
REMAINING PROBLEMS AND OPPORTUNITIES

The flood problem in the Elkhorn River Basin will not be entirely eliminated through the structural and nonstructural development included in in this Basic Framework. A program of constant reevaluation of the problem and further installation of local protection projects will be required to minimize or eliminate flood damages.

Streambank erosion will continue to be a problem and efforts at bank stabilization must be continued. Control of the amounts and sequence of runoff which would reduce the streambank erosion hazard can be accomplished by land treatment and conservation measures on the contributing drainage areas.

The land remaining suitable for irrigation but with an inadequate water supply amounts to several hundred thousand acres in the central and lower part of the Basin. There is opportunity to develop this land if suitable water supplies can be provided.

Further development and use of the water resource will make it even more imperative that water quality standards are met and maintained. Future



local and project development proposals should reflect this requirement in their plans and designs.

Local communities should explore the potential for developing recreational facilities at several of the watershed and flood control project sites outlined. Additional water oriented recreation areas will be needed later in the planning period.

Table 67 shows that considerable water would remain after in-basin development, but most of the readily available water is near the lower end of the Basin. Because of the location, there is little opportunity for storage and in-basin use of the remaining water, but it would be available for use after it enters the Platte River.

TABLE 67 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT
Elkhorn River Basin

Stream Location	1000 Acre-Feet Annually		
	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Elkhorn River at Ewing	116.4	23.2	93.2
Elkhorn River near Norfolk	330.7	111.7	219.0
Logan Creek near Uehling	119.4	28.5	90.9
Elkhorn River at Waterloo	809.2	192.4	616.8

Note: Based on average annual streamflow during the period 1954-63

Lower Platte River Basin

GENERAL DESCRIPTION

The Lower Platte River Basin is that part of the Platte River drainage area extending from the mouth of the Loup River to the Missouri River. It includes the valley of the Platte River, the drainage areas of Shell, Skull, Salt, and Wahoo Creeks, and a number of other small tributary streams.

The topography of the Basin varies from steep bluffs to flat valley plains. The upper end, in the Shell and Skull Creek drainage areas, is comprised of rolling hills and narrow tablelands between well defined drainageways. Through the central part of the Basin, especially on the north side of the River, the valley lands are broad and flat and the drainage is poorly defined. The lower Basin has steep, rolling hills and high, dissected tablelands which extend almost to the stream channel. Most of the uplands south of the river are rolling loess hills except for Todd Valley, which is a nearly level area in Saunders County covering an older buried valley of the Platte River.

Basin Resources. About 1,717,000 acres, or 93 percent of the agricultural lands in the Basin, are classified as arable and about 1.1 million acres are suitable for irrigation.

Upland soils in the Basin are comprised mostly of loess deposits on glacial materials. Much of the loess has been eroded leaving deeply entrenched drainage channels. Valley soils are heavy and quite fertile.

The average annual precipitation in the Basin is approximately 28 inches and varies from a low of about 23 inches in the upper Shell Creek drainage to a high of almost 30 inches near the mouth of the Platte River. Rainfall is generally adequate for crop growth during most years but occasional, sometimes severe, droughts do occur.

The Platte River channel in this Basin is wide and braided with numerous sandbars and islands. Streamflow is quite variable, ranging from almost dry conditions to large, raging floods. This is primarily because of the uncontrolled flow of its two major tributaries, the Loup and Elkhorn Rivers. During dry periods, the flow of the Platte River above its confluence with the Elkhorn River consists almost entirely of water from the steadier flowing Loup River. The Elkhorn River, which joins the Platte River in the lower part of the Basin, provides a significant but variable contribution to streamflow.

Ground water availability varies across the Basin. The area south of the Platte River valley is underlain by thick deposits of glacial till, a poor source of water both in quality and quantity. However, some stream valleys buried beneath this glacial till contain thick deposits of water bearing sand and gravel and in some areas, such as the Todd Valley in Saunders County, wells yield medium to moderately large quantities of water.

Most of the Platte River valley itself is underlain with thick deposits of water bearing sands and gravel that yield moderate to large quantities of good quality ground water to wells. Well fields in this aquifer supply water for the two largest metropolitan areas in the State, Omaha and Lincoln.

The lower part of the Shell Creek drainage is underlain by glacial till and has aquifer characteristics similar to those south of the river. Well yields in the upper reaches are similar to those in the Platte River valley.

The large deposits of sand and gravel in the Platte River valley have been developed extensively. Most of the material is used for concrete aggregate or for road surfacing.

Limestone is quarried near Louisville and used to manufacture cement. Several other quarries in the Basin produce roadstone, riprap, and agricultural lime.

Clay from a number of deposits in the Basin is used to make brick and tile at two locations. There are only two other brick yards in the State.

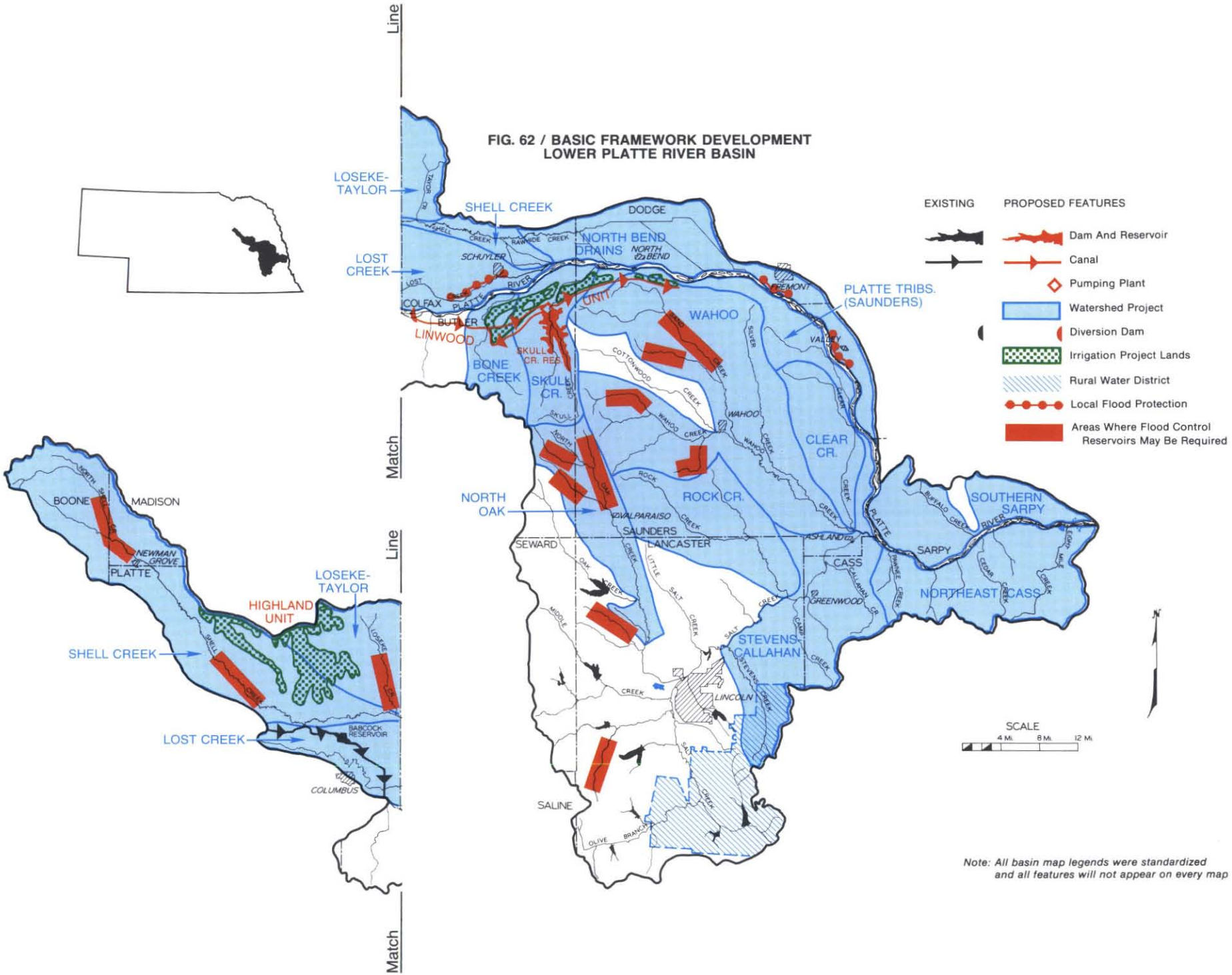
Timber resources in the Basin are limited but some rough lumber is produced in the area. Christmas tree farms have been increasing in number and importance in recent years.

The braided channel and numerous islands provide habitat for small game and deer. Fishery resources are limited mostly to warm water fish. Numerous brushy canyons and drainageways adjacent to cultivated lands provide cover for upland game.

Existing Development. During the 1960's, ten flood control reservoirs and many miles of channel improvement and levees along Salt Creek were completed in the Salt Creek drainage basin. Several of the reservoirs provide flood protection for Lincoln and other smaller towns in the Salt Creek valley. Additional small watershed project reservoirs provide flood protection and grade stabilization structures provide erosion control for the agricultural areas.

Irrigation development in the Lower Platte River Basin has been limited mostly to ground water

FIG. 62 / BASIC FRAMEWORK DEVELOPMENT
LOWER PLATTE RIVER BASIN



Note: All basin map legends were standardized and all features will not appear on every map

irrigation in the Platte River valley north of the river and in the Todd Valley south of the river.

The upland areas of the Basin are generally devoted to cultivated cropland with small amounts of grassland. The west central and southern portions of the Basin, including the area near the Missouri River, have steeply rolling hills and a greater proportion of these areas is devoted to grassland and woodland. The broad alluvial lowlands of the Platte River valley, except those lying nearest the river, are generally used to grow cultivated crops. The poorer, sandy soils and high ground water conditions near the river limit the use of much of this land to native, woody vegetation and pasture.

Non-irrigated agriculture is quite extensive in this Basin, especially in the lower portion. Lancaster County is normally the state's leading producer of grain sorghum. Saunders County is usually one of the top two counties in soybean production in the State.

Almost 1,150,000 acres are suitable for irrigation but only about 103,000 acres, or 9 percent, have been developed. The relative abundance of rainfall throughout the Basin during most years and the combination of small scattered tracts of land and the limited water supply in the rougher parts of the Basin are responsible for the lack of irrigation development.

The economy of the Basin is dominated by Lincoln, its largest city, which is the commercial and transportation hub for a large area of southeast Nebraska. In addition to being the State Capital and home of the University, it boasts a wide diversity of industry and small manufacturing plants. The economy of the remainder of the Basin is based largely on agriculture. Industrial activities are diverse, but generally center around processing agricultural products and manufacturing items to support agriculture.

Fish and wildlife values have been enhanced by the reservoir development in the Salt Valley. Enhancement of the existing fishery resource has been significant.

Recreation facilities have been constructed at several of the Salt Valley Reservoirs. The State Game and Parks Commission has provided facilities at many of the larger reservoirs and the city of Lincoln is developing a park and golf course in the area surrounding Antelope Lake.

PROBLEMS AND NEEDS

Flooding remains a major problem in all parts of this Basin except Salt Creek, where major improvements have been made. Urban and high value agricultural development on the wide, flat flood plains and a relatively high frequency of flooding combine to cause high flood damages. The relatively high frequency of flooding throughout the Basin results from lack of control of the tributary lower Loup and Elkhorn Rivers, and rapid runoff from the steep hills in the Shell, Wahoo, and Skull Creek drainage areas.

Soil loss from water erosion, particularly from the glacial till area south of the Platte River, is a definite problem. About one-third of the land in the Basin is presently receiving adequate watershed treatment but the remainder suffers greatly from erosion damage. Gully erosion in the more rugged portions of the glacial till area and streambank erosion on the Platte River and Salt Creek cause localized problems. Streambank erosion on Salt Creek has been aggravated by local attempts at channel straightening.

In southern Lancaster County ground water supplies often are not adequate for rural domestic and livestock needs. Rural water distribution systems may be needed to provide adequate water for existing and future needs.

Four communities in the Basin, including almost 90 percent of the urban population, are in need of improved sewage treatment facilities; two need to install secondary facilities, and the other two need to improve existing secondary facilities. Two of these communities discharge their sewage into Salt Creek which is one of the most seriously polluted steams in the State.

Drainage problems are experienced in the portion of the Platte River valley lying north of the river. Drainage channels have been constructed and other measures undertaken to alleviate the problem between Schuyler and Fremont, but between Schuyler and Columbus in the Lost Creek area drainage problems still remain.

The Lower Platte River Basin lies almost entirely within the Omaha, Lincoln, and Columbus socioeconomic areas. The Omaha and Lincoln SEA's are severely deficient in water based recreation opportunity such as fishing or boating, and the Columbus SEA has a moderate deficiency. Only about 4 percent of the total state fishery resources are located in these SEA's compared to about 21 percent of the demand. Much larger deficiencies are expected by the year 2000.

BASIC FRAMEWORK DEVELOPMENT

The development projected for this Basin during the planning period is that which could reasonably be attained and will meet a major portion of the needs identified.

Independent Local Development. Independent development in this Basin during the planning

TABLE 68 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Lower Platte River Basin

Subbasin	Municipal Systems				Private b/ Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020 a/	Present	2020
Platte River						
Loup River to North Bend	6,590	6,400	660	1,400	1,300	3,000
North Bend to South Bend except Lincoln Metro.	10,380	12,480	1,720	3,300	27,550	4,000
Lincoln Metropolitan Area c/	141,212	300,000	24,190	94,000	0	26,750
South Bend to Mouth	2,040	2,450	240	500	1,250	2,500
BASIN TOTAL	**160,222**	**321,330**	**26,810**	**99,200**	**30,100**	**36,250**

a/ Includes projected industrial reserve
b/ Includes cooling water requirements for existing thermal electric plants
c/ Lincoln Standard Metropolitan Statistical Area population, less people served by private systems (farms, etc.)

period will include additional water supply for M&I purposes, development of ground water irrigation, construction of farm ponds, land treatment for conservation of soil and water, improved sewage treatment facilities and development of single purpose, water based, outdoor recreation facilities.

Municipal and Industrial. Future M&I requirements are expected to more than double from a present use of about 57,000 afa to a future 2020 requirement of about 135,000 afa as shown in Table 68.

The increased requirement results from expected urban population growth and increased industrialization in Omaha, Lincoln, and Fremont. Presently, Lincoln and Fremont obtain their water from wells in the Lower Platte River valley and Omaha obtains about half of its water from the same source. The additional amounts required can be supplied from ground water by expansion of existing systems or developing new areas in the Platte River valley.

Municipalities within the Basin must provide at least secondary treatment of their wastes by January 1, 1972. This will require installation of secondary treatment facilities by two municipalities and the improvement of existing secondary treatment facilities by two others. As urban populations increase and existing treatment plants become outdated, other communities will be required to upgrade their facilities.

Rural Domestic and Livestock. The rural population of the Lower Platte River Basin, including the non-farm segment, is expected to more than double by 2020. The resulting increase in water requirement is due to a combination of population increase and increased per capita requirements. In most areas ground water supplies can supply additional demands. Rural water distribution systems may be required in the southern part of the Basin.

Livestock numbers are expected to increase with a resulting increase in water use from 5,900 afa at present to 16,000 afa by 2020. This can generally be provided from ground water with expanded facilities.

Irrigation. Ground water could be used for development of about 75,000 additional acres of land for irrigation during the planning period. Most of this land included in Basic Framework is located in the broad Platte River valley in Platte and Colfax Counties and in the area known as Todd Valley in northeast Saunders County.

Recreation. Many water based outdoor recreation facilities have been constructed through private initiative. Most of the existing developments are associated with Platte River frontage or exposed ground water lakes that are the end result of gravel mining operations. This type of development and other individual innovations are expected to continue through the planning period

Public Project Development. A number of small watershed projects to be constructed primarily for flood and erosion control are included as part of the Basic Framework. Also included are three local single purpose flood protection projects and one irrigation project. Part of the lands to be irrigated from the potential USBR Highlands Unit are in this Basin in the Shell Creek area. Several possible sites for additional flood storage reservoirs are shown on Figure 62 along with the other anticipated developments.

TABLE 69 / POTENTIAL SMALL WATERSHED PROJECTS
Lower Platte River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
Loseke-Taylor	142	34	4,450	340	None
North Oak (Oak-Middle)	98	35	4,640	350	None
Clear Creek	86	28	3,620	210	4
Potentially Feasible					
Bone Cr., Shell Cr., Skull Cr., Stevens-Callahan, Rock Cr., Wahoo, Southern Sarpy, Northeast Cass	1,544	Not Known	57,640	4,220	124
Lost Cr., North Bend Drains, Platte Tribs (Saunders)	401	None	None	None	85

a/ *Based on completed Work Plans or Preliminary Investigations*

Linwood Unit. This potential project would provide water for irrigation, recreation opportunities, and fish and wildlife values. Water would be diverted from the Platte River just below the Loup River Public Power District tailrace for irrigation of 10,600 acres in Butler and Saunders Counties. A pumping plant would lift part of the water into the proposed Skull Creek Reservoir for regulation and later release to lands too high for gravity service from the diversion dam. Flood control as a project purpose was also considered at Skull Creek Reservoir but does not appear feasible at this time.

The Bureau of Reclamation has completed a reconnaissance investigation of the project, but at present there is little local interest. Additional study will be required to determine the economic feasibility of the proposal.

Small Watershed and Flood Control Projects. An integrated flood and erosion control program for this Basin was partially formulated by the Corps of Engineers and the Soil Conservation Service as part of the MRB Study. A combination of small watershed structures and larger impoundments to temporarily store flood runoff would provide a total of about 220,000 AF of flood control storage in 14 watershed areas. The total water surface area available for recreation activities would be about 14,000 acres. Enhancement of fish and wildlife values would also be provided. The location of watershed project areas and general locations where flood storage reservoirs may be required are shown on Figure 62. Investigation of this potential flood control program has been given only cursory examination, but the combination of small watershed projects and larger flood storage at the 12 general locations shown should provide adequate structural protection.

Additional study will be required to determine the merits of individual segments of the program. Watersheds for which flood protection projects are potentially feasible are shown in Table 69. Three watershed projects have been studied in detail and appear to be feasible at this time. These projects are also summarized in Table 69.

As planning progresses, additional large reservoir sites may replace or be replaced by small watershed structures.

Local Flood Protection. Single purpose flood protection projects are proposed for three communities in the Platte River valley. These communities, Schuyler, Fremont and Valley, are located on the practically level flood plain along the Platte River where a system of levees would provide the most feasible method of flood protection.

Nonstructural Measures. Nonstructural measures, if implemented before major development occurs, can provide an effective form of flood damage prevention.

Regulation of urban development on the flood plains is highly important in this Basin. The city of Lincoln, in particular, has sustained millions of dollars of flood damages in the past but development of the type which is susceptible to flood damage is nevertheless continuing on the flood plain. A flood plain delineation study has been completed

for the city but zoning regulations have not been implemented. The city of Wahoo has a high priority for a flood plain delineation study. Many other municipalities in the Basin, including Ashland, are in need of such a study as a basis for flood plain management. The Corps of Engineers is investigating a complete program of flood plain management along the lower Platte River in lieu of flood control storage.

The Bureau of Outdoor Recreation has conducted a study to determine the recreation, scenic, natural, and historic value of the Platte River islands from the Loup River confluence to the community of Valley. Public acquisition of all of the islands plus development of a few would provide opportunity for a wide diversity of recreation opportunities. This island environment complete with a wide range of plant and animal life would provide an ideal educational and recreational opportunity for youth groups, e.g. Boy Scout Troops, church groups, and schools, as well as a recreation outlet for many adults.

Modification of Existing Development. One existing project is in need of modification and improvement. Union Dike, a levee on the east bank of the Platte River between Fremont and Valley, has proved inadequate to protect the area from floods. The levee should be raised and strengthened.

Although not resulting directly from the existing development, Shell Creek channel capacity is presently inadequate to carry even flood flows of low magnitude. Channel clearing, enlargement, and straightening has been proposed to increase the capacity from Newman Grove to the mouth. Undoubtedly, other streams in this partially wooded Basin have similar conditions.

Potential Effects. The development included in the Basic Framework will provide varied benefits. It provides for the satisfaction of independent local needs as far as they can be determined.

Development of the water resources of the Basin will help stabilize and boost the economy of the area. The irrigation development will require additional manufacturing and services to provide the necessary materials for intensification of production and to process the increased crop yields. The irrigation development and flood control measures, both structural and nonstructural, will tend to stabilize and augment the economy of the Basin and surrounding area by preventing economic losses associated with periodic droughts and floods. Recreation development, too, will have a beneficial effect on the economy. Increased manufacturing, services, and sales of such items as boats, campers, and summer homes, will have far-reaching effects.

Upstream flood storage and local flood plain zoning will improve the environment of municipalities by preventing potential blighted areas from developing in the flood plain. Improved treatment of municipal and industrial wastes will also improve environmental quality by eliminating odor problems experienced near some municipalities in the Basin. Improvement of stream quality downstream from municipalities will allow increased use of streams by fish and wildlife and for recreation purposes, thereby bettering the quality of the environment.

Development and protection of the Platte Islands area could have environmental implications of national impact. These islands comprise one of the last remnants of undeveloped land on the Great Plains. Public acquisition of these lands followed by wise management will allow preservation of this unique land form for future generations.

An estimate was made of in-basin water utilization by Basic Framework developments. Table 70 shows estimated average annual streamflow under 1970 conditions of development, depletions expected to occur during the planning period, and streamflow remaining.

The depletions shown are accumulated totals and represent the total net depletion in the drainage area upstream.

TABLE 70 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT

Lower Platte River Basin

	1000 Acre-Feet Annually		
Stream Location	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Platte R. @ North Bend	1,896.7	501.3	1,395.4
Platte R. nr. South Bend	3,122.5	741.1	2,381.4
Platte R. @ Mouth	3,183.7	799.4	2,384.3

Note: Based on average annual streamflow during the period 1954-63

REMAINING PROBLEMS AND OPPORTUNITIES

The structural and nonstructural flood control measures included in this Basic Framework will not completely eliminate flood damages. It will be necessary to review and update flood control studies and projects continuously as physical and economic conditions change. It will also be necessary to enforce and update nonstructural methods of flood control, particularly flood plain zoning, to insure effective regulation and reduction of flood damage.

Increasing streambank erosion damages on the Platte River are the result of increasingly higher valued development along the banks rather than any change in stream characteristics. The continuous meandering of the channel which causes the erosion is an entirely natural phenomenon for which present technology offers no ready solution. A complete stabilization program to prevent future damage would be prohibitively expensive under current economic criteria.

The shortage of water based recreation opportunity in this Basin will continue to increase. Population growth and increasing per capita demand for recreation will increase faster than water resource developments are constructed. More water surface area, possibly provided through single purpose recreation projects, will be needed to satisfy projected demands.

The "Remaining Streamflow" shown in Table 70 represents the average annual streamflow which would pass the points shown after Basic Framework development is complete. Not all of this water would be available for use because of its pattern of occurrence or prior rights downstream. Some would also be needed for fish and wildlife, recreation, and aesthetic purposes, or to dilute or carry away treated waste returns and irrigation return flows.

Significant quantities of water would still be available, however, if storage sites were available or provision could be made to divert it to areas of need. Its use would present some difficult problems because it occurs at downstream points where it would be at an elevation and location remote from many areas of need.

Republican River Basin

GENERAL DESCRIPTION

The Republican River Basin lies in the southwest corner of the State and occupies about one-eighth of the state's area. The river enters Nebraska at the extreme southwestern corner from the plains of Colorado and Kansas and reenters Kansas near Superior, Nebraska.

The high plains at the western border transcend into a narrow extension of the Sandhills which in turn merges into the loess plains. These loess plains are dissected by steep ravines providing a well defined drainage pattern. The river valley is narrow where it enters the State, but gradually broadens toward the east, or lower end of the Basin.

Basin Resources. There are nearly six million acres of agricultural land in this Basin, the third largest total in the State. Over 3.3 million acres of this total are arable, and 2.5 million acres have soils suitable for irrigation, much of it highly suitable. Much of the land is used for grassland and non-irrigated cropland, primarily because the majority of the area receives an average of less than 22 inches of precipitation annually.

Precipitation varies from 17 inches in the southwest corner to 25 inches at the lower end of the Basin. Rainfall is usually poorly distributed for optimum crop growth and where water is available irrigation is practiced.

Streamflow in tributaries to the Republican River varies with precipitation, except in the few streams originating in the Sandhills. The base flow is fairly steady in the Sandhills streams, but elsewhere there is very little inflow from ground water and during dry periods the streams have little or no flow.

A significant portion of the water resource of the Basin has been developed or controlled by storage reservoirs on the Republican River and its major tributaries. This has improved the availability of water to a great extent.

In addition to the alteration of the natural flow by storage, diversions, and return flows, an interstate compact exists on the Republican River. It has been in effect since 1943 between the States of Colorado, Kansas, and Nebraska. It provides for the allocation of flows of the Republican River and most of its major tributaries according to the computed virgin flow conditions. These virgin flows are recomputed

TABLE 71 / EXISTING IRRIGATION AND FLOOD CONTROL PROJECTS
Republican River Basin

Project or Unit	Reservoir	Flood Control Storage (1000 AF)	Conservation and Dead Storage (1000 AF)	Surface Area (Acres)
Frenchman	Enders	30	44	1,710
Meeker-Driftwood	Swanson	134	120	4,970
Cambridge	Swanson			
	Harry Strunk	52	37	1,850
Red Willow	Swanson			
	Hugh Butler	49	38	1,630
Bostwick	Harlan County	500	343	13,240

each year to determine if the variation from the original assumed virgin conditions is in excess of the original limits outlined. In essence, the compact provides for the beneficial consumptive use of about 11 percent of the water supply in Colorado, 40 percent in Kansas, and 49 percent in Nebraska.

In the northern and western part of the Basin, and along the valley of the river, ground water aquifers yield medium to moderately large amounts of water to wells. Elsewhere, moderate yields can be located in some places where buried bedrock valleys are filled with permeable Pleistocene deposits, but good supplies of ground water are difficult or impossible to locate in other areas, especially in the eastern part of the Basin and the area south of the river.

Oil was discovered in the Basin in 1960 with the opening of the Sleepy Hollow field in Red Willow County. This is now the top producing oil field in the State.

The fish and wildlife resources of the Basin are significant. Five large multipurpose reservoirs contain many species of fish, and some of the streams provide good catfish waters. The area in the north-central part of the Basin contains a number of marshes and potholes used by waterfowl, especially ducks, during migration or for nesting.

Recreation areas have been provided by the State and Federal Governments at the reservoirs and marshes for swimming, boating, and camping as well as hunting and fishing.

Existing Development. The water resources of this Basin have been developed as completely as any in the State, especially for flood control. Five USBR and Corps of Engineers project units serving flood control, irrigation, fish and wildlife, and recreation purposes are located on the Republican River and its major tributaries. As part of these projects, five major storage reservoirs have been constructed, two on the Republican River and three on tributaries. Information on the projects is summarized in Table 71.

Three small watershed projects, Dry Creek, Dry Creek South, and Stamford, have been completed in the Basin. Dry Creek was one of four pilot watershed projects and provides protection for the town of Bartley and agricultural lands in the vicinity.

Local flood protection projects have been completed for Bartley and Indianola. They consist of levees and channel improvements on local tributaries in the vicinity of these two communities.

Most of the land in this Basin is non-irrigated cropland or rangeland, but nearly 400,000 acres were being irrigated in 1969—about 87,000 from the USBR projects mentioned above. Water for the rest of the irrigated land in the Basin is provided mainly from ground water.

The economy of the Basin is based largely on agriculture. The major crops are wheat and corn. Perkins County is the second leading county in the State in the production of wheat.

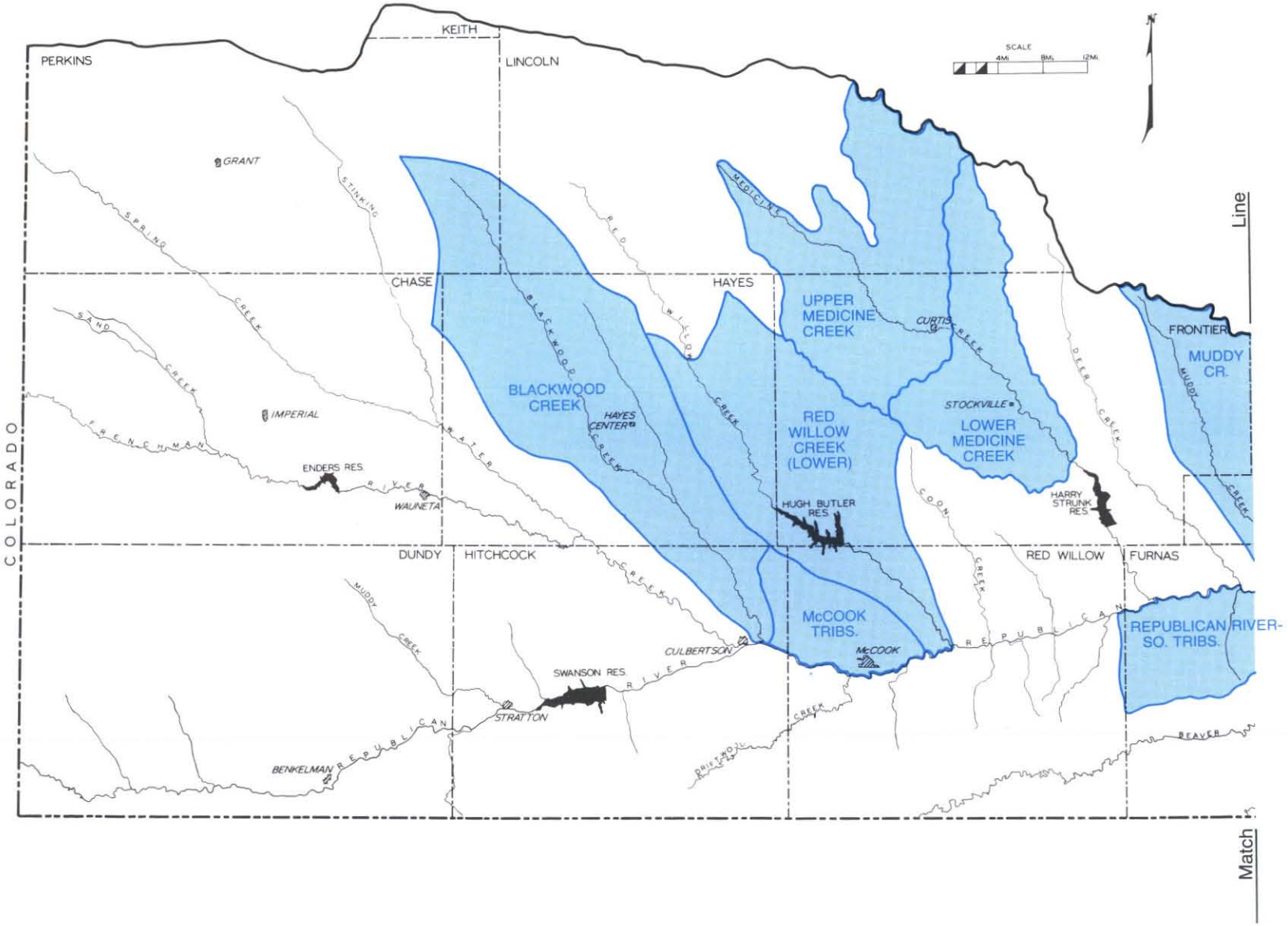
With the exception of oil and gas, the Basin's industries are devoted mainly to providing products or services to agriculture. The two largest communities are McCook, with a 1960 population of about 8,300, and Holdrege, population 5,226. They are important trading centers within the Basin.

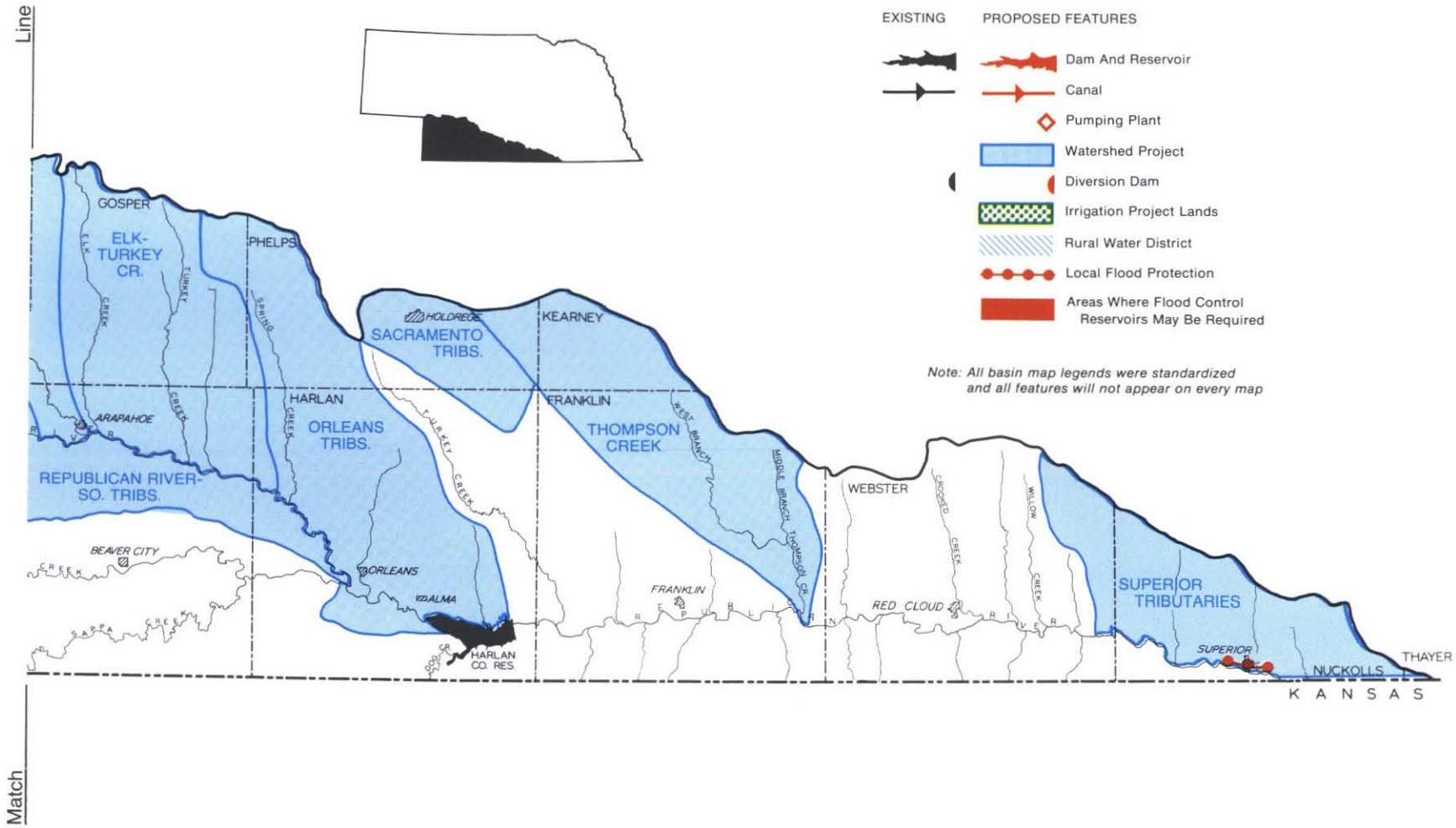
Recreation is becoming an important industry in the Basin. The five large multipurpose reservoirs draw recreationists, especially fishermen, from many parts of Nebraska and other states.

PROBLEMS AND NEEDS

Seven major reservoirs and a number of smaller flood protection projects constructed since the devastating flood of 1935 have greatly reduced Republican River floods in Colorado, Kansas, and Nebraska, but some Nebraska areas along the river still experience damaging floods. Of course, the

FIG. 63 / BASIC FRAMEWORK DEVELOPMENT
REPUBLICAN RIVER BASIN




Line
Match
EXISTING
PROPOSED FEATURES
Dam And Reservoir
Canal
Pumping Plant
Watershed Project
Diversion Dam
Irrigation Project Lands
Rural Water District
Local Flood Protection
Areas Where Flood Control Reservoirs May Be Required
Note: All basin map legends were standardized and all features will not appear on every map
GOSPER
ELK-TURKEY CR.
PHELPS
HOLDREGE
SACRAMENTO TRIBS.
KEARNEY
HARLAN
ORLEANS TRIBS.
FRANKLIN
THOMPSON CREEK
ARAPAHOE
REPUBLICAN RIVER-SO. TRIBS.
WEBSTER
BEAVER CITY
ORLEANS
ALMA
HARLAN CO. RES.
FRANKLIN
RED CLOUD
SUPERIOR TRIBUTARIES
SUPERIOR
NUCKOLLS
THAYER
KANSAS

tributary streams contribute to the flood problem. Medicine and Frenchman Creeks have both experienced severe floods, and many smaller tributaries produce flash floods periodically. Rapid storm runoff from the steep tributaries also produces flood problems on the flatter flood plains along the Republican River. It is estimated that the average annual flood damage is still $2,300,000 in this Basin.

The cause of flooding on the Republican River has changed since the reservoirs were constructed. The reduction in high flows below the reservoirs has allowed part of the area to fill with brush and snags. Thus, the channel capacity has been reduced, causing overbank flow at much lower discharge rates.

Adequate supplies of ground water for municipal and rural domestic uses are difficult, if not impossible, to find in some parts of this Basin, particularly in the eastern and southern parts. The quality of the water obtained is generally adequate, but most of it is hard enough to be objectionable to consumers. Potential customers of rural water distribution systems are generally too scattered to make such facilities economical. Surface water stored in ponds is often used for livestock.

Seventeen of the 50 communities in this Basin surveyed by the Nebraska Department of Health in its 1969 inventory of sewage treatment facilities had no sewage systems. These 17 communities had populations ranging from 55 to 337 in 1960, and an average population just over 200. Of the 33 communities with systems, six provided only primary treatment for the wastes from a combined population of 5,586. In addition, four systems provided secondary treatment but needed improved facilities to meet minimum standards for water quality.

BASIC FRAMEWORK DEVELOPMENT

Basic Framework development in this Basin includes the projects and programs which appear reasonable to meet the anticipated needs and problems using in-basin water resources. Allowances have been made for independent development which could likely materialize within the Basin during the planning period.

Independent Local Development. Allowance in water supply estimates was made for additional development of water resources by independent local developers. This includes development of water resources for irrigation, municipal and industrial use, and other related developments which affect the water resource indirectly, such as land treatment measures for soil conservation.

Municipal and Industrial. Projections indicate that the Basin's urban population served by municipal water systems will increase from 40,445 in 1960 to about 43,100 in 2020. It may be necessary for certain communities to go some distance from their locality to secure adequate supplies, but it is expected that additional water to meet future demands will, in most cases, come from ground water. Estimated municipal and industrial use in the Basin at the present time is about 8,200 afa, and it is estimated this will increase to almost 15,000 afa by 2020. Table 72 shows present and projected municipal and industrial water requirements.

Ten municipalities will have to improve their sewage treatment facilities as soon as possible to protect the quality of the surface water in the Basin and to comply with the Nebraska Water Quality Standards. Of these, six must construct secondary treatment facilities and four must improve existing secondary treatment facilities.

TABLE 72 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

Republican River Basin

Subbasin	Municipal Systems				Private a/ Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020 b/	Present	2020
Frenchman Creek						
State Line to Mouth	4,270	2,960	730	750	0	0
Republican River						
State Line to Stratton	1,630	1,090	350	300	0	0
Stratton to Orleans	18,485	20,100	3,950	6,550	0	500
Orleans to State Line	14,465	18,040	2,740	5,600	220	1,000
Beaver and Sappa Creeks	1,595	910	220	200	0	0
BASIN TOTAL	**40,445**	**43,100**	**7,990**	**13,400**	**220**	**1,500**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

Rural Domestic and Livestock. Rural domestic water use in this Basin is expected to increase slightly in the near future as more pressure systems are installed in farm homes. Projections indicate, however, that rural domestic use will decrease below current levels by 2020 as farm population continues to decrease.

Requirements for livestock water are expected to continue to increase. It is estimated that nearly 11,000 AF of water are now required annually and about 35 percent of this comes from surface water supplies. This requirement is expected to nearly triple by 2020. Reservoirs to store surface water will probably be constructed to meet a large share of this demand and to replace existing ponds as they fill with silt. Community water systems may be required to develop surface water storage, treatment, and distribution systems extensive enough to serve those rural areas where ground water is inadequate.

Irrigation. Future private irrigation development will be mostly from ground water. There is a large amount of land which is highly suitable or moderately suitable for irrigation in Perkins and Chase Counties at the western end of the Basin. This area has been developing rapidly in the past few years from ground water and will probably continue as long as adequate water is available.

Another block of highly suitable land is located adjacent to the Middle Platte and Little Blue River Basins. Although this area does not have particularly good potential for development of irrigation wells, ground water is being augmented by infiltration of surface water being used to irrigate land in the adjacent Platte River Basin. This is causing the ground water table to rise and providing a source of supply to wells in the Republican River Basin.

There are also lands moderately to highly suitable for irrigation scattered throughout the middle of this Basin that will be developed where adequate water is available.

Development of lands throughout the Basin for irrigation from ground water is expected to total nearly 380,000 acres during the planning period.

Individual surface water development for irrigation is expected to be minimal. Most new surface water irrigation appropriations will probably be replacements for abandoned or cancelled rights.

Public Project Development. As stated earlier, the surface water resources of this Basin have been developed to a greater extent than any other basin in the State, particularly in the sense of controlling floodwaters, and their utilization for irrigation, fish and wildlife, and recreation. Proposals for the development of multipurpose projects in Nebraska's part of the Basin are limited for this reason, but several major projects have been proposed in Kansas which would substantially benefit areas along the tributaries in Nebraska. At least one local flood protection project in Nebraska may be feasible.

Six small watershed projects would provide reservoirs for flood control, recreation, fish and wildlife. These and six other potential projects would also include channel improvements or levees for drainage and flood protection and grade stabilization structures for erosion control. The location of these projects is shown on Figure 63.

Small Watershed Projects. Three small watershed projects in this Basin have been investigated in detail and are feasible to construct. These projects, Lower Medicine Creek, Upper Medicine Creek, and Blackwood Creek, are primarily for flood control. Information about these projects is given in Table 73. The Lower Medicine Creek Project will also have 16 grade stabilization structures to protect 25 square miles of drainage area.

Nine other watershed projects appear to have potential for development during the planning period, but further investigation will be required to determine the feasibility of each project. Preliminary estimates of the features of these projects are summarized in Table 73.

Local Flood Protection. One single purpose flood control project to provide protection to the community of Superior appears to be feasible. This will require more than a mile of channel improvement and/or levee construction to protect approximately 100 acres of high value land from inundation.

Nonstructural Measures. The flood control structures in this Basin have reduced the flood damages substantially, but average annual flood damages are still high, particularly in rural areas. Regulation of the use of the flood plains through zoning will ensure the best use of flood prone areas by development which is least susceptible to flood damage and prevent an increase in the amount of damages.

One community, Red Cloud, already has a high priority for flood plain delineation which, upon completion, will allow implementation of flood plain zoning.

Modification of Existing Development. Several reaches of the Republican River have become partially clogged with brush and debris since the elimination of the large scouring floods which formerly plagued this Basin. The channel capacity is so restricted below Harlan County Reservoir that design flood control releases cannot be made without flooding the adjacent lands. A proposal to clear

TABLE 73 / POTENTIAL SMALL WATERSHED PROJECTS
Republican River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
Blackwood Creek	293	156	13,230	390	None
Upper Medicine Creek	367	173	13,360	380	None
Lower Medicine Creek	336	116	9,120	270	None
Potentially Feasible					
McCook Tribs, Orleans Tribs, Superior Tribs	728	Not Known	13,500	1,290	47
Red Willow Creek (Lower), Republican River South Tribs, Muddy Creek (Frontier & Gosper), Elk-Turkey Creeks, Sacramento Tribs, Thompson Creek	1,553	None	None	None	68

a/ Based on completed Work Plans or Preliminary Investigations

this section was developed by the Corps of Engineers, but it was rejected by the local people because of cost sharing arrangements. There should be continued efforts to solve this problem.

Potential Effects. The development included in the Basic Framework will provide varied and beneficial effects within the Basin. The greatest share of the economic effects from the development will accrue to the local area. Major effects will be felt from the additional irrigation, with its stabilization and increase in crop value and attendant livestock production. The expansion of agriculture will produce an accompanying expansion in the industries now serving agriculture in the Basin. This will help stabilize the Basin's population in the future.

Short range economic benefits will be provided to the local community during construction of the watershed projects. Thereafter, the flood control provided by these projects will produce long range benefits and economic relief for the protected areas and a better environment for those now threatened by floods.

Water quality will be improved by provision of adequate municipal waste treatment plants throughout the Basin.

An estimate was made of the effect of Framework development on streamflow to determine the extent of its utilization of the water resource. Table 74 shows the estimated streamflow under 1970 conditions, the estimated reduction in streamflow due to projected in-basin development, and the remaining streamflow.

The depletions shown are cumulative net totals of depletions above the location listed. Much of

TABLE 74 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT
Republican River Basin

Stream Location	1000 Acre-Feet Annually: Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Republican R. @ Stratton	109.4	28.6	80.8
Frenchman Cr. @ Culbertson	64.1	43.7	20.4
Republican R. nr. Orleans	188.6	88.4	100.2
Republican R. nr. Hardy	244.6	107.8	136.8

Note: Based on average annual streamflow for the period 1954-63

this depletion reflects anticipated development upstream in Colorado, but the expansion of irrigation from ground water within Nebraska is expected to have noticeable effects in several reaches of the streams.

Although it appears from the table that there is water remaining for development, most of it is at the lower end of the Basin where development would be difficult, and a large part would be flood flows. In addition, the compact between Nebraska, Kansas, and Colorado places restraints on the use of water in this Basin.

REMAINING PROBLEMS AND OPPORTUNITIES

The flood problem in this Basin will not be completely eliminated by structural or nonstructural means included in the Basic Framework. The process of studying and reevaluating this problem must be continued, and plans for protection projects must be carried out as the need arises.

As the ground water supply is exploited for the expansion of irrigation, the need may arise for supplemental surface water supplies to be used in conjunction with ground water. This is particularly true in the corner of the Basin adjacent to the Middle Platte and Little Blue River Basins and in the Perkins and Chase Counties area. A source of surface water is not available within the Basin, however.

Opportunities for development of recreational facilities at many of the projected watershed reservoir sites will be available to the local communities. This potential should be explored and incorporated in the final design to allow for more efficient development.

Little Blue River Basin

GENERAL DESCRIPTION

The Little Blue River Basin is located in south-central and southeastern Nebraska between the Republican, Middle Platte, and Big Blue River Basins. The Little Blue River rises in the plains near the Middle Platte River Basin and leaves the State at the Kansas-Nebraska state line southeast of Fairbury, Nebraska.

In the upper end of the Basin, the lands are loess plains with poorly defined drainage patterns. The plains become gently rolling in the central part of the Basin with a much better defined drainage pattern on the south side of the River. In the eastern, or lower end of the Basin, bedrock is near the surface and it outcrops on the steeper slopes which are severely eroded in some areas. The flood plain of the river becomes much narrower in the lower end of the Basin.

Basin Resources. Most of the land in this Basin, which covers 1,700,000 acres, is well suited to agriculture. About 1,640,000 acres are classified as agricultural lands and of that, 84 percent is arable. A little over one million acres are suitable for irrigation.

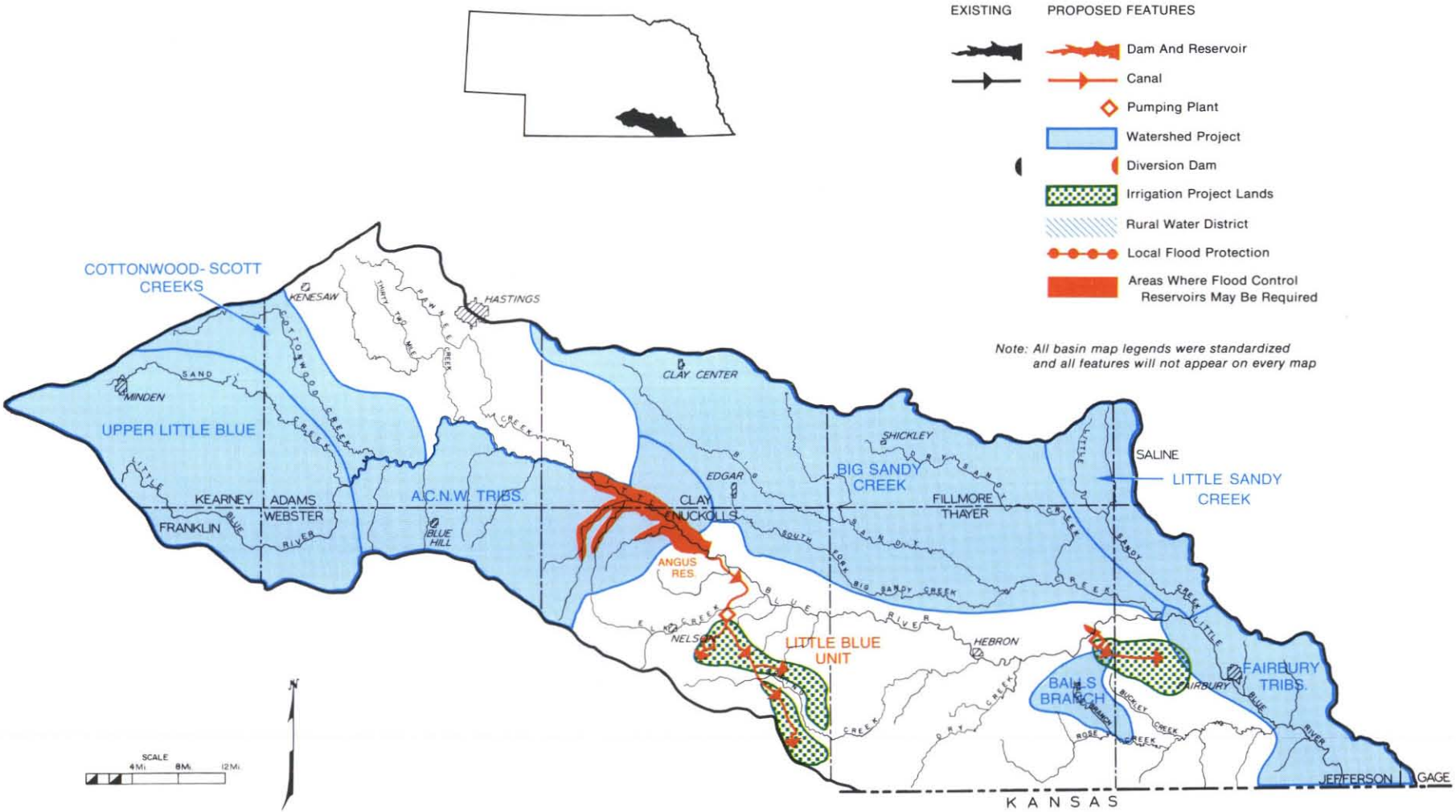
The average annual precipitation varies from about 23 inches at the western end to 29 inches in the east. Most of this comes as rain during the crop growing season, but supplemental water from irrigation is generally required to insure against crop failure. This is especially true for the lands at the western end of the Basin.

The character of streamflow in the Little Blue River is influenced by the water-bearing Pleistocene deposits that, where intercepted by the stream channels, contribute to a base flow that is steadier than that in either of the larger rivers on each side of this Basin. Streamflow still varies greatly in direct response to precipitation, especially in lower reaches of the river. The base flow comes mainly from those tributaries north of the river, which receive ground water influent.

Ground water supplies are plentiful in the northern and western parts of this Basin where the Pleistocene deposits of sand and gravel occur. Elsewhere, well yields sufficient for irrigation are difficult to obtain and only small to moderate yields are generally available. In the southeastern corner where glacial deposits underlie the loess soils, deep wells may obtain large supplies of water from the Dakota sandstones, but the water could be highly mineralized.

Limestone, clay, sand and gravel are important resources in this Basin. Sand and gravel pits are located along the river and several of the larger tributaries. Several limestone quarries and clay pits

FIG. 64 / BASIC FRAMEWORK DEVELOPMENT
LITTLE BLUE RIVER BASIN



are located in the lower end of the Basin where the bedrock is close to the surface. One of the state's four brickyards is located at Endicott in the lower Basin.

The fishery resources of this Basin are limited, but it is a valuable area for waterfowl. The wetlands and ponds in the rainwater basin area of Kearney, Adams, and Clay Counties provide habitat for nesting or migrating waterfowl.

Existing Development. About 330,000 acres of the one million acres suitable for irrigation in the Basin are presently being irrigated. This development from surface and ground water has been entirely private.

Three small watershed projects have been constructed in this Basin, and one local flood protection project has been completed at Fairbury. Nearly two miles of levees were constructed at Fairbury to protect 180 acres, including part of the city, from flooding.

Pertinent features of the three watershed projects are summarized in Table 75.

TABLE 75 / EXISTING SMALL WATERSHED PROJECTS
Little Blue River Basin

Project Name	Floodwater Retarding Structures		Channel Improvements (Miles)
	No.	Capacity (AF)	
Buckley Creek	6	2,520	19
Bowman-Spring Branch	8	3,100	0
32-Mile Creek	6	5,760	1

Economically, the Basin is largely dependent on agriculture, but there are a number of light industries in the Basin manufacturing plastic or paper products, iron and steel products, clothing and other light items requiring high amounts of labor and small shipping costs. Much of the industry in the Basin is oriented toward supplying the needs of agriculture or marketing agricultural products.

The upper part of the Basin is almost entirely devoted to cultivated cropland. In the rest of the Basin, the smoother uplands and the bottom lands near the streams are cultivated, but the rougher dissected plains are used mainly for pasture.

Corn and sorghum are the major crops grown. Clay County, which lies partly in the Little Blue and partly in the Big Blue River Basin, is the state's leading producer of irrigated sorghum.

The rainwater basin along the northern edge of this Basin is one of the better waterfowl production areas in the State. The U.S. Bureau of Sport Fisheries and Wildlife has purchased a number of tracts of land containing marshes and wetlands for the production of waterfowl and for public hunting areas.

PROBLEMS AND NEEDS

The flood problem in this Basin occurs mainly in the upper flat plains and along the Little Blue River in the lower part of the Basin. The most frequent damage occurs from ponded areas in the upper Basin because of poorly define drainage networks. The tributaries concentrate runoff in the lower mainstem causing overbank damage.

The supply of ground water in this Basin is generally adequate for municipal and domestic water supplies except in the area south of the river adjacent to the Republican River Basin. In this area, which includes parts of Adams, Webster, and Nuckolls Counties, it is sometimes necessary to go outside the immediate are to find dependable supplies of water.

Irrigation from ground water in areas where supplies have been found to be plentiful also presents a potential problem. In areas of intensive development, the water table has declined consistently for a number of years. In some parts of Adams, Clay, and Fillmore Counties, the water level has lowered as much as 25 feet. Additional development for irrigation will cause greater declines in water levels and pumping costs will increase.

In 1969, the Department of Health found that three sewage systems serving about 20 percent of the Basin's population provided only primary treatment of wastes. In addition, three other systems with secondary treatment facilities needed improvement to protect the quality of the water in the Basin and to comply with water quality standards.

The Little Blue River Basin lies primarily within the Hastings and Beatrice socio-economic areas outlined by the Game and Parks Commission. Both these areas have moderate deficiencies in water surface area available for recreation at the present time, and it is estimated that the deficiency will increase in the Hastings area in the future. It has been estimated that the use of the water in the Basin for fishing exceeds the recommended capacity of the waters by two and one-half times.

Many of the rainwater basins in the flat lands in the upper end of this Basin have been drained for agriculture and their value for waterfowl has been destroyed. The remaining ponds and marshes are important for waterfowl production and hunting and need to be preserved in order to maintain this resource.

BASIC FRAMEWORK DEVELOPMENT

Development, both independent and public, that appears reasonable to satisfy most indicated needs and is likely to occur within the planning period has been included in the Basic Framework for in-basin water development.

Independent Local Development. Additional independent development of soil and water resources will depend upon the demand for agricultural products and the economic capability of the land owners. Growth by municipalities and industrial development will increase the demand for water, and rural water use, particularly for livestock, will also increase in this Basin. Application of land treatment measures for control of erosion and soil and water conservation will also increase.

Municipal and Industrial. The projected urban population to be served by municipal water systems in 2020 is 16,900. This is about 5,400 persons less than in 1960. Since the amount of water used by each person is expected to increase for the next several decades, it is estimated that total municipal use will increase until 1980 and then start to decline. The additional supplies will probably come from ground water, even though some communities may have to go considerable distances to find good wells. Present estimated municipal and industrial water use in the Basin is 4,650 afa and is expected to increase to about 7,600 afa by 2020. The 2020 requirement includes 80 gpcd industrial reserve. Projected municipal and industrial requirements for the year 2020 are presented by subbasin in Table 76.

Rural Domestic and Livestock. Rural domestic use will increase until about 1980 as more pressure systems are installed in rural residences, but the total requirement for rural domestic use is expected to stabilize after that date as rural population declines. On the other hand, the number of livestock in the Basin is expected to increase steadily, and the future water requirement for livestock will be nearly three times the present requirement of 4,800 afa. The additional supplies needed for both domestic use and livestock will come mostly from ground water.

Irrigation. In the future, most private irrigation development will probably be from ground water. About one-third of the irrigable land in the Basin is now being irrigated and it is estimated that about 130,000 additional acres will be developed to utilize ground water supplies. Lands in the nothern half of the Basin are highly suitable for irrigation development and adequate ground water supplies are generally available for additional irrigation wells. Several areas with lands of moderate to high irrigation suitability lie in the southern and eastern parts of the Basin, but adequate supplies of ground water are scattered and difficult to locate in these areas.

Public Project Development. Several public projects in this Basin have been investigated by federal agencies. Most have been included in this Basic Framework. The location of these projects is shown on Figure 64.

Little Blue Unit. The Bureau of Reclamation has conducted a feasibility study of the Little Blue Unit, a part of the Missouri River Basin Project. The key feature of this development would be Angus Dam and Reservoir on the Little Blue River, which would provide a total of 440,000 AF of storage for irrigation, flood control, recreation, fish and wildlife purposes. Reservoir storage capacity of 94,800 AF is included to provide irrigation water for 20,000 acres.

About 337,000 AF of storage would be available for flood control. As an integral part of the Kansas River system, this storage could provide flood control benefits downstream through Nebraska and into Kansas. The surface area of the conservation

TABLE 76 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Little Blue River Basin

Subbasin	Municipal Systems				Private Industrial Systems a/	
	People Served		afa		afa	
	Present	2020	Present	2020 b/	Present	2020
Little Blue River						
Above Deweese	7,554	5,830	880	1,300	1,300	3,180
Deweese to Fairbury	14,005	10,580	2,200	2,600	110	400
Fairbury to State Line	705	490	160	100	0	0
BASIN TOTAL	**22,264**	**16,900**	**3,240**	**4,000**	**1,410**	**3,580**

a/ *Includes cooling water requirements for existing thermal electric plants*
b/ *Includes projected industrial reserve*

TABLE 77 / POTENTIAL SMALL WATERSHED PROJECTS
Little Blue River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
Balls Branch	21	11	1,930	130	None
Potentially Feasible					
Little Sandy	105	Not Known	6,400	620	12
Upper Little Blue, Cottonwood-Scott Creeks, A.C.N.W. Tribs, Big Sandy, Fairbury Tribs	1,613	None	None	None	76

a/ *Based on completed Work Plans or Preliminary Investigations*

pool available for recreation and fishery uses would be about 5,100 acres.

Small Watershed Projects. One small watershed project, Balls Branch, has been investigated and is feasible for construction. Floodwater retarding structures included in the project would have a total storage capacity of 2,850 AF and 130 acres of surface area. Drainage from 11 square miles would be controlled by these structures.

From the reconnaissance investigations completed for the MRB study, six other small watershed projects appear to have potential for future development. Additional investigation will be required to determine the feasibility of these projects. Preliminary estimates of the features of these projects are given in Table 77.

Nonstructural Measures. Methods of flood protection other than conventional structural measures are required to stop the continual increase of flood damages and reverse the trend. Flood plain management in the form of zoning, subdivision regulations, and floodproofing should be implemented in flood hazard areas throughout the Basin. The city of Fairbury has a high priority for flood plain delineation and regulation to supplement the existing local flood protection project and to minimize future damage from the remaining flood threat.

Modification or Improvement of Existing Developments. No existing water resource developments in this Basin were identified for modification or needed improvement. Although not resulting directly from development, land use practices in the Basin have caused sediment deposition and accumulation of brush and debris in stream channels. The lower reaches of several streams need to be cleared in order to reduce the flooding and prevent further reduction of channel capacity.

Potential Effects. Development of resources included in this Basic Framework will have significant effects within the Basin.

Independent local development will help stabilize the economy and the population of urban areas within the Basin. Trade centers on the edge of the Basin will also benefit.

Construction contracts for the multipurpose projects will have a short-term effect on the local economy, and additional irrigation development and flood control will have far-reaching effects. Since irrigation increases crop production and the value of crops, the agricultural sector of the economy will expand, and those industries based on agriculture will benefit.

The multipurpose projects would also provide benefits by reducing the threat of floods to health and safety, and by providing habitat for fish and wildlife. The surface area of the reservoirs will also provide outstanding recreational opportunities for residents within and around the Basin.

All projects must be planned to insure there will be no further unwarranted damage to the wetlands in the Basin which provide habitat for waterfowl. Flood control and drainage projects should be designed to enhance such environmental resources whenever possible.

An estimate was made of the effect of development on streamflow to determine the degree of utilization of the water resource after projected in-basin development has taken place.

TABLE 78 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT
Little Blue River Basin

Stream Location	1000 Acre-Feet Annually		
	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Little Blue R. nr. Deweese	103.0	14.9	88.1
Little Blue R. nr. Fairbury	252.2	51.6	200.6
Little Blue R. @ State Line	328.0	51.8	276.2

Note: Based on average annual streamflow during the period 1954-63

The estimated streamflow under 1970 conditions, the depletions expected from projected in-basin development, and the estimated streamflow remaining are shown in Table 78.

The estimated depletions shown are cumulative totals and reflect the net use of water above the location shown. The largest streamflow depletions result from projected irrigation development and evaporation from the large reservoir.

Table 78 indicates that substantial quantities of surface water would remain in the Basin. However, most of this water is floodwater and it occurs near the lower end of the Basin where development for use upstream would be difficult. There is no excess water in the upper part of the Basin where it is needed most and can best be utilized. Also, a compact being negotiated between Nebraska and Kansas on the Big and Little Blue Rivers may exert some control over the amount of water originating in the Basin which can be consumed and the amount which must remain to flow into Kansas.

REMAINING PROBLEMS AND OPPORTUNITIES

The flood control projects will reduce flooding considerably but floods will still be a threat in this Basin. It will be necessary to study and reevaluate the flood potential and possible protection projects regularly in the future. Flood plain management techniques and regulations will also require continual updating.

If ground water development for irrigation continues, ground water levels will continue to decline in some parts of the Basin. Conjunctive use of surface water irrigation with ground water supplies to increase recharge and decrease net withdrawals may be necessary to stabilize the water levels.

Some areas in Adams, Webster, and Nuckolls Counties south of the Little Blue River contain sizable tracts of land suitable for irrigation for which no water is available within the Basin. The development of these lands will depend upon the availability of water from sources outside the Basin.

Big Blue River Basin

GENERAL DESCRIPTION

This Basin is located in southeastern Nebraska between the Little Blue and Nemaha River Basins. The upper part of the Basin lies in the loess plains over thick deposits of silt, sand and gravel. The eastern and southern parts of the Basin lie within the glaciated area of the State. Here the plains change to rolling hills and bedrock outcrops occur in the valleys near the Kansas border.

The topography and drainage vary with the change of geology. The upper Basin is made up of broad flat plains which have virtually no drainage pattern in many locations. In the central portion, these give way to dissected tablelands with a better defined drainage pattern. Here the main stream channels are rather narrow and bounded by wide high terraces. The lower Basin contains both dissected tablelands and rolling loess hills with a well established drainage pattern.

Basin Resources. Most of the land in this Basin, 2,796,000 acres, is suitable for agricultural use and over 90 percent of this is suitable for cultivation. Slightly over two million acres are classed as suitable for irrigation, much of it highly suitable.

The average annual precipitation in the southeastern corner of the Basin is over 30 inches, but it decreases to about 22 inches at the western end. In the upper part of the Basin above DeWitt, ground water is used extensively to supplement the rainfall received during the crop growing season. In many years supplemental irrigation would also improve yields and insure against crop failure in the lower half of the Basin.

The hydrologic characteristics of this Basin are reflected in the records of the river gage at Barneston. The relatively impermeable loess soils allow little infiltration into the ground, so the base flow in most of the streams is small, and runoff is large and rapid during heavy storms. At Barneston the minimum discharge recorded during the period 1932 to 1968 was only one cfs but the maximum was 57,700 cfs.

Annual streamflow also varies a great deal. The average annual streamflow for Barneston's period of record is 556,000 AF, but the minimum was only 83,200 AF, or 15 percent of average, while the maximum was about 300 percent of average and 19 times the minimum.

Irrigation development has had an effect on streamflow. Runoff of ground water used for irrigation has increased the flow in some streams during the irrigation season, and in some cases this water is being reused by surface water irrigators.

A compact to apportion the waters of the Big and Little Blue Rivers is currently being negotiated between the States of Nebraska and Kansas. This compact will have some effect on future amounts of water which must be allowed to flow into Kansas.

Ground water supplies are as different as the drainage pattern, topography and geology of the upper and lower parts of the Basin. The lower part of the Basin, which contains glacial deposits under the loess soils, has only small supplies of ground water. Pleistocene deposits in the principal stream valleys or buried in bedrock valleys scattered under the glacial deposits provide the best sources of water in this area, but some water may be obtained from the deeply buried Dakota sandstones.

The upper part of the Basin, containing more than half the area, has a thick mantle of waterborne deposits under the loess. This includes water bearing sand and gravel layers which provide a plentiful supply of ground water for irrigation.

The mineral resources of the Basin are limestone, sand and gravel. Limestone quarries are located in the southern half of the Basin where bedrock is close to the surface, but the sand and gravel pits are scattered throughout the upper part of the Basin.

The fishery resource is mostly limited to the mainstem Big Blue River, but the entire Basin is an important area for wildlife, particularly waterfowl. Poor drainage in the upper part of the Basin creates marshes and rainwater basins that provide important habitat for nesting and migrating waterfowl. The Basin also provides excellent habitat for pheasants and quail.

Existing Development. The Big Blue River Basin has more total acres and a greater percentage of its area highly suitable for irrigation than any other basin in the State. About 740,000 acres in the Basin are already being irrigated. Only the Middle Platte River Basin has more acres under irrigation at the present time.

The major crops grown are corn and sorghum. Hamilton County has recently been the top irrigated corn producing county in the State while Clay County leads in irrigated sorghum production.

A number of projects have been developed for flood control in the Basin. One local protection project consisting of about 8,000 feet of levee has been constructed at Seward to protect 105 acres from Big Blue River floodwaters.

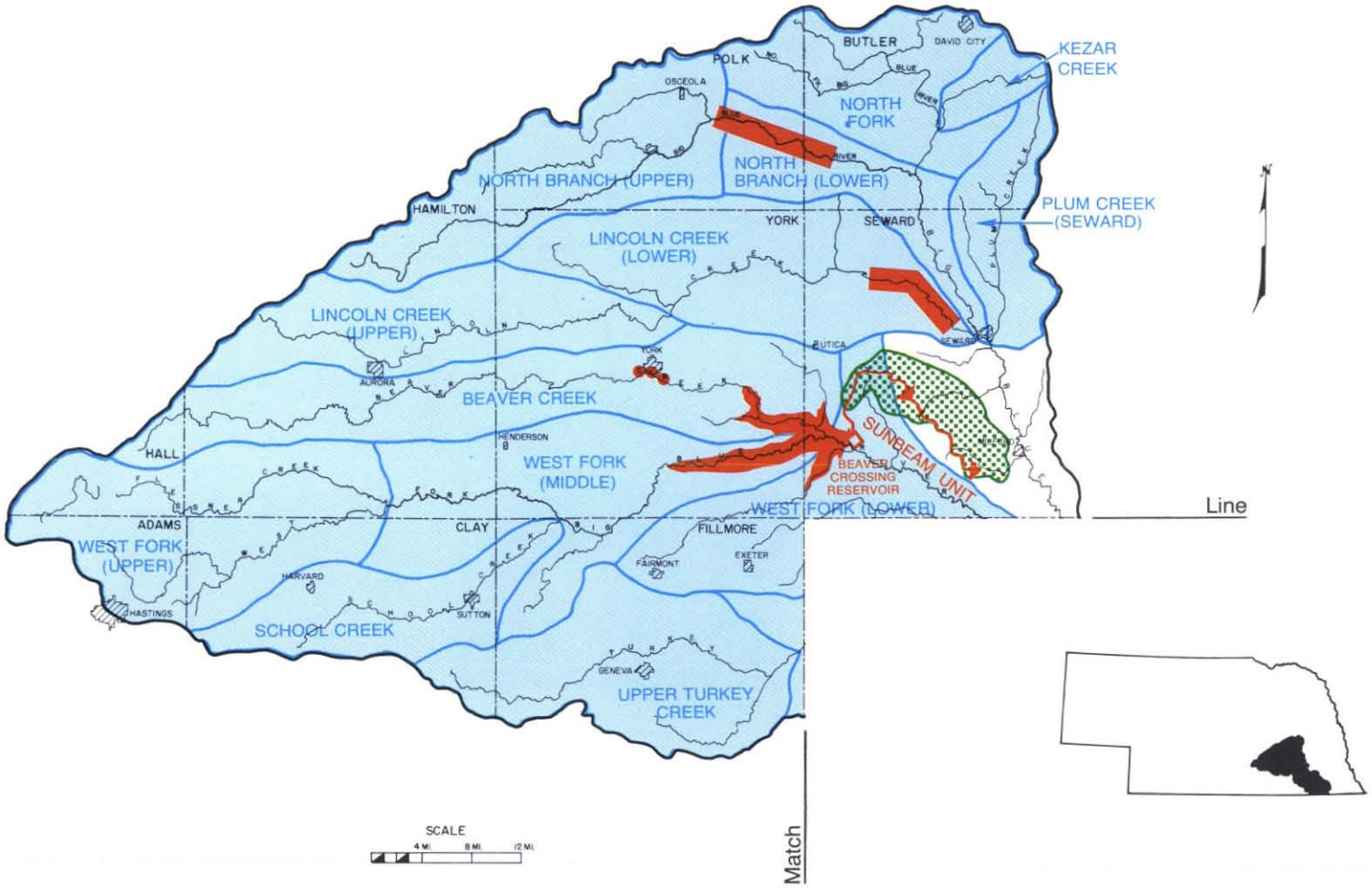
Nine small watershed projects are also completed or under construction. Most of these projects are located in the rolling hills of the lower portion of the Basin. Pertinent data on these projects is presented in Table 79.

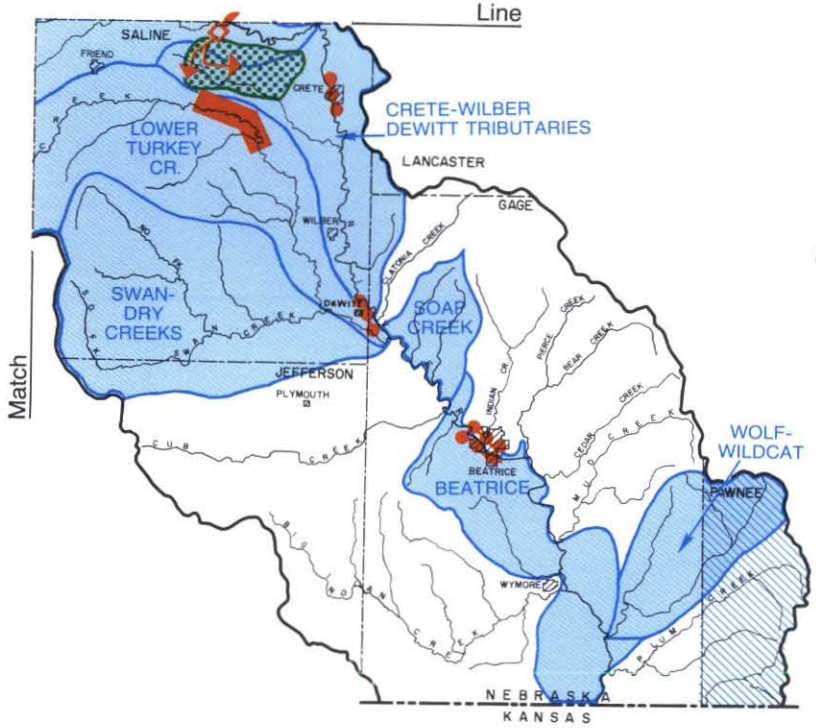
The economy of the Basin is largely dependent on agriculture. Some light manufacturing industries produce products such as clothing, electronic equipment, and aluminum products, but most of

TABLE 79 / EXISTING SMALL WATERSHED PROJECTS
Big Blue River Basin

Project Name	Floodwater Retarding Structures		No. of Grade Stabilization Structures	Channel Improvements (Miles)
	No.	Capacity (AF)		
Bear-Pierce-Cedar	27	8,930	6	0
Big Indian	32	22,080	3	0
Clatonia	8	3,185	0	0
Cub Creek	17	10,050	12	0
Dorchester	4	590	1	1.6
Little Indian Creek	24	5,070	39	0
Mission Creek	7	3,150	4	0
Mud Creek	11	6,600	20	0
Plum Creek	25	4,410	7	27
BASIN TOTAL	**155**	**64,065**	**92**	**28.6**

FIG. 65 / BASIC FRAMEWORK DEVELOPMENT
BIG BLUE RIVER BASIN





EXISTING

PROPOSED FEATURES

- Dam And Reservoir
- Canal
- Pumping Plant
- Watershed Project
- Diversion Dam
- Irrigation Project Lands
- Rural Water District
- Local Flood Protection
- Areas Where Flood Control Reservoirs May Be Required

Note: All basin map legends were standardized and all features will not appear on every map

the manufacturing and trade is based on service to farms or processing farm products. There are three cities with a 1960 population over 5,000 located in this Basin. Hastings, with 21,000, is located on the western divide and York, with about 6,000, is located near the center of the upper part of the Basin. Beatrice, with over 12,000 population, is located near the Basin's lower end. Each of these cities is a trade center for the surrounding area.

The U.S. Fish and Wildlife Service has developed some of the marshes and wetlands in York, Fillmore, and Clay Counties for the production of waterfowl and for public hunting. Wetlands in this Basin and the neighboring Little Blue River Basin provide valuable habitat for wildlife as well as recreation in the form of hunting. The State Game and Parks Commission has developed wayside rest areas along highways, day-use recreation areas, and some special use areas for hunting. The National Park Service maintains the Homestead National Monument in Gage County.

PROBLEMS AND NEEDS

Residents of this Basin have experienced many severe floods during this century. The main streams have flooded a number of times and the tributary streams flood frequently. Residents along Plum Creek have reported that its main channel has overflowed as many as seven times in one year.

Average annual flood damage in the Big Blue River Basin totals nearly 2.5 million dollars; third largest among the state's river basins. Nearly nine percent of the land is subject to flooding by the 100-year frequency flood and over 93 percent of the damage on this land occurs in rural areas.

Ground water is being developed extensively for irrigation in the upper part of this Basin, and it now ranks second in the total number of registered irrigation wells. Depletions from such use have already lowered the water table as much as 20 feet in parts of Hamilton, York, Clay, and Fillmore Counties and continued withdrawal at the same rate will cause further declines.

The supply of water for municipal, industrial, and domestic needs is generally adequate in this Basin, except in the glacial drift region on the eastern edge and in the southeastern corner. Some communities find it necessary to search outside their immediate area for wells with sufficient yields.

A Nebraska Department of Health inventory of the sewage treatment facilities in the Basin revealed there were four communities without sewer systems in 1969. Two communities which provide only primary treatment of their sewage wastes and five communities with inadequate secondary treatment facilities need to improve their facilities to comply with the Nebraska Water Quality Standards.

This Basin contains very little water surface area in public lakes or ponds useful for fishing and recreation. Streams are the main resource available. Three percent of the fishing in the State occurs in this Basin because of its close proximity to population centers, but the Nebraska Game and Parks Commission estimates that the Basin has only about one-half of one percent of the state's fishing capacity. Much of this Basin lies within the Lincoln SEA, which has the state's second largest deficiency in water surface area available for recreation.

BASIC FRAMEWORK DEVELOPMENT

Development included in this Basic Framework is composed of those projects and programs using in-basin water resources that appear reasonable to meet the anticipated needs and problems. Allowances have been made for independent local development that appears likely during the planning period.

Independent Local Development. Land and water resources are available for additional private irrigation development. In addition, independent development of water resources to meet increasing needs for municipal, industrial, and rural supplies will continue. Development indirectly affecting the water resource, such as land treatment measures for soil and water conservation, is also expected to increase.

Municipal and Industrial. The population served by municipal water systems is expected to increase from 81,000 in 1960 to about 100,000 by 2020. Estimated municipal and industrial water requirements will increase from 20,000 afa to 40,000 afa in the same period. Ground water will be used to meet these additional requirements even though some communities may have to go outside their immediate area to obtain adequate supplies. Projected municipal and industrial water requirements are given in Table 80.

Rural Domestic and Livestock. Rural domestic water use is expected to increase sharply until 1980 as more rural homes are equipped with pressure systems and additional water using facilities. After 1980, the requirement for this use is expected to increase at a much slower rate. Projected livestock water requirements will increase steadily from a present use of about 8,400 afa to about 24,000 afa by 2020. Additional rural domestic supplies and most of the increased livestock requirements will come from ground water.

Irrigation. The additional area likely to be developed for private irrigation by ground water is estimated to be about 190,000 acres. Most of the

TABLE 80 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

Big Blue River Basin

Subbasin	Municipal Systems				Private[a/] Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020[b/]	Present	2020
Big Blue River						
Above Seward	14,880	19,760	1,840	4,800	100	500
Seward to Crete	40,540	54,830	10,100	19,700	2,200	5,500
Crete to Barneston	25,590	24,460	3,740	6,700	2,000	2,190
Barneston to State Line	0	70	0	10	0	
BASIN TOTAL	**81,010**	**99,120**	**15,680**	**31,210**	**4,300**	**8,190**

a/ Includes cooling water requirements for existing thermal electric plants
b/ Includes projected industrial reserve

upper half of the Basin is highly suitable for irrigation development and much is presently irrigated. However, many parcels of nonirrigated land remain and moderate to large supplies of ground water are potentially available for additional irrigation. The potential for private development of the land and water resources for irrigation is as great in this Basin as any in the State.

Public Project Development. Public project development included in this Basic Framework includes a large multipurpose irrigation and flood control project, multipurpose small watershed projects, and single purpose local flood protection projects. The location of the various projects is shown on Figure 65.

Sunbeam Unit. The Bureau of Reclamation has conducted a reconnaissance investigation to determine potential projects in this Basin. One, the Sunbeam Unit, is being given more detailed study and consideration. Beaver Crossing Dam and Reservoir would be a part of the Sunbeam Unit and would store irrigation water for use on 19,000 acres in the Goehner area and 11,000 acres in the Dorchester area. It would also provide about 400,000 AF of flood control storage and 7,800 acres of water surface area for recreation.

Small Watershed Projects. Three small watershed projects in this Basin have been investigated in sufficient detail to determine that they are feasible for construction. These projects are intended primarily for flood control. Some data on these projects is given in Table 81.

Sixteen other small watershed projects appear to have some potential for development. Two proj-

TABLE 81 / POTENTIAL SMALL WATERSHED PROJECTS

Big Blue River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible For Construction[a/]					
Swan-Dry	254	139	21,000	1,350	None
Soap Creek	40	18	3,220	152	None
Wolf-Wildcat	87	41	6,000	460	7
Potentially Feasible					
Kezar Creek, Plum Creek (Seward)	132	Not Known	13,740	950	8
North Fork, North Branch (Upper), North Branch (Lower), Lincoln Cr. (Upper), Lincoln Cr. (Lower), West Fork (Upper), School Cr., West Fork (Middle), Beaver Cr., West Fork (Lower), Crete-Wilber-DeWitt Tribs, Upper Turkey Cr., Lower Turkey Cr., Beatrice	3,066	None	None	None	240

a/ Based on completed Work Plans or Preliminary Investigations

ects include flood control storage and appear feasible in the near future. In the remaining watersheds, upland water disposal systems may be warranted, but more detailed investigations are required to determine the feasibility of these projects. Some preliminary information based on the U.S. Department of Agriculture Big Blue River basin report is shown in Table 81.

Flood Control Projects. Additional flood storage will be required on major tributaries in the Basin as part of a total flood control program. The Corps of Engineers is presently conducting an investigation of the Basin to evaluate the potential for major flood control structures.

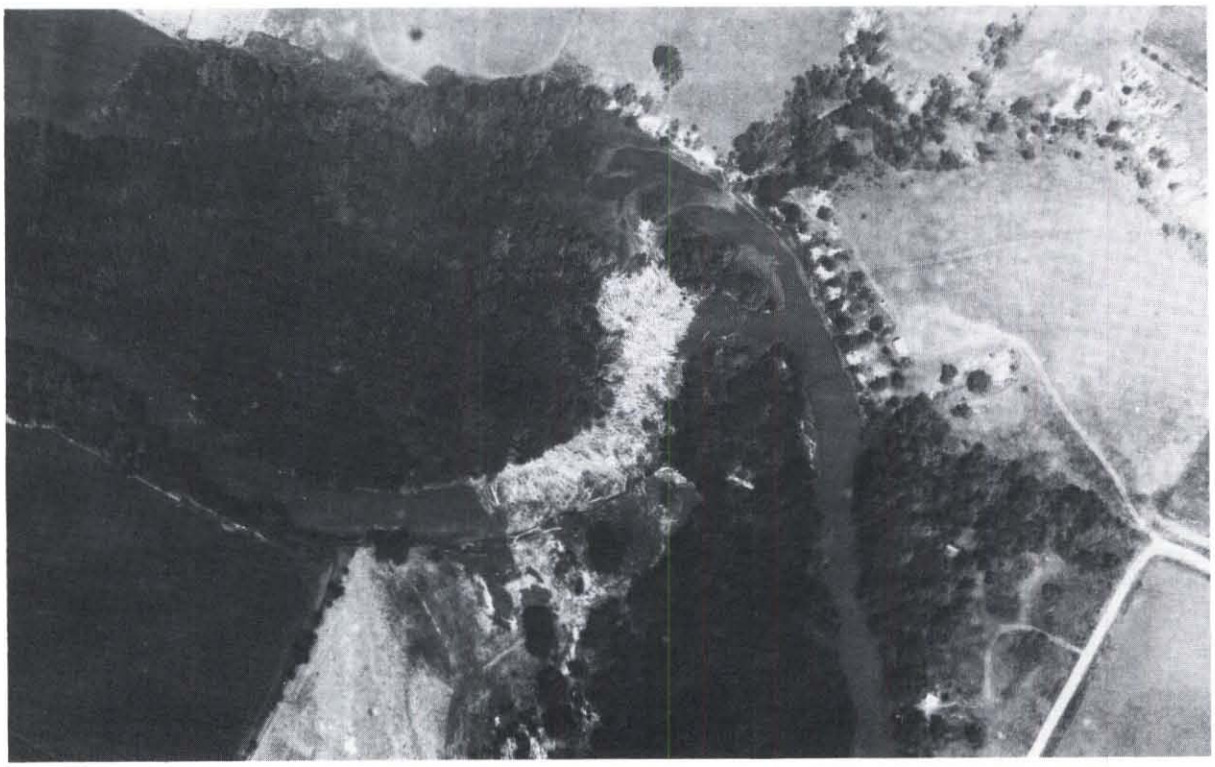
Three locations for reservoir flood storage were included in the USBR reconnaissance study of this Basin. These reservoirs have not been studied in detail, but it appears they would be able to provide about 400,000 AF of storage for floodwaters and 14,000 acres of water surface. Although these potential reservoirs are not shown, the general areas where flood control reservoirs may be required are indicated in Figure 65.

Local Flood Protection. Single purpose local flood protection projects have been proposed to protect Beatrice, York, Crete, and DeWitt. About 20 miles of channels and/or levees would be constructed to protect over 600 acres in the four communities.

Nonstructural Measures. The flood control structures included in this Basic Framework would significantly reduce flood damages, but they could not eliminate them entirely. Regulation of the use of the flood plains through zoning, subdivision regulations, and flood proofing of structures must accompany the structural measures. Beatrice, Hastings, York, and Crete already have high priorities for flood plain delineation studies which, when completed, can be used to initiate flood plain zoning.

Modification or Improvement of Existing Developments. There are no existing water resource developments in this Basin that were identified as requiring modification of rehabilitation. Although not directly caused by development, land use practices have reduced the capacities of many channels in the Basin through sediment deposition and clogging with trees and debris. This problem is probably more serious in this Basin than any other in the State. An example of this problem is a large accumulation of logs and debris in the main Big Blue River channel near DeWitt. Clogged channels need to be cleared in order to reduce flood and related damages.

Potential Effects. The development included in this study will have several effects on the economy of the Basin. The most noticeable will be the short-term effects from the construction contracts on multipurpose structures. The long-range effects



will come from the expansion of agriculture due to irrigation and the recreation industry which can be developed in connection with the reservoirs. Most of the reservoirs would be easily accessible from major population centers, and the potential for recreation development and for improved fish and waterfowl habitat is excellent.

Both farmers and the industries which serve agriculture and process agricultural products would benefit from additional irrigation. Nearly every sector of the Basin's economy is related to agricultural productivity in some way.

The environmental effects of Basic Framework development will be complex and varied. Flood control provided by the reservoirs will reduce the threat to health and safety on the flood plains downstream. Channel improvements will reduce flooding by increasing the capacity of streams, but care must be taken that such projects do not increase channel erosion and the silt load in the streams, or drain wetlands which are vital to wildlife in the Basin.

An estimate was made of in-basin water utilization by Basic Framework developments. Table 82 shows streamflow under 1970 conditions of development, estimated net depletions by projected in-basin development, and the remaining streamflow.

The depletions shown for the first two stations are independent amounts, but thereafter the figures are cumulative totals reflecting total flows and total net depletions. These figures reflect the depletions projected for irrigation development in the upper reaches of the Basin and those expected from flood control developments in the lower Basin.

Table 82 shows large quantities of water available at two locations in the lower part of the Basin where capture and storage would be difficult and the water would be far from the area of need in the upper part of the Basin.

Another factor which might affect the availability of this water is the compact now being negotiated between Nebraska and Kansas to cover the Big and Little Blue River Basins. This will exert some control over the amount of water which is available for use in Nebraska.

REMAINING PROBLEMS AND OPPORTUNITIES

Even with development included in this Basic Framework, flooding will continue to be experienced on some of the tributaries and on the lower mainstem. Sites are not available nor would it be feasible to control all flooding in the upper areas of the tributaries. Much of the flood damage in the lower Basin will be reduced or eliminated but occasional flooding will still occur from storms centered over the lower Basin or those storms which occur in rapid sequence over the upper Basin.

This Basin comprises almost one-third of the Lincoln SEA outlined by the Game and Parks Commission. Even after the completion of all in-basin development, this area will still have a deficiency in water surface area to meet the demand of recreationists. More water surface for boating, fishing, and other recreational activities will still be needed for the growing numbers of urban residents.

The expansion of irrigation from ground water will further complicate one of the problems emerging in this Basin. Withdrawals from the ground water reservoir now exceed the recharge in some areas, and the ground water table is declining in these locations. Continued pumping at the present rate could continue to lower these levels and an increase in pumping would accelerate the rate of decline and increase pumping costs.

TABLE 82 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT
Big Blue River Basin

	1000 Acre-Feet Annually		
Stream Location	Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Big Blue River at Seward	71.7	18.7	53.0
West Fork Big Blue River nr. Dorchester	124.1	41.3	82.8
Big Blue River nr. Crete	239.6	72.5	167.1
Big Blue River at Barneston	554.2	93.4	460.8
Big Blue River at State Line	571.7	93.9	477.8

Note: Based on average annual streamflow during the period 1954-63

Nemaha River Basin

GENERAL DESCRIPTION

The Nemaha River Basin, located in the southeast corner of the State, includes the drainage area of all streams entering the Missouri River between the mouth of the Platte River and the Nebraska-Kansas state line, with the exception of that portion of the Big Nemaha River drainage lying in northeastern Kansas.

The Basin lies entirely within the glaciated portion of the State and the loess soils lie on undulating glacial deposits. This creates a land surface consisting of a series of rolling hills which run down to the flat valleys of the major streams flowing into the Missouri River. These valleys are nearly level with poor drainage. The drainage pattern in the remainder of the Basin is well defined and surface runoff is rapid.

Many of the steeper slopes in this Basin are wooded, particularly the steep bluffs bordering the Missouri River valley. More different species of trees are found in the Basin than any other part of the State.

Basin Resources. Most of the land in this Basin is suitable for agricultural use. Nearly 1.7 million acres are classified as agricultural lands and 1,573,000 are considered arable. About two-thirds of the arable land, almost 1.1 million acres, is classified as irrigable, but only about 15 percent of the irrigable lands are well suited to irrigation. The remaining 85 percent have some limitations, such as slope, which give them only limited suitability for irrigation.

This Basin receives more precipitation than any other in the State, varying from a state high of about 35 inches in the southeast to 28 inches in the northwest part. Most of the rainfall comes during the growing season and is usually adequate for all types of crops grown in the Basin.

Most of the streamflow in this Basin is direct runoff from rainfall which creates high flows during periods of heavy rainfall and results in low flows during dry periods. Base flow from ground water, especially in the upper reaches of the streams, is very low or nonexistent.

Ground water is difficult to obtain in this glaciated area. That which is available usually produces only small yields to wells and is often highly mineralized. The principal stream valleys containing alluvial deposits and the bedrock valleys buried under the glacial till, which are filled with sand, gravel, or finer grained fluvial sediments, provide moderate yields to wells. Locally, specific layers of bedrock may also be a source of water in some locations, but it is likely to be highly mineralized. Only one other basin in the State has less ground water in storage.

Other resources of the Basin include limestone, clay, sand and gravel, various species of deciduous trees used for rough lumber, and a newly discovered stratum of gypsum.

Existing Development. There have been a number of developments to utilize or control the resources of this Basin. About 13,000 acres in the Basin are now being irrigated, seven small watershed projects are completed or under construction, several single purpose flood control projects have been constructed and rural water districts are being formed. In addition, several minerals are being mined and lumber and timber products are being produced.

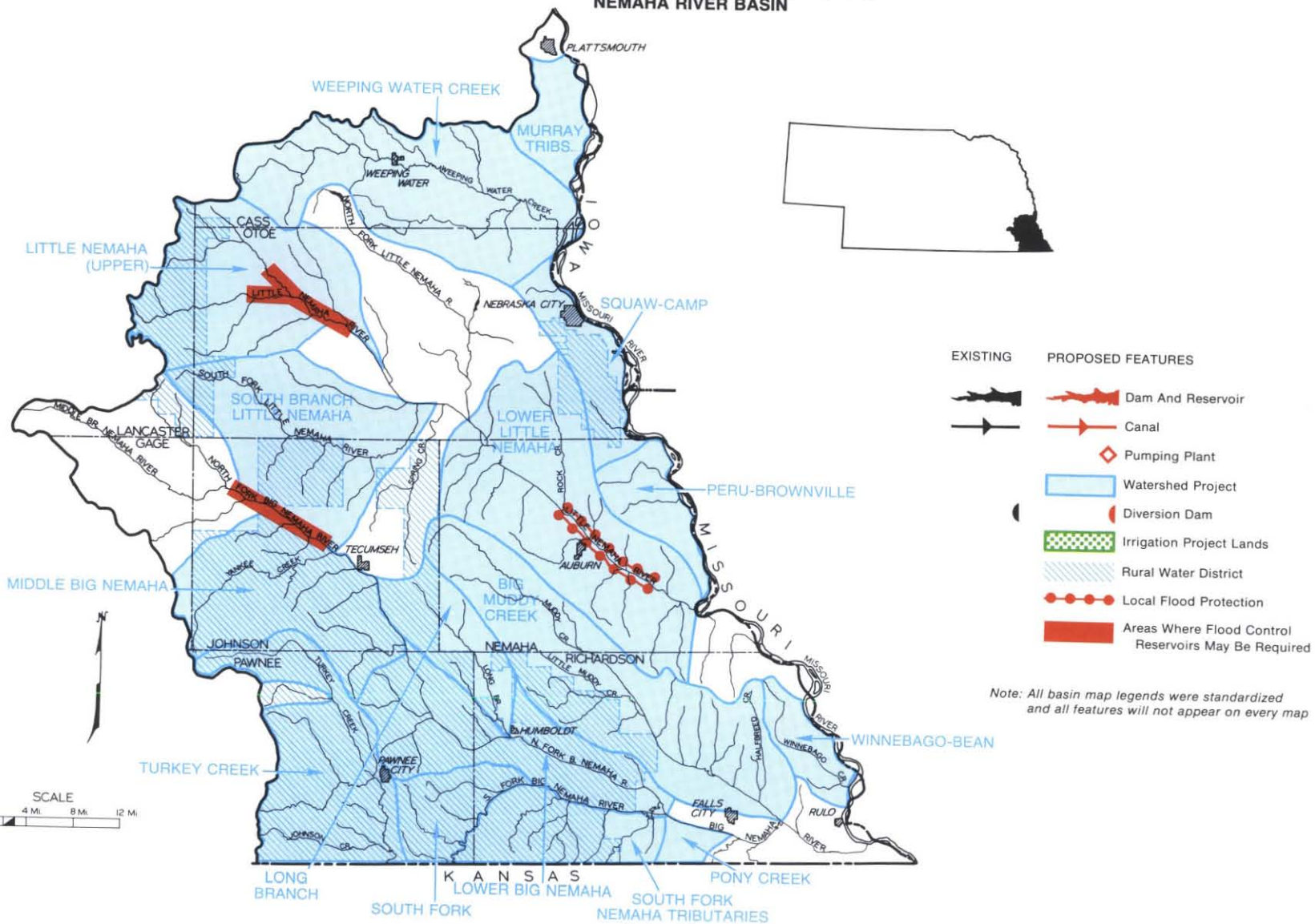
The U.S. Army Corps of Engineers has constructed several segments of a proposed levee system along the Missouri River for flood control. This is part of a comprehensive program to harness the Missouri River for navigation, reclaim riparian lands for agricultural production, and to provide flood control.

Seven small watershed projects have been constructed by the Soil Conservation Service for flood and erosion control. One project is primarily for erosion control while the others provide both flood and erosion control. A summary of the features of these projects is given in Table 83.

TABLE 83 / EXISTING SMALL WATERSHED PROJECTS
Nemaha River Basin

Project Name	Floodwater Retarding Structures		No. of Grade Stabilization Structures
	No.	Capacity (AF)	
Plattsmouth	10	351	1
Ziegler Creek	None	None	15
Wilson Creek	22	8,068	67
Upper Big Nemaha	38	16,285	59
Brownell Creek	9	734	36
Rock (Pawnee)	5	1,136	12
Spring Creek (Johnson)	7	2,276	21
BASIN TOTAL	**91**	**28,850**	**211**

FIG. 66 / BASIC FRAMEWORK DEVELOPMENT
NEMAHA RIVER BASIN



There are about 20 quarries producing limestone and several pits producing clay or sand and gravel in this Basin. In 1968 there were also 10 sawmills producing rough lumber, pallet stock, and crating.

One rural water district in Nemaha County has been formed and construction of the distribution system is nearing completion. Formation of other districts is under discussion in Otoe, Johnson, Nemaha, Pawnee, Richardson, and Lancaster Counties. The water for these systems, if constructed, will probably be supplied from ground water.

As in the rest of the State, the economy of the Basin is largely dependent upon agriculture. Much of the industry is dependent upon agriculture, but manufacturing is diversified. Light industries such as clothing, plastics, printing, and light machinery manufacturing head the list, but there is also some manufacturing of larger products such as mobile homes and travel trailers. Nebraska City, with a 1960 population of slightly over 7,000, is the largest city in the Basin, but Plattsmouth and Falls City are nearly as large. Both have populations over 5,000. Most of the flat land, which is on the drainage divides and in the valleys, is used for production of cultivated crops, and the slopes are used for pasture or woodland. Corn and sorghum are the major crops.

PROBLEMS AND NEEDS

The rainfall in this Basin often comes in intense storms and produces rapid runoff when it falls on the steep slopes of clayey soils. For this reason, large floods occur frequently in the Basin. In fact, the flood damage in this Basin ranks second in the State with estimated average losses of slightly over 2.5 million dollars annually. Nearly 15 percent of the land, about 265,000 acres, is subject to overflow from the 100-year frequency flood.

Serious gully and streambank erosion is prevalent throughout much of the Basin. A part of this problem is a result of past channel straightening. The Big and Little Nemaha Rivers have carved deep canyons into the loess soils. These are now becoming stabilized, but tributary channels are still subject to degradation and streambank erosion, and a sustained period of high flows would produce additional erosion in many channels.

Recharge of ground water is minimal in this Basin because of the relative impermeability of the soils. The supply of good quality ground water for municipal, industrial, rural domestic, and livestock uses is limited. Very few aquifers in the Basin will yield large amounts of water to wells, and most good aquifers cover only small areas. The quality of the available ground water is generally adequate, but it is more highly mineralized than is desirable.

Dependable supplies of ground water are sometimes impossible to locate. The rural water districts presently being formed to supply water from a common source will partially relieve the problem, but more are needed. Proper planning will be required to insure that the public interest is fully protected in the establishment and maintenance of such districts.

An inventory in 1969 showed that there were nine communities in the Basin without sewer systems and four others providing only primary treatment. These four, and one community with an inadequate secondary treatment plant, need to improve their treatment facilities to comply with the Nebraska Water Quality Standards.

This Basin lies near Lincoln and Omaha where large deficiencies in available water surface area for recreation presently exist. These deficiencies are expected to increase substantially in the future and create a severe shortage of water surface area.

BASIC FRAMEWORK DEVELOPMENT

A level of development which appears reasonable for the needs and conditions in the Basin has been included in the Basic Framework. Allowances have been made for independent local development anticipated to take place during the planning period. Public project development is based on the availability of in-basin water and related resources.

Independent Local Development. Independent development of the land and water resources will continue in order to meet the needs of the people and the demands of agriculture and industry. Agricultural development will depend upon the need for agricultural products and the economic capability of land owners. Growth of municipalities and industrial development will create demands for additional land and water. Projected independent development includes additional municipal, industrial, and rural water supplies and other developments, such as land treatment for conservation of soil, which indirectly affects the amount of water available.

Municipal and Industrial. The population served by municipal water supply systems in this Basin is expected to increase from the 1960 population of 38,364 to 47,720 by the year 2020. Estimated present water use for municipal and industrial purposes is about 5,500 afa and is expected to increase to about 12,000 afa by 2020. Table 84 shows projected municipal and related industrial water requirements for the Basin.

Rural Domestic and Livestock. Rural domestic water use is expected to increase slightly, from

TABLE 84 / PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
Nemaha River Basin

Subbasin	Municipal Systems				Private Industrial Systems	
	People Served		afa		afa	
	Present	2020	Present	2020 a/	Present	2020
Weeping Water Creek	2,338	1,230	200	200		
Little Nemaha River	7,170	13,170	790	2,800		
Big Nemaha River						
Above Humboldt	5,046	3,320	920	1,000		
Humboldt to Falls City	7,810	6,290	1,090	1,500		
Falls City to Mouth	700	300	60	100		
Missouri River						
Plattsmouth to Rulo	15,300	23,410	2,480	6,400		
BASIN TOTAL	**38,364**	**47,720**	**5,540**	**12,000**	**None**	**None**

a/ Includes projected industrial reserve

1,500 afa in 1960 to about 2,000 afa by 2020. It is expected that a large part of the rural area of the Basin will be served by rural water systems in the future.

The requirement for livestock water is expected to increase considerably, from about 5,400 afa presently to nearly 14,000 afa by 2020. A large part of this requirement will come from ground water, but surface water, principally from farm ponds, will also be needed where ground water availability is poor.

Irrigation. Future private irrigation development is expected to be minimal because of the adequate amount of rainfall normally received in the Basin and the absence of adequate ground water supplies. Only about 5,000 acres of irrigation development, all from ground water, are projected during the planning period. Almost all of the projected development is expected to occur in the stream valleys.

Public Project Development. Public project development included in this Basic Framework primarily consists of small watershed projects, local flood protection projects, and rural water supply systems. The locations of these various projects are shown on Figure 66.

Small Watershed and Flood Control Projects. Six small watershed projects in Nebraska and one lying mostly in Kansas have been investigated in detail and are feasible for construction. These projects are intended to provide flood and erosion control. A summary of the features of the six projects located in Nebraska is given in Table 85.

A number of other small watershed projects in this Basin appear to be potentially feasible for development. Cursory examination of these projects was made during the MRB Study but further investigations will be required in the future to determine the feasibility of each. A summary of the preliminary features based on reconnaissance estimates is given in Table 85.

The Corps of Engineers has conducted investigations of flood control projects on the Big and Little Nemaha Rivers. Some projects on the Big Nemaha River may be feasible and if built would provide additional flood control and recreation benefits in that watershed. It appears that several reservoirs with total storage capacity slightly over 100,000 AF and a surface area of nearly 3,000 acres have potential for development later in the planning period. Two general areas where flood control reservoirs may be required are shown on Figure 66. Recreation opportunities at reservoirs in these locations would also be significant.

The Corps and the SCS are currently coordinating their planning efforts in an attempt to provide an integrated program of small watershed and multipurpose flood control projects.

Local Flood Protection. In the Little Nemaha River watershed, the Corps of Engineers has found that a system of levees to protect the lower end of the watershed from flooding is feasible and could be constructed in the near future. Thirteen miles of levees would be constructed to connect with the existing Missouri River levees at the mouth of the Little Nemaha River. This system would protect 17,000 acres of rural land and 115 acres of urban land from flooding by a 30-year frequency flood.

TABLE 85 / POTENTIAL SMALL WATERSHED PROJECTS
Nemaha River Basin

Watershed	Watershed Area (Sq. Mi.)	Drainage Controlled (Sq. Mi.)	Flood Control Storage (AF)	Permanent Surface Area (Acres)	Channel Improvements (Miles)
Feasible [a/]					
For Construction					
South Branch Little Nemaha	198	78	8,800	520	None
Winnebago-Bean	19	None	None	None	None
Middle Big Nemaha	205	92	12,800	820	None
Long Branch	73	32	3,600	420	None
South Fork	51	12	2,390	100	None
Upper Little Nemaha	193	102	16,165	1,010	None
Potentially Feasible					
Weeping Water, Squaw-Camp, Peru-Brownville, Lower Little Nemaha, Turkey Cr., South Fork Nemaha Tribs, Pony Cr. (Kansas), Big Muddy	1,296	Not Known	72,160	4,900	10
Murray Tribs, Lower Big Nemaha	209	Grade stabilization structures only			

a/ *Based on completed Work Plans or Preliminary Investigations*

Rural Water Systems. Adequate water supplies for rural domestic and livestock use are difficult to develop in this Basin on an individual basis. Ground water aquifers throughout most of the area do not yield adequate supplies to wells. Community systems for development and distribution of water in rural areas appear to offer the best solution to the problem. Areas where systems of this type have been proposed are shown on Figure 66.

Nonstructural Measures. The flood plain of the Missouri River has always been subject to periodic inundation. Recently, the dams and reservoirs constructed on the river have succeeded in reducing floods, but floods cannot be eliminated entirely. Plans have been formulated by the States of Nebraska, Iowa, and Missouri to initiate studies which could lead to regulation of the use of the flood plain of the Missouri River through zoning.

Flood plain zoning will also be necessary to complement the local flood protection project on the Little Nemaha River. The area which could be inundated by floods of greater magnitude than the 30-year design flood, up to and including the 100-year flood, must be delineated and zoned to provide for the best use of this area to prevent an increase in future flood damages.

Modification of Existing Development. In the past, a number of projects were undertaken to straighten stream channels in the Basin to improve drainage and reduce floods. This resulted in severe erosion of these straightened channels. The channel bottom of the main streams has become stabilized but improvements are required in some areas to stabilize streambanks. Action is also necessary to prevent further degradation of the channels of tributaries and subsequent losses from erosion.

Potential Effects. The projected development included in this Basic Framework will have varied and significant effects on several areas of the Basin.

The economic effects of projected development will be felt primarily in the local area. Local development of dependable supplies of water for rural domestic and livestock use will help stabilize the economy and the population of the Basin. Short-range economic effects will be produced by the contracts and subcontracts for construction and supplies. Long-range effects will come from the reduction in flood damages to homes, industries, and agriculture and from the new business generated by recreation on the reservoirs. Reservoirs in the upper part of the Basin would attract recreationists from Lincoln and Omaha, and create a new industry in the local area to service and supply the needs of these people.

An estimate was made of the surface water remaining after allowances were made for in-basin

TABLE 86 / ESTIMATED STREAMFLOW REMAINING AFTER IN-BASIN DEVELOPMENT

Stream Location	Nemaha River Basin 1000 Acre-Feet Annually: Streamflow Reduced for 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Weeping Water Creek at Union	47.8	2.7	45.1
Little Nemaha River at Auburn	180.3	12.0	168.3
Big Nemaha River at Humboldt	151.6	8.4	143.2
Big Nemaha River at Falls City	382.9	19.8	363.1
Big Nemaha River at Mouth	483.0	24.7	458.3

Note: Based on average annual streamflow during the period 1954-63

development. Table 86 shows the average annual streamflow depleted for the 1970 level of development, the estimated net depletions due to Basic Framework developments, and the streamflow remaining. The depletions shown for the Big Nemaha River are cumulative totals.

REMAINING PROBLEMS AND OPPORTUNITIES

Flooding in the Nemaha River Basin will not be eliminated entirely by the projected development. Continuing evaluation and study of the potential flood hazard will be required as part of a total flood prevention program.

The Omaha and Lincoln areas will still have large deficiencies in the amount of water surface area available for recreation after projected in-basin development is completed. There may be opportunities to create recreational facilities on streams in this Basin through the construction of additional reservoirs for recreation and fish and wildlife. Opportunity also exists to make better use of the Missouri River for recreation in this Basin.

The "Remaining Streamflow" shown in Table 86 indicates that significant amounts of water will be available after projected in-basin development. An opportunity exists to make further use of this remaining streamflow. Not all of this water will be readily available, however, because of its occurrence during high runoff periods and because of its location near the lower end of the Basin. Storage reservoirs will be necessary to utilize this resource more efficiently.

Evaluation of Development Potential and Remaining Needs

Development of in-basin water supplies and resources would go far toward fulfilling the needs in most of the river basins. Some, more than others, would have remaining needs that cannot feasibly be fulfilled through development of the basin's water resources. Others would have water, unused, that could be utilized for fulfillment of needs in nearby basins.

WATER USE AND AVAILABILITY

Table 87 shows an estimate of the amount of streamflow depletion (reduction) at various locations across the State that would result from in-basin water development and use included in this Basic Framework.

Streamflow Depletion Estimates. The depletions which were projected to result from independent local development and the public project development included in the Basic Framework constitute one of the more important areas where judgement was necessary in place of data. Errors in the estimates could have substantial impact on streamflow remaining after development included in the Basic Framework.

Because of the lack of data, estimates of depletions were generous in order that resulting estimates of water availability would be conservative. Due to this conservatism, further refinement in the hydrologic analysis may show additional water available in some streams of the State.

TABLE 87 / AVAILABILITY OF STREAMFLOW AFTER IN-BASIN DEVELOPMENT

Stream Location	Average Annual Based on Period 1954 Thru 1963 in 1000 Acre-Feet: Streamflow Reduced For 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
White R. - Hat Cr. Basin			
Hat Cr. @ State Line	4.5	0.6	3.9
White R. @ Crawford	12.9	1.1	11.8
White R. @ State Line	17.6	6.8	10.8
Niobrara River Basin			
Niobrara R. nr. Gordon	74.9	42.1	32.8
Niobrara R. nr. Sparks	493.4	40.7	452.7
Niobrara R. nr. Spencer	1027.6	232.0	795.6
Niobrara R. @ Mouth	1292.3	204.7	1087.6
Ponca Cr. @ Mouth	68.4	−5.3 [a/]	73.7
Missouri Tribs. R. Basin			
Bazile Cr. @ Mouth	75.4	3.9	71.5
Bow Valley Cr. @ Mouth	80.6	5.2	75.4
Aowa Cr. @ Mouth	33.4	1.4	32.0
Omaha Cr. @ Homer	25.2	2.4	22.8
Papillion Cr. @ Mouth	80.7	8.8	71.9
North Platte R. Basin			
North Platte R. @ Lisco	647.8	14.0	633.8
North Platte R. @ Lewellen	713.5	15.4	698.1
North Platte R. @ North Platte	332.2	16.6	315.6
South Platte R. Basin			
Lodgepole Cr. @ Bushnell	7.6	4.3	3.3
Lodgepole Cr. @ Ralton	5.1	4.8	0.3
S. Platte R. @ North Platte	74.5	20.7	53.8
S. Platte R. @ Mouth	617.7	24.2	593.5
Middle Platte R. Basin			
Platte R. nr. Overton	437.8	276.1	161.7
Platte R. nr. Duncan	370.5	228.8	141.7
Platte R. @ Loup R.	370.5	229.4	141.1
Loup River Basin			
M. Loup R. @ Dunning	285.9	1.0	284.9
Dismal R. @ Dunning	236.5	0.8	235.7
M. Loup R. @ Arcadia	470.1	16.8	453.3
S. Loup R. @ St. Michael	161.8	71.9	89.9
M. Loup R. @ St. Paul	653.9	96.1	557.8
Calamus R. @ Burwell	227.6	95.7	131.9
N. Loup R. @ Taylor	348.1	0.9	347.2
N. Loup R. nr. St. Paul	677.5	90.9	586.6
Loup R. nr. Genoa	318.9	232.8	86.1 [b/]
Loup R. @ Columbus	424.8	256.5	168.3 [b/]
Elkhorn R. Basin			
Elkhorn R. @ Ewing	116.4	23.2	93.2
Elkhorn R. nr. Norfolk	330.7	111.7	219.0
Logan Cr. nr. Uehling	119.4	28.5	90.9
Elkhorn R. @ Waterloo	809.2	192.4	616.8

TABLE 87 / (Continued)

Stream Location	Average Annual Based on Period 1954 Thru 1963 in 1000 Acre-Feet: Streamflow Reduced For 1970 Conditions	Estimated Streamflow Depletion by Basic Framework Development	Remaining Streamflow
Lower Platte R. Basin			
Platte R. @ North Bend	1896.7	501.3	1395.4
Platte R. nr. South Bend	3122.5	741.1	2381.4
Platte R. @ Mouth	3183.7	799.4	2384.3
Republican R. Basin			
Republican R. @ Stratton	109.4	28.6	80.8
Frenchman Cr. @ Culbertson	64.1	43.7	20.4
Republican R. nr. Orleans	188.6	88.4	100.2
Republican R. nr. Hardy	244.6	107.8	136.8
Little Blue R. Basin			
Little Blue R. nr. Deweese	103.0	14.9	88.1
Little Blue R. nr. Fairbury	252.2	51.6	200.6
Little Blue R. @ State Line	328.0	51.8	276.2
Big Blue R. Basin			
Big Blue R. @ Seward	71.7	18.7	53.0
West Fork Big Blue R. nr. Dorchester	124.1	41.3	82.8
Big Blue R. nr. Crete	239.6	72.5	167.1
Big Blue R. @ Barneston	554.2	93.4	460.8
Big Blue R. @ State Line	571.7	93.9	477.8
Nemaha R. Basin			
Weeping Water Cr. @ Union	47.8	2.7	45.1
Little Nemaha R. @ Auburn	180.3	12.0	168.3
Big Nemaha R. @ Humboldt	151.6	8.4	143.2
Big Nemaha R. @ Falls City	382.9	19.8	363.1
Big Nemaha R. @ Mouth	483.0	24.7	458.3

a/ *Net accretions to streamflow of irrigation return flow from imported water.*

b/ *Does not include flow diverted through Loup River Power Canal to Platte River, which averaged 1,219,700 afa from 1954 through 1963*

Because of its vital importance to water development, a brief resume of the estimating procedure is included.

Streamflow depletions were estimated for all major consumptive uses including crop irrigation requirements, livestock requirements, land treatment, municipal and industrial use, and evaporation from impounded waters. The source of supply for some of these uses was ground water, but the estimated depletions to surface water caused by such use were substantial.

Evaporation estimates were taken from MRB Comprehensive Framework Study publications utilizing Weather Bureau data. The surface area of proposed reservoirs was obtained from MRB and individual project reports and adjusted to reflect an average condition for the year. The net evaporation rate for this geographical area was then applied to this average surface area to obtain an annual loss from the water surface.

Depletions due to project irrigation were estimated considering gross diversion requirements and return flow. The crop irrigation requirements used were those estimated by the USBR for surface water projects. Estimated diversion requirements were based on improved water application efficiencies in the future. These efficiencies considered the soil type, topography, improved distribution systems and location of the land being irrigated. Return flows were estimated considering land location, soils, topography, non-beneficial uses and prior USBR estimates.

Depletions caused by land treatment and livestock water use were derived from MRB data adjusted to meet those conditions estimated to exist in individual basins. The source of livestock water,

either ground or surface, was considered and only a small portion of the surface water segment was depleted from the streamflow.

Additional municipal and industrial pumping from ground water was assumed to affect streamflow only if the community was within six miles of a perennial stream. The upper limit of depletion used was 50 percent of the increased amount pumped above the present level. The precentage was varied depending upon the location of each community. Any increase in use was accompanied by an increase in return flow and only the net effect was applied to the streamflow. In general, municipal and industrial ground water use resulted in accretions to streamflow because of waste water discharges.

Ground water irrigation was assumed to decrease streamflow in certain instances. Only lands within a certain distance from a perennial stream were assumed to influence the streamflow. The amount of influence was varied depending on the transmissivity of the water bearing materials supporting the projected wells. Estimated transmissivity values were obtained from the Conservation and Survey Division of the University of Nebraska.

Each stream reach was analyzed separately and depletion effects were estimated on a volume basis. The pumping requirement was obtained by using the crop irrigation requirement previously derived by the Bureau of Reclamation and assuming an application efficiency of 80 percent. A deep percolation loss of 10 percent was assumed to return to the aquifer and an additional 10 percent lost to non-beneficial uses.

Projected ground water irrigation of lands in areas where the water table was within ten feet of the surface was assumed to be non-depleting. The effect of ground water pumping in this case was assumed to be a salvage of evapotranspiration losses in these areas.

Additional studies will be required to ascertain the validity of the assumptions made and the accuracy of the estimates obtained.

Remaining Streamflow. Major streams with large amounts of water remaining after taking into account the depletions from projected development would be the lower portions of the Niobrara and the Platte Rivers. Large contributors of unused water to the Platte River would be the Loup and lower Elkhorn Rivers.

The column titled "Remaining Streamflow" in Table 87 shows an estimate of surface water remaining after allowances have been made for the in-basin development described in this Basic Framework. Examination of the table shows that large amounts of water would still be available in the lower Niobrara River and throughout much of the Loup River system. Lesser amounts would remain near the junction of the North and South Platte

TABLE 88 / ESTIMATED STREAMFLOW REDUCTION FROM IN-BASIN WATER DEVELOPMENT

Stream Location	1970 Depleted Flow (1,000 AF)	Estimated Streamflow Reduction (1,000 AF)	Percent Reduction
Hat Creek at State Line	4.5	0.6	13.3
White River at State Line	17.6	6.8	38.6
Niobrara River at Mouth	1,292.3	204.7	15.8
Ponca Creek at Mouth	68.4	−5.3[a/]	--
Bazile Creek at Mouth	75.4	3.9	5.2
Bow Valley Creek at Mouth	80.6	5.2	6.5
Aowa Creek at Mouth	33.4	1.4	4.2
Omaha Creek at Homer	25.2	2.4	9.5
Papillion Creek at Mouth	80.7	8.8	10.9
Platte River at Mouth	3,183.7	799.4	25.1
Republican River near Hardy	244.6	107.8	44.1
Little Blue River at State Line	328.0	51.8	15.8
Big Blue River at State Line	571.7	93.9	16.4
Weeping Water Creek at Union	47.8	2.7	5.6
Little Nemaha River at Auburn	180.3	12.0	6.7
Big Nemaha River at Mouth	483.0	24.7	5.1
STATE TOTAL	**6,717.2**	**1,320.8**	**19.7**

a/ Net accretions to streamflow of irrigation return flow from imported water

TABLE 89 / COMPARISON OF BASIC FRAMEWORK DEVELOPMENT POTENTIAL AND NEEDS

Item	Development Potential	Need or Opportunity	Remaining Need or Opportunity
Irrigation Opportunity (Acres)	2,600,000	15,500,000	12,900,000
Flood Control Storage (AF)	2,300,000	Undetermined	— —
Water Surface Area for Recreation & Fish (Acres)	161,000	165,000	4,000

Rivers, on lower reaches of the Little and Big Blue Rivers, on the lower Elkhorn River and many of the streams directly tributary to the Missouri River along the state's eastern border. Development of much of these remaining water resources would be impracticable because of the elevation at which they occur, their distance from the areas of need, and the lack of adequate storage sites.

Table 88 shows the percent reduction of average annual streamflow for the major streams flowing out of Nebraska. The percent reduction in water leaving the State, considering these streams to be representative, will be about 20 percent.

BASIC FRAMEWORK DEVELOPMENT POTENTIAL VERSUS NEEDS

A simple comparison of the potential of the Basic Framework in-basin development with needs and opportunities is shown in Table 89 for those items which lend themselves to tabular presentation.

In addition to the potential water resource development shown in Table 89, provisions are included in the Basic Framework for adequate water supplies for all municipal, industrial, rural domestic, and livestock needs. Provisions for flood control other than by impoundments include levees, channel improvements, watershed treatment, and flood plain regulation.

All municipal and industrial sewage treatment needed to protect and enhance the state's water resources is included in the Basic Framework. Future cooling water requirements for electric power production can be satisfied with in-basin water supplies.

The opportunity for enjoyment of scenic rivers, historic site development, enrichment of environmental quality, and improvement of the quality of life cannot be quantified but items contributing to these needs have been included and should serve as a base for future planning.

REMAINING NEEDS

One item, irrigation, stands out as a remaining need and opportunity. The need for supplemental water for existing irrigated land and the opportunity to irrigate new lands is evident in some basins, even after in-basin development. Major areas with remaining needs for supplemental water supplies to satisfy either present needs or future irrigation opportunities are located:

(1) On the drainage divide between the South and North Platte River Basins in Cheyenne, Deuel, and Garden Counties.

(2) In Perkins and Chase Counties.

(3) Throughout the eastern Republican and upper Little and Big Blue River Basins.

(4) In northeast Nebraska, especially in Cedar and Knox Counties; in the southwestern part of the Elkhorn River Basin; and in the adjacent Shell Creek drainage area.

Needs for additional recreation water surface area would still exist in the eastern part of the State near the Omaha and Lincoln population centers. Approximately 50,000 additional acres would be required to satisfy estimated demands for water based recreation.

Undetermined amounts of water may be required at the upper ends of some river basins for water quality control and environmental purposes.

With these exceptions, it appears that most needs can generally be met by development, utilization, and control of in-basin water supplies.

Chapter 5 / CONCEPTS FOR INTERBASIN WATER TRANSFER

Optimum utilization of Nebraska's water and related land resources cannot be achieved through the development and use of water exclusively in the basins of origin. Evaluation of the potential effects of developments included in the Basic Framework described in Chapter 4, using in-basin water supplies and other available resources, shows that there will still be remaining needs and opportunities, especially for further irrigation development. Figure 67 shows the potential areas of water need, and Figure 68 shows the location of unused water occurring as average annual streamflow. Development of these surplus water resources to meet irrigation and other needs in areas of deficiency would also yield supplemental benefits to the basins of origin.

Additional flood control storage beyond that included in the Basic Framework was not considered a major purpose in the development of the interbasin transfer concepts in this study. Nevertheless, where reservoir storage would be provided for interbasin transfers, flood control must be evaluated in later studies for possible inclusion as a project purpose.

There will be a remaining need for additional recreational water surface area in the Lincoln-Omaha area after Basic Framework development. Although recreation and fish and wildlife are not included specifically in the interbasin transfer concepts of this study, their inclusion in interbasin projects should be considered in any future, more detailed studies.

The Basic Framework is to be a guide for development far into the future. Thus, in-basin needs projected into the early decades of the 21st Century were fully considered and were satisfied to the extent possible using in-basin water in its development. Large interbasin transfers of water required for further development will probably be even more futuristic. However, minor transfers in the near future could provide the solution to some problems already present.

This chapter describes concepts for interbasin water transfer that could be employed to more nearly balance water supplies and anticipated future demands on a statewide basis. Three differing schemes representing a wide range of transfer possibilities are presented. These are presented to stimulate thinking toward development of a broad guide that may be used in planning for future development. Several other transfer concepts were examined during the course of this study, but the three presented appear to offer the greatest range of physical possibilities as well as a wide variation in satisfaction of future needs and opportunities.

Issues of public policy are raised by the very presentation of these transfer concepts. These issues must largely be resolved before more specific planning can proceed, and their resolution is imperative before broad scale water transfers can be initiated. Some of these issues are described in Chapters 1, 6 and 7.

The law concerning interbasin water transfer in Nebraska is vague. The two Nebraska statutes that deal with this subject provide as follows:

> Section 46-206. *Appropriation; water to be returned to stream.* The water appropriated from a river or stream shall not be turned or permitted to run into the waters or channel of any other river or stream than that from which it is taken or appropriated, unless such stream exceeds in width one hundred feet, in which event not more than seventy-five per cent of the regular flow shall be taken.
>
> Section 46-265. *Embankments; maintenance; return of unused water; duties of owner.* The

FIG. 67 / AREAS WITH NEED OR OPPORTUNITY FOR USE OF OUT-OF-BASIN WATER SUPPLY

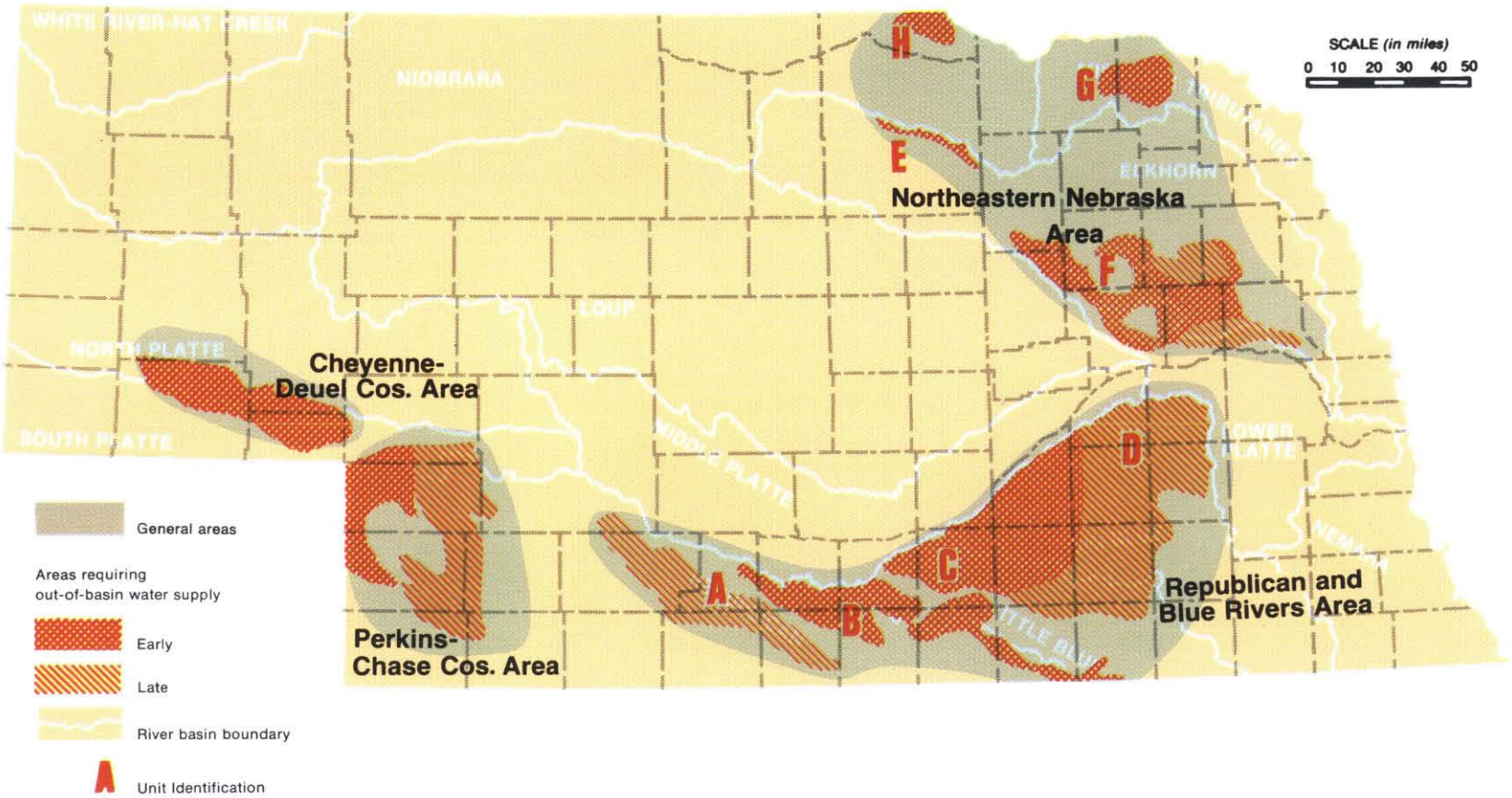
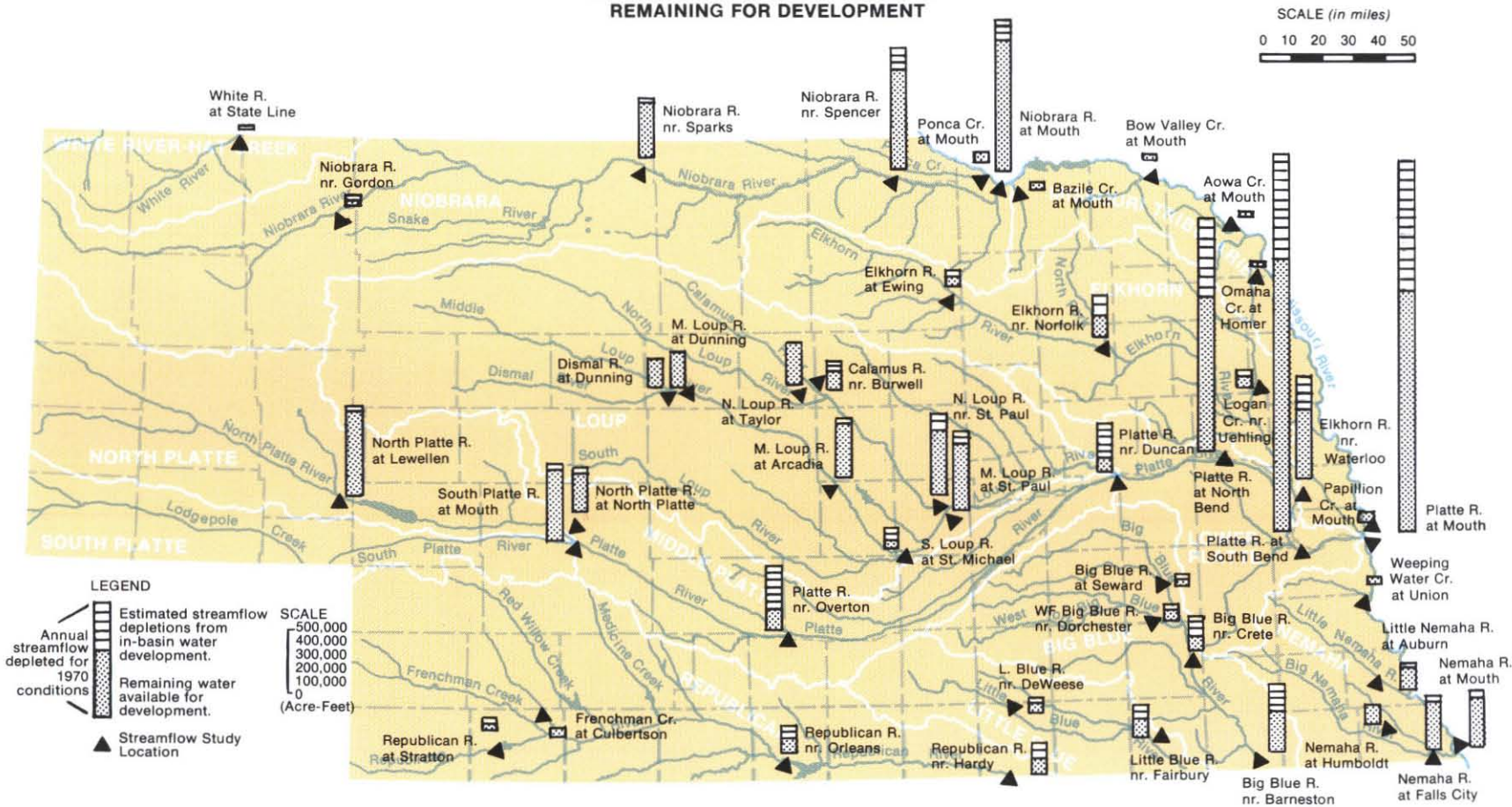


FIG. 68 / ESTIMATED STREAMFLOW REMAINING FOR DEVELOPMENT



Based on period 1954 through 1963

owner or owners of any irrigation ditch or canal shall carefully maintain the embankments thereof so as to prevent waste therefrom and shall return the unused water from such ditch or canal with as little waste thereof as possible to the stream from which such water was taken, or to the Missouri River.

Since all of Nebraska's surface water eventually flows into the Missouri River, it has at times been suggested that section 46-265 would permit all interbasin water transfer which would meet the limitations of section 46-206. This is, of course, an extremely broad interpretation of the law. Thus far, in the three cases in which the Nebraska Supreme Court has considered these sections and their relationships to interbasin water transfer, it has not seen fit to adopt such an extensive interpretation.

In the first case on this subject, *Osterman v. Central Nebraska Public Power & Irrigation District,* decided in 1936, the court ruled that a divide or watershed could not be crossed by an irrigation ditch or canal where the unused waters would not be returned to the source from which they were taken. However, a later case, *Ainsworth Irrigation District v. Bejot,* decided in 1960, permitted transfers from the Snake River to the Niobrara River on the basis of the court's opinion that the Snake and Niobrara Rivers were in fact one stream, basin, or watershed and that therefore the interpretation placed on section 46-265 by the *Osterman* case could still be controlling. Then in 1966 the latest case on this question heard by the Nebraska Supreme Court, *Metropolitan Utilities District v. Merritt Beach Company,* the court stated that the question of allowing interbasin transfer was to be decided upon the grounds of reasonable use and that where the taking of water beyond a watershed does not injure appropriators or riparians, then no reason exists for not permitting an interbasin diversion for a public and beneficial purpose. Although the language of the opinion seemed quite inclusive, the case did in fact involve a ground water source, and there is, therefore, uncertainty as to its application to surface water, which was the sole consideration of the first two cases discussed.

The circumstances under which transfer may be permitted has been determined in the past by court action on individual cases. Whether or not future determinations will be made on the same basis is impossible to predict. At any rate, the guidelines established for this study allow deviation from present Nebraska law and interpretations thereof to achieve planning goals. Therefore, the following assumptions relative to interbasin transfers were made based upon the assumption that Nebraska law either presently allows such transfers or that if it does not, proper amendments to the law may be made:

1. Transfer of water between river basins is permissible providing the basin of water origin has the opportunity to use water within the basin for reasonably full development.
2. Exchange of water with a present or planned use is acceptable if an alternative supply of equal quality and quantity can be provided.

Two planning guides were also established:

1. Water should generally be transferred the shortest distance possible to attain its utilization and yet preserve the opportunity for flexibility and staging of development within the system.
2. Where water is being stored on, or being diverted from a stream, an amount equal to 15 percent of the average annual historical flow of the stream during the period 1954 thru 1963 should be bypassed or released for environmental flows mainly for the purposes of fish, wildlife, recreation, maintenance of a live stream, and water quality control. This amount is a total volume and could be regulated, if specific storage were provided, to provide higher or lower flows during certain periods of the year to accomplish the above considerations.

The examination of needs and schemes for water transfers has been cursory. However, it is believed sufficient to develop transfer concepts to be used for discussion and as guides for more detailed planning. Additional investigation at reconnaissance and feasibility levels will be required before serious consideration can be given to implementation of any water transfer.

It must be recognized that estimates of both gross water supply and potential amounts of water available for transfer were studied and are presented on an average annual basis. Therefore, the estimated amounts available are somewhat higher (probably 10-20 percent depending upon the stream in question) than those which would be available on a firm basis using the critical water supply period and monthly flow analysis for river, reservoir, and diversion canal operations. But, no return flow from irrigation use of transferred water was considered and its inclusion would tend to offset possible overestimates of amounts of transferred water available for use in the basin of import.

Areas With Need for Additional Water

Examination of the potential accomplishments possible through development of in-basin and associated land resources shows four major areas where in-basin water supplies cannot meet present or future irrigation needs or potential opportunities for further development. Those areas, shown on Figure 67, include lands requiring an out-of-basin water supply "early" or "late" in the planning period.

The division between early and late was very general, and based mainly on data and reports indicating that problems were developing or in prospect. An "early" designation was assigned to areas already developed but presently experiencing problems with water supply, and to large expanses of land suitable for irrigation for which no in-basin water supply is available. The "late" designation was assigned to areas which are, or soon will be, developing ground water supplies and where it appears that lowering of the ground water level may be delayed, yet cause future problems.

A short description of each of the four areas, and the general problem leading to inclusion as an area of need or opportunity, is presented in the following sections.

CHEYENNE-DEUEL COUNTIES AREA

This area lies in northeastern Cheyenne, southern Garden, and northern Deuel Counties and is a high tableland on the divide between the North and South Platte River Basins. Soils throughout the area are highly suitable for irrigation. The average annual precipitation is only about 17 inches. There is no irrigation in this area because ground water is not available in quantities suitable for development of irrigation wells. Nearby water resources of both the North and South Platte Rivers have already been fully developed or committed and no other surface water supply is available within these river basins. The area could utilize an out-of-basin water supply early in the planning period.

PERKINS-CHASE COUNTIES AREA

This area covers most of Perkins and Chase Counties and small portions of Hayes, Dundy, and Hitchcock Counties. Soils in the western part of the area along the Colorado border are highly suitable for irrigation while soils in the eastern part of the area have moderate irrigation suitability. Precipitation averages only about 18 inches annually.

Ground water is presently being developed for irrigation at scattered locations throughout the area. During 1968 and 1969, this was one of the fastest growing ground water irrigation areas in Nebraska. Available ground water information indicates a limited amount of ground water in storage and low rates of natural recharge. This combination of increasing use, limited storage, and low recharge points toward a diminishing ground water supply with problems of declining water levels and increasing pumping costs developing early in the planning period. The problem is intensified because the area lies at the headwaters of streams tributary to the Republican River where little in-basin surface water supply is available for development. Consequently, an out-of-basin water supply will be required early in the planning period in parts of the area if irrigation is to be sustained.

REPUBLICAN AND BLUE RIVERS AREA

This area has been divided into four units because of their somewhat differing problems.

Unit A. This unit lies in the Republican River Basin covering parts of Frontier, Gosper, Furnas, and Harlan Counties. The area is moderately suitable for irrigation development. Many of the irrigable lands are located on long upland fingers between parallel tributaries of the Republican River. Some ground water has been developed for irrigation, but supplies will generally not sustain extensive development.

Local surface water supplies are not adequate for project-type irrigation development. Precipitation averages only about 20 to 22 inches annually, requiring supplemental irrigation supplies to insure crop production. In general, problems of water shortage in this unit are not immediate and the area was placed in the late category.

Unit B. This unit is south and east of the existing Central Nebraska Public Power & Irrigation District (CNPP&ID) irrigation service area. Parts of the area were originally in the CNPP&ID proposed service area, but were removed because of court decisions precluding service to them. In this case, the courts prohibited water transfer beyond the drainage divide of the Platte River into the Republican and Little Blue River Basins. The area lies in Gosper, Phelps, Harlan, Kearney, Franklin, Adams, Webster, Nuckolls, and Thayer Counties.

Soils in the area are highly suitable for irrigation. Some areas in this unit are presently being irrigated from ground water. Generally, however, ground water is not available for economical development. Also some areas, such as northern Webster County,

have no suitable ground water supplies for irrigation. Rural domestic and livestock water supplies also are difficult to locate in this area. Precipitation in the area averages from 22 to 24 inches annually, which is marginal for crop production. Therefore, crop failures are common to much of the area. The area is shown to require supplemental water early in the planning period.

Unit C. This unit covers an area in the northern Little Blue and western Big Blue River Basins covering parts of Kearney, Adams, Clay, Fillmore, Hall, Hamilton, and York Counties. Soils in the unit are highly suitable for irrigation and a high percentage of the area is presently irrigated by ground water. However, ground water levels have been dropping steadily with indications that the trend will continue.

No adequate surface water supply is available for development in the area. It is anticipated that continued pumping will make importation of surface water for conjunctive use with the ground water supply highly desirable early in the planning period.

Unit D. This area, adjacent to Unit C, is in the northern and central parts of the Big Blue River Basin and includes parts of Polk, Butler, York, Seward, Fillmore, Saline, Clay, Nuckolls, and Thayer Counties. Problems in this area are similar to Unit C, but ground water pumping is not as extensive in the area and significant water table declines have not yet occurred. However, as ground water development intensifies and pumping increases a situation similar to that in Unit C will likely develop.

Therefore, late in the planning period, a supplemental surface water supply will be desirable for direct use and for conjunctive use with the developed ground water supply wherever practicable.

NORTHEASTERN NEBRASKA AREA

Parts of this area are widely separated and have been divided according to each area's particular problem.

Unit E. This small area lies in the Elkhorn River Basin in Holt County, immediately south of the drainage divide between the Elkhorn and Niobrara River Basins. Precipitation averages only 22 inches annually. The area is suitable for project-type irrigation and lies adjacent to the proposed O'Neill Unit and Page Area irrigation service areas which lie in the Niobrara River Basin. It was omitted from those potential projects because of the legal constraints on interbasin water transfer discussed earlier. An adequate supply of water for this area could be developed from the Niobrara River as part of the O'Neill and Page projects, but service to this area would involve interbasin water transfer. Ground water supplies are marginal in the area and intensive development is occurring. This area can use imported water early in the planning period.

Unit F. This area lies in the lower part of the Elkhorn and northern Lower Platte River Basins and covers parts of Antelope, Boone, Madison, Platte, Stanton, Colfax, Cuming, and Dodge Counties. Soils vary from moderately to highly suitable for irrigation. Precipitation averages about 26 inches annually but an uneven distribution during the growing season sometimes causes crop failure. The lands of the proposed USBR highland and Norfolk Units lie within or adjacents to this area. Service to parts of this area early in the planning period could be considered in the planning for those projects if additional water was available from outside the Elkhorn River Basin. In other parts of the area some ground water development has taken place, and more is likely to occur. However, suitable supplies are sometimes difficult to locate, and the supply is generally limited. Supplemental surface water supplies may be required late in the planning period to augment the ground water supply.

Unit G. This unit, in Knox and Cedar Counties, lies generally in the Bow Creek drainage of the Missouri Tributaries River Basin but could include some lands farther south in the Elkhorn River Basin. Soils are moderately suitable for irrigation. Precipitation averages about 24 inches annually, but dry years and poor distribution during the growing season often cause crop failure. Adequate ground water is not available for irrigation in the area. Also, rural and urban ground water supplies are difficult to locate and, when found, they are often inadequate in quantity and quality. Drainage areas are small and large surface supplies cannot be developed. This area could utilize water early in the planning period, largely on lands tributary to the Missouri River and thus involving mostly in-basin water when considering water from the Missouri River. Water supplied from the Niobrara River, either directly by diversion or indirectly through intermediate storage on the Missouri River, would be considered an interbasin transfer.

Unit H. This unit, in Boyd County, is in the Niobrara River Basin on the divide between the Ponca Creek and small Missouri River tributaries drainages. Soils are marginal for irrigation development. However, because precipitation is unreliable and averages only 22 inches annually, and other resources are greatly limited, there is high interest for irrigation development early in the planning period. No ground water supply is available in the area, and local surface water supplies are not adequate to sustain irrigation development over and above small acreages in the Ponca Creek valley.

Some investigation has been made by the USBR of a project to pump water from the Missouri River to part of the area, but feasibility of the project was questionable and no action has been taken.

Conceptual Transfer Schemes

Potential out-of-basin water supplies were investigated for each of the general areas of need or opportunity described in the preceding sections and shown on Figure 67. Potential effects of the conceptual transfer schemes presented will be discussed generally with regard to these major areas of need. The amount of water required, or when it will be required, is not known beyond the stage of generalities. Amounts of water estimated to be available from each conceptual transfer scheme are only estimates of what could reasonably be developed for use in the areas indicated.

Investigation of these schemes has been at a cursory level. Neither economic analysis, detailed legal research, nor field investigations concerning the physical aspects of the schemes have been made. The purpose is to present only some possible transfer concepts showing the general range of water availability, not to propose specific transfer routes or estimate definite quantities of water available for transfer. Some earlier studies and reasonably good topographic maps were available as a basis for rough determination of the physical possibilities for transfer.

When alternative physical means for transfer were found, generally the least complicated, and probably least costly, was shown. For example, when a choice was between pumping and a longer gravity canal, the canal is shown in the schemes presented. There are often a great number of alternatives available. These can be investigated in more detail in later studies, but for representation of these concepts in this report the simplest methods available were chosen.

Of the many different conceptual schemes considered for interbasin transfer, three are diverse enough in plan and accomplishment to warrant explanation and presentation and thus illustrate the additional considerations needed beyond this study. These three concepts represent a wide range of physical transfer possibilities and are offered here for further consideration, but are not proposals for development. A broad spectrum of resulting state impacts and the gamut of public policy decisions necessary for implementation are also suggested by these concepts.

The three conceptual schemes are presented to stimulate thinking about interbasin transfer. The decisions to be made are difficult and should not be made in haste or without the benefit of relevant facts. Although the need for large water transfers may be several decades in the future, smaller early-stage transfers would provide immediate benefits to some areas.

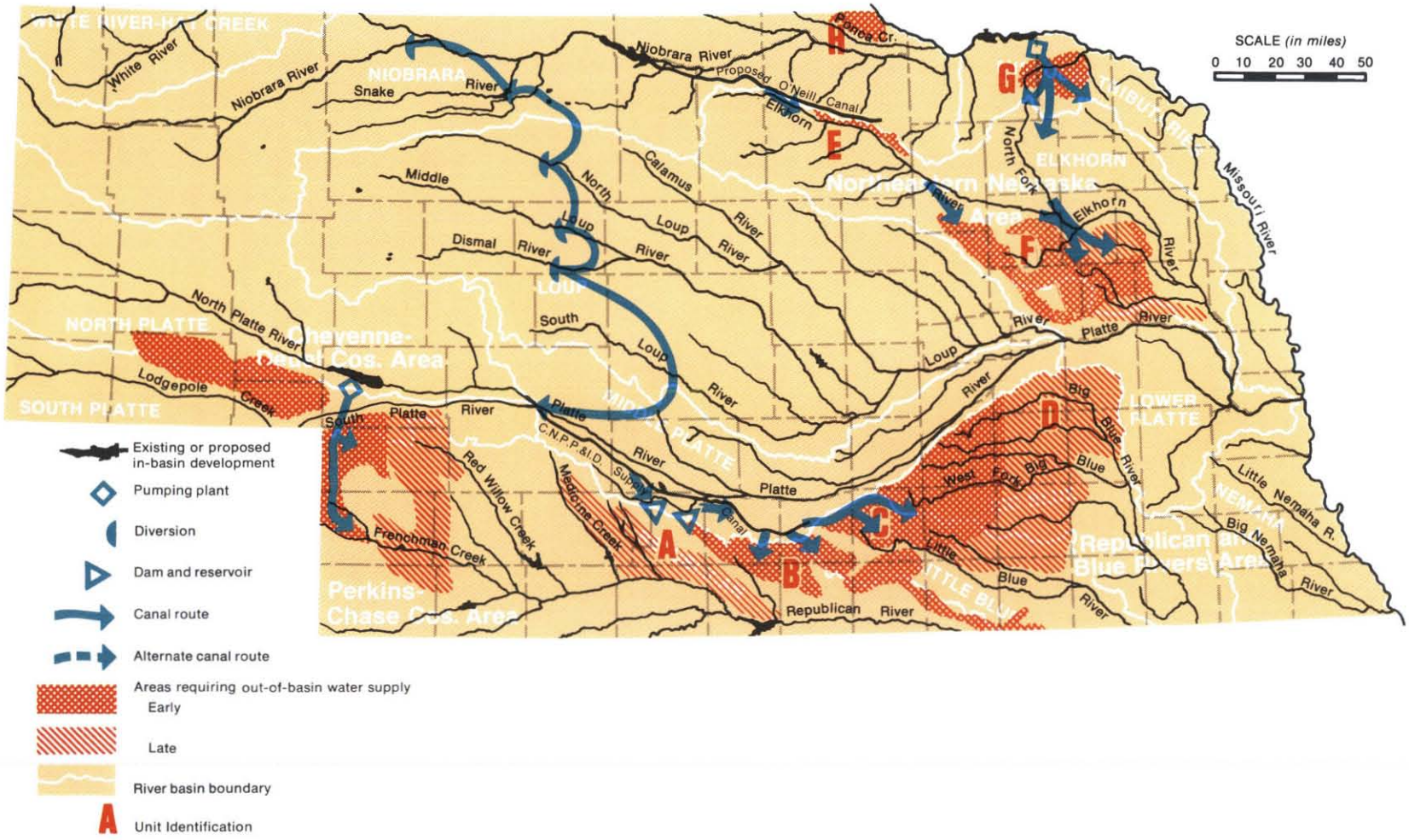
CONCEPTUAL TRANSFER SCHEME NO. 1

The major concept involved in this scheme, which is shown in Figure 69, is the collection of unused waters in the western part of the State to avoid conflict with present or proposed development and to take advantage of gravity flow and reuse of return flows from west to east across the State. The focal point of the scheme is a long gravity canal and several diversion dams that could be used to transfer water from the Niobrara River in Cherry County to the existing Tri-County (CNPP&ID) Diversion Dam on the Platte River.

Surplus water could be diverted from the Niobrara, Snake, North Loup, Middle Loup, and Dismal Rivers, or progressively by gradual extension in the reverse order under staged development. The amounts divertible would range from a low of about 60,000 afa from the Snake River to a high of approximately 170,000 afa from the Middle Loup River. These estimates of the amounts divertible allow for anticipated downstream development and for environmental streamflows below the diversion points. Total canal length would be nearly 400 miles through the heart of the Sandhills Region.

A total of about 430,000 AF of water could be delivered annually to the existing Tri-County Diversion Dam through this canal. Surplus winter and flood flows of the Platte River could also be diverted which together with the import water could be conveyed through the existing CNPP&ID supply canal for storage in potential reservoirs on Plum Creek. A portion of these waters could be used to replace the existing water supplies of the CNPP&ID and other downstream users. At the same time, this would free the replaced waters for use upstream. Water could then be pumped from Lake Mc-

FIG. 69 / CONCEPTUAL TRANSFER SCHEME NO. 1



Conaughy and diverted to the Perkins-Chase Counties Area where it could be distributed through canals by gravity.

Water could also be pumped from Lake McConaughy to the Cheyenne-Deuel Counties Area. However, this was not included in this scheme or either of the other two schemes because an economy based on irrigation has not developed in this area, as opposed to the development presently occurring in the Perkins-Chase Counties Area. In addition, service to the Cheyenne-Deuel Counties Area would be more difficult because of the higher pump lifts and longer pipeline required.

Waters stored in the potential Plum Creek Reservoirs surplus to the replacement waters could be released from storage and distributed through a series of gravity canals into the Republican and Blue Rivers Area for Units B and C. The large amounts of high quality lands in these units could probably utilize all of the available water.

Unit A could be served by pumping water from the CNPP&ID supply canal to these lands located at higher elevations. This was not included in the scheme because of the lower quality of land available for irrigation and the obvious high cost of pumping versus gravity use more easterly. It is mentioned, however, as a method of supplying water to Unit A.

The amount of water potentially available from the Plum Creek reservoirs for new uses depends upon the amount transferred to the Perkins-Chase Counties Area. For example, if 200,000 afa were pumped from Lake McConaughy, approximately 400,000 afa of added water would be available from the Plum Creek reservoirs. But, if 400,000 afa were taken into Perkins and Chase Counties, only about 250,000 afa of added water would be available from the Plum Creek reservoirs.

After water is allowed for the in-basin development discussed in Chapter 4, additional water would be available downstream from the diversion on the Niobrara River included in this scheme. Up to 70,000 afa could be diverted through the proposed O'Neill Unit facilities (enlarged) into the Elkhorn River Basin near the Holt-Rock County Line. This water could then be re-diverted from the Elkhorn River to expand proposed projects or to provide water for irrigation of additional lands in Unit F in the Northeastern Nebraska Area. Land in Unit E could be served by simply expanding the proposed O'Neill Unit and Page Area projects.

Approximately 880,000 afa would still be available at the mouth of the Niobrara River. Unit G in the Northeastern Nebraska Area could be served by pumping this water from Lewis and Clark Lake on the Missouri River. The pump lift for most of the area would exceed 300 feet, but the water could be used in Cedar and Knox Counties where not only is irrigation water needed, but rural and municipal supplies are difficult to obtain from ground water. Also, additional water could be pumped and transported into the Elkhorn River Basin from this source for irrigation use.

Irrigation water for Unit H in the Ponca Creek drainage area could be pumped from the Missouri River. A USBR survey of a project for the area shows marginal feasibility at the present time. This would not involve a transfer of water between basins in Nebraska. It is mentioned here only to illustrate the need for out-of-basin water supply.

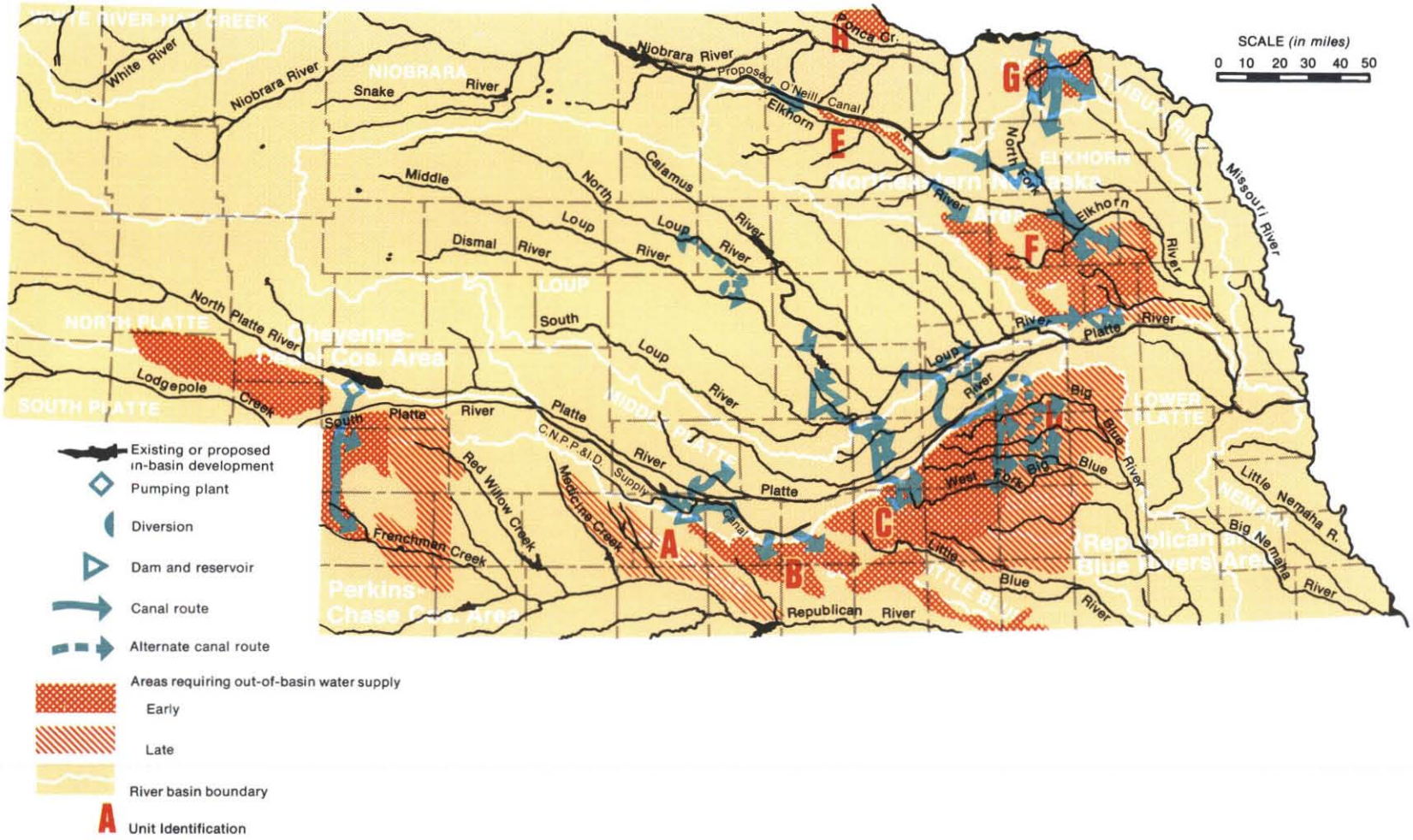
In summary, this conceptual scheme for interbasin transfer would annually provide up to 700,000 AF of irrigation water to large areas of land in southwestern and southcentral Nebraska. It would require a minimum of water exchanges, cause no transfer of existing water use, and provide the opportunity for reuse as water is moved and used progressively across the State. But, facilities constructed through the rugged Sandhills would involve difficult engineering problems, long canals, and considerable expense. Also, the single route over which the majority of water would be transferred would make the scheme somewhat inflexible in terms of staged construction. The commitment southerly of capacity required to convey ultimate water quantities would pose particular difficulty. This scheme would also interfere with preservation of the unique Sandhills streams and might seriously affect the ecological balance in parts of the Sandhills Region.

CONCEPTUAL TRANSFER SCHEME NO. 2

This concept involves the development of large amounts of unused water which are available in the lower reaches of the Loup River for direct transfer across the Platte River into the major areas of need in the Republican and Big and Little Blue River Basins. Through transfer and exchange of water with existing or proposed in-basin projects, large amounts of irrigation water could be made available when the anticipated need becomes urgent in these areas. Major features of this scheme are shown on Figure 70.

Water for the Perkins-Chase Counties Area could be pumped from Lake McConaughy into the northwestern corner of Perkins County, then distributed by gravity canal south and east throughout the area of need. As described in Scheme No. 1, most of the water that could be taken from Lake McConaughy is presently used downstream along the Platte River and in the CNPP&ID service area, or is com-

FIG. 70 / CONCEPTUAL TRANSFER SCHEME NO. 2



mitted to development of the proposed Mid-State District project.

If 200,000 afa were diverted to the Perkins-Chase Counties Area, replacement irrigation water for those downstream systems could be developed from reasonably full utilization of the surplus flow of the Platte River by diversion through the existing CNPP&ID supply canal to storage at a reservoir site on Plum Creek, and from increased efficiency in use of the present CNPP&ID supply.

If as much as 400,000 afa were diverted to the Perkins-Chase Counties Area, it would come in part from surplus Platte River water presently proposed for development under long standing active water right filings of the Mid-State District sponsors. Replacement of Mid-State water would be with Loup River water which would be developed and stored on the Middle Loup River. It could then be used to serve the central and lower Mid-State area. The western part of the Mid-State area would be served from Platte River flows as presently planned.

The Republican and Blue Rivers Area could be served with water from the Platte and Loup River Basins through a variety of routings.

Unit B could be served under this concept by extending the existing CNPP&ID service area to the south and east. Water could be made available through more efficient use of the present CNPP&ID supply, by storage of surplus Platte River winter and flood flows in a reservoir on lower Plum Creek, and by exchange of Mid-State Platte River water for water from the Middle Loup River. Up to 230,000 afa could be supplied to the area if 200,000 afa were to be taken to the Perkins-Chase Counties Area from Lake McConaughy. Only about 50,000 afa would be available for transfer to the area if 400,000 afa were to be taken to the Perkins-Chase Counties Area.

Unit C could be served by development of Middle and North Loup River waters through storage in a reservoir near Rockville on the Middle Loup River. Water from the North Loup River could be diverted to the existing Sherman Reservoir by utilizing and extending the proposed North Loup Division canal. From there, it could then flow by canal into the Middle Loup River storage site. An alternative diversion could be made by canal from the North Loup River near Brewster in eastern Blaine County into the Middle Loup River in northern Custer County. From storage on the Middle Loup River, nearly 400,000 afa could be conveyed by canal across the Platte River to an area in southeastern Hall County. This is in addition to water required for exchange of Mid-State Platte River water. This area is on the uplands between the Big and Little Blue River Basins and from this location distribution could be made by gravity throughout Unit C.

Unit D could be served with approximately 250,000 afa by diverting most of the remaining flow of the Loup River just below the confluence of the North and Middle Loup Rivers. From there, the water could be conveyed across the Platte River into the Big Blue River Basin near the Hamilton-Polk County line. Although some storage would be required on the Loup River at the diversion site, the major storage would be provided in the Big Blue River Basin under this scheme. In addition to regulation for irrigation, the reservoirs could provide flood control storage in the upper and central parts of the Basin.

An alternative method of supplying this area could be achieved by developing Loup River water remaining after upstream diversions in a storage reservoir near Fullerton. This water could be conveyed by canal across the Platte River to a point in the upper end of the Big Blue River Basin in central Polk County. It could then be distributed throughout the service area. Some terminal storage reservoir capacity in the Basin would be required for better regulation of the imported water.

Under either scheme the stabilizing effect of the Loup River on flow of the lower Platte would be lost when 600,000 to 700,000 afa of Loup River water was diverted out of the Platte River Basin. A reservoir on Shell Creek for storage of Shell Creek water, water diverted from Beaver Creek, and the remaining flow of the Loup River would provide the necessary regulation to maintain adequate flows in the lower Platte River below North Bend. A reservoir at this location would also provide control of floodwaters from Shell Creek.

The Northeast Nebraska Area could be served by water developed and diverted from the Niobrara River. Utilization of the proposed Norden Reservoir for storage and the proposed O'Neill Unit and Page Area canals for conveyance would allow movement of slightly over 200,000 AF of water annually into the upper Elkhorn River Basin. This water could then be conveyed by canal, or the Elkhorn River, to the largest area of need in Unit F. Extension of the proposed O'Neill Unit and Page Area into the Elkhorn River Basin would serve areas of need in Unit E.

Niobrara River water could also be pumped to Unit G in Knox and Cedar Counties from Lewis and Clark Lake on the Missouri River. If additional water should be required in Unit F, in the Elkhorn River Basin to the west, or along the Missouri Tributaries River Basin to the south of Unit G, the same source could be employed.

Unit H could be served with Missouri River water as described in Scheme No. 1.

In summary, this scheme presents a concept of interbasin water transfer and development that is flexible in design, possesses a great potential for staged development, and yet provides a high degree of balance between areas of water surplus and water shortage. About 900,000 AF of water could be supplied annually to areas in central and western Nebraska. In addition, several hundred thousand acre-feet could be supplied to northeastern Nebraska from Niobrara River water. There would be a minimum of interference with important fishing and unique river reaches and no disruption of the Sandhills Region. It would, however, interfere with present hydroelectric power operations in both the Platte and Loup River Basins. There would also be some water exchanges necessary in connection with existing and potential in-basin developments in the Platte River valley.

CONCEPTUAL TRANSFER SCHEME NO. 3

The major feature of this scheme is that limited additional development is possible in the major areas of need in the Republican and Big and Little Blue River Basins through interbasin transfer without substantially altering existing development—specifically hydroelectric power generation in the Loup and Middle Platte River Basins.

Major features of the scheme which involves transfer of water from the Niobrara River into, or across the Loup River Basin and then into the Blue River Basins are shown on Figure 71. Water developed and diverted from the Niobrara River through enlarged O'Neill Unit facilities could be conveyed by gravity canal across the Elkhorn River near the Holt-Rock County line. The canal would carry the water 120 miles southward into the North Loup River Basin to a storage site on Davis Creek at the common corners of Valley, Greeley, Sherman, and Howard Counties. Water released from this storage could be diverted from the Loup River below the confluence of the Middle and North Loup Rivers and thence conveyed by gravity canal and siphon into the upper Big Blue River Basin and distributed southward from a point in central Polk County into Unit D.

An alternative to delivery of water into the upper Big Blue River Basin could be accomplished by diverting water from the Middle Loup River in Sherman County and conveying it across the Platte River into southeastern Hall County. From this point water could be then distributed by gravity into both the western Big Blue and northern Little Blue River Basins in Unit C. This Loup River water would then be replaced by the water imported from the Niobrara River as described in the previous paragraph.

Approximately 150,000 afa could be diverted into the Blue River Basins south of the Platte River by either method without reduction of flow of the lower Loup River.

Niobrara River water pumped from Lewis and Clark Lake could be used in the Northeast Area as described in Scheme No. 1. Missouri River water could be supplied to Unit H of that area as also described in Scheme No. 1.

Surplus winter and flood flows of the Platte River could be developed in a reservoir on Plum Creek and used to serve the CNPP&ID lands. This would allow water presently used in the CNPP&ID project area to be taken from Lake McConaughy to the Perkins-Chase Counties Area. If 200,000 afa were pumped to Perkins and Chase Counties from Lake McConaughy, about 40,000 afa would be available for extension of the present CNPP&ID service area south into Unit B, or east into Unit C, of the Republican and Blue Rivers Area. If more than 200,000 afa were pumped from Lake McConaughy to the Perkins-Chase Counties Area, there would be a corresponding decrease in the water available for extension of irrigation in Units B and C.

In summary, this scheme would cause the least disruption to existing and potential in-basin development. There would be no interference with unique river reaches and no disruption of the Sandhills Region. It would not, however, provide large amounts of water for irrigation in the Republican and Big and Little Blue River Basins, nor would it make possible the consumptive use of the large water supply available in the Loup River Basin.

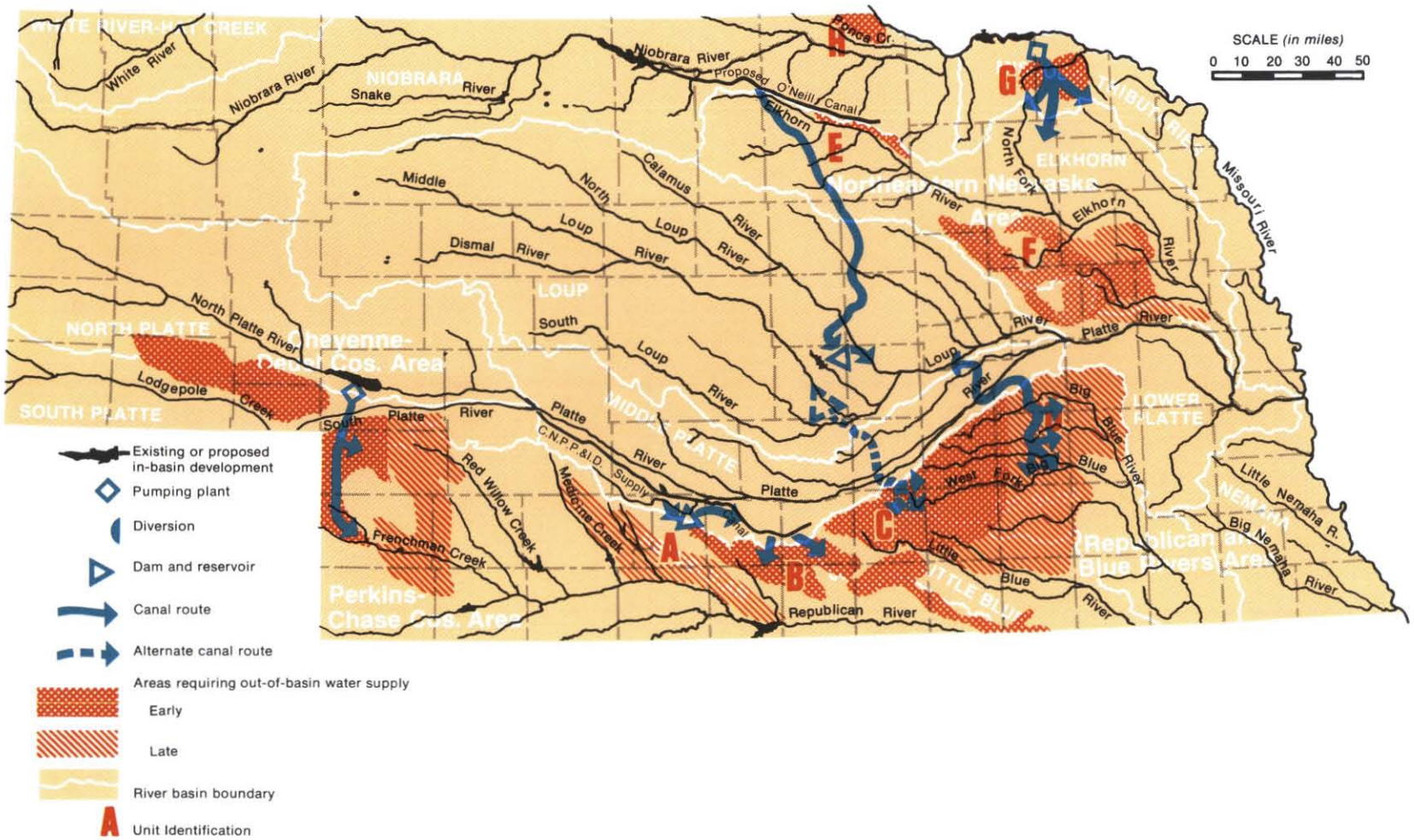
ADDITIONAL BENEFITS FROM INTERBASIN WATER TRANSFER

Major emphasis in the preceding discussion has been placed on the need and opportunity for interbasin diversion and use of surplus water for irrigation. This emphasis on irrigation results because the quantities required by this function far exceed all others. However, all other functions of water development must also be considered in the more detailed investigations of transfer alternatives that must be performed before any action toward interbasin transfers could be undertaken.

It is evident that significant correlative benefits would also result from this development. These benefits would include increase of minimum streamflow in import areas, silt reduction in controlled stream waters, and provision for firm domestic water supplies for some rural and urban areas.

Undoubtedly, additional reservoir storage capacity could be installed beyond that required for

FIG. 71 / CONCEPTUAL TRANSFER
SCHEME NO. 3



operational control of transferred water. These reservoirs, including provisions for additional storage, should present opportunities for flood control, recreation, and fishery enhancement. Early construction of certain transfer facilities, if there is a need and justification for interim use, would make it possible to derive some benefits for a period of years before the actual full transfer of water for irrigation and other deferred uses is necessary. For example, terminal storage reservoirs in the Elkhorn and Big and Little Blue River Basins could be constructed early to provide flood control and recreation benefits. Likewise, water diverted from the Niobrara Basin could be used for power generation on the Loup River interim to its use for irrigation in the Big or Little Blue River Basins.

Remaining Needs and Opportunities

If the concept of interbasin transfers of water is accepted and if what is found to be the most comprehensive scheme for transfer were implemented, there would still be areas with need or opportunity for irrigation development remaining within the State. There would also remain some undeveloped water resources, but further development would certainly be marginal as to feasibility and in some cases physically impractical of accomplishment.

It appears that reasonably full and efficient use could be made of the state's water through interbasin transfer by schemes such as presented herein. Presently two-thirds of the unused water leaves Nebraska through the Niobrara and Platte Rivers.

Virtually all unused water in the Niobrara River at the proposed Norden damsite location exclusive of environmental flows required downstream could be diverted and used in either the lower Niobrara or Elkhorn River Basins through conceptual schemes presented in this Framework. In-basin development would reduce the average annual flow of the Niobrara River at its mouth from the present level of 1,300,000 AF to about 1,100,000 AF. The maximum additional diversion from the Niobrara River shown in the conceptual transfer schemes would be about 200,000 afa, still leaving 900,000 afa at the mouth of the Niobrara River. The possibility of pumping portions of this remaining water from Lewis and Clark Lake into the Missouri Tributaries and Elkhorn River Basins was presented in each scheme. Utilization of this water would depend upon the economics of demand, but with large amounts of land suitable for irrigation in the lower Elkhorn River Basin it is conceivable that a large portion could eventually be put to beneficial use in Nebraska. If a total of 500,000 afa were used over and above the in-basin requirements, this would be about 55 percent utilization of the present Niobrara River outflow from Nebraska through both in-basin development and interbasin transfer.

In-basin development included in the Basic Framework would reduce the average annual flow of the Platte River at its mouth from the present level of 3,200,000 AF to 2,400,000 AF. Water transferred from the North Platte River, Platte River mainstem, and Loup River system into the Republican and Big and Little Blue River Basins would further decrease the Platte River flow leaving Nebraska. If, for example, Scheme No. 2 were implemented, about 1,000,000 afa could be transferred from the Platte River Basin to those river basins to the south. The average annual flow of the Platte River at the mouth would be reduced to approximately 1,400,000 AF. This would utilize almost 60 percent of the present Platte River outflow from Nebraska through both in-basin development and interbasin transfers.

The efficiency of use of waters in these two river systems, as contemplated in this Framework Study, is close to the maximum generally considered as within limits of economic feasibility.

Flood control is a continuing job. Major flood threats will be alleviated by developments included in the Basic Framework, but the degree of protection provided by both structural and nonstructural measures should be evaluated periodically to determine their adequacy.

Analysis at this time indicates that developments included in the Basic Framework will, with the exception of one area, provide adequate water surface for recreation demands up to the year 2020. The exception is the rapidly growing urban area formed by Omaha and Lincoln. However, in this general area there are many potential sites where water surface area could be developed specifically for recreation.

Additional recreation opportunities could be made available near the mouth of the Platte River. A reservoir formed by a dam near Ashland was investigated by the U.S. Army Corps of Engineers in

1969. Because of lack of local support and a low ratio of primary benefits to costs the project was not proposed.

At some later time it is possible that a reservoir lower on the Platte River near La Platte or Louisville, just upstream from the mouth, may be feasible. Opportunities for recreation would probably be as great as at the Ashland site, although smaller storage capacity would lessen flood control and navigation benefits.

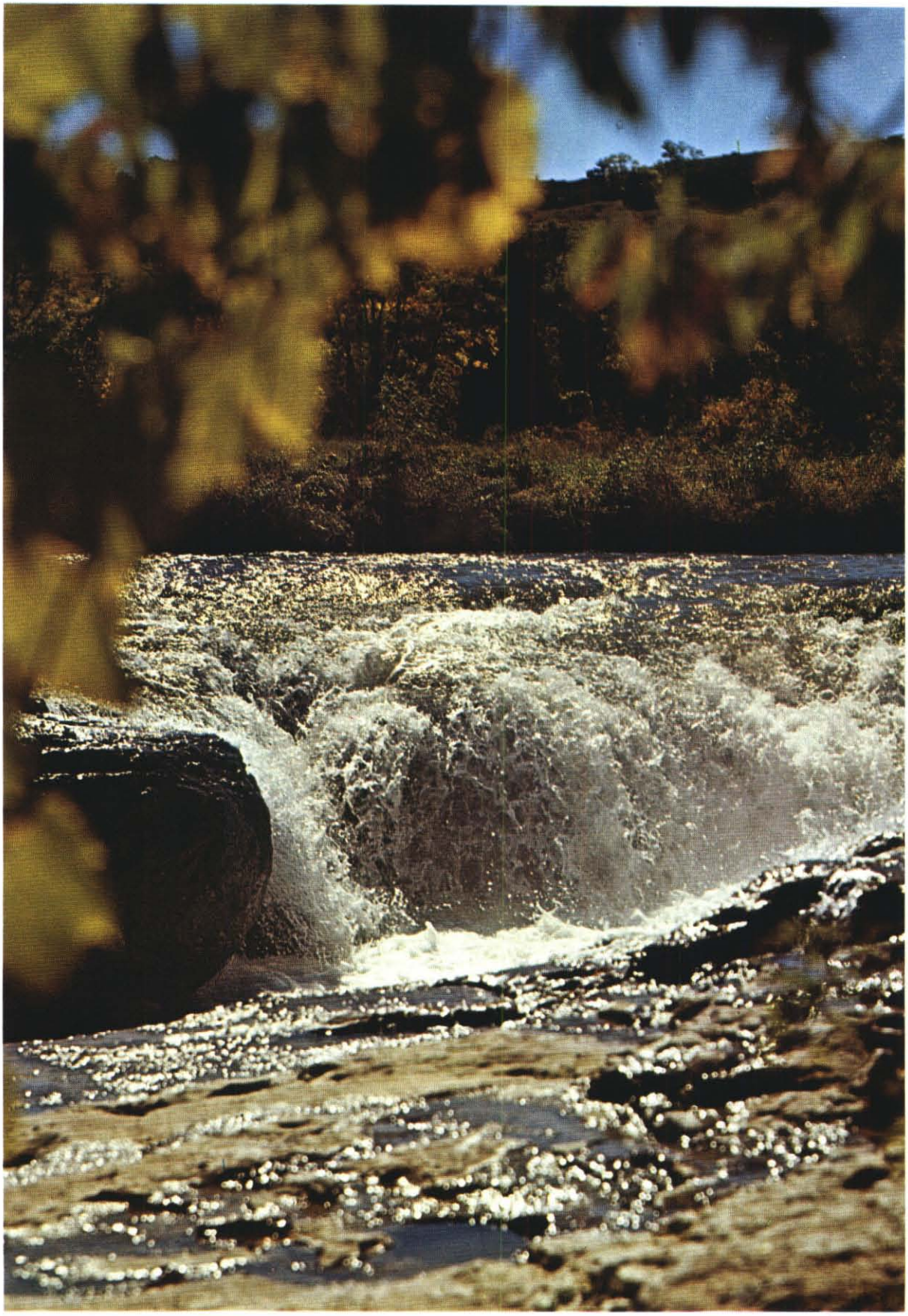
The needs of one area containing large amounts of land suitable for irrigation could not be met by the conceptual transfer schemes presented. This high tableland area is located in Cheyenne, Deuel, and southern Garden Counties and is bounded by the North and South Platte Rivers whose waters are fully developed and utilized. No local surface water supply is available for development in this low rainfall area and ground water is not sufficient for irrigation development.

Regional, National, and International Water Resource Development Schemes

Several schemes have been advanced for unprecedented major water transfers and balancing of water supplies for the region, the nation, and the North American continent. Most such schemes have had only minimal investigation. In addition to being more costly than any other water developments ever proposed, they involve not only interbasin water transfers, but interstate, inter-regional, and international transfers which would lead to involved and time consuming questions of policy and negotiation.

Some regional planning has progressed beyond the idea stage. A federal Type I Framework or reconnaissance level study has been completed for the entire Missouri River Basin. A report on this study will be complete in 1971. This study considers needs, problems, and future water utilization of the entire basin, which includes Nebraska and parts of nine other states. It is vital to further resource development in Nebraska that state participation be continued in more detailed federal-state water resource planning at the river basin or regional level.

It appears that, barring unforeseen widespread water shortages, any implementation of national or international schemes will be many years in the future and probably beyond this report's present planning scope. Nebraska should, however, maintain cognizance and participation in this type of water resource planning. Not because Nebraska is water-short, but because the State is in a favorable position between the water-short areas to the south and southwest and the areas of surplus in the north and northwest. Any water moved from north to south through the plains states area will necessarily go through or near Nebraska. With proper planning this could benefit the State by providing water to areas such as Cheyenne and Deuel Counties. Without proper cognizance and state participation in planning, Nebraska stands to lose from implementation of some of these transfer schemes.



Chapter 6 / CONSIDERATIONS RELATED TO FUTURE DEVELOPMENT

Water resources development has progressed in Nebraska through private and public initiative and investment. Freedom of action has encouraged the exploitation of streamflow and ground water supplies for municipal and industrial use, for irrigation, and for other purposes to improve the economy of the individual and of the State. Water and related land development for irrigation, flood control, power, and recreation, and for municipal and industrial use has progressed with minimum control and with too little regard for its effect on the overall hydrologic and physical systems.

Local water supply, water quality, and environmental problems are becoming apparent. Corrective measures will be required and better water resource management practices will need to be instituted to integrate the quantity and quality aspects of various water uses and needs. Also, environmental, social, and economic considerations will need to be adequately incorporated in planning and management schemes. Although considerable development has already occurred and certain problems have developed, the total water supply and the opportunities yet available for project and private development are considerable.

Previously, this report has described potential public projects and programs planned for the development, control and utilization of water resources which are needed, feasible, and awaiting implementation. In many cases the local governmental units and private organizations which are the sponsors of potential projects have already waited a decade or more for action on their implementation.

Ultimately, however, it is not an impersonal organization or governmental unit which waits; rather, the individuals who have labored years on behalf of projects, sometimes taxing themselves for funds to assist in securing help, wait for the benefits which would be provided by the needed projects and programs.

The requirements for implementation of public water resource projects were described in Chapter 1 as:

1. Plans of a type and detail suitable to the governmental entity which will consider implementation must be prepared,
2. Funds for the local, state, and federal costs of project development, operation, and maintenance must be available or assured,
3. Institutional arrangements which facilitate action are prerequisites or must be provided, and
4. Concerted and intensive support at the local and state level must be maintained.

This chapter deals with needed improvements in the above listed areas that can be made or influenced by the Legislature.

Preparation of Proper Plans

Resistance to the time required and funds expended for planning is often encountered. Planning is frequently referred to as being only an excuse for delay in implementing a simplistic solution to some visible, urgent problem. It often appears unimportant because it has no tangible result other than perhaps a report or a set of recommendations.

Planning, however, is a key activity in natural resource development. Its role is invariably recognized by those with responsibility for major public decisions of lasting importance. Knowledge of the means, cost, and results of alternative courses of action is a basic requirement in decision making.

It is commonly assumed that planning should be an inexpensive part of resource development but it is not. Each new general concern of the public must be integrated into the planning, thereby increasing the complexity of problem solution. As

technological advancement takes place and as new techniques for analysis become available, each adds a new dimension to the planning process.

Major public works, particularly those whose failure could be disastrous to public safety or welfare, must be planned carefully and designed to function safely and successfully into the distant future under all reasonably conceivable circumstances.

The public investment required for a single natural resource development project is generally large and federal expenditures often account for a substantial part of the total initial cost. Therefore, the Congress has insisted that definitive plans detailing physical and economic aspects of proposed projects must be available as a condition for federal approval and financial participation.

In view of the great growing concern for the environment, all proposed projects are presently being reevaluated with regard to their environmental effects and all new project planning will include environmental considerations. Similarly, the importance of water quality has grown rapidly in recent years and compliance with existing state and federal requirements must be reflected in all planning and fulfilled in water development and management.

Some nonfederal interests and beneficiaries of projects may feel that the additional considerations of environmental and water quality aspects of projects, or the frequent requests for economic reevaluation, are burdensome and unwarranted. However, if federal participation in project development and financing is desired, project plans must meet all current federal criteria.

Local, state, and federal water resource development planning efforts must be compatible if project implementation is to be attained. Particular areas where planning can be improved include basic data collection, water resource related research, improvement of water quality, and protection of the environment.

DATA COLLECTION

Basic data forms the foundation for planning, design and operation of projects and programs for resource development. Large amounts of funds are committed to resource development. The security with which these funds are invested depends upon knowledge of the conditions to be encountered and the performance which will be obtained from a particular planned project.

Data are essential at the outset to determine the magnitude and occurrence of both problems and resources. Possible solutions and perhaps the best solution to a given problem may not be apparent in the absence of adequate amounts of the appropriate data. In fact, perception of the problem may change as the adequacy of data increases.

Research, if it is to be more than an exercise in theory, requires sufficient and suitable data to model, test, and confirm hypotheses.

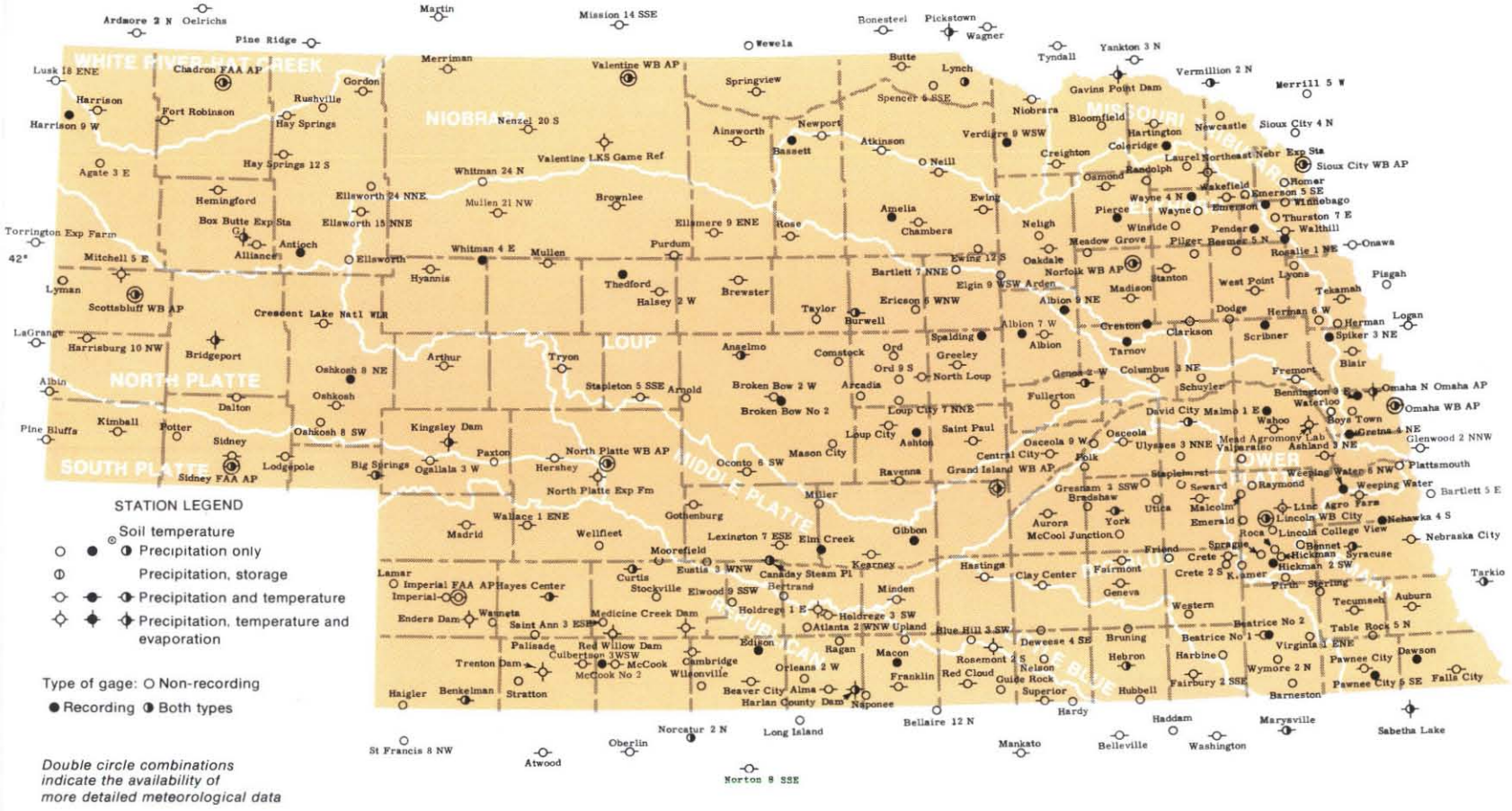
The collection and interpretation of data to provide needed information for those who plan, construct, and operate projects is basic to knowledgeable decision making, project implementation and resources management. The cost of providing facts as a basis for action is substantial, but it is small compared to the cost of failure or the need to modify improperly conceived and designed facilities.

Above all, the collection of certain types of variable data—i.e. rainfall, streamflow, etc.—is made more meaningful by continuity and coordination. Records of these types of information become more dependable and consequently more valuable as the length of record increases. Long term collection at appropriate locations is necessary to assure determination of the full range of possible values. In most cases, full interpretation of data relies on concurrent collection and interpretation of related phenomena.

Programs of basic data collection are of two general types. The first type is that collected on a broad scale to provide a base for understanding and general knowledge. Conclusions drawn from analysis of this type of data are generally sufficient for planning studies which form the basis for decisions on whether to proceed with detailed studies for implementation of projects or programs. The second type of basic data is generally more detailed and is used for advanced planning, for the design and operation of projects, and for regulation programs. These data become basic, in the sense of the first type, only if they are properly documented, identified, and preserved in a system that is available to other users. Both types of data are used in resource development by individuals and groups.

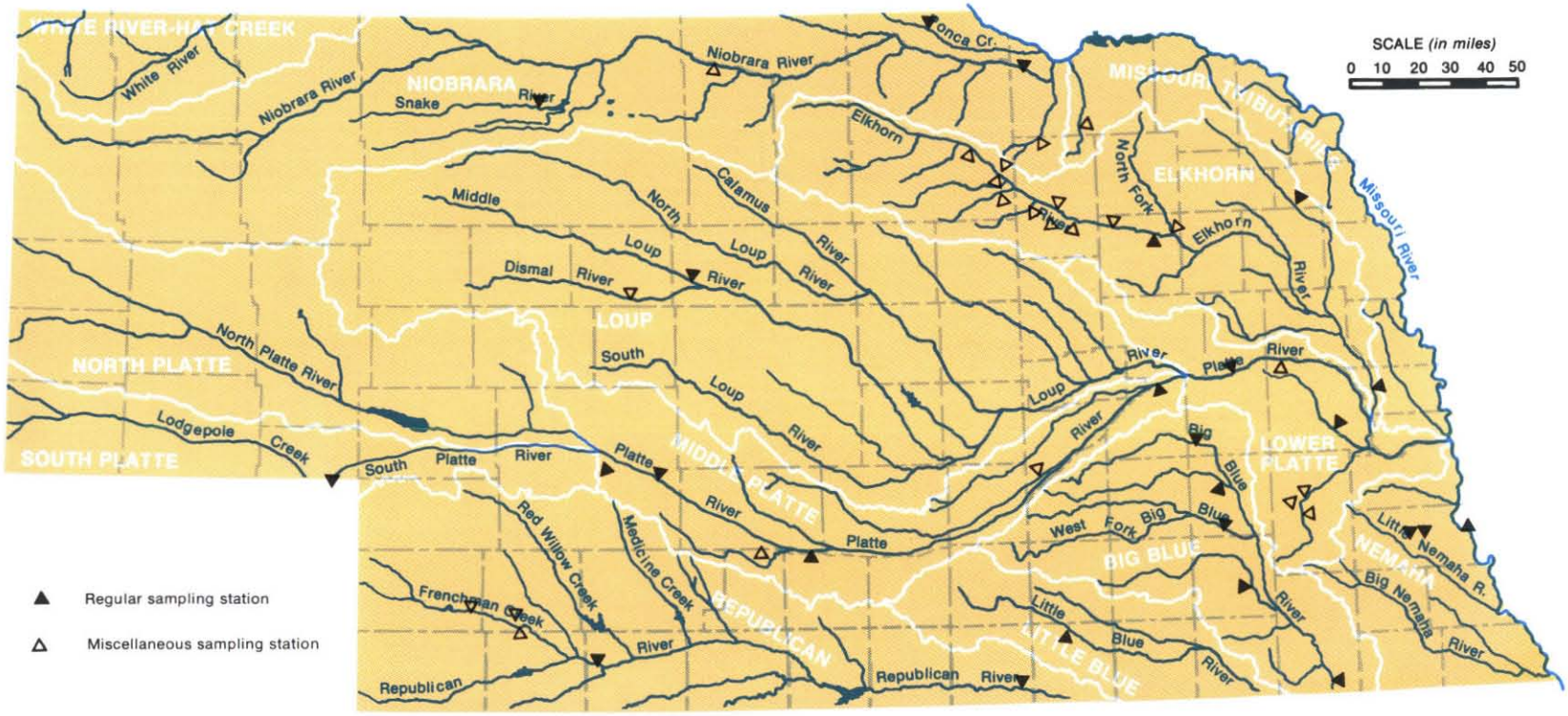
Present Programs. The amounts, types, and quality of water resources data presently being collected vary widely. Figure 72 shows the climatological data collection network in the State and the types of data being collected. Figure 73 shows the locations where information on streamflow quality was being collected in 1967. Figure 74 shows the location of stream gaging stations where streamflow data are presently collected on a regular basis. Figure 75 shows the observation well network used in monitoring ground water levels. Figure 76 shows the location of test holes drilled to collect information on the availability of ground water and the

FIG. 72 / CLIMATOLOGICAL STATIONS



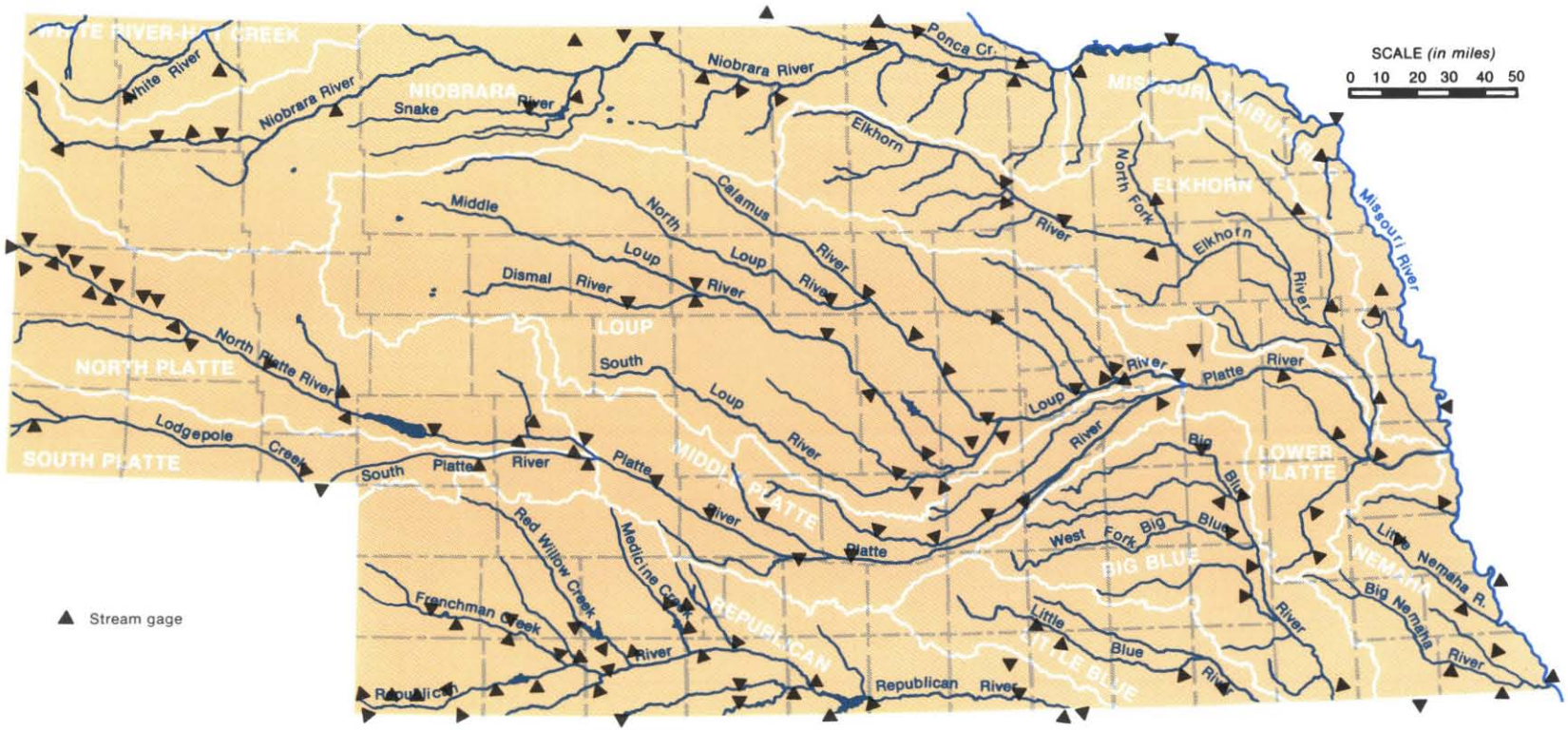
Source: U.S. Weather Bureau

FIG. 73 / LOCATION OF SURFACE WATER QUALITY STATIONS



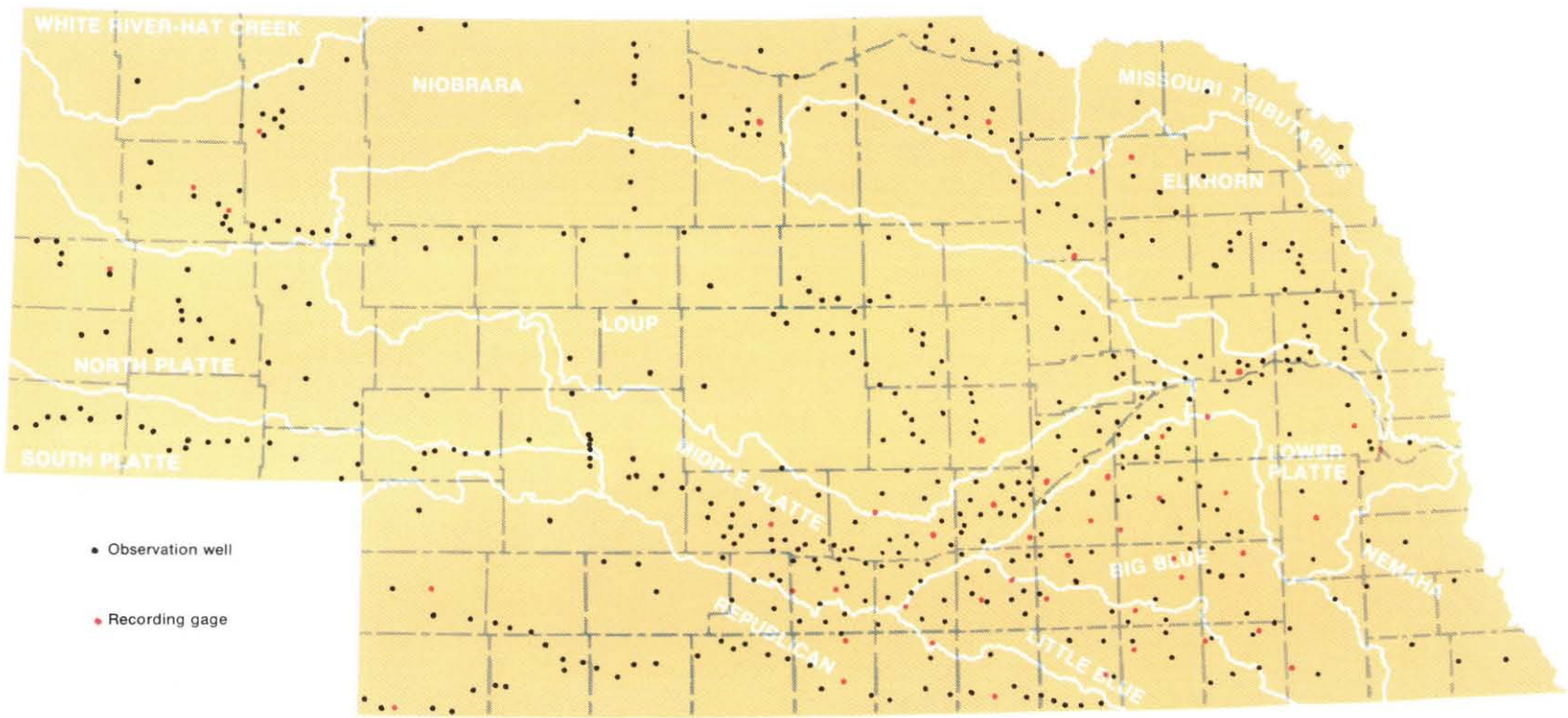
Source: *Water Resources Data for Nebraska*, U.S. Geological Survey

FIG. 74 / LOCATION OF STREAM GAGING STATIONS



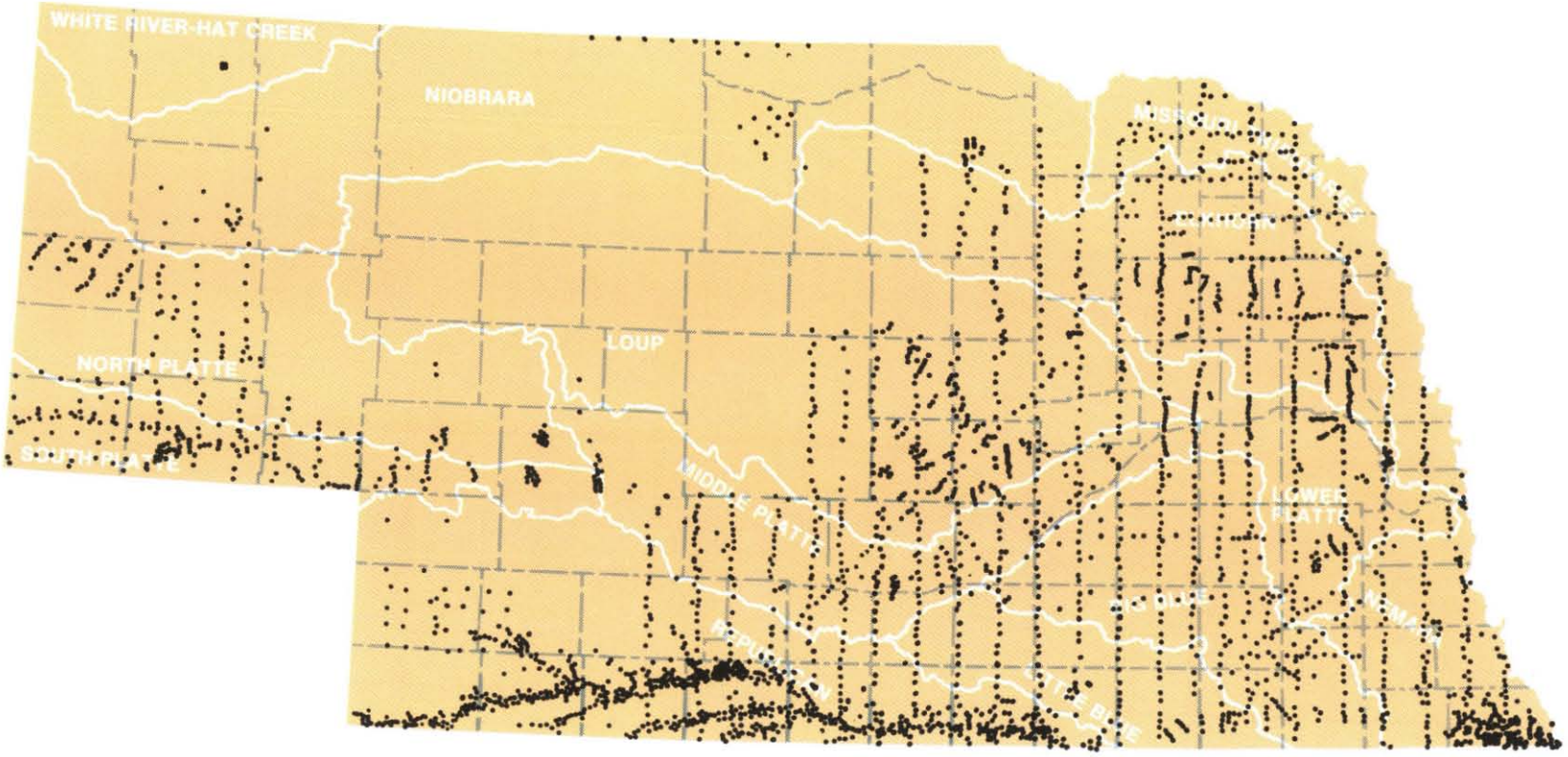
Source: *Water Resources Data for Nebraska*, U.S. Geological Survey

FIG. 75 / OBSERVATION WELL NETWORK



Source: Conservation and Survey Division, U. Of N.

FIG. 76 / GROUND WATER SURVEY
TEST HOLE LOCATIONS



Source: Conservation and Survey Division, U. of N.

physical characteristics of the materials in which it occurs.

Filing of irrigation well drill logs and other information about the ground water aquifers in which the wells occur has been required since 1957. This same information is now being filed for all new industrial and municipal wells. Information on the chemical and biological quality of water from all municipal wells is being collected periodically. Since 1960, the chemical and bacterial quality of streamflow samples collected at many locations in the State has been analyzed. All major stream diversion quantities and some stream pumpage are measured.

Considerable municipal water use data is being collected. Studies are being conducted on quantities of ground water pumped for irrigation in some parts of the State. Drill logs and material samples from test holes drilled for project evaluation and from wells drilled for water supply are being collected in a centralized file and sample library. Various types of drill logs, material samples, and drill cores of all tests holes for oil and gas or for other exploratory purposes have been systematically collected and filed.

Published topographic maps adequate for most generalized planning, development, and management of resources are presently available in the majority of the State as shown in Figure 77. In addition to their irreplaceable value as a basic form of data in resource planning, development, and management, adequate topographic maps are themselves an essential requirement for many data collection programs as adjuncts to the efficient storage, retrieval, manipulation, and management of data. Up-to-date topographic maps are needed for the entire State for these and other purposes. More detailed maps than those presently available will generally be increasingly needed in special problem areas for project planning and for regulation. These can be prepared on a timely basis as the needs become apparent.

Information on soil types, land use, land use capability, and conservation needs is available in both specific and generalized reports. Figure 78 shows the status of recent soil surveys containing most of this information.

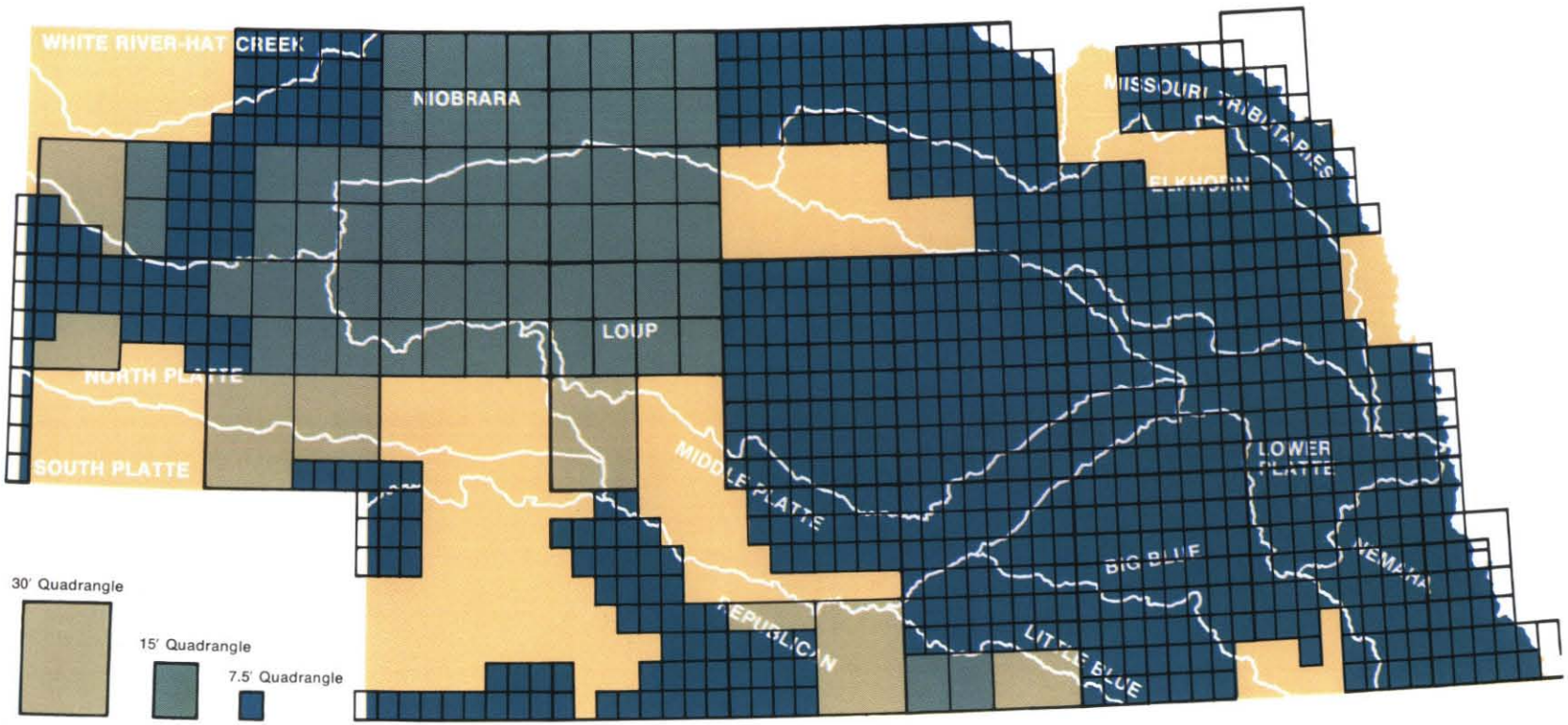
Economic data is limited generally to population, income, and other statistics of broad application. Little or no data is collected which would be useful in measuring specific economic impacts of natural resource development policies.

Basic data and interpretive reports are generally available from the state or federal agency charged with the particular data collection responsibility.

The following list was included in the 1968 report of the Legislative Council Interim Study Committee on Ground and Surface Water and shows "data which may be necessary for comprehensive water resources planning and development":

- Physical Conditions
  - Topographic Maps
  - Soil Surveys
- Geologic Conditions
  - Geologic Maps
  - Well Logs
  - Subsurface Exploration Information
  - Formation Characteristics
- Meteorologic and Climatic Factors
  - Precipitation
  - Air Temperature
  - Evaporation from Water Surfaces
  - Air Movement (wind)
  - Humidity
  - Solar Radiation
  - Cloud Cover
  - Upper Air Temperatures, Humidity
  - Storm Characteristics
- Surface Water Resources and Use
  - Streamflow
  - Water Storage in Reservoirs, Lakes
  - Diversions
  - Instream Uses
  - Return Flows
  - Streamflow Gains and Losses
  - Snowpack Storage
- Ground Water Resources and Use
  - Wells
  - Ground Water Levels
  - Extractions
  - Exports and Imports, including Waste Water
  - Recharge, Natural and Artificial
  - Natural Outflow or Discharge
  - Soil Moisture
  - Water Holding and Transmission Characteristics of Underground Formations
- Quality Characteristics of Surface, Ground, Waste, and Reclaimed Waters
  - Chemical
  - Biological
  - Biochemical
  - Bacteriological
  - Radiological
  - Temperature
  - Pesticidal
  - Physical
  - Sediment Production, Transport, and Deposition
- Water Use and Requirements
  - Population
  - Land Use
  - Water Rights

FIG. 77 / STATUS OF TOPOGRAPHICAL MAPPING



Source: U.S. Geological Survey

- Irrigation Cropping Patterns and Practices
- Municipal and Domestic Demands
- Industrial Water Use
- Recreational Use
- Fish and Wildlife
- Quality Control
- Power Production and Consumption
- Navigation

Characteristics of Facilities for Control, Conservation, Protection, Diversion, Treatment, Distribution, Reclamation, or Utilization of Surface, Ground and Waste Waters, and Return Flows

- Location
- Size
- Capacity
- Functions
- Area Served
- Operating Criteria
- Modifications
- Operation Records

Water Resources Augmentation

- Weather Modification
- Phreatophyte Control
- Evaporation Suppression
- Subsidence

Economic and Fiscal Factors

- Construction Costs
- Operation and Maintenance Costs
- Water Costs
- Benefits of Water Use

Some of these data are presently being collected adequately, but many are either included within existing programs in need of expansion or are not collected at all on a regular basis.

The Legislative Council Interim Study Committee's report also stated:

> "The complexities of modern development projects involving large financial investments require specialized and accurate data for planning and operation. Data collection in Nebraska deserves serious thought as to whether the present system will provide a satisfactory foundation for our future needs. ....it is the Committee's observation that some action is necessary to expand the data collection program in Nebraska and the coordination, processing and interpretation of this data. It is also this Committee's feeling that the development of a comprehensive management program for water and soil resource data will be a wise investment for Nebraska's future."

As one result of the Committee's report a Soil and Water Resources Data Bank was established by the 1969 Legislature. The program and the Technical Advisory Committee established for the Data Bank will provide a means for coordination and exchange of ideas between agencies collecting and/or using data in the State as well as a repository for data. Funding for the program has been inadequate to achieve the desired results. At present funding levels, many years will be required for the Data Bank to become fully operational. Data collection programs are not necessarily to be expanded as a result of the data bank program.

Needed Improvements. Data collection is presently carried out under budgets that limit collection of some types of data to those specifically needed for project and private development and operation, for broad-based monitoring, or for regulation. As the State has moved forward in resource development the need for new and expanded data collection programs has become apparent. Some problems and conflicts in resource use resulting from the present level of development have occurred already and will increase with continued development. Effective planning and management of the natural resources will require that considerably greater effort and expenditures be devoted to data collection in the future.

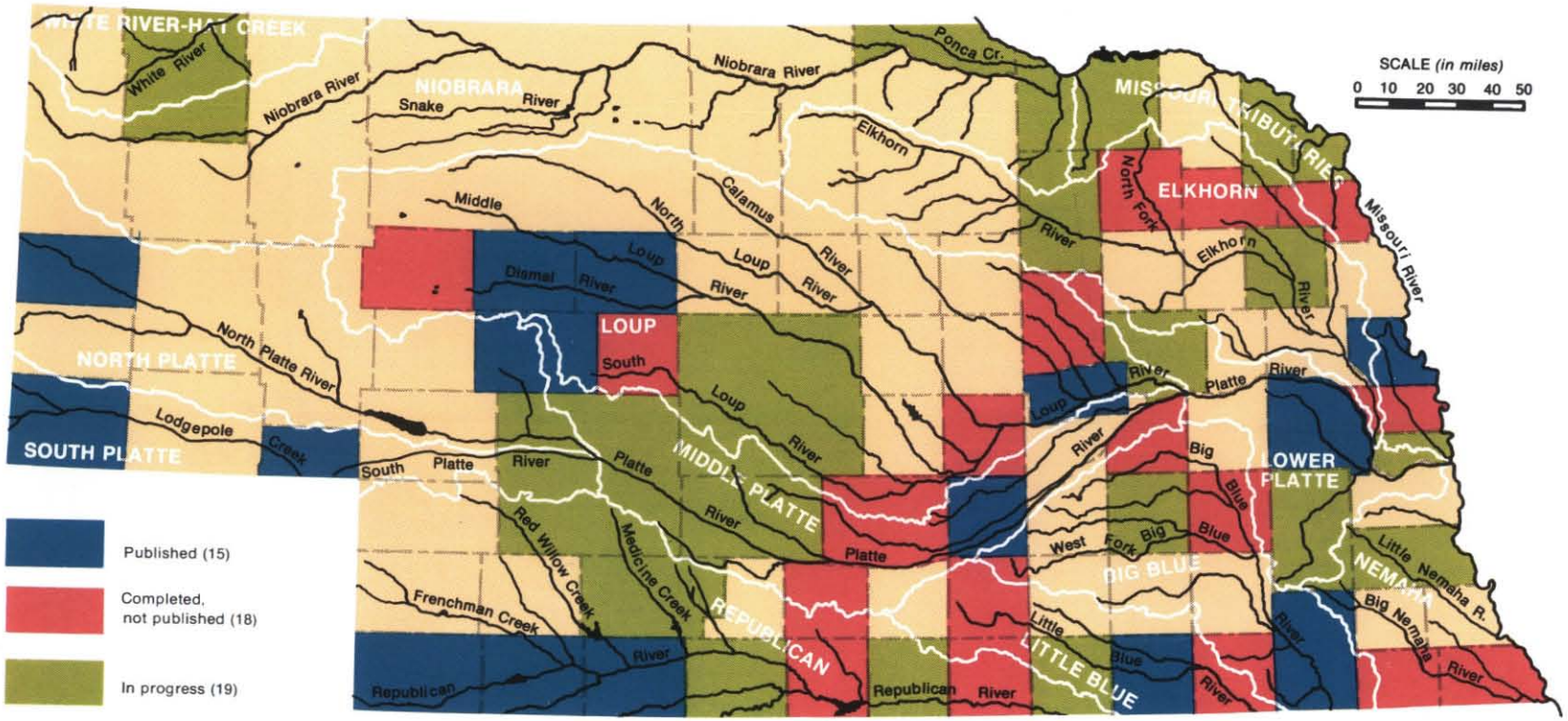
The predictable result of too limited and untimely data collection and availability is a delay in planning, design, or construction of new projects while the needed data is collected. During such periods, pressures to proceed even in the face of inadequate information are substantial. The present level of data collection, particularly in regard to surface water contamination and the effects of public and private land and water development projects on the physical and biological environment, is entirely insufficient to develop viable planning and management systems with any degree of certainty.

To overcome present deficiencies in data and to insure the availability of at least minimal amounts of data for future needs, a more intensive generalized data collection program is urgently needed in Nebraska.

While the lack of any type of data can be serious under some conditions, several specific types of data which are vital to new concerns of the public, such as the environment, require special emphasis. The following types of data will be essential to future water and water related resources planning in Nebraska:

1. Climate
2. Streamflow at critical points
3. Surface water diversions and returns
4. Ground water extractions and levels
5. Return flows from municipal, industrial and agricultural sources, both in terms of quantity and quality, to surface and ground waters

FIG. 78 / STATUS OF RECENT SOIL SURVEYS IN NEBRASKA



Source: U.S. Dept. of Agriculture

6. Water quality concerning both organic and inorganic constituents and pollutants, for both surface and ground waters
7. Sediment production, transport, and deposition
8. Topographic mapping
9. Potential dam and reservoir sites
10. Soils and land classification
11. Land use data
12. Economics
13. Environmental and social aspects
14. Water requirements
15. Recreational use and demands

Acceleration and expansion of Nebraska's Soil and Water Resources Data Bank as both a repository for data and a mechanism for coordination of data collection is needed to meet present needs for data management associated with water and water related resources. Data to be included is generally that pertaining to natural resource situations, relationships, and trends as necessary for planning. Basic research data would not normally be included. The data bank program will need to be strengthened increasingly as expanded basic data collection programs are funded and implemented in the future.

The manner in which the total program for observing, recording, collecting, interpreting, storing, retrieving, presenting, and publishing basic data is managed influences the degree to which the program will meet the informational needs of agencies of the state and local governments, the universities, private businesses, individuals, and the Legislature. Basic data collection is accomplished by a large number of state, federal, and local agencies. Coordination of the various data collection programs to meet the needs of users has generally been accomplished informally through consultation. This should be continued and the Technical Advisory Committee to the Soil and Water Resources Data Bank through the Data Bank program should assist in this coordination of data collection and in the dissemination of data and interpretive reports by:

1. Pooling information on data collection programs.
2. Examining the need and justification for data collection in new areas and expansion of existing data collection programs.
3. Encouraging adequate funding for essential data collection programs needed for water and water related resource management.
4. Establishing a priority rating scheme for maximizing program effectiveness within budgetary limitations.
5. Adopting standardized procedures for observing, analyzing, and recording basic data so that information obtained will be meaningful and consistent.
6. Developing data storage systems from which data can be retrieved easily at the time and in the form needed and to which new data can be added as they become available.
7. Encouraging the interpretation, publication, and dissemination of data to the public and user groups.

RESEARCH

Many innovations for better, more efficient use of the water resource have resulted from research. Applied research is aimed at developing new techniques, machines, and programs for solving specific problems. Other research, more basic in nature, is directed at increasing general knowledge of the resources. Both are valuable as adjuncts to planning.

Examples of complex research problems associated with resource development which are faced in Nebraska at the present time are:

1. Determination of desirable development of ground water usage in differing hydrologic situations,
2. Evaluation of basinwide flood control programs,
3. Evaluation of environmental changes resulting from resource developments,
4. Determination of the interrelationships between ground water, surface water, subirrigation and evapotranspiration,
5. Development of models to be used in water planning and management,
6. Development of methods of agricultural pollution control, and
7. Development of practices for more efficient use of precipitation and applied water for agricultural production.

These and other problems, equally complex, must be met and overcome as planning and development proceed.

The research required to resolve the many problems involved with water resource development is highly technical. Aside from adequate funding it will require special skills, training, experience and techniques.

Present Situation. The University of Nebraska quite properly carries out the bulk of water resources research activities in Nebraska. The Nebraska Agricultural Experiment Station has been especially active, particularly in the fields of pollution control and water conservation and utilization.

Funding for research is provided to the University primarily through state general fund appropriations and federal grants. The research is accomplished through individual academic departments and through cooperative programs. Some of the research serves in student training of future professionals. Research funds are often inadequate to support in-depth projects that eventually could lead to problem solution on a local and statewide basis.

The individual interests and capabilities of principal researchers and department awareness of research needs inevitably play an important role in selecting topic priorities. As a result the problems viewed as most urgent by the planners may not be so viewed by the researchers. But generally, there is adequate communication between research and planning agencies.

The general level in Nebraska of research having specific application to water resource planning and development is insufficient in view of the value of this resource to the state's agricultural economy. Coordination of research between the University of Nebraska, planning agencies, and water users has been accomplished primarily through informal means.

Needed Improvements. The general level of research activities should be increased, with specific attention given to close coordination between the University and various state agencies involved in resource management.

The role of the University in general water resource planning has been largely that of review and counsel. While this is an invaluable aid to the planning process, the special talents and capabilities of the University staff could be even better utilized. Research into the more sophisticated methods of resource management would offer an opportunity for University staff members to utilize their special expertise to a greater degree as conceptualizers and innovators. The specific means, organizational and otherwise, which would be required are matters internal to the University of Nebraska but they should provide for close contact with planning agencies.

A Water Resources Research Institute was established at the University in 1964. This Institute should be strengthened through state appropriations in order to serve its proper role as a focal point for coordinating research needs between state agencies and the University.

WATER QUALITY AND ENVIRONMENTAL PLANNING

Water quality and environmental aspects of development are discussed in this report. However, public manifestations of intense interest in these areas are so recent that adequate data and well formulated methodologies to accord them sufficient attention in the planning process were not available. Substantial further planning efforts in these areas are required if, for example, requirements for federal cost sharing of waste water treatment facilities are to be met and if an extensive program of environmental protection is to be pursued.

Present Programs and Requirements. The Federal Water Quality Act of 1965 required the states to adopt water quality standards for interstate streams which were acceptable to the Secretary of Interior. Nebraska has adopted such standards and these require secondary treatment of all municipal sewage discharged to waterways. Municipal sewage outletted directly into the Missouri River must receive secondary treatment by December 31, 1975, and municipal sewage discharged into streams internal to the State must be similarly treated before January 1, 1972.

To assist in compliance with these regulations, the Federal Government will share with municipalities in the costs of providing waste treatment facilities.

However, current federal regulations also require that:

> "No grant shall be made unless the Commissioner determines... that a project is included in an effective current basinwide plan for pollution abatement consistent with applicable water quality standards."
>
> "The Commissioner shall consider whether the plan adequately takes into account all, or such as may be appropriate of the following: (1) Sources of pollution.... (2) Volume of discharge .... (3) Character of effluent.... (4) Present treatment.... (5) Water quality effect.... (6) Detailed abatement program."

At the present time in Nebraska, no comprehensive plans for water quality management exist. Comprehensive water quality planning of a type consistent with federal requirements is now being implemented in the Salt Creek Basin within which Lincoln is located. Also, the Omaha-Council Bluffs Metropolitan Area Planning Agency is engaged in preparation of a plan that may be acceptable under

the federal regulations. Other than in these areas, federal grants for construction of waste treatment facilities will probably not be available in the future unless effective pollution abatement plans are developed.

If comprehensive basinwide plans for water quality management are to be prepared, some type of statewide plan will be necessary to correlate the individual basin plans and insure that some uniformity exists in their preparation.

Problems of agricultural pollution are particularly complex. Runoff from intensively farmed agricultural land and livestock feedlots frequently carries a large amount of sediment, organic matter, and associated agricultural chemicals. Accelerated installation of detention structures and soil and water conservation practices, such as terraces, waterways, and minimum tillage, would reduce stream pollution from these sources. About two-thirds of the cropland in Nebraska and one-fourth of the feedlots are in need of improved measures to prevent waste runoff.

While no broad program of planning for water quality management exists within Nebraska, several agencies carry on related activities of either planning or regulation. Development of an effective, comprehensive program is hampered by the existing division of responsibility. Without clear cut effective leadership, agencies capable of assisting to varying degrees lack both the stimulus and coordination to participate effectively.

In like fashion, the State needs a comprehensive approach to environmental planning. One of the most important parts of this activity, land use planning, is not being carried out specifically by any agency.

Obviously, water resource development and water quality and environmental planning are closely related and, as a result, several agencies' activities and authorities impinge or overlap to a considerable degree.

Needed Improvements. Water quality is inextricably related to water quantity, so planning for these functions should be carried out simultaneously and as part of the same overall plan for development and management of Nebraska's water resources. The Framework Study could serve as the basis for statewide water quality planning to insure that adequate recognition is given to the effects of, and the opportunities associated with, projected private and public projects. Expansion of the Framework Study to further incorporate water quality and other closely related environmental considerations offers the most efficient method of preparing statewide plans regarding these important matters.

Although considerable emphasis is being placed on control of agricultural pollution, more research dealing with problems of water quality management in rural areas, and its application, is needed.

Local, State, and Federal Funding

Major public resource development projects usually require large investments of public funds. The cost sharing arrangements between local, state and federal levels generally varies for the different purposes—e.g. flood control, irrigation, recreation, etc.—of development. Assistance is available from the Federal Government through a variety of programs.

Flood control is largely a federal cost except that a nonfederal sponsor must assume the costs of necessary lands, easements, and rights of way; provide operation and maintenance after completion; and assume liability for the project. Irrigation costs are, to the contrary, reimbursable to the federal treasury without interest over a long time period. Any separable project costs associated with recreation and fish and wildlife are divided equally between the federal and nonfederal sponsors.

Estimates prepared for the Missouri River Basin Study indicate that, overall, federal and nonfederal costs will be divided about evenly for implementation of the types of projects contained within the Basic Framework.

The Federal Government is indifferent as to who will contract to provide the nonfederal costs as long as the entity meets the necessary legal and financial requirements. Presently, both state and local political subdivision funds are utilized to meet nonfederal obligations.

PRESENT FUNDING

Present state financial support for implementation of resource development projects is limited principally to two programs. The Nebraska Soil and Water Conservation Commission administers the Small Watershed Flood Control Fund which helps defray the cost of land acquisition for certain types of projects. The statute permits the fund to be used to acquire 25 percent of the parcels of land required for a project. Monies are supplied by general appropriation and from some recapture of funds from the sale of lands purchased prior to construction but unnecessary for project operation. The fund is limited as to the types of projects for which it can be used. The arbitrary division of cost to the State bears no rational relationship to considerations of distribution of the benefits expected from a particular project.

Appropriations have until recent years been generally sufficient to meet requests under the present limited application of the fund, but far below the amount necessary if the program were to be expanded and the fund made available for broader purposes.

The state's only other significant investment in nonfederal costs of water resource development projects is made by the Nebraska Game and Parks Commission. Funds for this purpose come from a variety of sources and are used to meet the nonfederal costs associated with the fish and wildlife and recreation purposes of projects. Again this fund is severely limited in both amount and purposes for which it may be used.

No provision is presently made by the State to assist in construction of municipal sewage treatment plants. Costs are borne by communities and in part by the Federal Government through grants. The federal grant program is designed to encourage state financial participation by sharing with communities up to 33 percent of the costs of sewage treatment plants in the absence of a state program and sharing up to 55 percent of the costs when a 25 percent state share is provided. If a comprehensive water quality plan has not been developed, the federal share drops to 30 percent and 50 percent respectively.

Many local political subdivisions lack the financial capability to participate on a professional level in planning for even small projects. Funds are available for this purpose through taxation but various restrictions as well as reluctance on their part make it difficult to raise funds for planning before preliminary information indicates a project potential exists.

As a result, the planning is generally carried out by state and federal agencies, and local sponsors are not always aware of various planning alternatives. Under this arrangement, local input into the planning process may be insignificant, belated, and inexpert.

NEEDED IMPROVEMENTS

The Small Watershed Flood Control Fund should be redesignated, broadened in application, and funded at greatly increased levels to establish a comprehensive Water Development Fund. The Legislature should specify the general purposes for which the Water Development Fund could be used and prescribe a procedure for the division of nonfederal costs between the state and local political subdivisions.

Through the Water Development Fund, the State could make grants available to local political subdivisions to enable their early and strong participation in water resources planning activities of direct importance to the local area.

In view of the federal and state requirements for installation of waste treatment facilities and the large costs associated with their installation, provision should be made to meet existing federal cost sharing provisions. Large amounts of additional federal funds, perhaps millions of dollars annually, may be lost to Nebraska communities if adequate state cost sharing is not provided.

Institutional Considerations

The primary institutional problems blocking implementation of resource development projects are divided responsibilities and authorities at the local and state levels, and a lack of state goals to be achieved by resource development.

PRESENT SITUATION

Institutional problems arise at the local level due to the way in which local political subdivisions are formed with regard to boundaries and the division of authorities and responsibilities given them. These problems have been described previously in a Special Recommendation of Nebraska's State Water Plan titled *Modernization of Resource District Legislation.* That publication also contained very specific recommendations made by the Nebraska Soil and Water Conservation Commission of changes necessary to correct many of the existing problems.

Since publication of that Special Recommendation, legislation has been enacted implementing many of the specific changes suggested. The legislation is currently being reconsidered and the extent to which it will eventually meet the needs for institutional reform on the local level is presently unknown.

Comparable problems exist on the state level with responsibilities for different facets of resource development assigned to a variety of agencies. The inevitable emergence of special agency interests under these conditions inhibits joint activities, requires extensive efforts of coordination, and can delay implementation of needed projects and programs.

State goals for resource development were pointed out briefly in Chapter 1 as an item worthy of special attention by the Legislature. No state goals presently exist. The provision of clearly stated, specific goals would assist various state and local agencies considerably in working together for a common purpose. However, the establishment of goals is very difficult and will require detailed study of the ramifications of various courses of action.

While existing provisions of Nebraska water laws have not in the past significantly affected water resource development or impeded the economy to a great extent, they may impose severe restrictions on achieving full multipurpose use of Nebraska's water resources in the future. The existing provisions set forth the preferences of water use for domestic, agricultural and industrial purposes only. Changing public desires have created new demands for water not included in these categories.

Fish and wildlife, recreation, and the quality of the physical environment have now become added major public concerns. Each purpose may require the use of water. However, under present provisions of law, neither the State of Nebraska nor its political subdivisions can provide or secure water rights to fulfill these project purposes. The inability to assure water rights for these purposes could become a major impediment to project implementation.

NEEDED IMPROVEMENTS

Since the local institutional arrangements are presently under consideration by the Legislature, no further suggestions are made at this time. Based on the final outcome of the Legislature's consideration and experience with the resulting situation, further recommendations may be necessary in the future.

A basic improvement of institutional arrangements on the state level would be accomplished by the consolidation of closely related water resources planning responsibilities similar to those described for the area of water quality in a previous section of this chapter.

Increase of the level of financial participation in the resource development related areas of planning, data collection, and research as well as future assurances of funding for these programs would be of substantial benefit.

Studies leading to goal setting for water resource development should be undertaken as Special Recommendations of Nebraska's State Water Plan.

The 1969-1971 Legislative Council Interim Study Committee on Water and Land Resources has previously suggested the following as possible topics for studies:

1. Cost sharing for resources development,
2. Extent of development sought,
3. Conflict between environmental and economic objectives.
4. Indemnity for use of public resources,
5. Provision for multipurpose development,
6. Flexibility in water use, and
7. Emphasis on development of renewable water resources.

Participation by a wide range of public and private organizations should be sought in the discussions leading to goal setting.

Because of a changing emphasis on use of water consideration should be given to modifying the appropriation system for water rights to recognize all desirable uses of water.

Concerted Action

The competition for federal funds for resource development is keen. Proposed projects must compete with other resource development projects and other types of programs having high national priorities. Requests for federal support must be specific and well supported by state and local governments and by the private sector. Division in support of projects frequently results in congressional refusal of consideration. In many instances, federal departments will not even transmit proposals to the Congress until adequate unified support is apparent.

PRESENT SITUATION

No extensive state action has been taken in recent years to provide positive leadership to efforts aimed at promoting specific resource development projects.

The various state agencies have given approval and support to substantial numbers of projects. The Nebraska Soil and Water Conservation Commission has explicitly endorsed many projects as a part of Nebraska's State Water Plan. Nebraska's Governors have stated favorable official state positions on projects. But as yet, no formal indication has been made to Congress and the executive branch of the Federal Government of the preferences of the State of Nebraska as to the order of implementation of these desirable projects.

Without positive state leadership, each group of local sponsors has attempted to gain priority for its particular project. Rivalries develop between sponsoring groups and congressional delegations are faced with a complex and unending series of requests for support. The impact which could be gained by unified state support is lessened by the many factions which develop.

NEEDED IMPROVEMENTS

The assignment of a specific priority to various resource development projects is difficult. Simple chronological references are not adequate to array and rank such complex projects. The establishment of priorities must also consider the magnitude, distribution, and type of benefits to be provided, the urgency of need, and relationship to national priorities.

Projects can be grouped easily in like categories however. Specific action should be taken to give legislative cognizance to projects which are ready for congressional authorization and funding and which are deemed desirable by the State. Likewise, the Legislature should specifically enumerate those projects which it favors among those requiring further study.

A clear statement of state desires with regard to these specific projects would enable more effective support by Nebraska's congressional delegation and assist in directing the activities of federal executive departments along desired courses.

Chapter 7 / CONCLUSIONS AND RECOMMENDATIONS

The Framework Study on which this report is based has disclosed only a few problems, mainly flooding and soil erosion, that presently affect the entire State. However, severe problems such as poor domestic water supplies, falling ground water levels, drainage problems associated with irrigation development, poor surface water quality and lack of water based recreation opportunity exist in several areas. These problems retard the economy and adversely affect the welfare of residents in these areas.

The majority of the existing or potential problems can be avoided or mitigated with prompt and specific action, but modification of resource management in Nebraska will be required to achieve the desired results. If no substantial changes are made, the present problems, limited in extent and moderate in severity, will continue to grow until irreversible damage is done or remedial action on an emergency basis is necessary.

Besides the problems disclosed by the Framework Study, the investigation summarizes existing developments and reveals many opportunities for further resource development within the State. Irrigated agriculture, for example, has already contributed significantly toward the state's economic and social development, but further opportunity exists in this and other areas. The extent to which Nebraska capitalizes on these opportunities will in large measure shape her future economic progress.

The first conclusion and the accompanying recommendation are based on the Nebraska Soil and Water Conservation Commission's consideration of information in this Report on the Framework Study and the Basic Framework contained herein.

The remaining conclusions are based upon the availability of water and water related resources and the needs and opportunities for development in the State as described in this report. The accompanying recommendations are made by the Nebraska Soil and Water Conservation Commission to the Nebraska Legislature for appropriate action.

The Report on the Framework Study

CONCLUSION

This Report on the Framework Study is provided in reply to the request for a State Water Plan set down by Legislative Resolution 5 adopted by the 1967 Legislature.

The Basic Framework provides a flexible guide for efficiently meeting present and future water related needs using water solely within the basin of origin.

RECOMMENDATION 1

The Governor and the Legislature should: *(1) recognize the Basic Framework as the flexible guide for orderly control, protection, development, and in-basin utilization and management of the water and water related resources of Nebraska, (2) direct the officers, boards, commissions, agencies, and departments of the State to take cognizance of the Basic Framework in their future water related activities, and (3) encourage local political subdivisions of the State to conduct their water development activities within the Basic Framework.*

Expanded State Role in Development

CONCLUSION

Increased investments in projects and activities to develop water and water related resources will be required to maintain any appreciable rate of development in the future. However, federal assistance in resource development is limited, so the state's role must be expanded if land and water development on which economic stability and growth in Nebraska depend so heavily is to continue at a satisfactory rate.

The necessary development of water and water related resources increasingly will require the State to participate in and have explicit policies for the conception, planning, design, financing, construction, and operation of projects as necessary.

Present nonfederal costs of public projects are borne predominantly by local interests in spite of certain statewide benefits which often accrue from such projects. Inefficient development often results from the local entity's lack of financial capability to realize the full potential of multipurpose projects.

Increased state investments will be required to assure that projects appropriately reflect broad social goals. Such goals as the protection and enhancement of recreation, fish and wildlife, water quality, the environment and other aspects of development which may not return specific dollar benefits over a limited project area tend to be neglected by local entities for fiscal reasons. Only the State, as steward of the general welfare, can maintain the required focus on these long range social goals of broad coverage.

In addition, state financial assistance to municipalities will be required to take full advantage of the federal funds appropriated for assistance in the construction of municipal sewage treatment plants.

If planning and data collection in the water resources field are to be fruitful, they must be long term, continuous activities. Funding for these activities must be stabilized at an appropriate level to insure that no interruption occurs.

State assistance for those resource developments which have regional or statewide benefits will also be necessary to protect prior investments and to maintain efficient operational levels.

RECOMMENDATION 2

Studies should be initiated to determine the policies and legislation desirable and necessary to provide the requisite authority for the State to finance, design, construct, and operate, as necessary, water projects and to sell the vendible goods and services provided thereby.

RECOMMENDATION 3

A study should be initiated to determine the actions necessary to convert the Small Watershed Flood Control Fund into a Water Development Fund to be used for the following additional purposes, among others:

A. *The purchase of conservation storage in, or the water developed by, federally constructed reservoirs, or to underwrite the reimbursable costs allocated to recreation and enhancement of fish and wildlife resources, where local political subdivisions are financially unable to underwrite these features of such projects and where there is a regional or statewide interest.*

B. *Loans to local political subdivisions which lack the necessary financial capability to provide needed water development facilities, exclusive of distribution systems.*

C. *Grants to local political subdivisions to include project features which expand the multipurpose statewide benefits of proposed local water development projects, such as provision or maintenance of minimum flows for fish and for Protected River Reaches, water quality maintenance, and the provision of recreational opportunities for the general public.*

D. *For water resources planning by the State and for planning grants to local political subdivisions.*

E. For long term loans to local political subdivisions to rehabilitate irrigation distribution and associated drainage systems.

F. To finance necessary water project construction by the State.

G. To provide funds to participate in construction of recharge facilities for ground water replenishment.

RECOMMENDATION 4

A state program should be initiated and funded to meet the federal policies with respect to state matching grants for construction of municipal sewage treatment plants.

Future Planning

CONCLUSION

The solution of specific water related problems in Nebraska has been hampered and delayed by the absence of an overall approach to the planning process. The Basic Framework provides the necessary coordinating mechanism for the future detailed studies which are required. In short, it provides a conceptual platform of broad scope on which to base other studies.

But, the other three parts of Nebraska's State Water Plan, i.e. Basin Studies, Status Summary, and Special Recommendations, are also needed to give depth to specific programs and to provide detailed guidance in implementing the general recommendations of the Framework Study. These remaining parts of the State Water Plan warrant the earliest possible completion.

The Basin Studies, more detailed than the Framework Study, should be completed for the river basins of Nebraska. The appropriate level of study is that described by the Water Resources Council as "Regional or River Basin Studies."

A study of this type for the Platte River Basin in Nebraska, which includes the Platte, Loup, and Elkhorn Rivers, is pending and should be given an immediate priority in the Basin Studies series.

It is imperative that the State be a full partner in any federal or regional planning or resource development to assure the proper use of Nebraska's resources and that Nebraska's needs and opportunities are fully considered.

Available pollution studies are inadequate for planning for the proper management, protection, and improvement of water quality in Nebraska.

Water quality is inextricably related to water quantity and to the control, protection, development, and utilization of water and water related resources. Future planning, more detailed than the Framework Study, is necessary to amply recognize the importance of water quality in water resources protection and development and to fully integrate all future water quality considerations into the Basic Framework. Such planning must be broad, comprehensive, and consider all alternative methods of protecting and enhancing water quality.

RECOMMENDATION 5

The remaining three sections of Nebraska's State Water Plan—the Basin Studies, the Status Summary, and the Special Recommendations—should be completed at an early date.

RECOMMENDATION 6

The Governor and the Legislature should insure that all planning for development and utilization of the state's water and water related resources is carried out on a coordinated, comprehensive basis including quality and environmental as well as quantity aspects.

RECOMMENDATION 7

The State, through its several agencies, should participate actively and intensively in the regional or river basin planning activities to be accomplished under the general guidance of the Federal Water Resources Council.

RECOMMENDATION 8

A high priority should be accorded to the studies for the Platte River Basin and active support given through appropriations by the State and the Congress for initiating that study in fiscal year 1972.

Environmental Values

CONCLUSION

A satisfactory physical and natural environment must be maintained if the high quality of life available in Nebraska is to continue. Environmental aspects must be considered fully in planning for water resource development.

In recognition of this imperative, the following river reaches have been found to possess sufficient scenic, recreational or environmental values to warrant study for possible designation as Protected River Reaches.

...Niobrara River—from its confluence with Antelope Creek downstream to the headwaters of the proposed Norden Reservoir, including the lower 8 miles of the Snake River tributary.

...Snake River—from its headwaters to the headwaters of Merritt Reservoir.

...North Loup River—from its headwaters to 18 miles west of the Taylor Diversion Dam.

...Middle Loup River—from its headwaters to the Milburn Diversion Dam.

...Dismal River—from its headwaters to its mouth.

...Missouri River—from the headwaters of Lewis and Clark Reservoir west and north along the Nebraska border.

...Missouri River—from Lewis and Clark Reservoir (Yankton) to South Sioux City.

...Platte River—from the mouth of the Loup River to the confluence of the Missouri River.

...Big Blue River—from Crete to Beatrice.

Important historical areas include Lewis and Clark Trail along the Missouri River, and the Oregon and Mormon Trails and remnants of the Pony Express Route along the Platte River valley.

Because the cultures of the Plains Indians and their remaining artifacts are closely connected with water, archeological studies, including detailed exploration when necessary, should be carried out prior to water resource development to prevent permanent loss of such artifacts of irreplaceable historical and cultural value.

The ecological balance of the Sandhills appears to be fragile and therefore should be studied intensively. More knowledge is required to fully understand and assess the probable ecological consequences of any proposed structural developments and water resource utilization within this unique region and to be able to minimize any adverse ecological impacts.

RECOMMENDATION 9

In the interest of environmental quality of life and to assure the continued attractiveness of Nebraska, certain river reaches should be designated as Protected River Reaches and receive protection as appropriate, and certain water related areas of historic, scientific and cultural value should be preserved.

RECOMMENDATION 10

All future planning for development of the state's water resources should: (1) carefully examine possible environmental and ecological consequences that may result from development with the objective of minimizing any adverse impacts on the natural environment, (2) include the results of such examinations and mitigative measures in planning reports and (3) encourage public study and expression as a part of the steps taken toward implementation.

Fish and Wildlife Resources

CONCLUSION

In addition to their intrinsic value as a part of man's environment, fish and wildlife resources are important for their contribution to recreational opportunity and as vital components of complex ecosystems.

The fish and wildlife resources of Nebraska have undergone a series of major changes since the arrival of the first settlers. Fish and wildlife often have been adversely affected by extensive changes in habitat and loss of habitat resulting from agricultural pursuits. Some changes such as man's management of these resources, increased availability of grain and forage crops and reduction of natural predators have been beneficial. Water resources protection and development can greatly influence the future adequacy of fish and wildlife resources.

Nebraska's fish and wildlife resources can be protected and enhanced if early and full cognizance of their value is included in the planning process for structural developments. Measures are needed to enhance and expand water related habitat, maintain minimum flows at desirable levels, maintain proper water quality, and improve the public's access to these resources.

RECOMMENDATION 11

The fish and wildlife resources of the State should be further protected and enhanced in all water resource developments and associated land use programs with special emphasis on the maintenance of proper water quality and adequate minimum flows in critical stream reaches, and the continued maintenance of proper quality and a real extent of water related habitat.

Recreation Resources

CONCLUSION

Outdoor recreational opportunities are an important segment of the total environment and enable most Nebraskans to more fully enjoy life. Outdoor recreation is also a key to the state's tourist industry and contributes measurably toward the economic growth of the State.

Eastern Nebraska is very deficient in water oriented outdoor recreational opportunities. Other areas of the State will experience deficiencies in the future if additional opportunities are not provided. Greater public access to rivers, streams, lakes, and reservoirs and full consideration of recreation needs in the formulation, design, and management of all future water resource developments are needed to overcome these deficiencies.

RECOMMENDATION 12

Studies should be made to determine means of providing greater public access to rivers, streams and lakes for fishing, hunting and other outdoor recreation pursuits.

RECOMMENDATION 13

The maximum practical recreation potential of all future water and related land recource developments in the State should be realized by insuring that: (1) recreation is fully considered as a project purpose in the formulation, design and management of these resource developments, and (2) public access is provided to all reservoirs and other water related resource developments in which public funds have been invested provided that additional recreational opportunities are needed and compatible with other purposes.

Federal Projects

Numerous and varied federal projects have been included within the Basic Framework. Plans for these proposed projects were developed in response to specific local needs and desires, and they appear to be compatible with Nebraska's long-range development of water and water related resources. Several of these projects have met all engineering, economic, and environmental tests, have broad public support, and could be rapidly implemented if authorized and/or funded by Congress and/or the Executive Branch. Other federal projects included within the Basic Framework appear to be feasible but have been given only preliminary study. For these projects additional studies are required to complete plan formulation, determine feasibility, and to prepare reports suitable for transmittal to the Congress and Executive Branch for consideration of authorization and construction.

Agencies of three federal departments are primarily involved with water resource developments of the type included in the Basic Framework. These are the Soil Conservation Service, the Corps of Engineers, and the Bureau of Reclamation. The following conclusions and recommendations relate to potential projects presently being considered by these three agencies.

CONCLUSION

The Soil Conservation Service has examined a number of potential small watershed projects to determine their eligibility for construction under the Watershed Protection and Flood Prevention Act (P.L. 566). Twenty-two watershed projects are presently under construction but still require additional construction funds. These were considered as "existing" in the Framework Study. An additional sixteen potential projects have met all required tests of engineering and economic feasibility and are included within the Basic Framework. Four of these have recently been approved for installation, but construction has not yet begun. Preliminary investigations indicating favorable economic feasibility have been completed for eight other potential watershed projects. These also have been included in the Basic Framework, but funds are needed for further planning before feasibility can be firmly established.

Numerous applications for watershed planning assistance have been approved by the Commission, and more requests are received each year. At the present rate of funding, however, it will take at least ten years just to complete plans for those watersheds with approved applications.

RECOMMENDATION 14

The appropriate U. S. Congressional Committees or the approving authority should be urged to:

1. *Accelerate construction funds to complete all watershed projects presently under construction and to begin construction on the following recently approved projects:*

   Aowa Creek
   Corporation Gulch
   Medicine Creek (Upper)
   Medicine Creek (Lower)

2. *Approve and provide construction funds for the following feasible watershed projects for which Work Plans have been completed or are nearing completion:*

   Tekamah-Mud
   Winters Creek
   Creighton Valley
   Ash-Plum
   Oak-Middle (Supplement)
   Clear Creek
   Blackwood Creek
   Little Nemaha (Upper)
   South Branch Little Nemaha
   Winnebago-Bean
   Middle Big Nemaha
   South Fork

3. *Remove restrictions on the number of planning starts and provide increased planning funds to the Soil Conservation Service to complete Work Plans for the following potentially feasible projects for which Preliminary Investigations have been completed or are nearing completion:*

   Twin Creek
   Boxelder
   Maple Creek
   Bone Creek
   Wahoo Creek
   Swan-Dry Creek
   Long Branch
   Big Muddy Creek

CONCLUSION

The Bureau of Reclamation and collaborating agencies have investigated a number of potential multipurpose water resource development projects in Nebraska. The degree of investigation varies and the progress of individual projects toward construction is in differing stages. One has been authorized for construction and advanced planning funds are available, but it has not been funded for construction. Five others have met all required tests of engineering and economic feasibility. Detailed reports for two of these are before the Congress and reports for the other three are in various stages of completion. Four more have been investigated to some degree but lack feasibility investigation. All appear to be compatible with Nebraska's long-range planning for development of water and related land resources and have been included in the Basic Framework.

RECOMMENDATION 15

The U. S. Congress should be urged to:

1. *Provide funds to initiate construction of the authorized Mid-State Reclamation Project as soon as all advanced planning requirements of the authorizing legislation are met.*
2. *Provide early authorization and funding for construction of the following feasible projects which have local sponsoring districts.*

   North Loup Division
   O'Neill Unit, Lower Niobrara Division
   Mirage Flats Project (Supplemental Water)
   Little Blue Unit, Blue Division
   Cedar Rapids Division
3. *Provide necessary funds for continuation of the Bureau of Reclamation's Nebraska State Water Plan studies and for feasibility studies on the following potential projects:*

   Logan Unit, Elkhorn Division
   Highland Unit, Elkhorn Division
   Norfolk Unit, Elkhorn Division
   Sunbeam Unit, Blue Division

CONCLUSION

The Corps of Engineers has investigated a number of potential water resource development projects in Nebraska. The degree of investigation varies and the progress of individual projects toward construction is in differing stages. One is under continuing construction with additions being justified on an individual structure basis, and others have been authorized for additional planning and subsequent construction. Still others are being investigated, but have not been proposed for authorization for construction. All of those projects included in the Basic Framework appear to be compatible with Nebraska's long-range planning for development of water and related land resources.

RECOMMENDATION 16

The U. S. Congress should be urged to:

1. *Continue provision of construction funds for additions to the Missouri River Levee System.*
2. *Provide construction funds for the Papillion Creek and Tributaries Project and the Little Nemaha River Levees Project.*

3. *Continue to provide funds for completion of the following studies:*

   Big Blue River, Nebraska
   Lost Dry Creek and Twin Creek Basins
   Niobrara River, Nebraska
   Upper Republican River Basin
   Nemaha and Little Nemaha Rivers
   Loup River
   Elkhorn River Basin
   Salt Creek and Tributaries
   Wood River-Prairie Creek

CONCLUSION

Federal agencies are continually looking to the State for guidance in establishing priorities on proposed projects and programs. Expressions of support from the local level are imperative, but priority setting for projects within the State can be best accomplished at the state level. This avoids pitting one project against another for Congressional favor and allows the State to establish its priorities in the interest of all.

RECOMMENDATION 17

Criteria for setting priorities for planning, authorization, and funding of federal projects within Nebraska should be established. A priority list, based on the established criteria, should be prepared by the state agency responsible for water resources planning and fowarded to appropriate federal agencies and local interests for their use in future program planning. The priority list should be reviewed and updated biennially.

Interbasin Water Transfer Considerations

CONCLUSION

There are some areas where in-basin water resources are not adequate or could not be developed feasibly to irrigate all available high quality lands on a sustained basis. The principal general areas of such water deficiency as shown in Figure 67 are:

Cheyenne-Deuel Counties Area
Perkins-Chase Counties Area
Republican and Blue Rivers Area
Northeastern Nebraska Area

Other feasible sources of water must be found if these lands are to be fully irrigated in the future. Waters considerably in excess of the foreseeable future in-basin requirements for all beneficial uses are available in such areas as parts of the Niobrara and Loup River Basins.

Concepts for transferring water from areas of excess to areas of shortage are included as part of this Framework Study to illustrate the potential nature of such transfers and the issues of policy surrounding their consideration. The conceptual transfer schemes presented do not include all of the physical possibilities available for transfer but do show a wide range of possible action.

Large scale transfers of water over long distances will be major public works of great cost. Lengthy engineering, economic, environmental, and financial studies will be required prior to their implementation. Such studies should be initiated far in advance of the time when such transfers may be necessary.

Policy issues involved in interbasin transfers of water include among others:

...Reservations of water for projected developments in the basin of origin

...Right of water recapture by the basin of origin

...Exchange of water between areas and uses

...Transfer of water to higher preference use, e.g. from power to irrigation

...Condemnation or purchase of existing water rights or the right to interfere with present use

These, and numerous other issues of public policy, will require explicit solution before major transfers could be implemented.

RECOMMENDATION 18

A study of the public policy issues involved in interbasin transfers of water should be undertaken and Special Recommendations of Nebraska's State Water Plan should be prepared on this subject for legislative consideration.

RECOMMENDATION 19

The planning studies of alternative interbasin water transfer schemes should be carried forward so that a sound economic, engineering and environmental basis for decisions will be available when needed.

Flood Problems

CONCLUSION

Average direct flood losses in Nebraska are over $20,000,000 a year. Additional indirect losses attributable to floods probably are equally as large. Nearly 3,000,000 acres, including considerable residential and commercial development in the State, are subject to recurrent floods. The control of floodwaters to reduce flood damages is urgently needed. Implementation of a total program including land treatment, small upstream detention structures, large mainstream reservoirs, channel improvements, flood plain regulation, and efficient warning and emergency action is required to minimize flood damages.

RECOMMENDATION 20

The presently authorized state program for regulation of flood plains should be accelerated and expanded, with greater emphasis on public education.

RECOMMENDATION 21

The Special Recommendation of the State Water Plan titled Flood Warning and Community Action should be implemented to establish a program for the prediction of flood conditions and for warning the occupants of flood prone lands as early as possible prior to the onset of flood flows.

Underground Water Resources

CONCLUSION

Some important aspects of the development of ground water resources are not included in the Framework Study because of insufficient data.

Determination of the nature of the relationship between ground water withdrawals and streamflows will require detailed investigations.

A more complete knowledge of the water in storage and natural recharge rates in areas of declining water levels will be necessary in the future as a basis for development and management and to determine the time in the future when supplemental waters will be required, and the amounts necessary, if irrigation and other water uses in these areas is to be sustained.

The potential use of underground aquifers as reservoirs to store excess surface water flows for later use has received little statewide study. The potential use of such underground storage warrants early study.

RECOMMENDATION 22

Investigations of the geology, hydrology and hydraulics of Nebraska's underground resources, i.e. its aquifers and ground water; the relationship between ground and surface waters; and conjunctive use of ground and surface waters should be expanded and accelerated.

Basic Data

CONCLUSION

Some particular types of data, which would be useful now and will be needed increasingly in the future, are not collected in sufficient amount or detail or are not collected at all. It is particularly important to fill the voids in existing data collection programs. Coordination will be required to determine priorities and to assure that maximum efficiency and value is derived from funds invested in the collection, analysis and interpretation of these new data and the data provided by ongoing programs.

RECOMMENDATION 23

Development of the already authorized Soil and Water Resources Data Bank should be accelerated in order that it be made operational as soon as possible.

RECOMMENDATION 24

Programs for the collection of basic data should be expanded, particularly with respect to:

A. Climate

B. Streamflow at critical points

C. Surface water diversions

D. Ground water extractions

E. Return flows from municipal, industrial and agricultural sources, both in terms of quantity and quality, to surface and ground waters

F. Water quality concerning both organic and inorganic constituents and pollutants, for both surface and ground waters

G. Sediment production, transport, and deposition

H. Topographic mapping

I. Potential dam and reservoir sites

J. Soils and land classification

K. Land use

L. Economics

M. Environmental and social aspects

N. Water requirements

O. Recreation use and demands

Research Needs

CONCLUSION

Research on the control, protection, development, and utilization of water and water related resources conducted in the past and now underway is insufficient in view of the inestimable value of these resources to the State. Complex problems now exist and more are foreseen which involve economic, social, engineering, environmental, hydrologic and financial aspects of development.

Expanded research programs are needed to study these difficult problems to assure that future policy and timely planning decisions, some of statewide importance, are based on the best possible information. Appropriate communication and mutual development of schedules, priorities, and coordination will be required to assure that the research acquired knowledge is available when most needed.

RECOMMENDATION 25

Research, including provisions for careful programming and priority setting, of the economic, financial, hydrologic, hydraulic, engineering, agricultural, water quality, environmental, fish and wildlife, recreational and other complex problems associated with the future development and utilization of Nebraska's water and water related resources, should be promoted and coordinated through regular communication and pooled judgements of the units involved.

Erosion Control

CONCLUSION

The soils of the State are generally erodible and, when unprotected, are damaged by wind and water erosion. About 23,000,000 acres of land presently require treatment to maintain productivity and reduce sediment problems. The protection of Nebraska's land resource is fundamental to the continued growth of the agricultural and total economy.

RECOMMENDATION 26

Programs of soil and water conservation should be accelerated with emphasis on wind and water erosion control, agricultural pollution abatement, and water utilization and management.

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