
**DRAINAGE BASIN
PROBLEMS AND PROGRAMS**

**NATIONAL
RESOURCES COMMITTEE**

DECEMBER 1936

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LETTER OF TRANSMITTAL

NATIONAL RESOURCES COMMITTEE
INTERIOR BUILDING
WASHINGTON

December 9, 1936.

The PRESIDENT,
The White House.

MY DEAR MR. PRESIDENT:

The National Resources Committee transmits herewith the report of its Water Resources Committee on Drainage Basin Studies in the United States.

The investigation on which the report is based was undertaken, at your request with a view—

1. To determining the principal water problems in the various drainage areas of the country,
2. To outlining an integrated pattern of water development and control designed to solve those problems, and
3. To presenting specific construction projects and investigation projects as elements of the integrated pattern or plan, with priorities of importance and time.

The project lists embodied in the report provide a reservoir of meritorious undertakings intended to cover a period of 10 or more years, but the program is readily adjustable to the requirements of any policy that may be adopted with respect to either the rate or the mode of public expenditure, whether Federal or non-Federal, on water resources. The project lists do not constitute a fixed or final program. Year by year adjustments in the program will be needed in the light of new knowledge, shifting needs, and perhaps of altered policies.

It is a highly significant fact that this report represents the first coordinated attempt to formulate a nation-wide water plan and program through the joint efforts of Federal, State, and local agencies, official and nonofficial. The National Resources Committee approves of the essential approaches to the complicated and fundamental problems of water resources in their relationships to land use and other resources as set forth in the report, and emphasizes anew the necessity of appropriate provision for continued cooperative investigation for many of those problems in their interlocking relationships one to another. Water and land are the principal material foundations of our civilization. The Nation depends in no small measure upon the effectiveness with which they are conserved and used for the greater good of the greater number.

Sincerely yours,

HAROLD L. ICKES
Secretary of the Interior, Chairman

HARRY H. WOODRING,
Secretary of War.
HENRY A. WALLACE,
Secretary of Agriculture.
DANIEL C. ROPER,
Secretary of Commerce.
FRANCES PERKINS,
Secretary of Labor.

HARRY L. HOPKINS,
Works Progress Administrator.
FREDERIC A. DELANO.
CHARLES E. MERRIAM.
HENRY S. DENNISON.
BEARDSLEY RUMML.

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FREDERICK H. FOWLER,
Director, Drainage Basin Study

NATIONAL RESOURCES COMMITTEE

November 9, 1936.

INTERIOR BUILDING
WASHINGTON

Mr. FREDERIC A. DELANO,
Vice Chairman, National Resources Committee,
Interior Building, Washington, D. C.

MY DEAR MR. DELANO:

The Water Resources Committee submits herewith a report on Drainage Basin Studies in the United States. These studies were undertaken early in 1936 at the request of the National Resources Committee, with the following objectives:

- (1) To determine the principal water problems in the various drainage areas of the country,
- (2) To outline an integrated pattern of water development and control designed to solve those problems, and
- (3) To present specific construction projects and investigation projects as elements of the integrated pattern or plan, with priorities of importance and time.

The findings of the investigation are reasonably clear on the first and second items of the assignment. The third item presented special difficulties, particularly since it necessitated review and appraisal by the Committee of thousands of projects, aggregating billions of dollars in estimated cost and relating to water-resources development during a period of some 10 years. It was impossible in the time available for all members of the Committee to pass on all the projects. Individual responsibility of members of the Committee for final classification is therefore not to be assumed.

Action on certain highly controversial projects was deferred either because there was not time for an adequate review of the complex and, in some instances, voluminous material involved, or because data essential to sound action were lacking. In the latter case, further investigation was recommended. Completion of certain projects already constructed in large part was recommended even though their original merit appeared to be gravely in doubt; abandonment of them now with little or no salvage seemed wholly impracticable. Investigations under way and construction projects contingent upon a favorable outcome of investigations in progress or now recommended are not listed in most instances.

The study has been carried out through cooperative efforts of the Washington and field staffs of agencies represented directly on the Water Resources Committee,

and of the Bureau of Agricultural Engineering, Bureau of Indian Affairs, Forest Service, Grazing Division, International Boundary Commission, Resettlement Administration, and other Federal agencies concerned with problems of water use and control.

The preparation of the document herewith submitted would have been impossible without the support of State planning boards and other State agencies. The conscientious and tireless efforts of the regional water consultants likewise made the document possible. They have contributed in time and energy to an amazing degree to whatever success this preliminary study may attain. Their names follow: H. K. Barrows, Wesley W. Horner, Walter L. Huber, Nathan B. Jacobs, Gerard H. Matthes, Ralph I. Meeker, Samuel B. Morris, William McKinney Piatt, LeRoy K. Sherman, J. C. Stevens, Royce J. Tipton, Blake VanLeer, N. W. Bowden, and Fred H. Weed.

To the director of the drainage basin study, Frederick H. Fowler, and his headquarters staff, the Committee expresses its wholehearted appreciation for their continued patience and strenuous activities in the completion of this arduous task.

Respectfully submitted.

ABEL WOLMAN

*Chairman, Water Resources Committee
Chief Engineer, Maryland State Department of Health*

HARLAN H. BARROWS
*Professor of Geography
The University of Chicago*

H. H. BENNETT
Chief, Soil Conservation Service

EDWARD HYATT
State Engineer of California

Maj. Gen. EDWARD M. MARKHAM
*Chief of Engineers
U. S. Corps of Engineers*

JOHN C. PAGE
*Acting Commissioner
Bureau of Reclamation*

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*Chief Hydraulic Engineer
U. S. Geological Survey*

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*Senior Sanitary Engineer
U. S. Public Health Service*

THOMAS R. TATE
*Chief, Division of Power Resources and
Requirements
Federal Power Commission*

SHERMAN M. WOODWARD
*Chief Water Control Planning Engineer
Tennessee Valley Authority*

DRAINAGE BASIN PROBLEMS AND PROGRAMS

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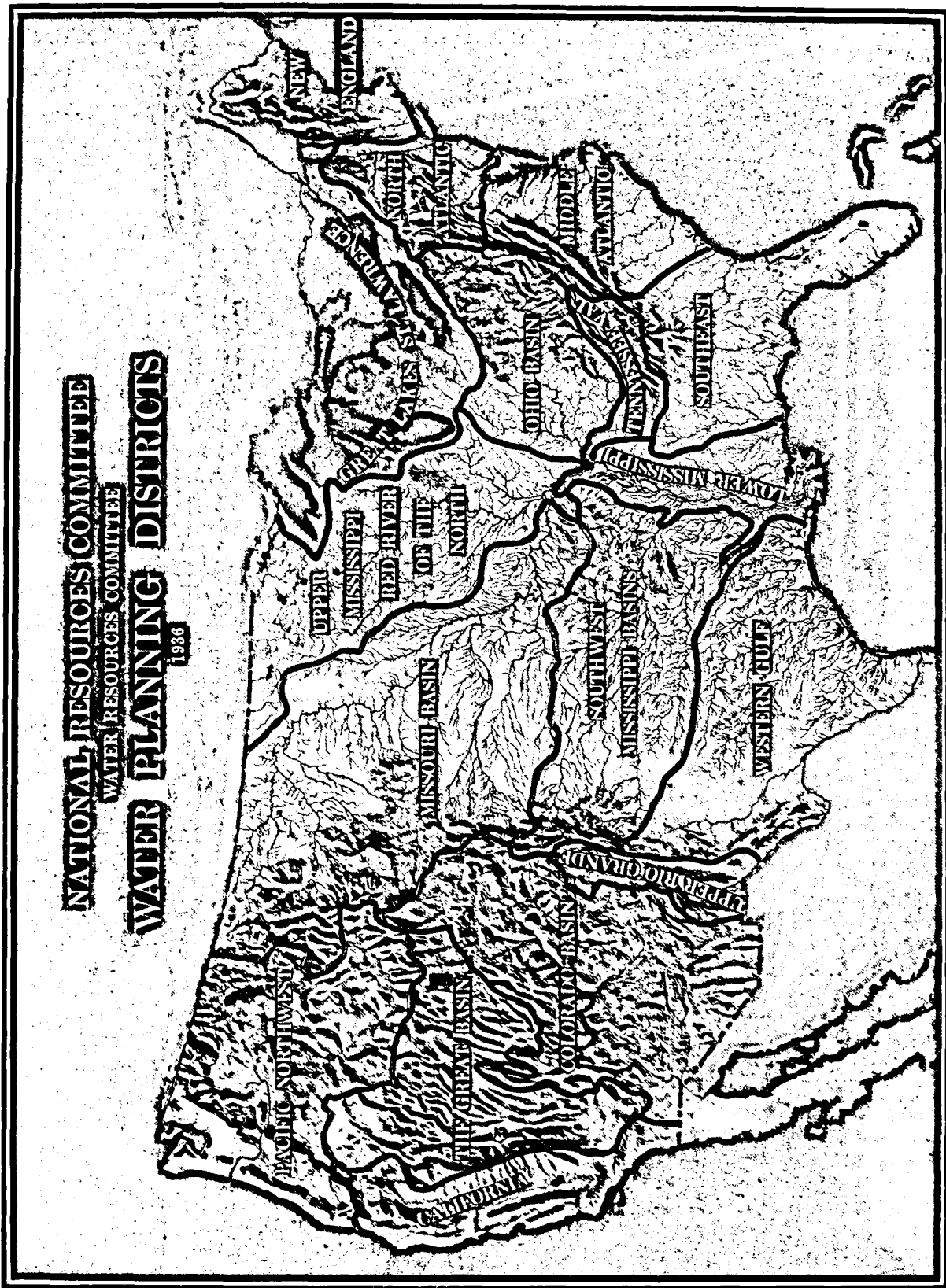
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NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
WATER PLANNING DISTRICTS
1936



PROCEDURE, POLICY, AND RECOMMENDATIONS

The Assignment

The Water Resources Committee of the National Resources Committee was instructed last winter to undertake a national drainage-basin study and to report the results for transmittal to the President on December 1, 1936. The investigation had three major objectives:

- (1) To determine the principal water problems in the various drainage areas of the country,
- (2) To outline in broad terms an integrated pattern of water development and control designed to solve those problems, and
- (3) To present specific construction projects and investigation projects as elements of the integrated pattern or plan, with general priorities of importance and time. Some of the projects are Federal, others State, and still others local in character.

The Procedure

To accomplish the task indicated, the Water Resources Committee set up a special organization involving as key members a director and 14 regional water consultants, each of whom had immediate responsibility for the conduct of the investigation, as planned by the Water Resources Committee, in one or more drainage basins. On the one hand, the organization worked as closely as practicable with all Federal agencies that deal in one way or another with water resources and water problems, availing itself fully of relevant data, published and unpublished, obtainable from them. On the other hand, it cooperated closely with State planning boards, with other State agencies and officials, and with local organizations, utilizing so far as possible the information they provided and profiting greatly from their active assistance.

For several reasons the investigation was decentralized to as great a degree as practicable, and, as already noted, State and local agencies were given full opportunity to participate. (1) It was evident that such a procedure would tend in greater degree than any other not only to insure a truly national water plan but also to serve both private and public interests. (2) It was obvious that the Federal Government could not impose any integrated water plan on the States, even were it disposed to do so, since the control of inland waters rests in large part with the several States. (3) Every State has responsibilities, no less than rights, in its waters, and these responsibilities cannot properly be shifted to the Federal Government. (4) No general water plan, however admirable in theory, could be put

into action successfully that did not represent close cooperation between the Federal Government and appropriate State agencies. The investigation recognized, it may be added, that such cooperation is needed on both sides. An individual State might solve various problems presented by streams lying wholly within its own territory without Federal aid in planning or execution, but neither an individual State nor a group of States could satisfactorily solve without Federal participation the problems of an interstate river or river system. Throughout the country, many of the major problems of surface waters are interstate, not intrastate, in character.

The regional water consultants, all of whom are engineers of high competence and long experience, have embodied their own findings and recommendations in the 127 basin reports submitted by them, and the Water Resources Committee, in turn, is responsible for the basin reports published in an accompanying volume. The full reports and all relevant data in hand are in the files of the National Resources Committee.

This drainage-basin study supplements and extends the work of the President's Committee on Water Flow (1934), the Mississippi Valley Committee of the Public Works Administration (1933-34), and the Water Planning Committee of the National Resources Board (1934-35).

Need for a Water Plan

With respect to water, people have been concerned, for the most part, only with their own immediate interests in particular types of problems. In planning the storage of water for irrigation in the arid West, the possibilities of concomitant power development have not always been emphasized. In planning the drainage of lands for agricultural use in the humid East, the possibility of injury to other interests affected by the behavior of water commonly has been ignored. Far too often in all sections of the country the control of a stream subject to destructive floods, the improvement of a river channel for navigation, the procurement of water from a stream for municipal and domestic use, the disposal of sewage and industrial waste in a drainage channel, or other concern in the use or control of water, has been treated as an isolated problem, in disregard both of the inherent relationships between various types of water problems and of the possibilities of multiple-purpose development. Too often, also, specific water problems have been treated solely in terms of

particular localities, urban or rural, with resultant injury to other localities on the same river system. Water development in general has been haphazard.

During the last few years it has become increasingly apparent that such orderless, unintegrated treatment of water problems, however natural and excusable it may have been under pioneer conditions, should no longer be tolerated. Water, though at times a merciless enemy of man, is perhaps the most precious natural resource of the Nation. The supply of water for essential purposes, available and potential, on the surface and underground, is strictly limited, though it varies from time to time at a given place as well as from place to place at a given time. The further development of large areas in all sections depends even now in considerable part on the extent to which the supply of available water can be increased by storing surface water, by pumping ground water, or by other means. Soon or later, wasteful use of water must cease. Soon or later, the maximum supply of water that can be made regularly available in each drainage area must be put to its best coordinated use.

Under these circumstances it would be unwise to depend solely on the long-run tendency of economic conditions to bring about the use of water in the places and ways in which it would have greatest value. The process would be far too slow and far too costly. Moreover, the sum total of individual and local interests in the waters of a drainage area may differ greatly from the best interest of the public at large in their use. Still further, continued uncoordinated development of waters might presently preclude in many basins their later control and utilization in an orderly, balanced manner conducive in greatest measure to the general welfare. The inherent conflict of interests in water, between private users, between private and public organizations, and even between public agencies, increases year by year. From every point of view, a practicable water development program that can be put into action promptly is needed in each river basin of the country. A plan without action is useless; continued unplanned action would be foolhardy.

Limitations of a Water Plan

No fixed or final water plan is possible. Future water requirements in most areas can be estimated only approximately and for comparatively short periods. They will be affected by changes in density of population, in land use, in industry, and in social conditions. From time to time emphasis doubtless will be placed upon different uses and problems of water. The nature and extent of future changes of these kinds will be influenced in turn by the supply of water. The supply now available may be insufficient even for present needs.

The extent to which it can be increased may be unknown for lack of basic data on precipitation, infiltration, stream flow, and the like. Such data are lacking to greater or less degree on both the surface and underground waters of almost every drainage area. The general removal of these deficiencies in hydrologic data will require many years even if adequate action to that end is initiated promptly, since long-term records are indispensable for many major purposes. The total supply of water that can be made available in a given drainage area may change through the operation of natural processes or through modification of surface conditions by human action. For these reasons, any water plan, no matter how frequently revised, must remain forever incomplete. Continuous planning is necessary.

The general water plan presented in this summary of the results of the current investigation and the plans for individual basins set forth in the accompanying volume involve many construction projects, and also many investigation projects, some Federal, others non-Federal, in character. The investigation projects relate in some cases to the extension or completion of investigations instituted earlier and in other cases call for necessary surveys or studies not as yet undertaken. Nevertheless, a framework of a national water plan is proposed that will permit early constructive action on sound lines along a broad front; a plan, moreover, that can be adjusted, filled in, and extended to meet changing conditions. A beginning has been made; the end can never be reached.

It is not assumed for a moment that the findings of the investigation or the recommendations based on them will all meet with general approval. The brevity and incompleteness of the study, the predilections of investigators, the paucity or complete lack of data on many pertinent subjects, the complexity of the varied problems involved, the attitudes dictated by local ambitions, the rivalries of different communities and regions, and the number and intensity of the conflicts in water claims alike preclude such a possibility. The limitations of the plan are inexorable.

Plan and Policy

Federal participation in an integrated plan to promote the efficient and equitable use and effective control of the water resources of the country for the greater good of the greater number of people will necessitate the adoption of a comprehensive Federal policy with respect to the various types of water problems in their interlocking relationships. There has long been a Federal policy concerning inland navigation, involving the improvement and maintenance of river channels at national expense for the free use of shippers; concerning the reclamation of west-

ern lands, involving the construction by the Government of irrigation works to be paid for ultimately by the water users; and concerning water powers on navigable streams and streams within the public domain, involving development by licensees. Recently, too, a Federal policy concerning flood control throughout the country was established by Congressional action. Without discussion of the merits or demerits of existing policy, it may be affirmed with confidence that a *coordinated* Federal water policy is now needed, not a collection of *unrelated* policies applicable respectively to individual types of water problems. Without such a new policy, the Federal Government cannot contribute effectively or equitably to the integrated development and control of water resources.

A sound water policy will have, it is believed, the following characteristics:

1. It will be concerned, in the final analysis, not with water *per se*, but with the promotion of public safety, public health, the public convenience and comfort, the economic welfare of the public, the establishment or maintenance of a high standard of living.

2. It will seek to promote the maximum integrated use and control of water, within the shifting limits imposed by considerations of technical feasibility and of economic and social justification.

3. It normally will treat drainage areas as units with respect to their waters in recognition of the train of connected problems that runs from river source to river mouth, from countless rivulets along the highland rim of the largest basin to the distant point where its master river enters the sea.

4. Though treating drainage areas as units, it will scrupulously observe the rights of the several States both in intrastate and interstate streams, seeking through cooperation to promote the full use of water in the best ways and in the proper places.

5. It will recognize and abide by the axioms that facts are indispensable prerequisites to sound action with respect to water, and that conclusions and commitments not based on predetermined facts almost certainly prove indefensible. In keeping with this recognition, it will promote by all feasible means continuous assembly of the basic data essential for an evolving, unending water plan. At the risk of repetition, the statement may be made categorically that the adoption of a plan and program for the use and control of the waters of any river basin without a definitive study of adequate data bearing on all phases of the interlocking physical and cultural problems involved would be illogical, would result in economic waste, would invite controversy, and might preclude desirable action later. As already noted, controversies over water multiply. They are most likely to arise where pertinent facts are

least known. An enlightened water policy will seek to obviate controversy by substituting facts for opinion.

6. It will assign the cost of constructing and operating projects undertaken from time to time as suitable elements in an evolving water plan among the agencies concerned in as close accordance as possible with the distribution of benefits. The proposition that those who will profit from a given undertaking normally should pay, in a manner not involving avoidable or undue hardship, in proportion to the advantage they will reap should be the basic principle of action.

7. In determining whether or not water projects are justifiable, and in distributing the costs of meritorious projects among the beneficiaries, it will take properly into account social benefits as well as economic benefits, general benefits as well as special benefits, potential benefits as well as existing benefits, wherever they are involved. Some of these benefits are not capable of measurement, and accordingly they commonly have been ignored in the past in evaluating certain types of enterprises. They are subject to reasonable appraisal, however, and their intangible nature will not justify their neglect in the future. In great measure, they concern the public at large. A public water policy should assiduously conserve and promote public interests. To this end, social accounting must take its place with economic accounting. As effective water planning proceeds year after year without interruption—planning based on fundamental and exhaustive engineering, economic, and social studies that cover all relevant conditions—there inevitably will result not only a clearer understanding of what constitutes the public interest, but also a greater opportunity to promote it through equitable control and orderly development of water resources.

Program and Plan

Since all the projects in a comprehensive water plan cannot be undertaken simultaneously, a program involving priorities is necessary. Many considerations may influence the judicious establishment of priorities among the projects of any given area. They are likely to relate to such matters as the quantity and reliability of the pertinent basic data in hand; the relationships of benefits and costs; the nature, relative desirability, number, and scope of the benefits respectively involved; relative urgency; the situation with respect to relevant nontechnical factors; relationships to the later stages of an evolving water plan; and the present status of the various projects under review. Since these factors present themselves in numerous combinations; since some projects are single-purpose enterprises, others dual-purpose, and still others multiple-purpose; and since the relative weight of a factor of a given type may vary much from one part of a large drainage area

to another, the problem of priorities in importance and time is complicated and difficult.

In general, preference has been given in the present study to investigation projects designed to afford information indispensable for proper action later; to construction projects for which adequate and reliable data are available; to projects involving benefits that exceed costs in relatively high degree; to multiple-purpose projects having relatively high social values for comparatively large numbers of people; to projects of immediate, rather than prospective, urgency; to projects not likely to be delayed by legal and other non-technical complications; to projects which it is believed would fit properly into a comprehensive water plan when it shall have reached a later and more detailed stage; and to projects already authorized by the Congress or now under way.

The application of the foregoing criteria, one by one, to a group of projects in a given area may result in findings not in harmony one with another. Projects of dissimilar character may not be comparable on any satisfactory basis. In the final analysis much depends on the judgment of the investigators responsible for the grouping adopted.

It was found impracticable and undesirable to assign absolute priorities to projects for the country as a whole, for regional groups of drainage basins, or even for individual basins. It was feasible, however, for individual basins and for groups of basins, to classify projects in three broad groups, a procedure deemed adequate for all practical purposes. The groups adopted were as follows:

Group A (immediate).—Projects which are ready for construction or study and which should be undertaken as soon as possible.

Group B (deferred).—Projects which, while desirable for immediate construction or study, (a) involve unsolved questions of public policy or (b) can have their priority definitely determined only after additional studies which cannot be completed in time for this report or (c) are now obstructed by legal, administrative or other difficulties. Group B also includes projects which should follow Group A in sequence of construction or of study.

Group C (indeterminate).—Projects which, although included in the plan of development for the basin, should follow Group B in sequence of construction or whose specific priority in the program is as yet indeterminate.

In this summary of the drainage basin study the projects of Group A and Group B are presented in a series of tables, one for each of the districts into which the country was divided for convenience. The districts adopted are the following:

New England.
North Atlantic.
Middle Atlantic.
Southeast.
Tennessee Valley.
Ohio Basin.
Lower Mississippi.
Western Gulf.
Southwest Mississippi Basins.
Upper Mississippi—Red River of the North.
Great Lakes—St. Lawrence.
Missouri Basin.
Colorado Basin.
The Great Basin.
California.
Upper Rio Grande.
Pacific Northwest.

The locations of the projects are shown on a corresponding series of district maps. The projects of Group C may be found in the basin reports of the accompanying volume.

The projects listed under these groups deal with problems of water use and control for:

Bank and coastal erosion control.
Domestic and industrial water supply.
Drainage.
Flood control.
Generation of electric power.
Irrigation.
Navigation.
Recreation.
Soil conservation and forest development.
Waste disposal and pollution abatement.
Wildlife conservation.

Basic Needs and Problems

Many of the basin reports emphasize the urgent need, already noted in this summary, for basic hydrologic data now lacking, and some of them also stress the pressing need for completion at an early date of the mapping of the United States.

A recent report on *Deficiencies in Basic Hydrologic Data* (United States Government Printing Office, 1936), prepared by our Special Advisory Committee on Standards and Specifications for Hydrologic Data, presents recommendations for increasing and making available information on rainfall, snowfall, stream flow, underground waters, losses of water by evaporation, the quality of surface and underground waters, and the like. The importance of the matters with which the report deals cannot be exaggerated. Unless existing facilities for gathering hydrologic data are increased along the lines recommended by the Special Advisory Committee and, in general, to the extent proposed by it, progress in dealing with water resources will be retarded more and more as years pass. The costs of ignorance, already heavy, will mount rapidly. Accordingly, expenditures, adequate but moderate, are recommended to implement a remedial program.

Topographic maps are indispensable tools not only for dealing with most water problems, but also for other purposes in countless number. Adequate topographic maps are now available for little more than one-fourth of the area of continental United States, exclusive of Alaska. Almost another fourth was mapped more than 40 years ago by methods and on scales wholly inadequate for most present needs. Approximately half the entire area remains to this day entirely unmapped topographically. Suitable allotments of Federal funds for mapping are recommended in accordance with the current program of the Board of Surveys and Maps.¹

Broadly speaking, problems relating to the use and control of water merge imperceptibly into problems concerning the use and protection of land. Water planning and land planning cannot properly be separated. This fact is reflected in various basin reports in connection especially with *soil erosion and forestry*. In most cases these reports treat very briefly and only in a general way of one or both of these collateral subjects. This treatment does not mean, however, that the great importance of both subjects is not recognized. Soil erosion is a serious menace to public welfare. Deforestation and overgrazing have contributed mightily. Soil washed from the fields and pastures upon which the Nation chiefly depends for its food tends to fill reservoirs, clog stream channels, and shoal harbors. Agriculture, industry, and commerce all are injured. Prevention of excessive erosion is imperative. Its prevention would directly or indirectly affect many problems of water as well as many aspects of land occupation and land use. Unfortunately, precise knowledge is lacking concerning many of the quantitative relationships involved. Unbiased, scientific research is particularly needed to determine in representative areas of considerable size the relationships of vegetal cover and cultural practices to yields of water. The research should be undertaken cooperatively by the various agencies concerned with the problem, thus insuring diversity of viewpoint in both the collection and the interpretation of data.

Finally, the various basin reports clearly indicate a basic need for investigations of the engineering and economic aspects of the production, transmission, and marketing of power in inter-basin areas in different parts of the country, with a view to setting up feasible programs for the integration of existing facilities and for the construction and operation of new water-power

facilities coordinate with navigation, flood control, and other relevant uses and problems of water.

As time passes and needs and views change, various subjects not immediately related to the use or control of water and not considered here may win places of more or less prominence in an evolving water plan.

Recommended National Data-Collection and Investigation Projects

A. Collection of Basic Hydrologic Data

	Cost					
	First year			Succeeding years		
	Federal	Non-Federal	Total	Federal	Non-Federal	Total
1. Precipitation.....	\$396,000	-----	\$396,000	\$223,000	-----	\$223,000
2. Snow surveys.....	169,000	\$39,000	208,000	58,000	\$12,000	70,000
3. Stream flow.....	1,450,000	450,000	1,900,000	370,000	120,000	490,000
4. Ground-water levels.....	406,250	131,250	537,500	312,500	112,500	425,000
5. Evaporation.....	35,000	-----	35,000	16,000	-----	16,000
6. Water quality.....	450,000	150,000	600,000	450,000	150,000	600,000
Total.....	2,906,250	770,250	3,676,500	1,429,500	394,500	1,824,000

B. Topographic Mapping

A revised program for topographic mapping for the United States is now in preparation in compliance with Senate Resolution 281 of the Seventy-fourth Congress. The program recommended by the Board of Surveys and Maps on October 29, 1934, was of the order of \$117,500,000 for a 10-year period. New cost estimates are not yet available.

C. Vegetal Cover and Soil Erosion Control

Quantitative studies of effect of vegetal cover and soil erosion upon hydrologic phenomena, with particular reference to silting of reservoirs and stream flow. Annual cost for 5-year period, \$250,000.

D. Power Market Surveys

1. Southeastern States.....	\$150,000
2. Middle Atlantic States.....	75,000
3. Upper Ohio Basin.....	250,000
4. Pacific Northwest.....	100,000
5. Pacific Southwest, including northern and central California.....	50,000
Total cost.....	625,000

E. Coastal Erosion Studies

Investigation of coastal erosion and the effects of beach protection works in selected localities. The relationships among beach profiles, offshore bars, sand movements, physical properties of beach material, waves, tides, and weather should be investigated in the field and in laboratories. Total cost, \$250,000.

F. Extension of Specific Drainage Basin Studies

Detailed investigations of basins, where critical water problems are pressing, to extend information beyond that now available and to provide bases for interstate action on permanent programs for use and control of water. Total cost, \$2,500,000.

¹ For list of organizations endorsing such a program, cf. Report of the National Resources Board, Dec. 1, 1934, p. 451.

Recommendations

The Water Resources Committee submits in the following tables and maps desirable projects for further investigation and projects which are ready for construction. It includes a list of projects which are now under way and which should be completed. The estimated cost of the projects in Group A-1 is approximately \$20,000,000, in Group A-2, \$1,727,000,000 and in Group B, \$1,024,000,000. With respect to certain large projects, only part of the requisite expenditure is shown in the cost column of the project lists involved. The additional sums needed to complete the projects are shown in the "remarks column." The aggregate sum needed to complete A-2 projects is \$600,000,000 and to complete B projects is \$400,000,000.

The lists provide a reservoir of meritorious undertakings in the field of water resources that should fit

National Resources Committee

during a period of years, perhaps a decade, into an integrated pattern of drainage basin development. The plan and program are readily adjustable, however, to the requirements of any policy that may be adopted with respect either to the rate or the mode of public expenditures on water resources. Both plan and program should be subject to continuous modification in the light of accumulating knowledge and shifting requirements.

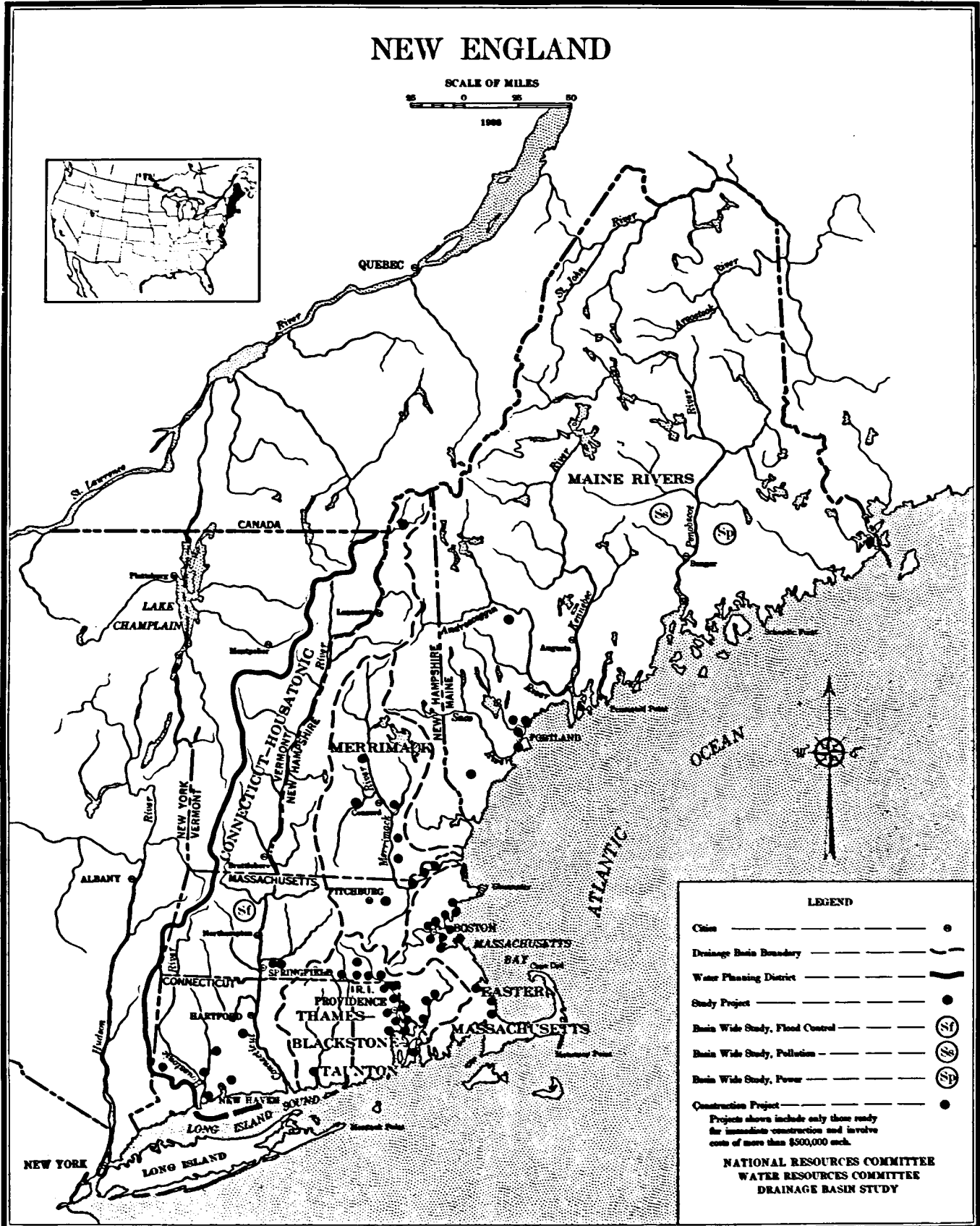
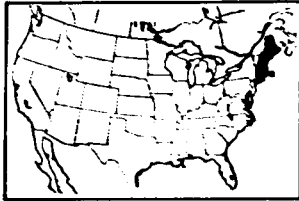
Neither the plan nor the program rests upon any assumptions as to how the proposed developments should be financed or administered. It is obvious, however, that the effective fulfillment of such a comprehensive water plan is contingent upon the effective solution from time to time of the pressing problems of financial and administrative policy.

PROBLEMS AND PROGRAMS OF DRAINAGE DISTRICTS

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NEW ENGLAND

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- Basin Wide Study, Pollution ———— (P)
- Basin Wide Study, Power ———— (E)
- Construction Project ———— ●

Projects shown include only those ready for immediate construction and involve costs of more than \$500,000 each.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

NEW ENGLAND

The water problems of New England are most acute in its great manufacturing belt of dense urban population between southern Maine and western Connecticut. Chief among them are flood control and pollution abatement.

The unprecedented floods of 1936 caused damages estimated at \$15,000,000 in the Merrimack Valley and \$50,000,000 in the Connecticut Valley. They inflicted damages in various other valleys, which, though not so high, established local records. These disasters focused public attention upon the urgent need for adequate protection against major floods and made the immediate determination of the best solution of the problem a matter of prime importance.

Flood control in New England must be approached not as an isolated problem, but as one of several benefits, including power development, improved sanitation, enhancement of recreational opportunities, and betterment of streams for navigation, that may result in combination from the construction of storage reservoirs to collect flood waters and release them later in relatively dry periods. The necessity for approaching the problem in this manner arises from the fact that reliable studies of the frequency of floods and of resultant damages indicate the latter may not alone justify the cost of the reservoirs needed to eliminate such damages. This is true despite the availability of many favorable sites for new reservoirs and the possibility of utilizing for storage numerous lakes and ponds, by controlling their outlets. Storage reservoirs accordingly must be built both for power and for flood protection consistent with provisions for adequate financing and reimbursement for project costs, where material power development does ensue. Experience in New England has confirmed the value of power-storage reservoirs in this respect. It is assumed that such reservoirs would be intelligently and adequately operated under the direction of a suitable agency.

A system of reservoirs in the Connecticut basin with about 1,120,000 acre-feet of storage controlling the run-off from about 53 percent of the drainage area would provide reasonable flood protection in the valley. Such a system can be built for approximately \$40,000,000. Of this amount, only part is justified for flood control and the remainder must be carried by reservoir power values and the other benefits of regulated flow.

Adequate control and regulation of the Merrimack River can be obtained with a reservoir system costing from 11 to 18 million dollars, of which only part may properly be allocated to flood control and the remainder

chiefly to power with some sanitary and recreational benefits.

The solution of this problem on interstate streams, such as the Connecticut and Merrimack, will require effective coordination and cooperation of Federal, State, and local agencies. Connecticut, Rhode Island, Massachusetts, New Hampshire, and Vermont, recognizing the necessity for cooperative action in these matters, have appointed interstate compact commissions which are empowered to draw up compacts dealing with the development of streams common to two or more of the States. At present, these commissions are jointly engaged with the New England Planning Commission in formulating compacts dealing with the Connecticut River and with the Blackstone River.

Pollution abatement, as already noted, is also a problem of major importance. Many rivers in this district are used as conduits for the disposal of sewage and industrial wastes by the communities along their courses. In many instances, pollution has impaired the usefulness of the rivers for industrial water supply and for recreational purposes and also has virtually destroyed fish life.

In the river valleys now devoted chiefly to industry restoration of the surface waters to a state of natural purity would involve expenditures far in excess of the benefits which could be realized. For the immediate future, at least, the program of stream sanitation should be limited to the elimination of nuisances, to the removal from sewage and wastes of the more objectionable deposits and scum-forming ingredients, and to the maintenance of a standard of quality at which the waters may be used satisfactorily for process purposes by the industries after treatment by conventional purification methods.

The upper tributaries of many New England rivers are used for domestic water supplies and for recreational purposes. Pollution along these headwaters is, in general, under reasonable control and further contamination should be prohibited. The cities along most of these upper streams are of moderate size and as a rule do not themselves contribute sufficient sewage to overtax seriously the diluting capacity of the streams. There are a number of borderline cases, however, where pollution is close to the limits generally accepted for avoidance of objectionable sanitary conditions.

Along the coastal waters, measures should be taken to protect the shellfish and recreational areas from the damaging and unhealthful effects of sewage contamination.

There has been a pronounced movement of population from the larger cities into suburban communities, with the result that the extension of sewers has frequently not kept pace with other developments. In consequence, there are many towns where sewer extensions are needed to prevent further contamination of water resources.

On the whole, public water supplies in New England are of good quality and adequate for present purposes. The water is taken, for the most part, from natural and artificial reservoirs, but, in a few instances, rivers and wells serve as sources of supply. The water-supply

problem pertains almost wholly to extension of existing works for domestic use or for fire protection. Some towns which have relied upon private wells have grown to such a size that provision of new supplies is probably justified to protect health and property.

Dredging of certain ship channels and anchorages and construction of breakwaters, jetties, and seawalls to protect sandy beaches from erosion constitute additional problems. The recreational facilities afforded by the water areas, though already great, doubtless will merit further improvement as the vast recreational industry of New England continues to grow.

New England Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Maine Rivers:		
<i>Pollution:</i>		
Androscoggin River, Maine and N. H.: Engineering investigation of stream pollution covering both industrial and domestic wastes.....	\$25,000	Survey to develop comprehensive plan and costs for abatement of pollution.
Maine: Study of all other rivers in Maine as well as coastal waters for pollution control.....	40,000	
Old Orchard, Maine: Study for sewage treatment plant.....	5,000	
Portland, Maine: Study of sanitary conditions in Portland Back Bay district.....	5,000	
<i>Water power:</i>		
Maine: Study of power and storage projects on the Androscoggin, Kennebec, Machias, Penobscot, Saco, St. Croix, St. John, and Union Rivers.....	200,000	Contingent upon international cooperation.
Fassamaquoddy-Eastport, Maine: Investigation and negotiation of international, construction costs and market aspects of proposed tidal-power development.....	100,000	
Merrimack:		
<i>Pollution:</i>		
Merrimack River: Pollution study from Massachusetts line to mouth.....	25,000	To precede construction project.
Nashua River: Continuation of investigation of problem of sewage disposal of towns and industries on the Nashua River.....	15,000	
Eastern Massachusetts:		
<i>Pollution:</i>		
Boston, Mass.: To determine a plan and program for relief trunk sewers and appurtenant works.....	75,000	Do.
Thames-Blackstone-Taunton:		
<i>Navigation:</i>		
Little Narragansett Bay, Newport Harbor, Pawtuxet yacht basin, Providence Harbor, Sakonnet Point Harbor, and Seekonk River, R. I.: Investigations of costs of dredging harbors.....	25,000	Dredging is necessary, but no investigations yet made.
Study of canalization project between Hampton Harbor, N. H., and Gloucester Harbor, Mass.....	25,000	
<i>Pollution:</i>		
Blackstone River Valley: Study of sanitation and pollution.....	25,000	Dredging is necessary, but no investigations yet made.
Central Falls, Cumberland, East Providence, and Pawtucket, R. I.: Study to determine relative merits of individual and district sewage treatment plants.....	10,000	
Coventry, Johnston, Warwick, and West Warwick, R. I.: Study for sewer systems and sewage-treatment plants.....	10,000	
Connecticut-Housatonic:		
<i>Flood control:</i>		
Connecticut River: Study of flood control and stream regulation.....	100,000	Preliminary study made, but further investigation necessary.
<i>Pollution:</i>		
Springfield, Mass.: Study for sewage treatment works.....	15,000	
2. Construction Projects		
Maine Rivers:		
<i>Navigation:</i>		
Cores Harbor, Maine: Dredging anchorage basin.....	44,000	Authorized by Congress.
<i>Pollution:</i>		
Ashland, Fort Fairfield, and Mount Desert Island, Maine: Sewer systems.....	201,000	Construction to await completion of Androscoggin River pollution study.
Auburn, Maine, Berlin and Gorham, N. H., and Lewiston, Maine: Sewage-treatment plants.....	800,000	
Bangor and Old Town, Maine: Improvements to sewer systems.....	330,000	
Bar Harbor, Bath, Biddeford, Kennebec, Old Orchard, Rockland, and Scarborough, Maine: Extensions to sewer systems.....	227,000	
Conway and North Conway, N. H.: Sewer systems.....	185,000	
Exeter and Portsmouth, N. H.: Extensions to sewer systems.....	75,000	
Portland and South Portland, Maine: Extensions to sewer systems.....	1,068,000	
Sanford, Maine: Extensions to sewer system, new pumping station, and treatment plant.....	1,000,000	
Wilton and Winthrop, Maine: Sewer systems.....	120,000	
<i>Water supplies:</i>		
Ashland and Eagle Lake, Maine: New water supplies.....	65,000	Preliminary studies made.
Auburn, Augusta, Bath, Kennebecport, Lewiston, Wells, and York, Maine: Extensions and improvements to water-supply systems.....	648,000	Do.
Dover and Rochester, N. H.: Extensions to water-supply systems.....	287,000	Do.
Eliot, Mount Desert Island, and South Paris, Maine: Extensions to water-supply systems.....	201,000	Preliminary studies made.
Epping, N. H.: New water-supply system.....	40,000	Preliminary study made.
Portland, Maine: Extensions to water-supply system.....	2,088,000	Plans made.
Sanford, Maine: Extensions to water system.....	126,000	Preliminary study made.
Merrimack:		
<i>Drainage:</i>		
Middlesex County, Mass.: Swamp drainage for mosquito control and to improve sanitation.....	170,000	Preliminary studies made.
<i>Flood control:</i>		
Merrimack Valley: Reservoir system for flood control and stream regulation.....	11,250,000	Cost estimate rough and preliminary.
<i>Pollution:</i>		
Antrim, Bennington, Contoocook, East Jaffrey, Henniker, Hillsboro, Peterboro, and Warner, N. H.: Sewer systems and treatment plants.....	344,000	Preliminary studies made.
Concord, Manchester, and Nashua, N. H.: Intercepting sewers and sewage treatment works.....	4,301,000	Cost estimate rough and preliminary.
Derry, Meredith, and Wolfeboro, N. H.: Sewer systems and sewage treatment.....	416,000	Do.
Franklin, Manchester, Nashua, and Pembroke, N. H.: Extensions to sewer systems.....	105,000	Preliminary plans made.

New England Project List—Continued

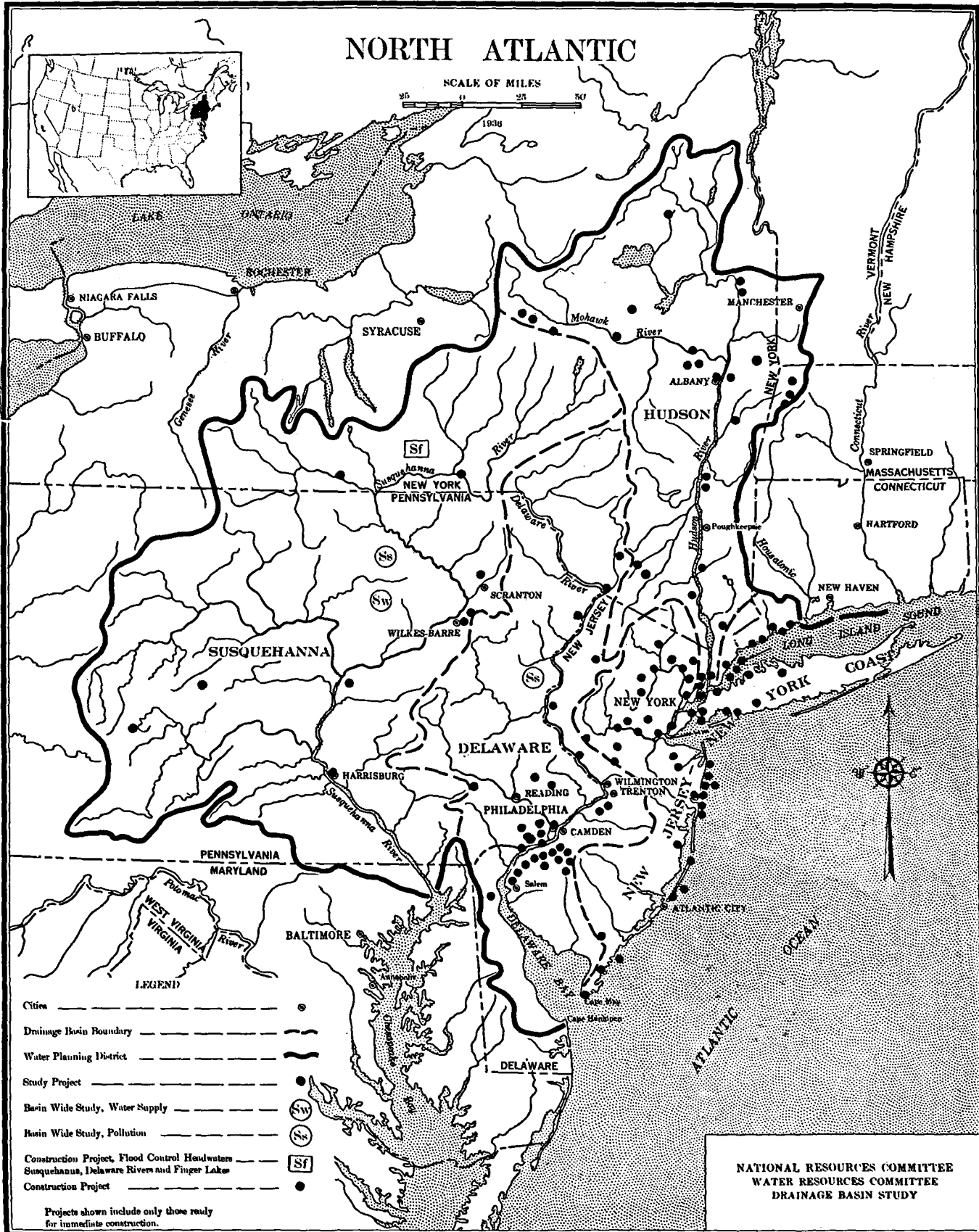
Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Merrimack—Continued.		
Pollution—Continued.		
Holden, Mass.: Sewer system.....	\$125,000	Preliminary plans made.
Laconia, N. H.: Sewage treatment plant.....	400,000	Preliminary study made.
Lancaster, Mass.: Extension of sewage treatment system at State Industrial School for Girls.....	75,000	Preliminary plans made.
Merrimack Valley communities in Massachusetts: Sewage disposal facilities for communities covered by investigation project.....	15,000,000	Should await completion of study project. Cost estimate rough and preliminary.
Methuen, Mass.: Extensions to sewer system.....	45,000	Preliminary plans made.
Tewksbury, Mass.: Extensions to sewer system.....	100,000	Do.
Westboro, Mass.: Sewage treatment system for Lyman School for Boys and State Hospital.....	83,000	Do.
Water supply:		
Amherst, Belmont, Bradford, Franklin, Hollis, Kingston, New Ipswich, Plaistow, and Rumney, N. H.: Water supplies.....	400,000	Cost estimate rough and preliminary.
Andover, Clinton, Fitchburg, Framingham, and Leominster, Mass.: Extensions to water systems.....	663,000	Preliminary plans made.
Bedford, Bolton, Harvard, Holden, Lancaster, Princeton, Rutland, Tewksbury, and Westminster, Mass.: Water supplies, extensions and improvements.....	500,000	Cost estimate rough and preliminary.
Concord, Mass.: Water treatment.....	80,000	Preliminary plans made.
Franklin, N. H.: Dike around water filtration plant.....	25,000	Do.
Haverhill, Mass.: Water-supply extension and improvement.....	200,000	Cost estimate rough and preliminary.
Hooksett, N. H.: Waterworks system.....	83,000	Preliminary plans made.
Lawrence, Mass.: Extension to water filtration plant.....	800,000	Do.
Lowell, Mass.: Additions to water supply and filtration plant.....	651,000	Do.
Lunenburg, Mass.: Water-supply system.....	150,000	Do.
Methuen, Mass.: Water-supply extensions and filtration.....	470,000	Do.
Eastern Massachusetts:		
Drainage:		
Boston, Mass.: Drainage of fresh and salt water marshes along Neponset River and at other places in city of Boston.....	236,000	
Erosion (coastal):		
Barnstable, Brewster, Chatham, Dennis, Duxbury, Edgartown, Falmouth, Harwich, Hull, Ipswich, Marshfield, Oak Bluffs, Orleans, Plymouth, Provincetown, Quincy, Revere, Sandwich, Scituate, South Wellfleet, Truro, Wellfleet, Winthrop, and Yarmouth, Mass.: Beach protection.....	3,000,000	Preliminary surveys under way.
Boston, Mass.: Sea wall along Charles River, Boston Harbor.....	210,000	Preliminary survey made.
Gay Head, Marthas Vineyard, Mass.: Riprap cliffs along shore.....	336,000	Survey and study made, no plans adopted.
Sagamore, Mass.: Riprap shore at Manomet Point.....	576,000	Preliminary study made.
Swampscott, Mass.: Breakwater.....	220,000	Preliminary survey made.
Navigation:		
Boston, Mass.: Removal of ledge in channel from main ship channel to drydock at Army base.....	660,000	Final check survey needed.
Boston, Mass.: Dredging and rock removal in main channel in Boston Harbor.....	1,800,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$1,629,000. Authorized by Congress.
Boston, Mass.: Dredging channel in Weymouth Fore River from Hingham Bay to river bridge at Quincy Point.....	233,000	
Boston, Mass.: Dredging channel in Weymouth Back River.....	60,000	Do.
Cape Cod Canal, Mass.: Deepening and widening channel from Cape Cod Bay to Buzzards Bay.....	6,714,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$3,100,000. Recommended in report of Chief of Engineers. Authorized by Congress.
Edgartown, Mass.: Dredging channel from Nantucket Sound to deep water of inner harbor.....	21,000	
Lynn, Mass.: Deepening channel in Lynn Harbor.....	336,000	
New Bedford, Mass.: Dredging and ledge removal in New Bedford and Fairhaven Harbor.....	142,000	Do.
Quincy, Mass.: Dredging Town River.....	550,000	Preliminary plans made.
Pollution:		
Danvers, Mass.: Sewer system.....	415,000	Do.
Fairhaven, Hingham, Hoolbrook, Mattapoisett, Medfield, Millis, Provincetown, and Wareham, Mass.: Sewer systems.....	2,500,000	Cost estimate rough and preliminary.
Falmouth, Mass.: Sewer system.....	100,000	Preliminary plans made.
Ipswich, Rockland, and Sharon, Mass.: Sewer systems and sewage-treatment plants.....	725,000	Cost estimate rough and preliminary.
Plymouth, Mass.: Intercepting sewers and outfall works.....	750,000	Plans and cost estimates.
Randolph, Mass.: Sewer system.....	300,000	Preliminary studies commenced.
Salem, Mass.: Closed conduit for North River.....	649,000	Preliminary studies made.
Salem, Mass.: Sewage-treatment plant and pumping station.....	375,000	Do.
Saugus, Mass.: Sewer system and trunk sewer to city of Lynn.....	750,000	Preliminary plans and cost estimates made.
Weymouth, Mass.: Sewer system.....	1,550,000	Plans and cost estimates made.
Recreation:		
Barnstable, Bourne, Chatham, Duxbury, Gloucester, Mashpee, and Westport, Mass.: Public beaches.....	850,000	For purchase of beaches and necessary adjacent property.
Water supply:		
Boston, Mass.: High-pressure-service mains to outlying districts.....	650,000	Plans made.
Boston, Mass.: Extensions to water mains.....	750,000	Do.
Cambridge, Mass.: Water filtration plant improvement.....	165,000	Construction plans made.
Danvers, Mass.: Water filtration plant.....	165,000	Preliminary study made.
Dartmouth, Everett, Marblehead, Quincy, Salem, Stoughton, Swampscott, Winchester, and Wrentham, Mass.: Extensions to water supply systems.....	1,023,000	Preliminary plans made.
Dennis, Hamilton, and Sandwich, Mass.: Water supply systems.....	400,000	Cost estimate rough and preliminary.
Dover, Mass.: Water supply system.....	130,000	Do.
Essex, Mass.: Water supply system.....	140,000	Preliminary plans made.
Foxboro, Mass.: Extension to water supply system.....	80,000	Do.
Gloucester, Mass.: Reservoir, filtration plant, and water mains.....	325,000	Do.
Holliston, Mass.: Water supply extension.....	50,000	Do.
Medway, Mass.: Water supply extension.....	25,000	Do.
Norwell, Mass.: Water supply system.....	200,000	Do.
Rockport, Mass.: Water supply extension.....	35,000	Plans made.
Walham, Mass.: Waterworks treatment plant.....	150,000	Preliminary study made.
Thames-Blackstone-Taunton:		
Drainage:		
Worcester County, Mass.: Drainage for mosquito elimination.....	150,000	
Navigation:		
Fall River Harbor, Mass.: Widening channel for navigation.....	65,000	Authorized by Congress.
Taunton River, Mass.: Dredging channel for navigation.....	600,000	Do.
Thames River, Conn.: Deepening channel for navigation.....	820,000	Do.
Pollution:		
Baltic-Ocum, Jewett City, North Grosvenor Dale, Stafford Springs, Stonington, and Taftville, Conn.: Sewage-treatment works.....	600,000	
Blackstone, East Douglas, Millbury, Millville, and Uxbridge, Mass.: Sewer systems and sewage-treatment works.....	2,235,000	Preliminary studies made.
Central Falls, Cumberland, East Providence, and Pawtucket, R. I.: Intercepting sewers and treatment works for these communities individually or as a district.....	2,000,000	Rough estimate. Should await completion of study project of Pawtucket-Central Falls District.
Cranston, R. I.: Sewer system and sewage-treatment plant.....	4,000,000	Preliminary study made.
Danielson, Conn.: Sewage treatment plant extensions.....	135,000	Preliminary plans made.
Fall River, Mass.: Intercepting sewers, treatment works, and outfall sewer.....	2,500,000	Do.
New London, Conn.: Sewage treatment.....	250,000	Preliminary study made.
Newport, R. I.: Sewer system extensions and sewage disposal improvements.....	2,000,000	Preliminary plans made.
North Kingston and South Kingston, R. I.: Sewer systems.....	300,000	Preliminary study made.

New England Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Thames-Blackstone-Taunton—Continued.		
<i>Pollution—Continued.</i>		
Norwich, Conn.: Sewage treatment plant extensions.....	\$225,000	Preliminary plans made.
Taunton, Mass.: Sewage treatment works.....	850,000	Preliminary plans made and land purchased.
Tiverton, R. I.: Sewer system.....	100,000	Preliminary study made.
Webster, Mass.: Sewage treatment plant.....	600,000	Preliminary plans made.
Willimantic, Conn.: Sewage treatment plant extensions.....	125,000	Do.
<i>Water supply:</i>		
Bellingham, Blackstone, Manchaug, and Millville, Mass.: Waterworks systems.....	345,000	Preliminary studies made.
East Lyme, Groton, and Waterford, Conn.: Extensions and improvements to water supply systems.....	270,000	Preliminary plans made.
Harrisville and Pascoag, R. I.: Joint waterworks system.....	325,000	Plans being prepared.
North Kingston, R. I.: Waterworks construction.....	210,000	Preliminary study made.
Pawtucket, R. I.: Water treatment plant.....	400,000	Do.
Raynham, Mass.: Water supply system.....	45,000	Do.
Swansea, Mass.: Water supply system.....	290,000	Preliminary plan made.
Tiverton, R. I.: Waterworks construction.....	85,000	Do.
Woonsocket, R. I.: New water supply reservoir to supplement existing sources.....	2,180,000	Do.
Connecticut-Housatonic:		
<i>Flood control:</i>		
Pittsburg, N. H.: Dam and reservoir for flood control and stream regulation.....	1,700,000	Plans completed.
Victory, Vt.: Dam and reservoir for flood control and stream regulation.....	379,000	Preliminary study made.
<i>Navigation:</i>		
Connecticut River: Dredging 15-foot channel from mouth to Hartford, Conn.....	200,000	Cost given is for first 2 years. Additional needed to complete, \$50,000. Authorized by Congress.
Bridgeport, Conn.: Completion of Poquonock River channel.....	20,000	Sum needed to complete. Authorized by Congress.
<i>Pollution:</i>		
Amherst, Athol, Chicopee, Dalton, East Longmeadow, Great Barrington, Greenfield, Lee, Northampton, and Westfield, Mass.: Sewer systems and/or sewage-disposal facilities.....	2,000,000	Cost estimate rough and preliminary.
Amherst, Mass.: Sewer extensions, including pumping station.....	176,000	Preliminary plans made.
Ansonia, Derby, and Shelton, Conn.: Sewer extensions and sewage-treatment works.....	1,435,000	Preliminary study made.
Brattleboro and Chester, Vt.: Extensions.....	314,000	Cost estimate rough and preliminary.
Bridgeport, Conn.: Extensions and improvements to present sewage-treatment facilities.....	1,700,000	Preliminary plans made.
Bridgeport sanitary district (Bridgeport, Stratford, Trumbull, Easton, Fairfield, and Westport, Conn.): Sewage-treatment plants.....	3,300,000	
Cavendish, Ludlow, and Springfield, Vt.: Sewer systems and sewage-treatment plants.....	200,000	Cost estimate rough and preliminary.
Danbury, Conn.: Sanitary sewers, industrial waste collecting sewers and treatment.....	500,000	
East Hartford, Conn.: Sewage-treatment plant.....	125,000	
Fairfield, Conn.: Sewers and sewage treatment for Fairfield-Stratford district.....	267,000	
Farmington and Kensington, Conn.: Sewer systems and sewage-treatment works.....	200,000	Preliminary plans made.
Forestville, Conn.: Sewer system and sewage-treatment plant.....	185,000	
Glastonbury, Conn.: Sewage-treatment plant.....	267,000	
Hartland, Vt.: Drainage, sewer system, and sewage-treatment plant.....	40,000	
Hinsdale, Mass.: Sewer system.....	52,000	Do.
Meriden, Conn.: Enlargement of sewage-treatment facilities.....	240,000	Do.
Naugatuck, Conn.: Sewage-treatment plant.....	125,000	
New Haven, Conn.: Extensions and improvements to present sewage disposal facilities.....	1,400,000	Do.
New Milford, Conn.: Sewage treatment plant.....	318,000	
Plainville, Conn.: Sewers and sewage-treatment plant.....	425,000	
Springfield, Mass.: Sewage treatment plant.....	2,000,000	Cost estimate rough and preliminary.
Waterbury, Conn.: Intercepting sewers, and sewage-treatment works.....	1,100,000	
Winsted, Conn.: Sewage-treatment plant.....	285,000	
<i>Water supply:</i>		
Ainstead, Westmoreland, and Winchester, N. H.: Water-supply systems.....	250,000	Do.
Amherst, Mass.: Reinforcement of water distribution system.....	150,000	
Completion of water system for State college and State sanitarium.....	46,000	
Bethel, Canaan, Meriden, and Windsor, Conn.: Extensions and improvements to water-supply systems.....	309,000	
Brattleboro, Vt.: Water-supply extensions.....	218,000	Preliminary plans made.
Cavendish, Vt.: Water-supply system for Proctorsville Village.....	50,000	
Colchester, East Hampton, and Plymouth, Conn.: Water-supply systems.....	300,000	Cost estimate rough and preliminary.
East Longmeadow, Mass.: Water-system extensions.....	39,000	Preliminary plans made.
Granby, Mass.: Water-system.....	30,000	
Hartland, Vt.: Water-supply system.....	35,000	
Lanesboro and Templeton, Mass.: Water-supply systems.....	175,000	Cost estimate is rough and preliminary
Lyndonville, Vt.: Additions and improvements to water system.....	30,000	
New Britain, Conn.: New water-treatment works.....	599,000	Preliminary plans made.
North Haverhill, N. H.: Water-supply system.....	49,000	Do.
North Stratford, N. H.: New water mains.....	24,000	Do.
North Swansey, N. H.: Water-supply extension from Keene, N. H., system.....	30,000	Do.
Rochester, Sharon, and Tunbridge, Vt.: Water supply and improvements.....	300,000	Cost estimate rough and preliminary.
St. Johnsbury, Vt.: Filtration plant and water-supply extensions.....	108,000	Preliminary study made.
South Hadley, Mass.: Water-supply additions and improvements.....	98,000	Preliminary plans made.
West Stockbridge, Mass.: Complete new water system.....	93,000	Do.
Whately, Mass.: Water-supply system, including reservoir and distribution system.....	130,000	
GROUP B—FOR DEFERRED CONSTRUCTION		
Maine Rivers:		
<i>Navigation:</i>		
Hampton, N. H.: Construction of jetties and dredging of Rye Harbor.....	\$202,000	Plans and survey made.
<i>Pollution:</i>		
Old Orchard, Maine: Sewage-treatment plant.....	100,000	Construction should await completion of study.
<i>Water supply:</i>		
Bangor, Maine: Waterworks improvements.....	235,000	Preliminary study made.
Calais, Maine: New water supply.....	226,000	Do.
Merrimack:		
<i>Pollution:</i>		
Ayer, Billerica, and North Andover, Mass.: Sewer system extensions and improvements.....	386,000	Cost estimates rough and preliminary.
<i>Water supply:</i>		
Ayer (Fort Devens), Billerica, Concord, Hudson, Marlboro, Maynard, and North Andover, Mass.: Extensions and improvements to water-supply systems.....	765,000	Do.
Eastern Massachusetts:		
<i>Miscellaneous:</i>		
Waltham, Mass.: Dam and sluiceway.....	35,000	Plans partially prepared.
<i>Navigation:</i>		
Boston, Chatham, Dorchester, East Boston, Fairhaven, Gloucester, Manchester, Marlon, Marshfield, Nantucket, Orient Heights, Plymouth, Quincy, Revere, South Boston, Tisbury, Truro, and Winthrop, Mass.: Dredging projects.....	1,631,000	

New England Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Eastern Massachusetts—Continued.		
<i>Navigation—Continued.</i>		
Boston, Mass.: Dredging harbor along Atlantic Avenue waterfront.....	\$155,000	Final check survey needed.
Boston, Mass.: Removal of ledge in channel to pier no. 5 of the Commonwealth of Massachusetts.....	100,000	Final check survey needed, preliminary plans made.
Edgartown, Mass.: Dredging channel.....	45,000	Surveys and plans prepared.
Saugus, Mass.: Dredging Saugus River.....	350,000	Survey and estimates made.
Seltuate, Mass.: Dredging Scituate Harbor.....	350,000	Preliminary plans made.
<i>Pollution:</i>		
Arlington, Mass.: Relief sewer from North Metropolitan Sewerage District.....	290,000	Construction plans not ready.
Arlington, Cambridge, Lexington, Melrose, Reading, Revere, Somerville, and Waltham, Mass.: Extensions and improvements to sewer systems.....	2,480,000	Preliminary plans made.
Boston, Mass.: Sewage-treatment works at the main outfalls into Boston Harbor.....	16,000,000	Investigation now under way.
Boston, Mass.: New reservoir to improve sanitary conditions in Charles River Valley.....	242,000	Construction plans not ready.
Boston, Mass.: Enlargement of culverts at outlet of Spot Pond and improvement of Spot Pond Brook.....	160,000	Do.
Boston, Mass.: Relief sewers and pumping station for North Metropolitan District at East Boston and Deer Island.....	3,970,000	Do.
Boston, Mass.: Reconstruction and relief sewer for Alewife Brook section of North Metropolitan District.....	705,000	Do.
Boston, Mass.: Relief sewers and appurtenant works for metropolitan area.....	24,000,000	To be constructed after completion of study project.
Boston, Mass.: Relief sewer for Charles River Valley.....	1,000,000	Construction plans not ready.
Boston, Mass.: Dredging of Mystic River to improve sanitary conditions.....	1,075,000	Do.
Braintree, Canton, Dedham, Milton, Needham, Norwood, Quincy, Stoughton, and Walpole, Mass.: Extensions and improvements to sewer systems.....	2,661,000	Preliminary plans made.
Cambridge, Mass.: Relief sewer and additional pumps for metropolitan commission.....	2,427,000	Construction plans not ready.
Charlestown, Mass.: Extension to main discharge sewer system for metropolitan commission.....	420,000	Do.
Gloucester, Lynn, Marblehead, Salem, and Swampscott, Mass.: Extensions to sewer and storm drainage systems.....	3,523,000	Preliminary plans made.
Hull, Mass.: Sewer system and sewage treatment plant.....	2,200,000	Construction plans not ready.
Malden, Mass.: Relief sewer for Malden River.....	675,000	Do.
Winchester, Mass.: Dredging upper Mystic Lake.....	30,000	Plans partially prepared.
<i>Water supply:</i>		
Bourne, Mass.: Water-supply system.....	66,000	Preliminary plans ready. Legislation required.
Lynn, Mass.: New reservoir to supplement present system.....	3,000,000	Cost estimate rough and preliminary.
Weston, Mass.: Extensions to waterworks system.....	106,000	Preliminary cost estimates made.
Thames-Blackstone-Taunton:		
<i>Flood control:</i>		
Blackstone, Millville, and Uxbridge, Blackstone River, Mass.: Channel improvement.....	430,000	Allotment for project made. Start of project awaiting action of towns involved.
Uxbridge, Mass.: Reconstruction of Rice City Dam.....	200,000	Dam weakened by March 1936 flood.
<i>Navigation:</i>		
New London, Conn.: Dredging a straight channel to State pier.....	16,000	Surveys completed.
<i>Pollution:</i>		
Abington, Easton, Mansfield, and Whitman, Mass.: Sewer systems and sewage treatment plants for village centers.....	1,500,000	Further study needed.
Coventry, Johnston, Warwick, and West Warwick, R. I.: Initial construction of sewers and sewage-treatment plants.....	1,500,000	Cost estimate rough and preliminary.
<i>Water supply:</i>		
Newport, R. I.: Additional water supply.....	500,000	Further study needed.
Seekonk, Mass.: Water-supply system.....	100,000	Do.
Connecticut-Housatonic:		
<i>Drainage:</i>		
Longmeadow, Mass.: Drainage channel to Connecticut River—cleaning and extending.....	60,000	
<i>Erosion:</i>		
Brattleboro, Vt.: Flood wall to protect industrial property.....	213,000	Preliminary plans made.
Connecticut River: Riprap for protection of banks at Agawam, Hadley, Hatfield, Holyoke, Montague, Northampton, Northfield, Sunderland, and Whately, Mass.....	290,000	Do.
Hartford, Vt.: Protection of banks of White River against erosion.....	45,000	
<i>Flood control:</i>		
Ashburnham, Mass.; Cavendish Township, Vt.; Claremont, N. H.; East Haven and Gayesville, Vt.; Grantham, N. H.; Groton, Vt.; Huntington and Hydeville, Mass.; Londonderry, Ludlow, Lyndonville, Newfane, North Landgrove, North Springfield, and Randolph Township, Vt.; Royalston and Winchendon, Mass.; South Corinth, South Randolph, South Tanbridge, and Thetford Township, Vt.; and West Canaan, N. H.: Reservoirs for flood control and river regulation.....	25,328,000	Preliminary study made. Sites not acquired and legislation needed.
<i>Pollution:</i>		
Bethlehem, N. H.: Sewer system extensions.....	100,000	
St. Johnsbury, Vt.: Storm sewers.....	33,000	
<i>Water supply:</i>		
Pittsfield, Mass.: Water main extensions.....	75,000	



NORTH ATLANTIC

The North Atlantic drainage basins comprise the Hudson, Delaware, and Susquehanna River systems, and the contiguous coastal plain from Bridgeport, Conn., to Indian River, Del. About one-sixth of the entire Nation lives in this district. About two-thirds of this population, in turn, live in two metropolitan areas—New York and Philadelphia. The scope and urgency of the principal water problems, those of water supply and pollution, result from the size and nature of these great urban concentrations.

New York City and its urban satellites, particularly the municipalities in northern New Jersey, face immediate expenditures on new and additional water supplies that will exceed \$300,000,000. Philadelphia and its neighboring communities will soon take steps in the same direction. The additional water supplies for both groups of cities will come from the Delaware River system, a fact that indicates the wisdom of rating the provision of public water supplies as the highest use of the Delaware River tributaries. The experience of these cities should serve as a warning, it may be noted, to other cities and groups of cities to look years ahead and provide themselves with potential water supplies to care for future needs. For this purpose, comprehensive investigations of both underground and surface water resources are essential. For the purpose of utilizing these resources when need arises, plans should be formulated now for cooperation through interconnection of systems and the formation of metropolitan water districts.

Hardly second to water-supply requirements in these metropolitan areas is the intolerable situation caused by excessive pollution of their surface waters. An Interstate Sanitation Commission has been formed to promulgate standards and find solutions for the pollution problems of the coastal area centering in New York City. Here about \$100,000,000 must be spent to protect health, shipping, recreation, and shellfish. The recently formed Interstate Commission on the Delaware has adopted pollution abatement as its first objective. This involves sewage treatment at Philadelphia, both for the city itself and for surrounding communities in Pennsylvania and New Jersey.

Abatement of industrial pollution is progressing slowly through cooperative action of the industries with State and Federal agencies. Pollution from mines particularly concerns this district because the anthracite coal fields lie entirely in the Delaware and Susquehanna basins. Culm waste and acid mine waters afford a field for research that may provide beneficial byproducts.

The great metropolitan areas are not the only offenders with respect to pollution. Many other cities and towns are allowing untreated sewage to enter streams of the district, while still others have most inadequate and unsanitary facilities. At many places, untreated sewage enters streams used^o at lower points for water supply, bathing, and fishing. While these communities with few exceptions acknowledge a moral obligation to treat and purify their sewage, most of them are unable to raise the funds for treatment works or are disinclined to spend money for such a purpose.

Because of the great urban power market, hydroelectric installations have been made on various streams of the district, usually in conjunction with systems supplied largely by steam-electric power plants. Further development of power on these streams apparently can be made practicable by combining it with other objectives. Large-scale storage with draw-down facilities not only could supplement the firm power of the streams during dry-weather flow, but also would benefit navigation and help to repel salinity invasion (critical on the Delaware), to dilute the effluents from sewage and industrial waste-treatment plants, and to preserve fish life. The lakes formed by such reservoirs would be capable of development for recreational purposes, and manipulation of the structures to conserve water would make them a valuable adjunct in flood abatement. Federal funds already have been made available for flood-abatement studies in those parts of the Susquehanna and Delaware drainage areas which lie in southern New York and northern Pennsylvania. Similar studies should be made in other parts of the district, with due regard to the possibilities of multiservice reservoirs.

The destructive action of water in the district is not restricted to the ravages of occasional floods. Almost every resort city on the coast of New Jersey now has projects for jetties and bulkheads to prevent beach erosion and protect property against the ceaseless action of waves and currents. These municipalities will be aided in this work by the Federal Beach Erosion Board. Deposition of material from anthracite mines in the channels of the port of Philadelphia and in the Schuylkill River above Fairmont Dam also requires immediate study.

The ports of New York and Philadelphia rank first and second in tonnage in the country. As in the past, concentration of commerce at these ports makes the improvement of their commercial waterways and harbors a matter of almost constant concern.

North Atlantic Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Hudson:		
<i>Miscellaneous:</i>		
Lower Hudson River Basin, New York and New Jersey: Study for coordinated development of water resources, including water supply, flood control, pollution abatement, water power, and recreation.	\$100,000	
Mohawk River Basin, N. Y.: Study for development of water resources including flood protection, erosion control, and multiservice reservoirs.	25,000	
Upper Hudson River Basin including Hoosic River in New York, Massachusetts, and Vermont: Study for development of water resources, including flood protection, erosion control, and multiservice reservoirs.	25,000	
New Jersey-New York Coast:		
<i>Pollution:</i>		
Hudson County, N. J.: Study of intercepting sewers and sewage treatment problems.....	50,000	
<i>Water supply:</i>		
Study of interconnections to existing water-supply systems in northern New Jersey metropolitan district to provide for proper distribution of available supplies and to devise method of administrative control.	75,000	
Delaware:		
<i>Water supply:</i>		
Northeastern New Jersey municipalities: Study of future water supply, including consideration of proposed Tock's Island Reservoir and other sources.	40,000	Preliminary study made.
Philadelphia, Pa.: Study of future water supply, including consideration of proposed Tock's Island Reservoir and other sources.	60,000	Do.
Susquehanna:		
<i>Pollution:</i>		
Study to determine methods of eliminating mine wastes from the Susquehanna and Delaware Rivers and tributaries, thereby removing existing pollution.	25,000	
<i>Water supply:</i>		
Study to determine the future water supply needs for all municipalities over 25,000 population throughout the basin including advisability of creating a metropolitan water-supply project for Harrisburg, Pa., and vicinity.	75,000	
2. Construction Projects		
Hudson:		
<i>Flood control:</i>		
North Adams, Mass.: Clearing of channel and construction of drift barriers in the Hoosic River above the city for flood control.	66,000	Plans not ready. Authorized by Congress.
<i>Navigation:</i>		
Great Lakes to Hudson River Waterway, N. Y.: Deepening and widening New York State Barge Canal from the Hudson River to Oswego on Lake Ontario.	15,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$2,165,000. Authorized by Congress.
Rondout, N. Y.: Deepening navigation channel in harbor.....	15,000	Survey completed. Authorized by Congress.
<i>Pollution:</i>		
Adams, Mass.: Sewage treatment plant and trunk sewer extension.....	155,000	Preliminary plans completed.
Beacon, N. Y.: Sewage treatment plant.....	150,000	Plans completed.
Chatham, N. Y.: Sewage treatment plant.....	178,000	Do.
Cohoes, N. Y.: Sewage treatment plant.....	500,000	Do.
Fort Edward, N. Y.: Sewage treatment plant.....	77,000	Do.
Greenburgh, N. Y.: Sewage treatment plant.....	230,000	Do.
Hudson, N. Y.: Sewage treatment plant.....	250,000	Do.
Menands, N. Y.: Sewage treatment plant.....	35,000	Do.
Middletown, N. Y.: Sewage treatment (secondary) plant.....	210,000	Do.
Mohawk, N. Y.: Sewage treatment plant.....	27,000	Do.
Pleasantville, N. Y.: Sewage treatment plant.....	70,000	Do.
Schenectady, N. Y.: Improvement to sewage treatment plant.....	170,000	Do.
Scotia, N. Y.: Sewage treatment plant.....	95,000	Do.
Troy, N. Y.: Sewage treatment plant.....	1,500,000	Do.
Utica, N. Y.: Sewage treatment plant.....	1,150,000	Do.
West Point, N. Y.: Sewage treatment plant.....	49,000	Do.
Williamstown, Mass.: Trunk sewer and sewage treatment plant.....	100,000	Rough estimate.
Whitesboro, N. Y.: Sewage treatment plant.....	169,000	Plans completed.
<i>Water supply:</i>		
Adams, Mass.: Reservoir for fire district.....	200,000	Do.
Glens Falls, N. Y.: Water treatment plant.....	175,000	Do.
Indian Lake, N. Y.: Water supply system.....	60,000	Do.
Schenectady, N. Y.: Additional water supply.....	200,000	Do.
New Jersey-New York Coast:		
<i>Drainage:</i>		
Hudson County, N. J.: Drainage of 90,000 acres of marshland for mosquito extermination.....	169,000	Survey being made.
<i>Erosion (coastal):</i>		
Avon, N. J.: Beach erosion control by jetties and bulkheads.....	82,000	Preliminary plans completed.
Belmar, N. J.: Beach erosion control by jetties and bulkheads.....	105,000	Preliminary plans prepared.
Bradley Beach, N. J.: Beach erosion control by jetties and bulkheads.....	160,000	Plans prepared.
Deal, N. J.: Beach erosion control by jetties and bulkheads.....	370,000	Do.
Long Branch, N. J.: Beach erosion control by jetties and bulkheads.....	570,000	Survey and preliminary plans completed.
<i>Flood control:</i>		
Clifton, N. J.: Improvement of Weasel Brook channel for flood protection.....	205,000	Plans completed.
Middlesex, Somerset, and Union Counties, N. J.: Channel improvements of Green and Stony Brooks for flood control.	350,000	
Paterson, N. J.: Channel improvements on Passaic River from Great Falls to Newark Bay.....	6,000,000	Including cost of study of storage reservoir and mosquito elimination between Great Falls and Little Falls.
<i>Navigation:</i>		
Barnegat Inlet, N. J.: Dredging navigation channel.....	533,000	Authorized by Congress.
Mamaroneck, N. Y.: Dredging navigation anchorage in west basin of harbor.....	53,000	Do.
New York, N. Y.: Dredging of Bay Ridge and Red Hook Channels.....	120,000	Sum needed to complete. Authorized by Congress.
New York, N. Y.: Dredging of anchorage at Red Hook Flats.....	2,431,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$624,000. Authorized by Congress.
New York, N. Y.: Deepening of Buttermilk Channel.....	783,000	Survey completed.
New York, N. Y.: Channel deepening of New York-New Jersey channels, from point near Sandy Hook, through Gedney and Bayside Channels, Lower New York Bay, Raritan Bay, and Staten Island Sound to Upper New York Bay.	10,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$12,119,000. Authorized by Congress.
New York, N. Y.: Widening channel of Hudson River.....	257,000	Sum needed to complete. Authorized by Congress.
New York, N. Y.: Straightening channel of Harlem River.....	200,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$300,000. Authorized by Congress.
Port Chester, N. Y.: Remove isolated rock shoals.....	12,000	Survey completed. Authorized by Congress.

North Atlantic Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
New Jersey—New York Coast—Continued.		
<i>Pollution:</i>		
Darien, Rowayton, and Westport, Conn.: Sewage treatment plants.....	\$625,000	Projects proposed.
Flemington, Hawthorne, Sea Girt, Sea Isle City, and Westwood, N. J.: Sewer system and/or sewage treatment plants.....	184,000	
Fort Lee, N. J.: Replacement of combined sewer outfall to Hudson River.....	100,000	Plans completed.
Hempstead, N. Y.: Sewer system.....	684,000	Preliminary plans prepared.
Middlesex, N. J.: Sewer system and sewage treatment plant.....	551,000	
New York, N. Y.: Sewage treatment plant at Tallmans Island.....	7,155,000	Plans completed.
New York, N. Y.: Sewage treatment plant at Jamaica Bay.....	3,888,000	Plans being prepared.
New York, N. Y.: Sewage treatment plants.....	74,310,000	Preliminary plans made. To complete 10-year program.
Ocean Township, N. J.: Sewer system and sewage treatment (partial) plant.....	100,000	Plans prepared.
Raritan, N. J.: Interceptor sewers and sewage treatment plant.....	264,000	Do.
Somerville, N. J.: Interceptor sewers and sewage treatment plant.....	211,000	Do.
South Plainfield, N. J.: Sewer system and sewage treatment plant.....	387,000	Plans completed.
Union Beach, N. J.: Sewer system and sewage treatment (partial) plant.....	399,000	Plans prepared.
Valley Stream, N. Y.: Sewage treatment plant.....	1,758,000	
Watchung, N. J.: Extension of sewer system.....	111,000	Plans completed.
West Cape May, N. J.: Sewer system.....	51,000	Plans prepared.
Woodbridge, N. J.: Intercepting sewers and sewage treatment plant.....	180,000	Do.
<i>Water supply:</i>		
Bunnvale or Chimney Rock, N. J.: Dam, aqueducts, aerators, filtration plant, and distribution systems for water supply to northeastern New Jersey communities.....	47,000,000	Preliminary studies completed.
Bayville, N. Y.: Chester and Long Branch, N. J.; and Northport, N. Y.: Water supply systems.....	189,000	Plans completed.
Centre Island, N. Y.: Waterworks system.....	55,000	Preliminary plans prepared.
Harrison and Mamaroneck, N. Y.: Water supply improvements.....	419,000	Do.
Jersey City, N. J.: Rehabilitation of 72-inch water main.....	651,000	Sketch plans in preparation.
Lincoln Park, N. J.: Waterworks system.....	241,000	Plans prepared.
Parsippany and Troy Hills, N. J.: New water supply.....	73,000	Plans completed.
Rocky Hill, N. J.: Waterworks system.....	65,000	Do.
Wanaque, N. J.: New water supply.....	18,000	Do.
Dalaware:		
<i>Flood control:</i>		
Retarding dams in headwaters of Susquehanna and Delaware Rivers and Finger Lakes region for flood control.....	See remarks.	Estimated cost of reservoirs in Delaware Basin included in Susquehanna Basin project.
<i>Navigaton:</i>		
Big Timber Creek, N. J.: Dredging channel 10 feet deep and 60 feet wide.....	38,000	Survey complete. Authorized by Congress.
Chesapeake and Delaware Canal: Dredging channel to a depth of 27 feet.....	5,393,000	Sum needed to complete. Authorized by Congress.
Mantua Creek, N. J.: Dredging channel 10 to 12 feet deep, 60 to 100 feet wide.....	25,000	Do.
Maurice River, N. J.: Dredge channel 8 feet deep and 150 feet wide.....	65,000	Cost to complete. Authorized by Congress.
<i>Pollution:</i>		
Abington Township, Pa.: Sewer system, pumping stations, and complete sewage treatment plant.....	1,400,000	Plans completed.
Birdsboro, Pa.: Sewer system and first stage sewage treatment plant.....	300,000	Preliminary plans made.
Brooklawn, N. J.: Reconstruction of sewage treatment plant.....	35,000	Survey being made.
Camden, N. J.: 2 first stage sewage treatment plants.....	3,000,000	Preliminary plans and estimates made.
Chester, Pa.: First stage sewage treatment plant.....	600,000	Do.
Delaware and Montgomery Counties, Pa.: District sewer system and sewage treatment plants to serve 27 communities.....	6,000,000	Plans completed.
Florence, N. J.: Sewer system and sewage treatment plant.....	140,000	Do.
Haddon Township, N. J.: Sewage treatment plant.....	48,000	Sketch plans in preparation.
Hatfield, Pa.: Sewer system and sewage treatment plant.....	180,000	Preliminary plans made.
Haverford and Radnor Townships, Pa.: Sewage treatment plant for complete treatment.....	328,000	Plans completed.
Lambertville, N. J.: Sewage treatment plant.....	229,000	Do.
Landsdale, Pa.: Sewer construction.....	100,000	Comprehensive plan made.
Philadelphia, Pa.: Sewer system; interceptors and 2 first stage sewage treatment plants and extension of existing plant.....	25,000,000	Preliminary plans and estimates made.
Port Jervis, N. Y.: Sewage treatment plant for complete treatment.....	300,000	Preliminary plans made.
Rose Valley, Pa.: Sewage treatment plant.....	37,000	Plans completed.
Souderton, Pa.: Sewer system and sewage pumping station.....	150,000	Do.
<i>Water supply:</i>		
Alpha, N. J.: Water supply system.....	60,000	Do.
Andover, N. J.: Water supply system.....	45,000	Sketch plans prepared.
Bordentown, N. J.: Water supply collecting system.....	28,000	Plans in preparation.
Camden, N. J.: Wells and water mains.....	810,000	Plans completed.
Clementon, N. J.: Extension and repairs to waterworks system.....	42,000	Do.
Gloucester, N. J.: Wells and water mains.....	55,000	Do.
New York, N. Y.: Additional water supply; reservoirs on Neversink River, East Branch of Delaware and Rondout Creek (Hudson Basin) with interconnecting aqueducts and appurtenant structures.....	272,587,000	Plans completed. Of the estimated cost, \$17,500,000 has been appropriated by New York City, construction to extend over 8 to 10 years.
Philadelphia, Pa.: Water supply improvements in existing filter plants, pumping stations and distribution system, including installation of pumping mains.....	3,130,000	Plans completed.
Pine Hill, N. J.: Water supply system.....	150,000	Plans prepared.
Susquehanna:		
<i>Flood control:</i>		
Retarding dams in headwaters of Susquehanna and Delaware Rivers and Finger Lakes region for flood control.....	31,516,000	Cost to complete as authorized by Congress. Plans being prepared. Includes estimated cost of land, \$5,930,000.
Kingston and Edwardsville, Pa.: Levees on North Branch of Susquehanna River for flood protection.....	226,000	Authorized by Congress.
Sunbury, Pa.: Levee on Susquehanna River for flood protection.....	109,000	Authorized by Congress. Plans being prepared.
Wilkes-Barre and Hanover Township, Luzerne County, Pa.: Levees on North Branch of Susquehanna River for flood protection.....	261,000	Authorized by Congress.
<i>Pollution:</i>		
Altoona, Pa.: Sewage treatment plant.....	1,250,000	
Bedford, Pa.: Sewer system and sewage treatment plant.....	170,000	Plans completed.
Binghamton, Endicott, and Johnson City, N. Y.: Sewage treatment plants.....	1,600,000	
Borough of State College, Pa.: Sewage treatment plant.....	121,000	Do.
Clarks Summit, Pa.: Sewer system and sewage treatment plant.....	391,000	Do.
Elmira, N. Y.: Intercepting sewers and sewage treatment plant.....	900,000	

North Atlantic Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION		
Hudson:		
<i>Flood control:</i>		
Chain Lakes, Hamilton County, N. Y.: Dam and reservoir on Cedar River for flood and low-flow control.	\$1,600,000	Preliminary plans completed.
Washington County, N. Y.: Shushan Dam and Reservoir on Batten Kill for flood and low-flow control.	1,397,000	Do.
<i>Pollution:</i>		
Amsterdam, N. Y.: Sewage treatment plant.....	700,000	
Athens, Castleton, Catskill, Coxsacke, Coldspring, Dobbs Ferry, Ellenville, Fishkill, Monroe, New Paltz, Valatie, N. Y.: Sewage treatment plants.....	785,000	
Bennington, Vt.; Fonda, Fort Plain, Green Island, Greenwich, Hoosick Falls, Salem, Schuylerville, St. Johnsville, and Waterford, N. Y.: Sewage treatment plants.....	473,000	
Cambridge, N. Y.: Sewage treatment plant.....	105,000	
Glens Falls, N. Y.: Sewage treatment plant.....	277,000	
Haverstraw, N. Y.: Sewage treatment plant.....	110,000	
Highland Falls, N. Y.: Sewage treatment plant.....	232,000	
Hudson Falls, N. Y.: Sewage treatment plant.....	130,000	
Ilion, N. Y.: Sewage treatment plant.....	198,000	Plans not completed.
Kingston, N. Y.: Sewage treatment plant.....	560,000	
Mechanicville, N. Y.: Sewage treatment plant.....	167,000	
Newburgh, N. Y.: Sewage treatment plant.....	470,000	
Northville, N. Y.: Sewage treatment plant.....	82,000	
Peekskill, N. Y.: Sewage treatment plant.....	340,000	
Poughkeepsie, N. Y.: Sewage treatment plant.....	800,000	
Rensselaer, N. Y.: Sewage treatment plant.....	224,000	
Rhinebeck, N. Y.: Sewage treatment plant.....	105,000	
Stillwater, N. Y.: Sewage treatment plant.....	120,000	
Warwick, N. Y.: Sewage treatment plant.....	147,000	
Watervliet, N. Y.: Sewage treatment plant.....	320,000	
<i>Water supply:</i>		
Amsterdam, N. Y.: Water treatment plant.....	237,000	
Clayville, N. Y.: Additional water supply.....	80,000	
West Point, N. Y.: Military Academy water supply.....	100,000	
New Jersey-New York Coast:		
<i>Drainage:</i>		
Bergen County, N. J.: Cleaning and regrading brooks to improve drainage for mosquito elimination.	302,000	Survey started.
<i>Navigation:</i>		
Atlantic, Cape May, and Ocean Counties, N. J.: Redredging of inland waterways for navigation.	52,000	Surveys completed.
Middlesex and Monmouth Counties, N. J.: Dredging channel of Shrewsbury River and construction of yacht basin in Raritan Bay.	80,000	Survey completed.
Perth Amboy, N. J.: Dredging navigation channel in Raritan River.....	267,000	Do.
Point Pleasant, N. J.: Protective bulkheads for navigation.....	100,000	Do.
<i>Pollution:</i>		
Long Branch, N. J.: Intercepting sewer, pumping station and force main.....	266,000	
Sloatsburg, N. Y.: Sewage treatment plant.....	98,000	
<i>Water supply:</i>		
Butler, N. J.: Dam for water supply.....	246,000	Sketch plans in preparation.
Ocean Beach, N. Y.: Improvements to water supply.....	130,000	
<i>Miscellaneous:</i>		
Rockaway Township, N. J.: Dam for third naval district, Lake Denmark.....	40,000	Do.
Delaware:		
<i>Flood control:</i>		
Philadelphia, Pa.: Raise height of seawall and erect protective fence at Frankford Arsenal.....	100,000	Plans being prepared.
<i>Navigation:</i>		
Delanco, N. J.: Excavation of a cross channel off Delanco, N. J., 200 feet wide and 8 feet deep.....	32,000	Surveys completed.
Dennis Creek, N. J.: Dredging channel from deep water in Delaware River to Dennis Creek.....	110,000	Survey completed.
Gloucester and Salem Counties, N. J.: Dredging channels from deep water in Delaware River into creeks.....	85,000	Do.
Harbor of Refuge, Delaware Bay: Dredge channel 15 feet deep and 300 feet wide.....	65,000	Surveys completed. Authorized by Congress.
Mispillion River, Del.: Extension of north jetty at mouth of river for approximately 3,500 feet.....	90,000	Survey completed.
<i>Pollution:</i>		
Conshohocken, Pa.: Sewer system and first-stage sewage treatment plant.....	804,000	Preliminary plans made.
Delhi, N. Y.: Sewage treatment plant.....	100,000	
Fleischmans, N. Y.: Sewage treatment plant.....	300,000	
Gloucester, N. J.: Sewer system and first-stage sewage treatment plant.....	300,000	Plans complete for system only.
Hancock, N. Y.: Sewage treatment plant.....	86,000	
Morrisville, Pa.: Sewer system and first-stage sewage treatment plant.....	375,000	
Paulsboro, N. J.: Sewage treatment plant.....	76,000	Plans completed.
Phoenixville, Pa.: Sewer system and first-stage sewage treatment plant.....	750,000	Plans being prepared.
Spring City, Pa.: Sewer system and sewage treatment plant.....	205,000	Investigation made.
Walton, N. Y.: Sewage treatment plant.....	210,000	
Susquehanna:		
<i>Flood control:</i>		
Bloomsburg, Forty Fort, Jersey Shore, Lock Haven, Milton, Montgomery, Muncy, Nanticoke, Plymouth, Swyersville, and West Pittston, Pa.: Levees for flood control.....	5,891,000	Plans being prepared. Authorized by Congress.
Harrisburg, Pa.: Levees on Susquehanna River for flood protection.....	109,000	Plans prepared. Authorized by Congress.
Williamsport, Pa.: Levees on West Branch of Susquehanna River for flood protection.....	2,600,000	Do.
York, Pa.: Retarding dams on Codorus Creek.....	2,600,000	Do.
<i>Pollution:</i>		
Canton, Pa.: Sewage treatment plant.....	50,000	
Cardiff, Md.: Sewer system and sewage treatment plant.....	25,000	
Cherry Valley, N. Y.: Sewage treatment plant.....	50,000	
Cortland, N. Y.: Sewage treatment plant.....	314,000	
Harrisburg, Pa.: Sewage treatment plant.....	1,200,000	
Huntingdon, Pa.: Sewage treatment plant.....	150,000	
Mount Union, Pa.: Sewage treatment plant.....	420,000	
Nanticoke, Pa.: Sewage treatment plant.....	400,000	
Sayre, Pa.: Sewage treatment plant.....	160,000	
Spring Garden Township, York County, Pa.: Sewer system.....	795,000	
Tyrone, Pa.: Sewage treatment plant.....	180,000	
Wilkes-Barre, Pa.: Sewage treatment plant.....	1,300,000	
Williamsport, Pa.: Sewage treatment plant.....	700,000	
York, Pa.: Improvements to sewage treatment plant.....	150,000	
<i>Water supply:</i>		
Greenwood, Pa.: Reservoir and water supply system.....	136,000	
Lebanon, Pa.: Water filtration plant.....	250,000	

MIDDLE ATLANTIC

Water-supply and sewage-disposal improvements constitute the chief immediate steps in water-conservation programs for the basins of the rivers flowing into the Atlantic between the Potomac River at the north and the Edisto River at the south. The boundary between Piedmont Plateau and Coastal Plain divides these drainage areas into two provinces from the standpoint of water problems. Hydroelectric-power generation and erosion control are outstanding problems on the Piedmont. On the Coastal Plain, prospective programs relate in large measure to drainage for malaria control and to local navigation improvements. In both provinces projects bearing on municipal sanitation overshadow other specific undertakings in number and present importance.

The outstanding current need of the district is for sewage-treatment plants at small and medium-sized communities. In most basins there are towns which lack public water supplies, sewers, or sewage-disposal facilities. A few of the large urban areas—notably Cumberland and the suburban areas of Washington and Baltimore—require extensions of present water-supply systems. Many cotton milling and other manufacturing towns of the Piedmont have grown rapidly and have not made provision for sanitary disposal of domestic and industrial waste. During periods of low water flow some of the streams in that section are heavily polluted. Stream pollution is less serious on the Coastal Plain because of small urban population, less irregular stream flow, and greater utilization of underground waters for municipal supplies. At Beaufort, S. C., however, and at Hampton Roads, Va., pollution has assumed proportions which have necessitated restrictions on shellfishing. A number of treatment plants to correct, in part, these unsanitary conditions are recommended in the accompanying project list. Initiation of pollution-control projects in the deferred priorities should, if practicable, await completion of basin-wide pollution surveys for the entire district. Essential data on sources of pollution, degree of waste dilution, stream flow, and the economic effects of pollution are now lacking. Surveys of this type should be undertaken promptly and should be supplemented later by investigations to determine the quality and availability of underground and surface waters from the standpoint of possible use by municipalities.

Although the streams of the Piedmont in the Carolinas have been utilized extensively for hydroelectric power, large undeveloped power resources remain in

the Carolinas, the Virginia and Maryland section of the Piedmont, and the Shenandoah Valley. Additional installations of 300,000 kilowatts on the upper Santee River, 235,000 kilowatts on the Yadkin-Peedee system, and 1,030,000 kilowatts on the Potomac River have been investigated, together with possible installations on the Roanoke, Meherrin, James, and minor streams. Doubt has been cast on the feasibility of these programs because the possible market for the power to be generated may be absorbed by other projects under construction or proposed. Heretofore, the programs have been studied intensively only from the standpoint of individual drainage basins. All possible power developments in the Middle Atlantic district and contiguous areas should be examined in relation one to another, and in relation also to competing steam-plant generation and to prospective markets for power. A comprehensive survey of this nature should precede construction of new power plants, and is recommended. No recommendation is included in this report concerning the Santee-Cooper Power and Navigation Project since that proposal has already been approved by the President and is now in litigation.

The soils of the Piedmont generally are susceptible to heavy erosion under improper cropping practices. The resultant soil losses injure agriculture, and contribute in unknown degree to reservoir silting, to the turbidity of streams, and to clogging of small stream channels. Quantitative investigations of these relationships between soil erosion and water utilization are needed.

Malaria control through drainage is an outstanding public-health problem in the Carolina and Virginia portions of the Coastal Plain and in scattered parts of the Piedmont where heavy silting of stream channels has occurred. County-wide drainage projects planned by the respective State boards of health are recommended for early execution. Projects in other counties where malaria causes heavy losses should be drawn up following further studies which would give due attention to the restoration or abandonment of old drainage systems.

In general, the navigation facilities of the district are as well developed as warranted by transportation requirements. Small-scale channel improvements have been authorized by the Congress in a number of tidal estuaries along the coast, chief of which are the Potomac and the James.

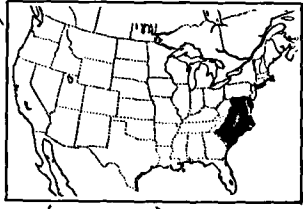
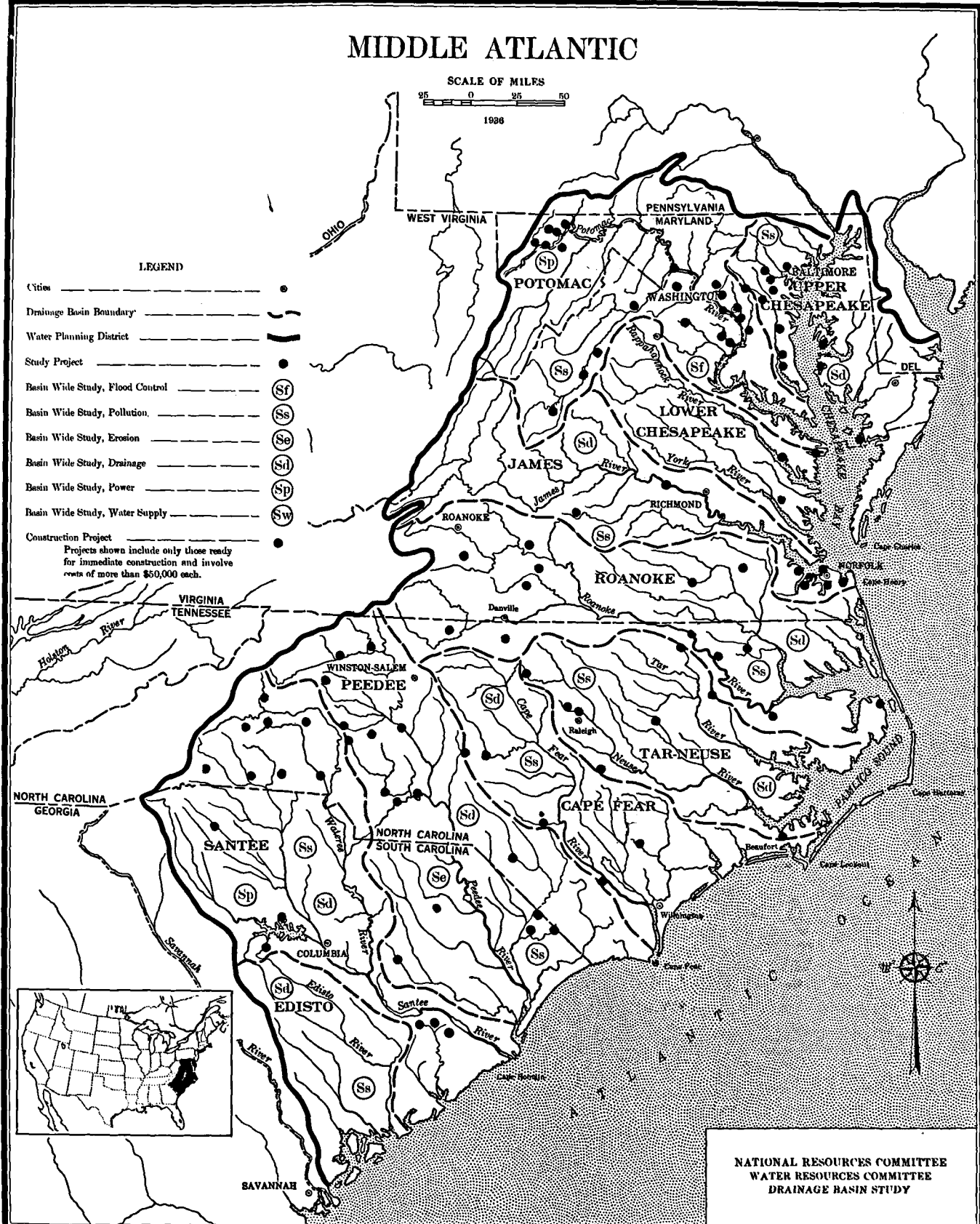
MIDDLE ATLANTIC

SCALE OF MILES



1986

- LEGEND**
- Cities ———— ●
 - Drainage Basin Boundary ————
 - Water Planning District ————
 - Study Project ———— ●
 - Basin Wide Study, Flood Control ———— (Sf)
 - Basin Wide Study, Pollution ———— (Ss)
 - Basin Wide Study, Erosion ———— (Se)
 - Basin Wide Study, Drainage ———— (Sd)
 - Basin Wide Study, Power ———— (Sp)
 - Basin Wide Study, Water Supply ———— (Sw)
 - Construction Project ———— ●
- Projects shown include only those ready for immediate construction and involve costs of more than \$50,000 each.



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Middle Atlantic Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Upper Chesapeake:		
<i>Drainage:</i> Comprehensive study of drainage problems in the basin.....	\$5,000	Cooperative investigation by State and Federal agencies.
<i>Pollution:</i> Comprehensive study of stream pollution problems in the basin.....	50,000	For protection of oyster beds.
Potomac:		
<i>Drainage:</i> Comprehensive study of drainage problems in the basin.....	8,000	Cooperative investigation by State and Federal agencies.
<i>Pollution:</i> Preparation of basin-wide program for pollution control in conjunction with flood control, navigation, and power development.	300,000	Recommended in report of advisory committee on water pollution, and endorsed by State departments of health.
<i>Water supply:</i> Georges Creek Valley, Md.: Development of metropolitan district for water and sewerage.....	10,000	Preliminary plans made.
James:		
<i>Drainage:</i> Comprehensive study of drainage problems in the basin.....	5,000	Cooperative investigation by State and Federal agencies.
<i>Pollution:</i> Comprehensive study of stream pollution problems in the basin.....	10,000	
Roanoke:		
<i>Drainage:</i> Comprehensive study of drainage problems in the basin.....	14,000	Do.
<i>Pollution:</i> Comprehensive study of stream pollution by municipal and industrial wastes in the basin.....	15,000	
Tar-Neuse:		
<i>Drainage:</i> Comprehensive study of drainage problems, both for land use and mosquito control.....	6,000	Do.
<i>Pollution:</i> Comprehensive study of stream pollution by municipal and industrial wastes.....	8,000	
Cape Fear:		
<i>Drainage:</i> Comprehensive study of drainage problems in the basin.....	4,000	Do.
<i>Pollution:</i> Comprehensive study of stream pollution caused by municipal and industrial wastes.....	5,000	Do.
Peedee:		
<i>Drainage:</i> Comprehensive study of drainage problems in the basin.....	12,000	Do.
<i>Pollution:</i> Comprehensive study of stream pollution by municipal and industrial wastes and soil erosion in the basin.	18,000	Do.
Santee:		
<i>Drainage:</i> Comprehensive study of drainage problems in the basin.....	16,000	Do.
<i>Pollution:</i> Comprehensive study of stream pollution by municipal and industrial wastes in the basin.....	32,000	Do.
Edisto:		
<i>Drainage:</i> Basin-wide study of potential drainage, both for land use and mosquito control.....	5,000	
<i>Pollution:</i> Basin-wide study of stream pollution.....	5,000	Do.
2. Construction Projects		
Upper Chesapeake:		
<i>Drainage:</i> Baltimore, Md.: Lafayette Avenue storm drain.....	623,000	Plans completed.
<i>Navigation:</i> Annapolis, Md.: Dredging channel 15 feet deep, 100 feet wide, in Severn River and Anchorage Basin in Opa Creek.	24,000	Survey completed.
<i>Pollution:</i> Baltimore, Md.: Jones Fall intercepting sewer.....	2,024,000	Plans completed.
Baltimore, Md.: Boston Street and Bayliss Street sewers and sewage disposal for Camp Holabird.....	241,000	Do.
Baltimore County metropolitan district, Md.: Sewer system extensions.....	750,000	Preliminary plans made.
Baltimore County, Md.: Montrose School for Girls: Sewer system extensions.....	4,000	Plans completed.
Berterton, Chesapeake City, Church Hill, East New Market, Elkridge, Ellicott City, Hampstead, Manchester, Mardela Springs, Hillsboro, North East, Oxford, Princess Anne, Public Landing, Queen Anne, Queenstown, Rock Hall, Round Bay and Severna Park, St. Michaels, and Secretary, Md.: Sewer systems and sewage treatment plants.	821,000	
Brooklyn Park, Md.: Sewer system.....	125,000	Do.
Cambridge, Md.: Sewage treatment plant.....	105,000	Do.
Cambridge, Md.: Sewage treatment plant for Eastern Shore State Hospital.....	30,000	
Chesapeake Beach and North Beach, Md.: Sewer system and sewage treatment plant.....	150,000	No plans have been made.
Chestertown, Federalsburg, and Springfield State Hospital, Md.: Sewer system extension.....	165,000	Plans completed for Federalsburg and Chestertown only.
Crisfield, Md.: Sewer system extensions and sewage treatment plant additions.....	120,000	
Crowsville, Md.: Relief outfall sewer.....	12,000	Plans completed.
Easton, Md.: Sewage treatment plant.....	125,000	Preliminary plans made.
Henryton Tuberculosis Sanatorium, Maryland Training School for Colored Girls, and Rosewood, Md.: Sewage treatment plant additions.	50,000	
Maryland House of Correction, Maryland Training School for Boys, and Ridgely, Md.: Sewage treatment plants.	122,000	
Ocean City, Md.: Sewer system extensions and sewage treatment plant additions.....	250,000	Partial plans made.
West Annapolis, Md.: Sewer system.....	57,000	Plans completed.

Middle Atlantic Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Upper Chesapeake—Continued.		
<i>Water supply:</i>		
Betterton, Charlotte Hall, Chestertown, and Edgewood Arsenal, Md.: Water supply extensions.....	\$95,000	
Bowie, Cecilton, Church Hill, Chesapeake City, Galena, Goldsboro, Hebron, Hillsboro, Mardela Springs, Marion, Millington, North East, Prince Frederick, Queen Anne, Round Bay and Severna Park, Solomons, Stillpond, Sudlersville, Sykesville, and Upper Marlboro, Md.: Water supply systems.....	571,000	
Chesapeake Beach and North Beach, Md.: Water supply systems.....	100,000	No plans have been made.
Crownsville and Ellicott City, Md.: Water supply extensions and filtration.....	115,000	
Washington Suburban Sanitary District, Md.: Water supply development from Patuxent River.....	275,000	Plans completed.
<i>Potomac:</i>		
<i>Flood control:</i>		
Cumberland, Md.: Levees and diversion for flood protection.....	887,000	Authorized by Congress.
Harpers Ferry, W. Va.: Levees and walls.....	169,000	Do.
Moorestown, W. Va.: Levees and walls.....	47,000	Do.
Washington, D. C.: Levees and grade raising for flood protection.....	587,000	Do.
<i>Navigation:</i>		
Washington, D. C.: Deepening harbor channels to 24 feet.....	173,000	Do.
Washington, D. C.: Potomac River waterfront.....	1,650,000	Survey completed. Authorized by Congress.
Westmoreland, Va.: Nomini Creek. Dredging channel.....	10,000	Authorized by Congress.
<i>Pollution:</i>		
Alexandria, Va.: Construction of sewers and partial treatment plant.....	250,000	Preliminary report made.
Cumberland, Md.: Sewage treatment plant.....	300,000	No detailed plans made.
Falls Church, Va.: Sewer system and sewage treatment plant.....	170,000	Plans completed.
Leesburg, Va.: Construction of sewers and complete treatment plant.....	140,000	Preliminary report made.
Staunton, Va.: Sewage treatment plant.....	244,000	Plans completed.
Washington Suburban Sanitary District, Md.: Anacostia River and Little Falls Branch.....	925,000	Preliminary plans made.
Waynesboro, Va.: Construction of sewers and complete sewage treatment plant.....	100,000	Preliminary report made.
<i>Restoration:</i>		
Restoration of Chesapeake & Ohio Canal as recreational waterway and extension of George Washington Memorial Parkway.....	9,100,000	Authorized by Congress in part.
<i>Water supply:</i>		
Adamstown, Cheltenham, Libertytown, Keedysville, Sharpburg, Waldorf, Walkersville, and Vindex, Md.: Water supply systems.....	185,000	No plans made.
Beltsville, Md.: National agriculture-research center. Additions to present waterworks system.....	90,000	Plans not completed
Beltsville, Md.: U. S. Bureau of Plant Industry. Improvement and extension of waterworks and irrigation systems.....	46,000	
Buckeystown, Kitmillersville, Lewistown, Point of Rocks, and Woodsboro, Md.: Water supply systems.....	125,000	No plans made.
Crabbottom, Va.: Development of springs and construction of mains.....	9,000	Plans completed.
Cresaptown, Md.: Water-supply system.....	100,000	Preliminary plans made.
Cumberland, Md.: Everts Creek development. Additional water supply.....	1,000,000	Do.
Cumberland and upper Potomac River, Md.: Savage River Dam for regulating flow of Potomac River.....	1,600,000	Plans in preparation.
Fairfield, Fannettsburg, Iron Springs, Marion, McKnightstown, Mont Alto, Quincy, Scotland, and Wellersburg, Pa.: Water-supply systems.....	222,000	No plans made.
Herndon, Va.: Water-supply system.....	68,000	Preliminary plans made.
Kinsale, Va.: Water-supply system.....	30,000	No plans made.
Luray, Va.: Construction of mains and development of new water supply.....	60,000	Preliminary plans made.
Marshall, Va.: Development of new water supply.....	39,000	Do.
Washington Suburban Sanitary District, Maryland: Great Seneca Creek water-supply development.....	650,000	Do.
Washington Suburban Sanitary District, Maryland: Paint Branch water-supply development.....	160,000	Do.
Winchester, Va.: Development of water supply from Cedar Creek.....	532,000	Plans completed.
Lower Chesapeake:		
<i>Drainage:</i>		
Essex, Gloucester, King and Queen, and Middlesex Counties, Va.: Cleaning of Dragon River to improve flow and for mosquito control.....	81,000	Preliminary survey made.
<i>Flood control:</i>		
Madison County, Va.: Clearing river channels for flood control.....	7,000	Survey completed.
<i>Navigation:</i>		
King and Queen, King William, Lancaster, Middlesex, and Northumberland Counties, Va.: Dredging navigation channels in Mattaponi River, Carters Creek, Mill Creek, and Cockrells Creek.....	98,000	Surveys completed.
<i>Water supply:</i>		
Parkley, Va.: Waterworks system.....	39,000	Preliminary plans made.
James:		
<i>Drainage:</i>		
Charles City, Chesterfield, Dinwiddie (Petersburg), Goochland, Hanover (Ashland), Henrico (Highland Springs), James City (Williamsburg), Norfolk, Powhatan, Princess Anne, Prince Edward, and Prince George Counties, Va.: Drainage for mosquito control.....	126,000	Preliminary surveys made.
<i>Navigation:</i>		
Hampton Creek and Phoebus Channels, Va.: Dredging to improve navigation.....	88,000	Survey made. Authorized by Congress.
James River, Va.: Dredging 25-foot channel from Hopewell to Richmond.....	1,186,000	Cost is given for first 2 years. Additional needed to complete, \$61,000. Survey completed.
Richmond, Va.: James River, dredging channel above city wharf for navigation.....	29,000	Plans completed.
<i>Pollution:</i>		
Albemarle County, Va.: Sewer system and sewage treatment plant for Fry Springs sanitary district.....	84,000	Preliminary plans made.
Campbell County, Va.: Partial sewage treatment plant for Brookville sanitary district.....	95,000	Do.
Fort Monroe, Va.: Sewage treatment plant.....	52,000	Survey completed.
Hampton, Newport News, Norfolk, Phoebus, Portsmouth, South Norfolk, etc., Va.: Combined project for sewers and sewage treatment plant.....	8,000,000	Preliminary survey made.
Keoughtan, Va.: Sewage treatment plant.....	25,000	Survey in progress.
Virginia Beach, Va.: Sewage treatment plant.....	150,000	Preliminary only.
<i>Water supply:</i>		
Fort Monroe, Va.: Improvement of Big Bethel water supply.....	145,000	Preliminary sketches made.
Keoughtan, Va.: Renewal of water supply system.....	12,000	Survey in progress.
Windsor, Va.: Water supply system.....	24,000	Plans completed.
Roanoke:		
<i>Drainage:</i>		
Bedford, Charlotte, Dinwiddie, Greensville, Lunenburg, Mecklenburg, Prince George, Princess Anne, Southampton, and Sussex Counties, Va.: County-wide drainage projects.....	137,000	Preliminary plans made.
<i>Pollution:</i>		
Charlotte Court House, Va.: Sewer system, and sewage treatment plant.....	24,000	Plans completed.
Halifax Court House, Va.: Sewer system and sewage treatment plant.....	19,000	Preliminary report ready.
Schoolfield, Va.: Sewer system.....	25,000	Plans not started.
Waverly, Va.: Sewer system and sewage treatment plant.....	96,000	Preliminary report ready.
Roanoke County Va.: Sewer system for Williamson Road sanitary district.....	271,000	Plans completed.

Middle Atlantic Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Roanoke—Continued.		
<i>Pollution and water supply:</i>		
Bedford County, Va.: 5 septic tanks and 9 wells for county schools.....	\$17,000	Plans completed.
Blackstone, Va.: Water supply, sewer system, and sewage treatment plant.....	125,000	Do.
Colerain, N. C.: Water supply system, sewers, and sewage treatment plant.....	31,000	Do.
Crosswell, N. C.: Water supply and sewer systems.....	47,000	Do.
Gatesville, N. C.: Water supply system, sewers, and sewage treatment plant.....	25,000	
Halifax, N. C.: Water supply system, sewers, and sewage treatment plant.....	68,000	
Manteo, N. C.: Water and sewer systems.....	73,000	Do.
Rich Square, N. C.: Water supply system, sewers, and sewage treatment plant.....	104,000	Preliminary plans made.
Seaboard, N. C.: Water supply system, sewers, and sewage treatment plant.....	67,000	Do.
Stoneville, N. C.: Water supply system, sewers, and sewage treatment plant.....	75,000	Do.
Yanceyville, N. C.: Water supply system, sewers, and sewage treatment plant.....	64,000	Do.
<i>Water supply:</i>		
Columbia, N. C.: Extensions to water supply system.....	41,000	
Halifax, Va.: Water supply system.....	52,000	Plans completed.
LaCrosse, Va.: Water supply system.....	38,000	Do.
Pittsylvania County, Va.: Water supply, 8 wells at county schools.....	6,000	Plans not started.
Plymouth, N. C.: Water supply system.....	65,000	Preliminary plans made.
Powellsville, N. C.: Water supply system.....	11,000	Do.
Winton, N. C.: Water supply system.....	87,000	Do.
Tar-Neuse:		
<i>Pollution:</i>		
Hillsboro, N. C.: Sewer system.....	96,000	
Middlesex, N. C.: Sewer system.....	31,000	
Raleigh, N. C.: Sewage treatment.....	790,000	Do.
Stantonsburg, N. C.: Sewer system.....	40,000	Do.
Tarboro, N. C.: Sewage treatment.....	245,000	Do.
<i>Pollution and water supply:</i>		
Battleboro, Creedmoor, Everett, Farmville, Four Oaks, Grimesland, Nashville, Oriental, Pikeville, Pink Hill, Princeton, Stem, Vanceboro, Walstonburg, Winterville, and Youngsville, N. C.: Water supply and sewer systems.....	966,000	
Wilson, N. C.: Water supply and sewer system.....	998,000	Do.
<i>Water supply:</i>		
Garner, N. C.: Water supply system.....	35,000	
Selma, N. C.: Water supply system.....	74,000	Do.
Cape Fear:		
<i>Navigation:</i>		
Smith's Creek, N. C.: Dredging channel.....	11,000	Surveys completed.
<i>Pollution:</i>		
Durham, N. C.: Sewage treatment works extension.....	350,000	Report and estimates in preparation.
Jonesboro, N. C.: Sewage treatment plant.....	51,000	
Morehead City, N. C.: Sewage treatment plant.....	231,000	Preliminary plans and estimates made.
<i>Pollution and water supply:</i>		
Archdale and Trinity, N. C.: Water supply system and sewage treatment plants.....	173,000	
Beulaville, N. C.: Water supply and sewer systems.....	33,000	
Cameron, N. C.: Water supply and sewer systems.....	27,000	
Carthage, N. C.: Water supply system and sewage treatment plant.....	58,000	
Garland, N. C.: Water supply system and sewage treatment plant.....	33,000	
Hope Mills, N. C.: Water supply system and sewage treatment plant.....	80,000	
Liberty, N. C.: Waterworks extensions and sewage treatment plant.....	18,000	
Rose Hill, N. C.: Water supply system and sewage treatment plant.....	67,000	Do.
Salemberg, N. C.: Water supply system and sewage treatment plant.....	40,000	Do.
Peedee:		
<i>Drainage:</i>		
Chesterfield, Clarendon, Darlington, Dillon, Florence, Georgetown, Harry, Lee, Marion, Marlboro, Sumter, and Williamsburg Counties, S. C.: Drainage for malaria control.....	280,000	Preliminary plans made.
<i>Pollution:</i>		
Albemarle, N. C.: Sewage treatment plant and incinerator.....	280,000	Do.
Benton Heights, N. C.: Sewer system and sewage treatment plant.....	36,000	
Concord, N. C.: Sewage treatment plant.....	195,000	
Darlington, S. C.: Sewage treatment plant.....	75,000	Do.
Loris, S. C.: Sewer system and sewage treatment plant.....	58,000	Do.
Loris, S. C.: Sewer system and sewage treatment plant.....	81,000	Do.
Rockingham, N. C.: Sewage treatment plant.....	293,000	Do.
Statesville, N. C.: Sewage treatment plant and extensions to sewer system.....		
<i>Pollution and water supply:</i>		
Clarkton, N. C.: Water supply and sewer system; sewage treatment plant.....	40,000	
Denton, N. C.: Water supply and sewer system; sewage treatment plant.....	86,000	
Fair Bluff, N. C.: Water supply and sewer system.....	76,000	
Landis, N. C.: Water supply and sewage systems; sewer treatment plant.....	176,000	
Mooresville, N. C.: Extensions to water supply and sewer systems; sewage treatment plant enlargement.....	127,000	
Oakboro, N. C.: Water supply and sewer system; septic tanks.....	60,000	Do.
Parkton, N. C.: Water supply and sewer system; treatment plant.....	49,000	Do.
Pembroke, N. C.: Water supply and sewer system; sewage treatment plant.....	57,000	Do.
Pilot Mountain, N. C.: Water supply and sewer system; Imhoff tank.....	127,000	Do.
Rockwell, N. C.: Water supply and sewer system; sewage treatment plant.....	60,000	Do.
Rural Hall, N. C.: Water supply and sewer system; sewage treatment plant.....	73,000	Do.
Sumter, S. C.: Sewage treatment plant and extensions to water supply and sewer systems.....	96,000	Do.
Tabor City, N. C.: Sewer system with treatment plants; water supply extension.....	104,000	Do.
<i>Water supply:</i>		
Bladenboro, N. C.: Water supply system.....	38,000	
Shallotte, N. C.: Water supply system.....	38,000	Do.
Santee:		
<i>Drainage:</i>		
Berkeley, Calhoun, Charleston, Clarendon, Dorchester, Lexington, Richland, Sumter, and Williamsburg Counties, S. C.: Drainage for malaria control.....	160,000	Do.
Charleston ordinance depot, South Carolina: Drainage project and filling swamp area for mosquito control.....	7,000	
Davidson Creek drainage district, Iredell and Mecklenburg Counties, N. C.: Drainage project.....	18,000	
<i>Erosion:</i>		
Calhoun County, S. C.: Soil erosion control.....	225,000	Preliminary plans made.
<i>Pollution:</i>		
Belmont, N. C.: Sewage treatment plant.....	30,000	Plans and estimates made.
Hickory, N. C.: Sewage treatment plant.....	216,000	
Lenoir, N. C.: Sewage treatment plant.....	251,000	
Morganton, N. C.: Sewage treatment plant.....	120,000	Preliminary plans made.
Summerville, S. C.: Sewer system and sewage treatment plant.....	113,000	Preliminary plans completed.
Tryon, N. C.: Sewage treatment plant.....	100,000	Preliminary plans made.

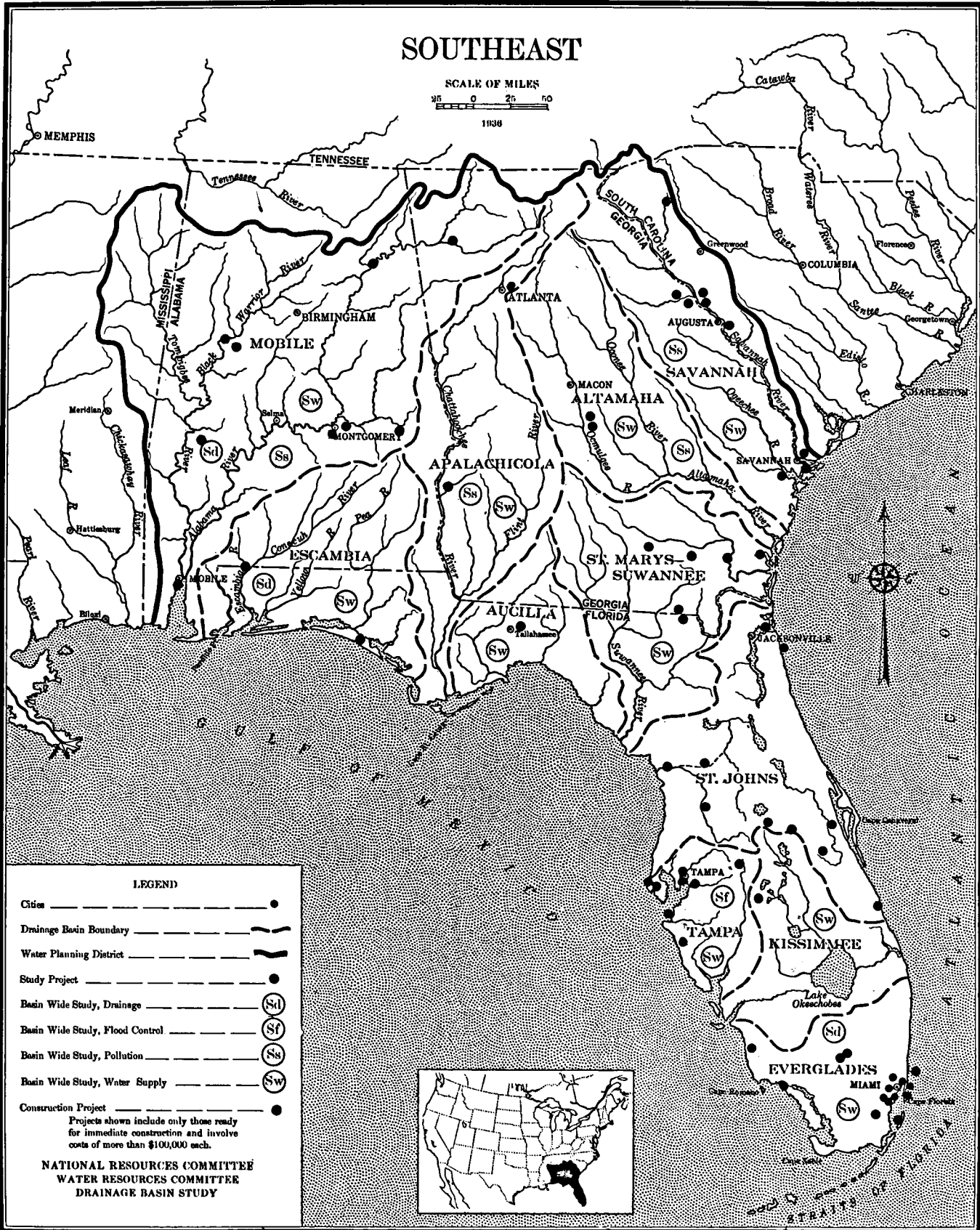
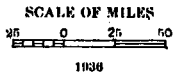
Middle Atlantic Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Santee—Continued.		
<i>Pollution and water supply:</i>		
Camp Jackson, near Columbia, S. C.: Water supply and sewer systems.....	\$140,000	Preliminary plans made.
Kings Mountain, N. C.: Extensions to water supply and sewer systems; new sewage-treatment plant.....	98,000	Do.
Moncks Corner, S. C.: Water supply and sewer systems and sewage-treatment plant.....	69,000	Do.
Pineville, N. C.: Water supply and sewer systems.....	62,000	Do.
St. Stephen, S. C.: Water supply and sewer systems and sewage-treatment plants.....	53,000	Do.
Tucapau, S. C.: Water supply and sewer systems.....	82,000	Do.
Valdese, N. C.: Water supply and sewer systems.....	108,000	
<i>Water supply:</i>		
Charlotte, N. C.: Extension of filtration plant and raw water supply; ground storage and elevated storage for clear water.....	1,000,000	No plans made.
Claremont, N. C.: Water-supply system.....	38,000	
Ebenezer, S. C.: Water-supply system.....	17,000	Preliminary plans completed.
Ellenboro, N. C.: Water-supply system.....	38,000	
Greenville, S. C.: Water-supply system (Westville water and sewer subdistrict).....	21,000	Do.
Leesville, S. C.: Water-supply system.....	51,000	Preliminary plans made.
Long View, N. C.: Water-supply system.....	60,000	Do.
Matthews, N. C.: Water-supply system.....	36,000	
Sullivans Island, S. C.: Water-supply system.....	133,000	Do.
Waxhaw, N. C.: Water-supply system.....	38,000	Do.
Edisto:		
<i>Drainage:</i>		
Aiken, Allendale, Bamberg, Barnwell, Beaufort, Calhoun, Colleton, Dorchester, Edgefield, Hampton, Jasper, Lexington, Orangeburg, and Saluda Counties, S. C.: Drainage work throughout Edisto Basin for malaria control.....	250,000	Do.
<i>Pollution:</i>		
Hampton, S. C.: Sewer system and sewage treatment plant.....	49,000	Do.
<i>Water supply:</i>		
Bowman, S. C.: Water supply system.....	27,000	Do.
Norway, S. C.: Water supply system.....	27,000	Do.
Olar, S. C.: Water supply system.....	27,000	Do.
Sycamore, S. C.: Water supply system.....	11,000	Do.
Yemassee, S. C.: Water supply system.....	33,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION		
Upper Chesapeake:		
<i>Drainage:</i>		
Baltimore, Md.: Vail Street storm drain.....	\$60,000	Preliminary plans made.
<i>Flood control:</i>		
Salisbury, Md.: Flood gates and spillway at Shoemakers Pond.....	20,000	Do.
<i>Pollution:</i>		
Baltimore County metropolitan district, Maryland: Sewer system extensions and sewage treatment plant.....	750,000	Do.
Baltimore, Md.: Chesapeake outfall sewer.....	4,158,000	Do.
Bowie, Cecilton, Fairlee, Galena, Goldsboro, Hebron, Marion, Millington, Prince Frederick, Solomons, Still Pond, Sudlersville, Sykesville, Trappe, and Upper Marlboro, Md.: Sewer systems and sewage treatment plants.....	373,000	Plans have not been made for any of these projects except Goldsboro, which has partial plans.
Denton, Mount Airy, Pocomoke City, and Snow Hill, Md.: Sewer system extensions and sewage treatment plants.....	190,000	Plans complete for Mount Airy, and partial plans for Denton, Pocomoke City, and Snow Hill.
Ferndale, Glen Burnie, Homewood-Germantown, Linthicum Heights, and Overlook, Md.: Sewer system extensions.....	42,000	Preliminary plans made for each project.
Salisbury, Md.: Sewage treatment plants.....	250,000	Plans have not been made.
Sharptown and Vienna, Md.: Sewage treatment plant.....	50,000	Partial plans made for each project.
<i>Water supply:</i>		
Baltimore, Md.: Raise Loch Raven water supply reservoir.....	17,200,000	Preliminary plans made.
Baltimore, Md.: Strengthen Loch Raven-Montebello water supply tunnel.....	1,800,000	Do.
Fairlee, Md.: Water supply system.....	20,000	Plans have not been made.
Washington suburban sanitary district, Maryland: Additional water supply on Patuxent.....	1,000,000	Preliminary plans made.
Potomac:		
<i>Pollution:</i>		
Adamstown, Boonsboro, Brunswick, Clear Spring, Cresaptown, Funkstown, Keedysville, La Plata, Leonardtown, Libertytown, Myersville, New Windsor, Taneytown, Thurmont, Union Bridge, and Walkersville, Md.: Sewer systems and sewage treatment plants.....	605,000	
Arlington Experiment Farm, Broadway, Front Royal, Herndon, Lorton, Middleburg, and Shenandoah, Va.: Sewer systems and sewage treatment plants.....	230,000	Complete plans for Broadway, Front Royal, Herndon, Lorton, and Shenandoah; plans not complete for Middleburg; no detailed plans for Arlington Experiment Farm.
Buckeystown, Kitzmillersville, Lewistown, Point of Rocks, Sharpsburg, Vindex, Waldorf, and Woodsboro, Md.: Sewer systems and sewage treatment plants.....	190,000	No plans made.
Colonial Beach, Dayton, Elkton, Harrisonburg, Luray, Monterey, Stanley, Stephens City, and Stuarts Draft, Va.: Sewer systems and provision for partial treatment of sewage.....	315,000	Preliminary report made.
Edinburg, Fort Belvoir, Mount Jackson, Purcellville, Round Hill, Strasburg, Timberville, Vienna, and Woodstock, Va.: Sewer systems and provision for treatment of sewage.....	255,000	Do.
Greencastle, Hyndman, Littletown, McConnellsburg, and Mercersburg, Pa.: Sewer systems and primary treatment plants.....	425,000	No plans made.
Lower Chesapeake Bay:		
<i>Drainage:</i>		
Caroline, Essex, Gloucester, Hanover, King William, Lancaster, Middlesex, Northumberland, Richmond, Spotsylvania, Westmoreland, and York Counties, Va.: Drainage work for mosquito control.....	30,000	Preliminary surveys made.
<i>Erosion:</i>		
Langley Field, Va.: Sea wall to protect laboratory.....	100,000	Preliminary plans made.
<i>Navigation:</i>		
Lancaster and Mathews Counties, Va.: Complete channel in creek at Mathews, and build two jetties at Windmill Creek.....	14,000	Surveys completed.
<i>Pollution:</i>		
Bowling Green, Cape Charles, Chincoteague, Gloucester, Gordonsville, Madison, Marshall, Mineral, Onancock, Parksley, Reedville, Sperryville, and Washington, Va.: Sanitary sewers and sewage treatment plants.....	390,000	Preliminary report made.
Orange, Va.: Sewage treatment plant for complete treatment.....	20,000	Do.
Urbanna and West Point, Va.: Sewage treatment plants.....	40,000	Do.
<i>Water supply:</i>		
Acomaco and Eastville, Va.: Water supply, wells, and distributing systems.....	55,000	Do.

Middle Atlantic Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
James:		
<i>Flood control:</i> Amelia, Cumberland, and Prince Edward Counties, Va.: Flood protection, project on creeks at the following locations: Farmville, Little Guinea, Sandy and Flat Creeks.	\$6,000	Plans completed.
<i>Navigation:</i> Lafayette River, Va.: Dredging yacht basin.....	16,000	Surveys made.
Menchville, Va.: Dredging Deep Creek for navigation.....	34,000	Survey completed.
<i>Pollution:</i> Amelia, Appomattox, Amherst, Buchanan, Burkeville, Chester, Charlottesville, Claremont, Clifton Forge, Colonial Heights, Craigsville, Crozet, Fincastle, Glasgow, Goshen, Highland Springs, Iron Gate, Lovingsston, Millboro, Newcastle, Smithfield, Stanardsville, and Windsor, Va.: Sewer systems and sewage-treatment plants.	750,000	No plans made.
<i>Water supply:</i> Amelia and Appomattox, Va.: Water-supply systems.....	58,000	Do.
Roanoke:		
<i>Pollution:</i> Roanoke, Va.: Sewage-disposal plant.....	250,000	Preliminary investigation made.
Altavista, Bassett, Bedford, Boones Mill, Boykins, Cambria, Chase City, Chatham, Crewe, Danville, Dendron, Franklin, Ivor, Keysville, Lacrosse, Martinsville, Salem, Shawsville, South Boston, Stony Creek, Stuart, Surry, and Vinton, Va.: Sewer systems and sewage-treatment plants.	760,000	Do.
<i>Water supply:</i> Bassett, Va.: New wells for water supply.....	40,000	Preliminary study made.
Tar-Neuse:		
<i>Flood control:</i> Baker's Mill, N. C.: Flood control on Little River.....	873,000	Preliminary surveys and estimates made.
Falls, N. C.: Flood control on Neuse River.....	1,332,000	Do.
Wiggin's Mill, N. C.: Flood control on Contentnea Creek.....	625,000	Do.
Wilson Mills, N. C.: Flood control on Neuse River.....	1,460,000	Do.
<i>Navigation:</i> Bayboro, N. C.: Cleaning and improving Bay River Channel for navigation.....	9,000	Surveys completed.
Tarboro to Rocky Mount, N. C.: Cleaning and dredging of Tar River Channel for 39 miles.....	83,000	Plans and surveys made.
Cape Fear:		
<i>Navigation:</i> Morehead City, N. C.: Harbor inlet jetties.....	1,000,000	Survey completed; construction delayed pending further observations of inlet-scour.
Pamlico Sound to Beaufort, N. C.: Dredging channel to Atlantic, North Carolina.....	13,000	Surveys completed.
Peedee:		
<i>Drainage:</i> Lee County, Ashwood Rural Community, S. C.: Drainage.....	29,000	Preliminary plans completed.
<i>Navigation:</i> Georgetown County, S. C.: Dredging navigable channel of Winyab Bay.....	136,000	Plans completed.
<i>Pollution:</i> Lake City, S. C.: Sewage treatment plant.....	40,000	Preliminary plans completed.
Myrtle Beach, S. C.: Sewer system and sewage treatment plant.....	200,000	Do.
<i>Water supply:</i> Greasleyville, S. C.: Water supply system.....	31,000	Do.
Olanta, S. C.: Water supply system.....	29,000	Do.
Santee:		
<i>Navigation:</i> Charleston, S. C.: Dredging channel of Ashley River, 7¼ miles long from mouth of river to Standard Wharf, for navigation.	340,000	Surveys completed.
<i>Pollution:</i> Lancaster, S. C.: Sewage-treatment plant.....	170,000	Preliminary plans made.
<i>Pollution and water supply:</i> Pelzer, S. C.: Water-supply and sewer extensions.....	204,000	Do.
Edisto:		
<i>Drainage:</i> Orangeburg and suburbs, South Carolina: Storm drainage, deepening and widening ditches.....	26,000	Do.
Orangeburg County, S. C.: Clearing 10 miles of South Fork Edisto River Channel; and 23 miles of North Fork Edisto River Channel.	35,000	Plans completed.
<i>Pollution:</i> Beaufort, S. C.: Sewage-treatment plant.....	50,000	Recommend further study.
Orangeburg, S. C.: Sewage-treatment plant.....	125,000	No plans made.

SOUTHEAST

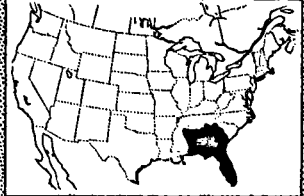


LEGEND

- Cities ——— ●
- Drainage Basin Boundary ———
- Water Planning District ———
- Study Project ——— ●
- Basin Wide Study, Drainage ——— (Sd)
- Basin Wide Study, Flood Control ——— (Sf)
- Basin Wide Study, Pollution ——— (Sp)
- Basin Wide Study, Water Supply ——— (Sw)
- Construction Project ——— ●

Projects shown include only those ready for immediate construction and involve costs of more than \$100,000 each.

**NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY**



SOUTHEAST

Promotion of the public health by abatement of pollution in streams and bays, improvement of dwindling and unpotable water supplies, and drainage of malaria-infested lowlands are dominant water-resource needs of the southeast district. Improvements of these types are the objectives of most of the construction and study projects recommended in the accompanying project list. The needs for public sanitation outweigh those for beach-erosion control and for coastal-navigation facilities. They likewise overshadow the prospective needs for integrated programs of river regulation in upland areas.

Municipal sewer, sewage-disposal, and water-supply facilities have failed to keep pace with the growth of population and with technical improvements in many towns and cities of the Piedmont manufactural area, in commercial centers of the coastal plain of Alabama and Georgia, and in the fast-growing recreational resorts of Florida. Some urban areas are without sewer facilities. Others have sewer systems inadequate to carry away the rainfall from intense storms. Still others discharge raw or partially treated wastes into streams which serve as a source of water for cities or into coastal waters which support fisheries. The water supplies of certain cities on the coastal plain in Alabama and Georgia—many of them highly mineralized—are threatened by overdraft on underground reserves, and by salt contamination. In many municipalities in the Piedmont section inadequate wells should be replaced by reliable sources. Plans are now available for widespread extensions of sewer systems to communities hitherto unserved, for plants to treat raw sewage, for plants to treat relatively unpotable water, and for extension of water mains and water-storage facilities. Miami, Tampa, Tallahassee, Macon, and scores of smaller municipalities are involved.

Malaria takes a relatively heavy annual toll of human life, vigor, and comfort throughout parts of the district, especially in rural and small urban communities. Its incidence may be reduced materially by drainage of low-lying swamps, marshes, borrow pits, and other areas of stagnant water which serve as breeding grounds for the *Anopheles* mosquito. Individual drainage projects for this purpose are small in size, but they bulk large in the aggregate. They should be prosecuted widely and should be carried out judiciously in accordance with State- or basin-wide programs. Drainage of this type is not to be confused with drainage for agriculture, a large proportion of which has been unsuccessful in the southeast district.

Although a number of specific programs for municipal sanitation and malaria control are shown in the accompanying project list, a much larger volume of work remains which cannot be undertaken with confidence until comprehensive studies of pollution conditions, surface and underground water supplies, and drainage have been made in both Piedmont and Coastal Plain sections. Data concerning pollution and water supply are notably deficient, especially in Georgia.

Soil erosion has long been responsible for the depletion of agricultural resources in the Piedmont section of Georgia and in the uplands of Alabama, but surveys are lacking on which remedial work related primarily to water conservation might be based.

Beach-erosion control and navigation improvements are of moment at scattered points along the Gulf and Atlantic coasts of the district. Beach-protection works and studies looking to the preparation of designs for such works are essential to prevent the loss of commercial and recreational areas subject to rapid erosion during recurrent Gulf storms. Segments of the intra-coastal waterway for small and medium-sized craft as authorized by the Congress are now incomplete. Steps to complete this coastal channel are recommended, together with a few harbor improvements.

In the basins of the streams flowing into Mobile Bay, the Apalachicola River, the Savannah River, and other upland streams of Alabama and Georgia, plans for the integrated development of river-regulation works for hydroelectric power, flood control, municipal water supply, and navigation doubtless will loom large in the future. In general, immediate construction of this kind is not in order because basin-wide studies looking toward multiple use of water are incomplete, because competitive aspects of the power market in the southeastern area demand that a careful survey be made before new hydroelectric plants are constructed, and because the requisite economic justification for additional navigation improvements is doubtful. Initiation of the Clark Hill project on the Savannah River and of other proposed hydroelectric plants should await completion of the recommended power-market survey.

Construction operations on the proposed Florida ship canal have been suspended due to lack of Congressional authorization. A further investigation of the project is in progress, however, and additional data upon the relation of the canal to underground water supplies are being collected. The committee reserves its recommendation pending review of those reports.

Southeast Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Savannah Basin:		
<i>Water power:</i> Clark Hill, Ga.: Project for flood control, navigation, and power development; investigation of engineering and economic aspects.		To be included in general study of the power situation and of the proposed power projects in the Southeastern states.
<i>Flood control:</i> Study to determine feasible methods of flood protection of area of 140,000 acres along Ogeechee River below the Canoochee River, Ga.	\$20,000	Preliminary studies made. Hearings scheduled.
<i>Pollution:</i> Augusta, Ga.: Study of extent of sewage pollution and health hazards.....	10,000	Cooperative investigation by State and local agencies.
Georgia and South Carolina: Study to determine extent to which pollution endangers public health throughout the Savannah Basin.	50,000	Cooperative investigation by State and Federal agencies.
Savannah, Ga.: Study of extent of sewage pollution and health hazards.....	10,000	Cooperative investigation by State and local agencies.
Altamaha:		
<i>Pollution:</i> Study to determine extent of pollution and to formulate a policy regarding sewage treatment in the Altamaha Basin, Ga.	30,000	
St. Marys-Suwannee:		
<i>Pollution:</i> Brunswick, Ga.: Study to determine proper plans for sewage-treatment plant.....	5,000	
Waycross, Ga.: Study to determine type and cost of sewage-treatment plant and sewer system....	5,000	No plans.
<i>Water supply:</i> Study to determine the desirability of establishing swamp reservoirs in Okefenokee Swamp to serve as the source of recharging the underground water supply in Georgia and Florida.	30,000	Do.
St. Johns:		
<i>Erosion (coastal):</i> Study to prepare plans and estimates for control of beach erosion, North Atlantic Coastal Slope at Amelia Island (Fernandina Beach), Fort George Island, Jacksonville Beach, and vicinities.	50,000	
<i>Flood control:</i> Study to determine method for flood control on the Withlacoochee River.....	2,000	
<i>Navigation:</i> Study of Atlantic-Gulf Ship Canal, Florida: Navigation project to provide intercoastal ship canal-dredging jetties and accessory works.		Now under investigation.
Study to determine plans for the improvement of navigation on the St. Johns River at or near Sanford, Fla., to Tampa, Fla., via Kissimmee and Alafia Rivers and Tampa Bay. Also, St. Johns River to Kissimmee River, Fla., and thence to Okeechobee. Cross-Florida canal channel: Navigation improvement; dredging.	5,000	
Study of surveys to determine cost and location of additional channels connecting the St. Johns River Basin and the Intra-coastal Waterway (East Coast Waterway) for navigation, flood control, and recreation by dredging and flood gates.	50,000	
Tampa:		
<i>Erosion (coastal):</i> Bradenton, Fla.: Studies and plans for beach erosion control.....	5,000	
<i>Flood control:</i> Basin-wide flood control studies.....	25,000	
Everglades:		
<i>Erosion:</i> Everglades Drainage Basin: Soil conservation, controlled drainage and irrigation.....	25,000	
<i>Flood control:</i> Bonita Springs, Lee County, Fla.: Flood-control studies.....	5,000	
Dade County, Fla.: Flood-control studies in vicinity of Miami River.....	5,000	
<i>Navigation:</i> Florida Bay to Caloosahatchee River: Navigation channel.....	10,000	Would materially assist in development of Everglades National Park.
<i>Recreation and wildlife:</i> Everglades National Park and adjoining areas: Study of problems of management and development.	100,000	Joint study by interested agencies.
Apalachicola:		
<i>Pollution:</i> Study and survey of stream pollution throughout the basin to formulate policy regarding sewage treatment and to determine extent of pollution.	30,000	
Escambia:		
<i>Drainage:</i> Study of drainage for malaria control in specific areas with high malaria incidence.....	10,000	Pertains to construction project.
Mobile:		
<i>Drainage:</i> Study to determine drainage and reclamation projects necessary for malaria and mosquito control throughout the basin.	50,000	
<i>Pollution:</i> Study to determine means for pollution control of streams by gathering data on domestic and industrial waste throughout the basin.	50,000	
2. Construction Projects		
Savannah:		
<i>Drainage:</i> Aiken County, S. C.; Candler County, Ga.; Hampton and Jasper Counties, S. C.; Jefferson and McIntosh Counties, Ga.: Malaria control and drainage.	399,000	Under varying degrees of completion.
Augusta, Ga.: Channel improvements in Rocky Creek to improve drainage and sanitary conditions.	151,000	Plans and specifications completed.
<i>Erosion (coastal):</i> Fort Screven, Ga.: Seawall to prevent beach erosion.....	92,000	Study completed.
<i>Flood control:</i> Augusta, Ga.: Completion of earth levee and concrete retaining wall for flood protection.....	685,000	Plans completed. Authorized by Congress approximately 50 percent complete.
<i>Navigation:</i> Augusta, Ga.: Completion of lock and dam and bank protection for navigation on Savannah River below Augusta.	862,000	Surveys completed.
Savannah, Ga.: 30-foot navigation channel from ocean to city.....	467,000	Plans completed.
<i>Pollution:</i> Honea Path, S. C.: Improvements to waterworks system and sewage-treatment plant.....	40,000	Preliminary plans completed.
<i>Recreation and wildlife:</i> Savannah, Ga.: Water-impounding structures to provide migratory bird refuge.....	25,000	Do.
<i>Water supply:</i> Crawfordville, Ga.: Water supply and distribution system.....	33,000	

Southeast Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Altamaha:		
<i>Drainage:</i> Appling, Ben Hill, Bibb, Bleckley, Butts, Candler, Clarke, Clayton, Coffee, De Kalb, Dodge, Dooly, Glynn, Greene, Gwinnett, Jackson, Jasper, Jefferson, Johnson, Laurens, McIntosh, Oconee, Peach, Pulaski, Telfair, Treutlen, Twiggs, and Wayne Counties, Ga.: Drainage and malaria control.	\$485,000	Under varying degrees of completion.
Macon, Ga.: Trunk line storm sewer to eliminate open drains.....	270,000	Preliminary plans in progress.
<i>Pollution:</i> Macon, Ga.: Sewer system and sewage-treatment plant.....	178,000	Preliminary plans made.
St. Marys-Suwannee:		
<i>Drainage:</i> Alachua County, Fla.; Berrien County, Ga.; and Bradford County, Fla.: Construction of ditches and canals to drain agricultural lands.	25,000	Preliminary plans completed.
<i>Recreation and wildlife:</i> Brentley and Ware Counties, Ga.: Stream improvements, recreational lakes, game refuge, and forestry near Waycross, Ga.	203,000	Resettlement Administration likely to complete this project before fiscal year 1938.
<i>Water supply:</i> Madison and Mayo, Fla.; St. Marys, Ga., and Waldo, Fla.: Waterworks and distribution systems.....	121,000	Plans complete for St. Marys, Ga., and Madison, Fla. Preliminary plans only for Waldo and Mayo, Fla.
Trenton, Fla.: Waterworks and sewer system.....	30,000	Plans completed. Awaiting decision of Supreme Court on Senate Bill 515.
St. Johns:		
<i>Drainage:</i> Camp Foster near Yukon; Duval County, East Palatka, Jacksonville and Polk County, Fla.: Malaria and mosquito elimination.	203,000	Plans for Camp Foster project completed. Preliminary plans completed.
Duval, Putnam, St. Johns, and Volusia Counties, Fla.: Drainage for agricultural purposes.....	175,000	Preliminary plans completed.
<i>Erosion:</i> Neptune Beach, Fla.: Erosion control by construction of concrete seawall.....	111,000	Do.
<i>Navigation:</i> Cedar Key, Fla.: Dredging harbor for improvement of navigation.....	4,000	Estimated cost given is amount needed for completion.
Jacksonville, Fla.: Dredging channel Jacksonville to Palatka for improvement of navigation.....	14,000	Do.
Jacksonville, Fla.: Dredging channel of St. Johns River to ocean for improvement of navigation.....	330,000	Do.
Leesburg, Fla.: Dredging channel of Ocklawaha River from St. Johns River to Leesburg for improvement of navigation.	36,000	Do.
Port Inglis, Fla.: Dredging channel of Withlacoochee River from Port Inglis to mouth for improvement of navigation.	100,000	Do.
<i>Pollution:</i> Leesburg, Fla.: Sewage-treatment plant.....	90,000	Preliminary plans completed.
Tavares, Fla.: Sewer system.....	82,000	Do.
Vero Beach, Fla.: Sewage-treatment plant.....	149,000	Do.
<i>Pollution and water supply:</i> Atlantic Beach, Port Orange and Winter Garden, Fla.: Waterworks systems.....	177,000	Do.
Camp Foster, near Yukon, Fla.: Extension of sewer and waterworks systems.....	69,000	Plans completed.
Jacksonville Beach, Fla.: Extension of water and sewer systems.....	47,000	Preliminary plans completed.
<i>Water supply:</i> Fruitland Park, Fla.: Extension of waterworks system.....	14,000	Do.
Orlando, Fla.: Waterworks extensions.....	617,000	Do.
Tampa:		
<i>Erosion (coastal):</i> Clearwater, Fla.: Construction of groins to protect and build up beaches.....	160,000	Study completed.
<i>Pollution:</i> Clearwater, Fla.: Extensions and improvements to sewer system.....	316,000	
Sarasota, Fla.: Extensions to sewer system.....	115,000	
Tampa, Fla.: Improvement to existing sewer system and installation of sewage-treatment plant.....	1,450,000	
Tampa, Fla.: Improvements to storm-sewer system.....	164,000	
<i>Water supply:</i> Tampa, Fla.: Improvements and extensions to water-supply system.....	1,760,000	
Winter Haven, Fla.: Improvement to water-supply system and sewage-treatment plant.....	160,000	
Everglades:		
<i>Drainage:</i> Dade County, Highland Section, Fla.: Drainage and water control.....	74,000	
<i>Erosion:</i> Delray Beach, Fla.: Retaining wall along intracoastal waterway to prevent bank erosion.....	23,000	
<i>Navigation:</i> Miami to Florida Bay, Fla.: Intracoastal waterway, 7-foot channel.....	130,000	Survey completed. Authorized by Congress.
Miami Harbor—Biscayne Bay, Fla.: Deepening harbor channels.....	800,000	Authorized by Congress: \$2,200,000 has been spent on project.
Port Everglades—Hollywood Harbor, Fla.: Dredging 35-foot channel.....	930,000	Surveys completed. Authorized by Congress.
<i>Pollution:</i> Miami, Fla.: Sewage-treatment plant.....	5,000,000	
Miami Beach, Fla.: Storm sewer for relief of flood conditions.....	391,000	
<i>Recreation and wildlife:</i> Everglades, Fla.: Establishment of national park.....	1,000,000	
<i>Water supply:</i> Miami, Fla.: Extensions to water-supply system for increasing distribution.....	500,000	
Miami, Fla.: 2 additional reservoirs for water supply.....	110,000	
Miami Beach, Fla.: Extensions to water-supply system for additional supply.....	407,000	
South Miami, Fla.: Water-supply system for Greater Miami area.....	221,000	
Aucilla:		
<i>Pollution:</i> Tallahassee, Fla.: Extension to sewer system.....	265,000	Plans completed.
Thomasville, Ga.: Sewage-treatment plant and improvement to sewer system.....	94,000	Do.
<i>Water supply:</i> Cross City, Fla.: Water-supply system.....	36,000	Do.
Apalachicola:		
<i>Drainage:</i> Chattahoochee, Clay, Clayton, Coweta, Crawford, Crisp, Decatur, De Kalb, Dooly, Early, Fayette, Hall, Harris, Macon, Meriwether, Mitchell, Muscogee, Seminole, Talbot, Troup (2), Terrell, Taylor, Turner, and Worth Counties, Ga.: Malaria control.	491,000	Plans for most of the projects completed.
<i>Pollution:</i> Fort Gaines, Ga.: Sewer system.....	34,000	Plans completed.
Marianna, Fla.: Sewage-collecting system and treatment plant.....	65,000	Do.
Chipley, Ga.: Sewer system.....	18,000	Do.
Zebulon, Ga.: Sewer system and treatment plant.....	16,000	Do.

Southeast Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Apalachicola—Continued.		
<i>Pollution and water supply:</i>		
Cleveland, Ga.: Waterworks, sewer system, and sewage-treatment plant.....	\$39,000	Plans completed.
Cumming, Ga.: Water supply and sewer systems.....	44,000	Do.
<i>Water supply:</i>		
Ashford, Ala.: Water-supply system.....	28,000	Do.
Atlanta, Ga.: Filtration plant.....	695,000	Preliminary plans completed.
Butler, Ga.: Water-supply system.....	22,000	Do.
Cottontdale, Fla.: Water-supply system.....	36,000	Do.
Demorest, Ga.: Water-supply system.....	32,000	Do.
Eufaula, Ala.: Dam and storage reservoir, water-treatment plant, and mains.....	105,000	Plans completed. Land acquired.
Fort Benning, Ga.: Improvement to waterworks.....	105,000	Preliminary study made. Land acquired.
Fort Benning, Ga.: New storage reservoir.....	75,000	Preliminary sketches made. Land acquired.
Meansville, Ga.: Water-supply system.....	24,000	Plans completed.
Midway, Ala.: Water-supply system.....	31,000	Do.
Port St. Joe, Fla.: Water-supply system.....	36,000	Do.
Senola, Ga.: Well, elevated tank and distribution system for water supply.....	36,000	Preliminary plans completed.
Union City, Ga.: Water-supply system.....	25,000	Do.
Escambia:		
<i>Flood control:</i>		
Flomaton, Ala.: Levees or improvement of flood channels.....	154,000	Authorized by Congress.
Brewton, Ala.: Levees or improvement of flood channels.....	242,000	Do.
<i>Navigation:</i>		
Choctawhatchee Bay to West Bay, Fla.: Intracoastal waterway extension; dredging 26-mile channel 100 feet wide, 9 feet deep.....	770,000	Plans under way. Authorized by Congress.
<i>Pollution:</i>		
Dohan, Ala.: Improvements to sewer system.....	48,000	
Frisco City, Ala.: Sewer system with septic tank.....	30,000	
Milton, Fla.: Sewage-treatment plant for primary treatment.....	44,000	Plans completed.
Pensacola, Fla.: Improvements to sewer system.....	84,000	Do.
<i>Water supply:</i>		
Pensacola, Fla.: Additional water supply with installation of new wells.....	26,000	Do.
Mobile:		
<i>Drainage:</i>		
Drainage for malaria control throughout the basin.....	1,968,000	Preliminary plans completed. This is dependent upon study project.
<i>Drainage and navigation:</i>		
Itawamba County, Miss.; Jefferson County, Ala.; Lee and Monroe Counties, Miss.: Drainage canal projects for mosquito control, land reclamation and channel improvement.....	188,000	Plans completed.
<i>Navigation:</i>		
Clark and Washington Counties, Ala.: Dredging cut-off canal at Sunflower bend on the Tombigbee River from mile 78 to mile 90 for navigation and flood control.....	335,000	Plans completed. Cost includes \$37,000 for land and damages.
Clark and Washington Counties, Ala.: Dredging channel for 8-foot depth on the Tombigbee River from mouth to dam and lock no. 1 at mile 111, for navigation and flood control.....	30,000	Plans completed. Authorized by Congress. Under construction.
Tombigbee-Warrior Rivers, Ala.: Installing temporary 1-foot flashboard on dams no. 1 to no. 9, inclusive, to increase channel depth from mouth to lock no. 10.....	36,000	Plans completed. Authorized by Congress.
Tuscaloosa County, Ala.: Construction of new dam and lock no. 10 on Warrior River at mile 361 near Tuscaloosa, Ala., to replace dams nos. 10, 11, and 12.....	2,550,000	Plans completed. Authorized by Congress. Amount needed to complete project. Cost includes \$25,000 for land and damages.
<i>Pollution:</i>		
Alexander City, Ala.; Baldwin, Miss.; and Berry, Boaz, Camden, Fort Payne, Gadsden (Club Heights), Grove Hill, Hamilton, Livingston, Oakman, Talladega, Ala.: Sewer systems and extensions.....	448,000	Plans completed.
Attalla, Blocton, Cordova, Goodwater, Jacksonville, Jasper, Leeds, Linden, Opelika, and Sylacauga, Ala.: Sewer systems or extensions.....	455,000	Do.
Auburn and Jasper, Ala.: Sewage-treatment plants.....	97,000	Preliminary plans completed.
Gadsden, Ala.: Sewage-treatment plant.....	390,000	Do.
Montgomery, Ala.: Sewage-treatment plant for complete treatment.....	220,000	Plans completed.
<i>Pollution and water supply:</i>		
Akron and Ashville, Ala.; LaFayette, Ga.; and Pine Hill, and Wadley, Ala.: Waterworks and sewer systems.....	258,000	Do.
<i>Water supply:</i>		
Blocton, Center, Eclectic, Lafayette, and Wilton, Ala.: Water-supply systems.....	190,000	Do.
Boston, Brent, and Cuba, Ala.; East Tupelo, Miss.; Gordo, Haleyville, Helena, Jackson, and Kennedy, Ala.; Maben, Miss.; Marion, Montgomery, Oakman, Pleasant Grove, and Ragland, Ala.; Sallito, Miss., Talladega and Wilsonville, Ala.: Waterworks and water-supply systems or extensions.....	611,000	Do.
Montgomery, Ala.: Improvements and extensions to waterworks system, including 6 wells, pumps, and storage tank.....	340,000	Do.
Rome, Ga.: Improvements and extensions to waterworks system.....	240,000	Do.
Tuscaloosa, Ala.: Extensions to waterworks system.....	47,000	Do.
Tuskegee, Ala.: Water supply and waterworks improvements.....	113,000	Do.

GROUP B—FOR DEFERRED CONSTRUCTION

Savannah:		
<i>Drainage:</i>		
Hartwell, Ga.: Deepen channels, ditch swampy ground, and eliminate mosquito-breeding places.....	\$32,000	Plans and specifications ready.
Savannah River Basin, Ga. and S. C.: Malaria control, drainage and maintenance to continue present program.....	775,000	No plans.
<i>Erosion:</i>		
Georgia and South Carolina: Soil and water conservation by reforestation, terracing, and other methods of controlling erosion throughout the basin.....	2,000,000	First program of operation subject to results of preliminary survey.
<i>Pollution:</i>		
Abbeville, Allendale, S. C.; Brooklet, Ga.; Central, S. C.; Claxton, Ga.; Edgefield, S. C.; Guyton, Ga.; Liberty, McCormick, S. C.; Midville, Millen, Newington, Ga.; North Augusta, S. C.; Pembroke, Ga.; Pickens, S. C.; Pooler, Rocky Ford, Ga.; Seneca, Springfield, S. C.; Sylvania, Ga.; Walhalla, S. C.; Waynesboro, Ga., and Westminster, S. C.: Sewage collection and treatment works.....	690,000	Reported by State boards of health as needed to promote public health.
<i>Water power:</i>		
Abbeville, S. C.: Dam generating plant, transmission lines; dam located 15 miles west of city, on Rocky River.....	435,000	Awaiting compliance of town to acquire improved property.
Westminster, S. C.: Hydroelectric plant, 4½ miles west of city; dam and reservoir.....	118,000	Further study necessary to determine feasibility of project.

Southeast Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Savannah—Continued.		
<i>Water supply:</i>		
Augusta, Ga.: Additions to water distribution system and modernization of treatment plant.....	\$201,000	Study necessary before plans can be completed.
Brooklet, Claxton, Louisville, Midville, Millen, Pembroke, Sandersville, Savannah, Statesboro, Wadley, Ga.: Waterworks additions and extensions. Hilltonia, Portal, and Twin City, Ga.: Water supplies.	390,000	
Wrens, Ga.: Improvements to waterworks system and sanitary sewers.....	75,000	Do.
<i>Miscellaneous:</i>		
Walhalla, S. C.: Extension of fish cultural facilities at hatchery, 24 miles from Walhalla.....	25,000	U. S. Bureau of Fisheries has completed plans.
Altamaha:		
<i>Drainage:</i>		
Lower Altamaha Basin, Ga.: Malaria control.....	610,000	
<i>Water supply:</i>		
Adrian, Alamo, Baxley, Cochrane, Collins, Glennville, Hawkinsville, Hazlehurst, Helena, Jesup, Lumber City, Lyons, Reidsville, Soperton, Swainsboro, Tennille, Vidalia, Wrightsville, Ga.: Waterworks additions and extensions. Ludowici, Ga.: Water supply.	570,000	
St. Marys-Suwannee:		
<i>Drainage:</i>		
Appling, Atkinson, Bacon, Ben Hill, Berrien, Brantley, Brooks, Camden, Clinch, Colquitt, and Coffee Counties, Ga.; Hamilton County, Fla.; Lanier and Lowndes Counties, Ga.; Madison, Suwannee, and Taylor Counties, Fla.; Tift, Turner, Wayne, and Worth Counties, Ga.: Ditches and canals to drain swamp areas for malaria control.	828,000	Preliminary plans only prepared. Actual plans not to be made until work progresses.
<i>Flood control:</i>		
Alachua, Bradford, and Union Counties, Fla.: Widening and straightening existing channels for flood control.	48,000	Preliminary plans completed.
<i>Pollution:</i>		
Douglas, Ga.: Sewer system and sewage-treatment plant.....	28,000	Plans and specifications completed.
<i>Recreation and wildlife:</i>		
Okfeokee migratory waterfowl refuge, Georgia and Florida: Construction of dam and improvements.	103,000	
<i>Water supply:</i>		
Branford, Fla.: Waterworks and system, including deep well and tank.....	29,000	Do.
MacClenny, Fla.: Waterworks and Diesel engine power plant.....	65,000	Preliminary plans completed.
Broxton and Douglas, Ga.: Waterworks improvements.....	60,000	
St. Johns:		
<i>Flood control:</i>		
Duval, Lake, Orange, and Pasco Counties, Fla.: Improvement of creek channels and canals.....	120,000	Do.
St. Augustine, Fla.: Flood control by construction of dam and spillway.....	15,000	Do.
<i>Erosion:</i>		
St. Johns River, Fla.: Protection of shore line by rock revetment.....	88,000	Under consideration by War Department.
<i>Navigation:</i>		
Melbourne, Fla.: Dredging new channel and turning basin of Melbourne Harbor and Inlet and Crane Creek for improvement of navigation.	12,000	Plans completed.
<i>Recreation:</i>		
Welaka, Fla.: Conservation project—Fish hatchery and game farm; construction of 50 acres of rearing ponds and accessory plant.	235,000	
Winter Garden, Fla.: Dredging canal from Winter Garden to Lake Apopka in connection with park improvements and recreation.	21,000	Preliminary plans prepared.
Klssimnee:		
<i>Drainage:</i>		
Glades County, Fla.: Drainage of agricultural lands in "Highlands" section.....	247,000	Further plans and study required.
Martin, Polk, and St. Lucie Counties, Fla.: Drainage projects for mosquito control.....	134,000	Plans insufficient. All interested agencies should be consulted.
Tampa:		
<i>Drainage:</i>		
Peace River Basin—Malaria and pest mosquito control by drainage in 6 counties.....	345,000	Plans insufficient. Further study necessary.
<i>Erosion (coastal):</i>		
Boca Ciega, Fla.: Construction of groins to protect beaches and improvements.....	216,000	Study almost completed by Beach Erosion Board.
<i>Navigation:</i>		
Charlotte Harbor, Fla.: Deepening and widening existing channel to 30 by 300 feet, from Gulf of Mexico to Boca Grande.	59,000	Surveys completed.
St. Petersburg Harbor, Fla.: Dredging channel 20 feet deep by 200 feet wide in Tampa Bay.....	123,000	
Clearwater and Sarasota, Fla.: Improvement and enlargement of ditches and canals for storm water drainage.	36,000	Plans insufficient. Further study necessary.
Everglades:		
<i>Drainage:</i>		
Fort Lauderdale, Fla. (in vicinity of Fort Lauderdale within Broward County anti-mosquito-control district): Drainage.	39,000	Further investigation required.
Monroe County, Fla.: Drainage for mosquito control.....	25,000	Do.
Ojus, Virginia Key and Tahiti Beach, Fla.: Mosquito control.....	78,000	Do.
Palm Beach County, Fla.: Drainage for mosquito control.....	39,000	Do.
<i>Flood control and navigation:</i>		
Fort Lauderdale, Fla.: New river channel to Fort Lauderdale, Fla.; intracoastal waterway for navigation and flood control.	40,000	Surveys and plans completed.
<i>Navigation:</i>		
Miami Harbor, Fla.: Extending present turning basin.....	300,000	Surveys completed.
Palm Beach, Fla.: Deepening port to 27 feet.....	448,000	
<i>Pollution:</i>		
Miami Beach, Fla.: Extension to sewer system.....	245,000	Plans completed.
Auclla:		
<i>Drainage:</i>		
Florida portion of basin: Drainage for malaria control.....	226,000	Plans not completed. Further study necessary.
Georgia portion of basin: Drainage for malaria control.....	117,000	Do.
<i>Navigation:</i>		
Dixie County, Fla.: Dredging channel 6 feet deep to Steinhatchee River.....	68,000	Do.
Increase depth of entrance channel to Steinhatchee River from 6 feet as now recommended to 9 feet.....	250,000	Do.
Wakulla County, Fla.: Dredging channel 10 feet deep to St. Marks River.....	75,000	Do.
Escambia:		
<i>Drainage:</i>		
Alabama portion of basin: Drainage for malarial mosquito control.....	328,000	Plans incomplete. Further study necessary. Should await completion of study project.
Florida portion of basin: Drainage for malarial mosquito control.....	146,000	Do.
<i>Flood control:</i>		
Caryville, Fla.: Flood-control improvements.....	139,000	Tentative plans ready.
<i>Navigation:</i>		
Pensacola Harbor, Fla.: Dredging channel and basin to provide refuge and repair basin for medium-sized vessels.	40,000	Surveys completed.

Southeast Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Mobile:		
<i>Drainage:</i>		
Dallas County, Ala.: Drainage for malaria control throughout the county.....	\$113,000	Plans being prepared.
Dallas and Lamar Counties, Ala.: Drainage canal for malaria control and land reclamation.....	83,000	Plans completed.
Montgomery County, Ala.: Drainage for malaria control throughout the county.....	124,000	Plans being prepared.
Mobile County, Ala.: Drainage for malaria control, land reclamation, and channel improvement of Three Mile Creek near Mobile.	300,000	Plans completed.
<i>Flood control:</i>		
Northport, Tuscaloosa County, Ala.: Levees.....	100,000	Preliminary survey completed.
Itawamba County, Miss.: Straightening river channel on East Fork of Tombigbee River near Fulton for flood control.	109,000	Do.
Rome, Ga.: Levees for flood control.....	330,000	Plans being prepared. Cost includes pumping equipment and changes in bridges, street levels, railroads, etc. Authorized by Congress.
<i>Pollution:</i>		
Gadsden, Ala.: Sewer-system extensions.....	200,000	Plans completed.
Homewood, Ala.: Sewer-system extension.....	96,000	Do.
<i>Water supply:</i>		
Bessemer, Ala.: New waterworks system and supply.....	1,018,000	Do.
Gadsden, Ala.: Improvements to waterworks system.....	96,000	Do.
Talladega, Ala.: Dam and reservoir for water supply.....	74,000	Plans being prepared.

TENNESSEE VALLEY

A comprehensive program for control of water in the Tennessee River for navigation, flood control and incidental power development is now under way. The completion of the system of dams already planned by the Tennessee Valley Authority will provide effective regulation of the main river. An all-embracing plan for development involving tributary rivers is still under investigation. Individual improvements of water supply, waste disposal, and malaria control have been planned by the respective State boards of health.

The annual rainfall and run-off in the Tennessee Basin are relatively heavy and their seasonal and annual distribution is highly irregular. The control of this irregular run-off according to an integrated plan for the purposes of navigation, flood control, and incidental power development is authorized in the Rivers and Harbors Act of 1930 and the T. V. A. Act as amended in 1935. Under these acts, the Tennessee Valley Authority has developed a program for the maintenance of a 9-foot navigable channel on the Tennessee River from Knoxville, Tenn., to its mouth, for the control of destructive floods in the Tennessee Valley and for reduction of flood crests along the lower Mississippi. In 1933, the pools behind Wilson Dam and Hales Bar Dam (a privately owned power development) provided the only 9-foot navigation facilities in the river. In order to complete the navigation project, the Authority has constructed, or has under construction, the Pickwick Landing Dam, Gunterville Dam, Chickamauga Dam, and the Wheeler Dam; each of them equipped with locks. There remain approximately 184 miles of lower and 120 miles of upper river which are unimproved. To meet these needs, locks and dams at Gilbertsville, Watts Bar, and Coulter Shoals are proposed as shown upon the accompanying map. The main stream structures are being supplemented by the construction of two dams on tributaries; the Norris Dam on the Clinch River and the Hiwassee Dam on the Hiwassee River. These will create tributary storage reservoirs which will be used to increase low-water flows and decrease flood flows reaching the main stream. A third tributary storage dam, the Fontana Dam on the Little Tennessee River, is recommended. The integrated operation of both groups of structures will result in the maintenance of an improved waterway, control of floods at Chattanooga and other points in the main valley, reduction of flood heights in the lower Mississippi River, and the generation of a large quantity of power. Hydroelectric units with a total capacity of about 400,000

kilowatts have been or will be installed at Norris, Wheeler, Pickwick Landing, Gunterville, and Chickamauga Dams. An installation of 184,000 kilowatts had been made earlier at Wilson Dam. At all dams intake openings probably will be provided for new generating units which may be installed if needed.

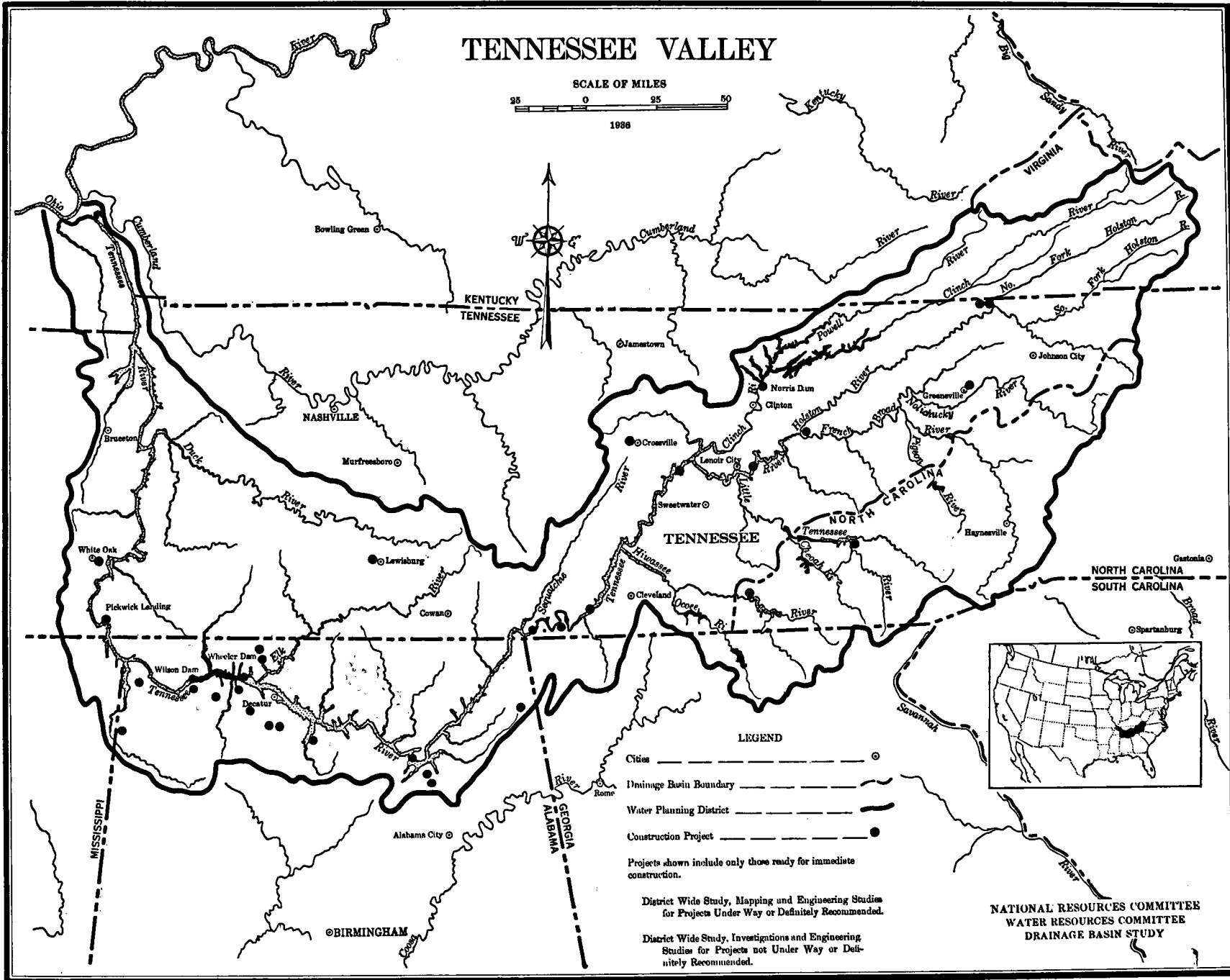
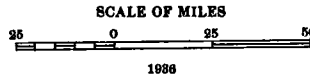
The Tennessee Valley Authority is now preparing a plan for the operation of these works when completed, and in addition is investigating the need for improvements on tributary streams. A few of the streams in the eastern section of the basin have been utilized in part by private interests for hydroelectric power, but the possible utilization of the remaining streams has not been explored fully. It may be expected that as a result of investigations to be made, comprehensive plans on a smaller scale will be outlined for the French Broad, Holston, Clinch, Elk, and Duck Rivers and for each of the other tributaries.

In addition to the work in progress for the regulation of the major rivers in the valley, numerous improvements in the interest of public health are being planned and carried on in scattered municipalities and farming areas of the valley. New water-supply systems and enlargements of old systems are needed at the places shown in the accompanying list of projects. Although stream pollution is not now a critical problem along the Tennessee River and its major tributaries because of sufficient stream flow to dilute raw sewage, a few localities now require new facilities for collection, treatment, and disposal of sewage.

The work of land drainage for malaria control is now under the direction of the respective State departments of health, and is supplemented by malaria-control activities undertaken by the Tennessee Valley Authority in its reservoir areas.

Complementary to its river regulation activities, the Tennessee Valley Authority is engaged in basin-wide soil-erosion control, forestry, agricultural demonstration, power marketing, and land planning studies. In the light of these studies, programs for land use and for the generation and sale of power are being developed. The Tennessee basin is the only river basin in the United States in which continuous investigation of the use and control of water and of related problems is maintained by the Federal Government through the medium of a single administrative agency. The Authority's accomplishments point to the ultimate unified development of the Tennessee River. The method of attaining that end remains an experiment in governmental administration of water resources.

TENNESSEE VALLEY



LEGEND

Cities ———— ○

Drainage Basin Boundary ————

Water Planning District ————

Construction Project ———— ●

Projects shown include only those ready for immediate construction.

District Wide Study, Mapping and Engineering Studies for Projects Under Way or Definitely Recommended.

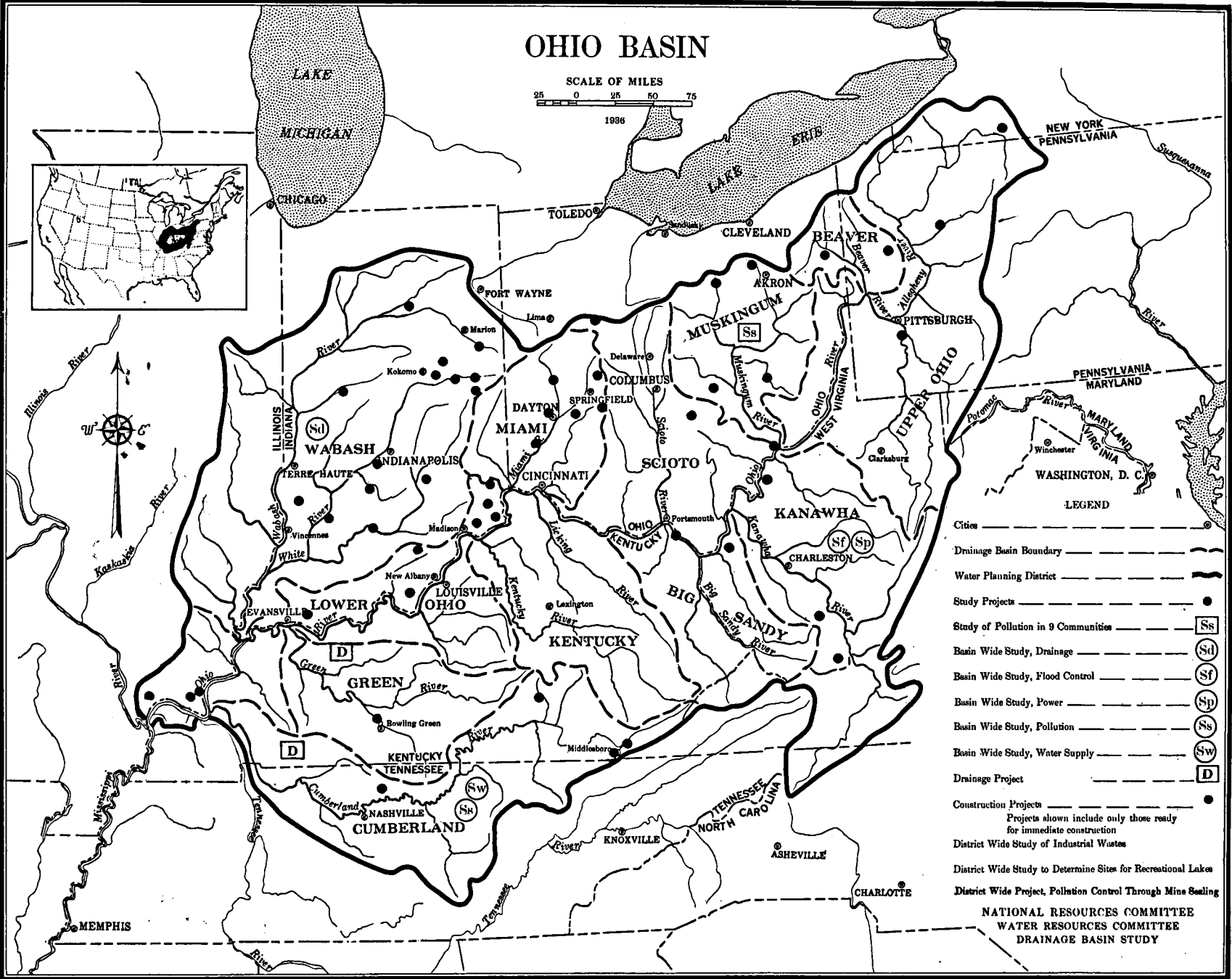
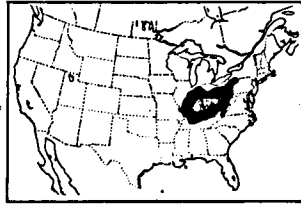
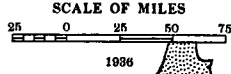
District Wide Study, Investigations and Engineering Studies for Projects not Under Way or Definitely Recommended.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Tennessee Valley Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Tennessee:		
<i>General problems:</i>		
Program of mapping, engineering studies, borings, and investigations needed for design in connection with construction projects now under way.	\$2,100,000	
Program of mapping, engineering studies, borings and foundation studies, and preparation of preliminary plans in connection with construction projects already definitely recommended.	1,400,000	
Program of surveys, investigations, engineering studies, borings, and preparation of preliminary plans and estimates for additional projects on major tributary streams of the Tennessee River, including the French Broad, Holston, Clinch, Little Tennessee, Hiwassee, Sequatchie, Elk, and Duck Rivers.	500,000	Preferably to be done concurrently with projects now under way. Essential for extending comprehensive plan of development to tributary streams.
2. Construction Projects		
<i>Flood control:</i>		
Bristol, Washington County, Va.: Flood control, stream clearance, and retaining wall.....	20,000	Plans completed.
<i>Flood control, navigation, and water power:</i>		
Chickamauga Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	24,008,000	Work in progress. Cost given is for next 2 years. Additional needed to complete dam and initial appurtenances, \$7,375,000.
Guntersville Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	23,697,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances.
Hiwassee Dam on Hiwassee River: Construction for navigation, flood control, and incidental power development.	7,900,000	Work in progress. Cost given is for next 2 years. Additional needed to complete dam and initial appurtenances, \$4,785,000.
Norris Dam on Clinch River: Construction for navigation, flood control, and incidental power development.	90,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances, including two 50,000-kilowatt generating units.
Pickwick Landing Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	8,950,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances, including two 36,000-kilowatt generating units.
Wheeler Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	3,856,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances, including two 32,000 kilowatt generating units.
<i>Pollution:</i>		
Albertville, Marshall County, Ala.: Sewer system.....	95,000	Preliminary plans prepared.
Boaz, Marshall County, Ala.: Sewer system.....	49,000	Do.
Bristol, Sullivan County, Tenn.: Sewage collection and treatment.....	750,000	Do.
Greeneville, Greene County, Tenn.: Sewage treatment plant and new outlet.....	250,000	Do.
Hartselle, Morgan County, Ala.: Sewer system.....	66,000	Do.
Lewisburg, Marshall County, Tenn.: Sewage treatment plant additions.....	26,000	Do.
Moulton, Lawrence County, Ala.: Sewer system and sewage treatment plant.....	40,000	Do.
Red Bay, Franklin County, Ala.: Sewer system and sewage treatment plant.....	38,000	Do.
<i>Water supply:</i>		
Cherokee and Leighton, Colbert County; Rogersville, Lauderdale County; and Town Creek, Lawrence County, Ala.: Waterworks and waterworks improvements.	115,000	
Courtland, Lawrence County, Ala.: Waterworks.....	29,000	Plans prepared.
Crossville, Cumberland County, Tenn.: Water supply; new source, treatment, and extensions.....	78,000	Preliminary plans prepared.
Moulton, Lawrence County, Ala.: Waterworks improvements.....	31,000	Plans prepared.
Sheffield and Tusculum, Colbert County, Ala.: Waterworks.....	297,000	Preliminary plans prepared.
GROUP B—FOR DEFERRED CONSTRUCTION		
Tennessee:		
<i>Flood control, navigation, and water power:</i>		
Fontana Dam on Little Tennessee River: Construction for navigation, flood control, and incidental power development.	\$8,225,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances (preliminary estimate only), \$20,775,000.
Gilbertsville Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	10,000,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances (preliminary estimate only), \$68,756,000.
Watts Bar Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	7,280,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances (preliminary estimate only), \$23,720,000.
Coulter Shoals Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	475,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances (preliminary estimate only), \$19,525,000.
<i>Drainage:</i>		
Beech River, Decatur, and Henderson Counties, Tenn., and Knoxville, Knox County, Tenn.: Drainage and ditch lining for malaria control.	175,000	
Chattanooga, Hamilton County, Tenn.: Lining of ditches for malaria control.....	100,000	Plans completed.
White Oak, Hardin County, Tenn.: Drainage for malaria control.....	25,000	Plans completed. Work begun in 1934, but discontinued due to lack of funds.
<i>Pollution:</i>		
Athens, McMinn County, Tenn.: Sewer system including sewage treatment plant.....	150,000	
Bristol, Washington County, Va.: Sewers and sewage treatment plant.....	300,000	
Bruceston, Carroll County, Tenn.: Sewage treatment plant.....	47,000	Preliminary plans prepared.
Cleveland, Bradley County, Tenn.: Sewer system improvements.....	200,000	
Cowan, Franklin County, Tenn.: Sewer system improvements and sewage treatment plant.....	75,000	
Fayetteville, Lincoln County; Jefferson City, Jefferson County; Manchester, Coffee County; Mount Pleasant, Maury County; Shelbyville, Bedford County; South Pittsburg, Marion County; Tullahoma, Coffee County, Tenn.: Sewer extensions, sewage treatment, and collecting plants; new installations and improvements.	618,000	
Hazelwood and Waynesville, Haywood County, N. C.: Sewage treatment plant.....	221,000	Do.
Johnson City, Washington County, Tenn.: Sewage treatment plant and new outfall sewer.....	350,000	
Sweetwater, Monroe County, Tenn.: Sewer system improvements and sewage treatment plant.....	50,000	
<i>Water supply:</i>		
Abingdon, Washington County, and Clintwood, Dickenson County, Va.; Englewood, McMinn County; Erwin, Union County, Jasper, Marion County, Tullahoma, Coffee County; and Waverly, Humphreys County, Tenn.: Water supply systems, improvements, and extensions.	290,000	
Athens, McMinn County, Tenn.: Water system improvements.....	100,000	
Cleveland, Bradley County, Tenn.: Water supply, new source and treatment.....	200,000	
Lenoir City, Loudon County, Tenn.: Water treatment plant.....	50,000	
Sweetwater, Monroe County, Tenn.: Water supply, improvements and treatment.....	35,000	
Washington County Sanitary District, Virginia: Water supply system.....	478,000	Plans prepared and project ready to advertise, except for some legal and other difficulties.

OHIO BASIN



- LEGEND
- Cities ———— ●
 - Drainage Basin Boundary ————
 - Water Planning District ————
 - Study Projects ———— ●
 - Study of Pollution in 9 Communities ———— [Ss]
 - Basin Wide Study, Drainage ———— [Sd]
 - Basin Wide Study, Flood Control ———— [Sf]
 - Basin Wide Study, Power ———— [Sp]
 - Basin Wide Study, Pollution ———— [Ss]
 - Basin Wide Study, Water Supply ———— [Sw]
 - Drainage Project ———— [D]
 - Construction Projects ———— ●
 - Projects shown include only those ready for immediate construction
 - District Wide Study of Industrial Wastes
 - District Wide Study to Determine Sites for Recreational Lakes
 - District Wide Project, Pollution Control Through Mine Sealing
- NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

OHIO BASIN

(Except the Tennessee Valley)

The Ohio River is a sewer, a source of water supply, an outlet for floods, and a highway. One-seventh of the population of the United States is concerned directly with the waters of the Ohio Basin, which present grave dangers and great opportunities.

The Ohio River system now furnishes the chief means of disposal for nearly all the waste products of the many communities that line its banks, and provides the water essential to the health of millions of people and to the operations of thousands of industrial plants. Pollution of the main river and some of its tributaries by untreated domestic sewage and industrial wastes is a constant and serious threat to public health. Acid drainage from mines complicates the problem. It is estimated that the sewage produced by 6,500,000 people drains to the Ohio River directly or through tributaries. Less than 30 percent of the sewage receives any treatment. On days of minimum flow, about one quart in every gallon of water in the main river at certain points has passed through a sewer system. This grossly polluted water after filtration is used as drinking water by 2,500,000 people. A determined attack on the pollution problem of the Ohio River system is imperative, and for that purpose various undertakings are included in the accompanying list of projects.

High floods have swept down the Ohio from time to time since the days of earliest settlement along its banks. It has contributed more than any other stream to the devastating floodwaters of the lower Mississippi. The unprecedented floods of March 1936 in parts of the upper basin focused public attention upon this problem and led to an insistent demand for remedial measures. A system of flood-control reservoirs on the tributaries would provide the most practical means of controlling the floods of the Ohio and its larger branches. Protection against major floods was provided years ago in the Miami drainage area and soon will be afforded in the Muskingum Basin by a system

of reservoirs now under construction. A comprehensive plan developed by the Corps of Engineers includes some 89 reservoirs for flood control and power production. Many of the possible benefits in flood control could be obtained by building 39 of these reservoirs, about half of which are judged to be economically justified at this time. Fourteen were authorized by the Congress in the Flood Control Act of 1936. Despite the conflict between the need of reservoir space for storage of floodwaters and for storage of water for other purposes, the integrated use of a *system* of large reservoirs for control of floodwaters, for augmentation of low flow, for power development, for water supply, and for recreation is possible. A study of such possibilities in the Ohio Basin is recommended. Its water problems are complex and inter-related. In few drainage areas, if any, is there greater need or greater opportunity to solve water problems in combination, and to provide simultaneously for multiple uses of water.

The Ohio River and some of its tributaries, notably the Monongahela, carry the heaviest river traffic in the country. Further improvement of the Ohio, including replacement of obsolete dams, changes to facilitate operation of locks and dams, channel dredging, and the like, are recommended for immediate or deferred construction. The most ambitious scheme of recent years for the creation of a new commercial waterway within and near the Ohio Basin calls for a canal through the Beaver, Mahoning, and Grand Rivers to connect Lake Erie with the Ohio River at an estimated cost of some \$165,000,000. The project is now being restudied by the Corps of Engineers. Because this study is incomplete, the project has not been considered for inclusion in the present plan.

Water recreational facilities are meager throughout the basin. Erosion is locally a serious problem, notably in the Muskingum drainage and in West Virginia.

Ohio Basin Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Ohio, general: <i>Flood control, low-water flow control, navigation, recreation, and water power:</i> District-wide investigation to plan an integrated system of reservoirs for multiple use.....	\$500,000	A continuation and expansion of previous surveys by the Corps of Engineers.
<i>Pollution:</i> Study of industrial wastes in Ohio Valley to determine points of most pollution, to devise means of handling industrial wastes, and to adopt a common policy in cooperation with industry in regard to corrective measures required.	50,000	
<i>Recreation:</i> Study to determine suitable sites for recreational lakes in relation to cost and accessibility to population.	50,000	Many proposed projects in need of classification.
Beaver: <i>Pollution:</i> Study in the Youngstown district on the Mahoning River of low flow augmentation, sewage treatment, and industrial wastes, with consideration of flood control.	50,000	Preliminary investigation has been made.
Muskingum: <i>Pollution:</i> Study to determine economic justification for and to devise means of removing industrial waste pollution from plants at Canton, Mansfield, Barberton, Massillon, Zanesville, Newark, Coshocton, Rittman, and Cambridge, Ohio.	15,000	
Miami: <i>Flood control, recreation, and wildlife:</i> Study of proposed reservoir for recreational use and possible flood control on Little Miami River..	5,000	
Wabash: <i>Drainage:</i> Study of drainage policy for Wabash Basin to determine whether additional land drainage is desirable, and whether some existing work should be abandoned.	25,000	A controversial question requiring thorough investigation.
<i>Flood control:</i> Study of flood protection for Indianapolis to determine what levees should be included and cost and benefit balance.	15,000	To include projects authorized by Congress.
Cumberland: <i>Pollution:</i> Pollution stream survey and laboratory tests to obtain adequate information of existing and potential pollution. Also hydrologic study.	200,000	Intensive 2-year program, followed by continuing annual work.
2. Construction Projects		
Ohio, general: <i>Navigation:</i> Dredging Ohio River to provide 500-foot width channel.....	2,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete; \$2,700,000.
<i>Pollution:</i> Aliquippa and Ambridge, Pa.; Ashland, Ky.; Buden and Beaver, Pa.; Bellsire, Ohio; Bellevue, Ky.; Benwood, W. Va.; Bridgeport, Ohio; Catlettsburg, Ky.; Chester, W. Va.; Cincinnati, Ohio and vicinity; Covington and vicinity and Dayton, Ky.; East Liverpool, Ohio; Evansville, Ind.; Follansbee, W. Va.; Freedom, Pa.; Gallipolis, Ohio; Henderson, Ky.; Hollidays Cove, W. Va.; Hopewell Township, Pa.; Huntington, W. Va.; Ironton, Ohio; Jeffersonville, Ind.; Louisville and Ludlow, Ky.; Madison, Ind.; Marietta and Martins Ferry, Ohio; Maysville, Ky.; McMechen, W. Va.; Metropolis, Ill.; Middleport, Ohio; Midland, Pa.; Mingo Junction, Ohio; Monaca, Pa.; Mount Vernon, Ind.; Moundsville, W. Va.; New Albany, Ind.; New Boston, Ohio; New Martinsville, W. Va.; Newport, Ky., and vicinity; Norwood, Ohio, and vicinity; Owensboro and Paducah, Ky.; Parkersburg, W. Va.; Pittsburgh, Pa.; Pomeroy and Portsmouth, Ohio; Sistersville, W. Va.; Steubenville, Ohio; Tell City, Ind.; Toronto, Ohio; Wellsburgh, W. Va.; Wellsville, Ohio; Wheeling and Weirton, W. Va.: Collecting sewers and one or more primary sewage treatment plants at each place to clean up the Ohio River, safeguard water supplies and provide water recreation.	75,000,000	Will probably require concerted action by States and communities. Estimate is highly approximate. Includes cost of surveys which should be undertaken prior to construction.
Ohio Basin, general: Sealing of abandoned mines to protect public water supplies, to reduce acid in streams which injures concrete and metal structures, boats, and piping, and aggravates pollution.	7,000,000	Program now under way.
Upper Ohio: <i>Pollution:</i> Knox, Pa., and Mifflin Township, Pa.: Sewage treatment plant for reduction of nuisance; and sewer system for Mifflin Township, Pa.	280,000	Plans completed.
Beaver: <i>Pollution:</i> Girard, Niles, Warren, and Youngstown (including Campbell), Ohio: Primary sewage treatment plants and collecting sewers to lessen unsanitary conditions and pollution in Mahoning and Beaver Rivers and to improve quality of industrial water taken from them. Linesville and Slippery Rock, Pa.: New sewage treatment plant to protect Pymatuning reservoir at the former place; at latter place, additional units to existing sewage treatment plants.	8,000,000 40,000	Plans required to be in conformity with the study recommended under group A. Plans completed.
Muskingum: <i>Pollution:</i> Ashland, Barberton, Buckeye Lake, and Cambridge, Ohio: Sewer systems and complete treatment plants.	2,200,000	General plans ready for Cambridge; detailed plans for other communities.
Scioto: <i>Pollution:</i> Kenton, Ohio: Improvements to existing sewage plant which discharges into stream above Columbus water reservoirs. Lancaster, Ohio: Sewage treatment plant.....	40,000 400,000	Investigation and preliminary plans made. Do.
Miami: <i>Pollution:</i> Dayton, Ohio: Construction of 10 additional sprinkling filters for sewage plant.....	150,000	Plans made in connection with present improvements.
Hamilton, Ohio: Intercepting sewers and treatment plant construction; plans to include control of industrial pollution.	1,000,000	Final plans needed.
South Charleston, Ohio: Complete sewage treatment plant.....	40,000	General plans ready.
Yellow Springs, Ohio: Complete sewage treatment plant.....	50,000	General plans made.
<i>Recreation and wildlife:</i> Piqua, Ohio: Dam to provide cooling water for power plant and recreation lake for city.....	55,000	There are preliminary plans. Final plans now being made.
<i>Water supply:</i> Springfield, Ohio: Increased water supply.....	800,000	

¹For first year.

Ohio Basin Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Wabash:		
<i>Pollution:</i>		
Anderson, Muncie, Newcastle, and Noblesville, Ind.: Sewage treatment plants.....	\$3,000,000	Plans ready; need imperative
Crawfordsville, Edinburg, Elwood, and Martinsville, Ind.: Sewage treatment plants.....	650,000	Do.
Hartford City, Ind.: Correction of excessive pollution from domestic sewage and large paper mills.....	180,000	Do.
Mitchell and Peru, Ind.: Sewer systems and sewage treatment plants.....	675,000	Plans ready.
<i>Water supply:</i>		
Bloomington, Carlisle, and Elnora, Ind.: Water supply systems.....	200,000	Do.
Green:		
<i>Drainage:</i>		
Davies, Henderson, Hopkins, McLean, Muhlenburg, Ohio; Todd and Webster Counties, Ky.: Drainage to exterminate mosquitoes and control malaria with incidental benefits to farm land.	960,000	A 6-year program now being started.
<i>Water supply:</i>		
Bowling Green, Ky.: Covering of water distribution reservoirs to safeguard water supply against contamination.	44,000	Plans completed.
Cumberland:		
<i>Drainage:</i>		
Caldwell, Christian, Livingston, Lyon, Todd, and Trigg Counties, Ky.: Drainage to exterminate mosquitoes and control malaria with incidental benefits.	288,000	A 6-year program now being started.
<i>Flood control:</i>		
Middlesboro, Ky.: Construction of levees to protect property from floods.....	600,000	Preliminary study and plans completed. Detail plans needed.
<i>Pollution:</i>		
Gallatin, Tenn.: Sewers and sewage treatment plant.....	150,000	Preliminary plans ready.
Middlesboro, Ky.: New sewer system for large population without sewers.....	150,000	Plans ready; need urgent.
Somerset, Ky.: Sewer system and sewage treatment plant.....	200,000	Do.
Lower Ohio:		
<i>Drainage:</i>		
Ballard, Crittenden, Daviess, Henderson, Hopkins, Livingston, McCracken, Union, and Webster Counties, Ky.: Drainage to exterminate mosquitoes and control malaria with incidental benefits to farm land.	640,000	A 6-year program now being started.
<i>Pollution:</i>		
Batesville, Ind.: Interceptors and complete sewage treatment plant.....	180,000	Preliminary plans completed.
Corydon and Salem, Ind.: Complete sewage treatment plants.....	200,000	Plans completed.
<i>Water supply:</i>		
Madison, Milan, and Vevay, Ind.: Chlorination, water plant improvements, and/or filtration plants.	150,000	Preliminary plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION		
Ohio general:		
<i>Flood control:</i>		
Ohio River flood control project, including construction of 14 reservoirs as follows: Allegheny, Tionesta, Crooked Creek, French Creek, Conemaugh River, Loyalbanna, Mahoning Creek, Red Bank Creek, West Fork River, Clendenin, Big Bend, Bluestone, Falmouth, and Cave Run Reservoirs.	\$85,350,000	The preliminary estimates given will be revised as a result of study project now in progress. Authorized by Congress.
<i>Navigation:</i>		
At Ohio dams nos. 43, 39, 30, 27, and 21: Construction of additional bear trap capacity to facilitate operation of dams and maintain pool levels for navigation.	1,300,000	Plans prepared.
At Ohio dams nos. 18, 47, 51, 52, and 53: Raise each dam 2 feet to reduce dredging costs.....	900,000	Preliminary plans ready.
Reconstruct dam no. 48 to raise pool 2 feet and facilitate operation.....	3,000,000	Do.
Upper Ohio:		
<i>Pollution:</i>		
Accident, Md.; Glenfield, Pa.; Mountain Lake Park, Md.; North Apollo, Pa.; St. Clairsville and Stowe Township, Ohio: Sewer systems for public health and convenience.	500,000	Preliminary plans for North Apollo, survey for Glenfield. Others—no plans available.
Arnold, Canonsburg, Connellsville, and Donora, Pa.; Friendsville, Md.; Greensburg, Huston, Johnstown, Mount Pleasant, Nanty Glo, New Kensington, and Waynesburg, Pa.; and Woodsfield, Ohio: Intercepting sewer and sewage treatment plants.	3,000,000	Plans partly completed for Greensburg and Connellsville (which includes pumping stations). Others—no plans available.
Bradford, Coudersport, East Brady, Edinboro, Emlenton, Ford City, Franklin, Homer City, Johnsonburg, Kane, Kittanning, Mount Jewett, Oil City, Fort Allegany, Polk State School, Ridgway, St. Marys, Sheffield Township, Smethport, Tidioute, Tionesta, Warren, and Youngsville, Pa.: Primary sewage treatment plant and intercepting sewer to clean up the Allegheny River.	3,000,000	Preliminary plans for Coudersport, Sheffield Township, Emlenton, and East Brady. Plans partly completed for Smethport, Bradford, Warren, Franklin, and Kittanning. Plans completed for Edinboro, Tidioute, Oil City, and Polk State School. Others—no plans available.
Clarksburg, 4-H Camp, and Weston, W. Va.: Sewage treatment plants.....	860,000	No plans available.
East McKeesport and Latrobe, Pa.: Interceptor sewers.....	270,000	Do.
Irwin, Marianna, and Oakdale, Pa.: Sewage treatment plants.....	100,000	Do.
Salamanca, N. Y.: Collecting sewers and sewage treatment plant to clean up the Allegheny River.....	310,000	Preliminary plans made.
<i>Water supply:</i>		
Bentleyville, Bradfordwoods, Brookville, and Daisytown, Pa., and Marietta, Ohio: Water filtration plant to produce better water supply.	415,000	Contract awarded at Daisytown. Plan completed for Brookville. Study completed for Bentleyville. No plans available for Bradfordwoods and Marietta.
Carmichaels and Salisbury, Pa.: Complete new water supply systems.....	150,000	Plans ready.
Clarksburg, 4-H Camp, and Weston, W. Va.: Reservoir for joint water supply.....	800,000	No plans available.
Beaver:		
<i>Pollution:</i>		
Butler Township, Jackson Township, New Brighton, North Bessemer, Rochester Township, Sharon, South New Castle, Union Township, West Middlesex, and White Township, Pa.: Community-wide sewer systems.	800,000	Plans are complete for White Township, Union Township, South New Castle, and Jackson Township; partly complete for West Middlesex and North Bessemer. Others have no plans.
<i>Water supply:</i>		
Beaver, Harrisville, and Slippery Rock, Pa.: Water softening plants at Beaver and Slippery Rock; water system at Harrisville.	150,000	Harrisville plans completed. Others—preliminary plans.
Muskingum:		
<i>Pollution:</i>		
Coshocton, Crooksville, Dennison, Newark, and Uhrichsville, Ohio: Sewer systems and sewage treatment plants.	1,400,000	General plans for Coshocton; all other places no plans available. Probably combined plant for Dennison and Uhrichsville.
Dover, Minerva, New Philadelphia, and Wooster, Ohio: Sewage treatment plants or secondary treatment plant to supplement existing plants.	600,000	Plans needed.
Malta, McConnelsville, Mount Vernon, Rittman, and Zanesville, Ohio: Sewage treatment plants.....	825,000	Existing Rittman plant subject to overflows by floods.
<i>Water supply:</i>		
Mansfield, Ohio: Increased water supply.....	700,000	Inadequate industrial supply.

Ohio Basin Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Kanawha:		
Pollution:		
Beckley, W. Va.: Sewage treatment plant.....	\$200,000	Plans needed.
Princeton, W. Va.: Sewage treatment plant.....	125,000	Do.
Scioto:		
Pollution:		
Circleville, Hillsboro, and Wellston, Ohio: Sewage treatment plants.....	360,000	Investigation and plans are lacking.
Big Sandy:		
Pollution:		
Williamson, W. Va.: Sewage treatment plant.....	125,000	No plans available.
Water supply:		
Elkhorn City, Fullerton, and Raceland, Ky.: New water supply systems.....	250,000	Preliminary plans completed.
Miami:		
Pollution:		
Germantown, Ohio: New sewage treatment plant.....	130,000	Preliminary plans made.
Middletown, Ohio: Sewage treatment plant and relief sewers.....	1,000,000	Plans and surveys needed for both domestic and industrial sewage treatment works.
Piqua, Ohio: Primary sewage treatment plant.....	300,000	Plans needed.
Urbana, Ohio: Reconstruction and extension of sewage treatment plant.....	35,000	Do.
Water supply:		
DeGraff, Ohio: Municipal waterworks, wells, pumps, distribution system.....	70,000	Preliminary plans.
Kentucky:		
Pollution:		
Georgetown, Hazard, Irvine, Mount Sterling, Nicholasville, Paris, and Versailles, Ky.: Sewage treatment plants and/or outfall sewers and/or sewer systems.....	600,000	Plans partly completed for Hazard; elsewhere plans have not been prepared.
Water supply:		
Richmond, Ky.: Filter plant to purify supply from stream of poor quality.....	120,000	Plans ready.
Wabash:		
Pollution:		
Altamont, Newton, and Paxton, Ill.: Sewer systems and complete sewage treatment plants.....	500,000	Plans needed.
Brazil, Ind.: Secondary sewage treatment.....	100,000	Plans not yet ready.
Casey, Charleston, Fairfield, Georgetown, Greenup, Hoopston, Marshall, Mattoon, Palestine, Paris, and Olney, Ill.: Complete sewage treatment plants and collecting sewers in some cases to remove nuisance conditions, prevent suits and improve water for agricultural purposes.....	1,800,000	Plans needed.
Delphi, Logansport, Marion, and West Terre Haute, Ind.: Sewer systems and sewage treatment plants.....	1,300,000	Plans not ready.
Terre Haute, Ind.: Sewage treatment plant, including some sewers to correct excessive river pollution and remove menace to water supplies of cities downstream, including Vincennes.....	2,300,000	Do.
Water supply:		
Hazelton and Oakland City, Ind.: Water purification plants.....	75,000	Do.
Jasonville, Ind.: Water supply.....	350,000	Do.
Logansport, Ind.: Water purification plant improvements.....	30,000	Do.
Green:		
Pollution:		
Campbellsville, Ky.: Sewer system and sewage treatment plant.....	150,000	Preliminary plans and specifications completed.
Water supply:		
Auburn, Brownsville, Cave City, Hartford, Island, Leitchfield, and Munfordville, Ky.: Water supply for communities now depending on individual supplies.....	410,000	Cave City, Hartford, Island, and Leitchfield plans ready; other places, no plans available.
Cumberland:		
Pollution:		
Hopkinsville, Ky.: Major extension of sewer system and addition of sewage treatment plant.....	425,000	Plans completed.
Princeton, Ky.: Sewage plant for complete treatment of sewage.....	60,000	Preliminary plans ready.
Williamsburg, Ky.: Sewage treatment plant.....	100,000	Do.
Water supply:		
Albany, Burnside, Evarts, Livingston, and Whitley, Ky.: Water supply systems.....	500,000	No plans available.
Baxter, Erin, and Smyrna, Tenn.: Water supply systems.....	135,000	Preliminary plans ready.
Lower Ohio:		
Pollution:		
Lawrenceburg, Ky.: Sewer system.....	120,000	Preliminary plans completed.
Water supply:		
Corydon, Dixon, Lewisport, and West Point, Ky.: Water supply systems.....	250,000	Preliminary plans completed.
Versailles, Ind.: Water supply, wells, pumps, tank, and distribution system.....	60,000	No plans available.

GREAT LAKES—ST. LAWRENCE

The economic growth of the Great Lakes drainage area has hinged in large measure upon the utilization of the lakes system as a waterway. The St. Lawrence River link to the Atlantic Ocean now is the outstanding waterway project in the district, and most other proposed large improvements, other than pollution-control works, are related directly or indirectly to it.

Under the terms of a pending treaty with Canada, the St. Lawrence River would be provided with a navigable channel of 27 feet, thus allowing many ocean-going vessels free access to the Great Lakes. Locks and dams would be constructed on the St. Lawrence River, and the connecting channels between the Great Lakes would be deepened. Hydroelectric plants in the international section with an installed capacity of 1,640,000 kilowatts would be constructed in connection with the navigation works. The estimated cost of the project to the United States is \$265,000,000, assuming a two-step development. This plan of development is the basis of the pending international agreement. This project may be undertaken as soon as the necessary treaty with Canada is ratified.

Compensating works on the Niagara and St. Clair Rivers which would operate to restore and maintain lake levels on Lake Erie, Lake Huron, and Lake Michigan, respectively, should be constructed.

The scenic value of Niagara Falls is now impaired by occasional low-water flows. Remedial works on the Niagara River above the falls accordingly have been designed by the International Niagara Board of Control. No further diversions of water for power above the falls should be allowed until the efficiency of these works has been tested in practice.

Throughout the Great Lakes area maintenance of lake levels—primarily for navigation—and of scenic features, such as waterfalls, is of the utmost importance to the rapidly growing recreational industry. In the Superior Lake drainages of Minnesota and Wisconsin, and in the Adirondacks, as well as in international waters, the preservation of natural-water bodies is a critical problem.

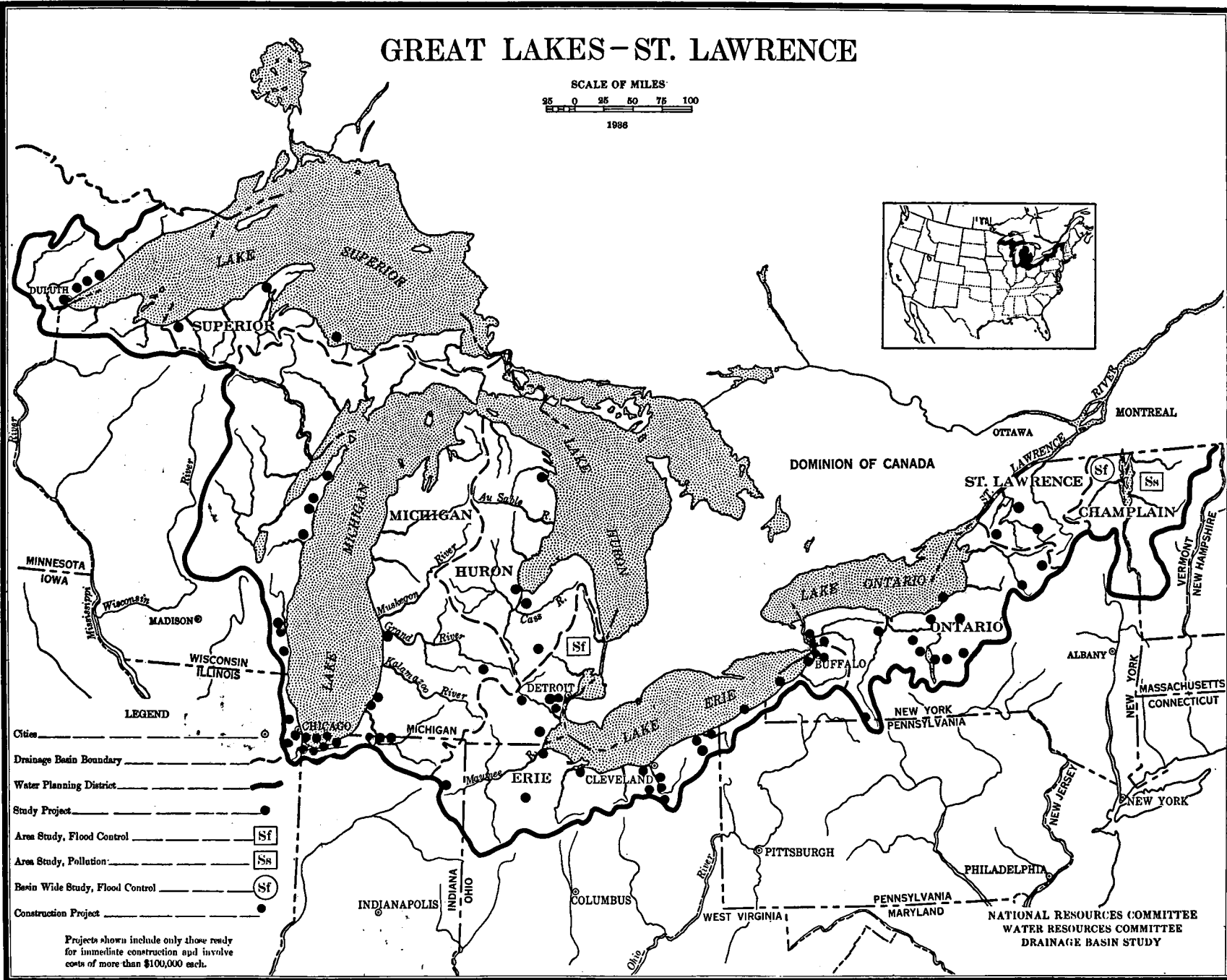
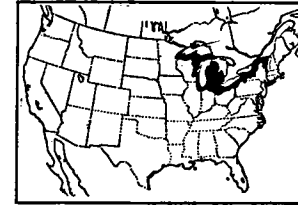
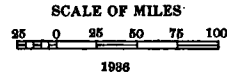
Flood protection in the short and relatively flat streams which drain into Lakes Michigan, Huron, and Erie may be planned with little reference to conditions in the lakes themselves. In the basins of the Black, Genesee, Racquette, Lake Champlain, and other drainages into Lake Ontario and the St. Lawrence, there

are numerous opportunities for combination of flood-control and low-water control reservoirs with hydroelectric power developments. A few multiple-use reservoirs in the rugged uplands of northern New York are recommended for deferred construction. Many others would generate power that would have value chiefly for supplying peak loads to supplement the St. Lawrence plants, and their initiation should await construction of the St. Lawrence project. Thus, plans for integrated regulation of the eastern tributaries of the lakes depend in considerable part upon plans finally adopted for the major waterway project.

Lake traffic has been a primary factor contributing to the growth of the Great Lakes cities. The lakes now carry more than 100 million tons of traffic a year, principally grain, iron ore, coal, and oil. In recent years, traffic has concentrated more and more in a few ports such as Duluth, Milwaukee, Chicago, Detroit, Cleveland, and Buffalo. For that reason the need for additional harbor improvements at the many smaller ports is slight, although operations involving greater depth and more room are justified at the larger ports.

The metropolitan areas on the shores of the Great Lakes have drawn freely upon the lakes for water supply. They also have dumped waste into the lakes indiscriminately. Chicago is now completing its great sewage-disposal plant, but the adjacent manufactural towns in Indiana have continued to contaminate the lake waters with sewage and industrial waste. The raw sewage from the northern Indiana cities should be treated, and provisions should be made against discharge of the effluent into the lake during flood periods on the Calumet River. Waters also are unduly polluted by sewage at Duluth and Detroit. At those points, as well as at the southern tip of Lake Michigan, sewage-treatment plants are necessary for the maintenance of satisfactory public-health conditions. Plans for appropriate works are ready in most cases, and construction should begin promptly. Sewage-treatment plants also are in demand in the densely populated valleys tributary to Lake Ontario, and in the Lake Champlain and St. Lawrence areas where recreational use of water is dominant. In addition, filtration and water-treatment plants are required at a few of the above-mentioned cities, and at Chicago, Duluth, Akron, and Cleveland extensions of the water-supply systems are warranted by growth in demand for water.

GREAT LAKES - ST. LAWRENCE



- LEGEND**
- Cities
 - Drainage Basin Boundary
 - Water Planning District
 - Study Project
 - Area Study, Flood Control (Sf)
 - Area Study, Pollution (Sp)
 - Basin Wide Study, Flood Control (Sf)
 - Construction Project

Projects shown include only those ready for immediate construction and involve costs of more than \$100,000 each.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Great Lakes—St. Lawrence Project List

Drainage basin and project description	Estimated cost,	Remarks
GROUP A—PROJECTS FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Michigan:		
<i>Flood control:</i>		
Grand River, Mich.: Flood control.....	\$40,000	With specific reference to Lansing and Grand Rapids.
Milwaukee River, Wis.: Flood control.....	5,000	
Huron:		
<i>Flood control:</i>		
Saginaw River and Sebawaing River: Flood-control studies.....	45,500	To determine flood hazards and best method and cost of abatement, with special reference to Saginaw, Bay City, Sebawaing River and Sebawaing village.
<i>Pollution and water supply:</i>		
Saginaw, Mich.: Water supply and industrial waste control or a new source of water supply.....	10,000	Preliminary studies have been undertaken.
Erie:		
<i>Flood control:</i>		
Clinton, Huron, Raisin, and Rouge Rivers, Michigan: Flood-control studies.....	5,000	
<i>Navigation:</i>		
Lake Erie-Ohio River Canal through Youngstown, Ohio, via Mahoning and Beaver Run.....	50,000	A study to extend the review now being made by the Corps of Engineers to provide consideration of alternate routes.
St. Lawrence:		
<i>Flood control:</i>		
Indian River Branch of Oswegatchie River, N. Y.: Stream regulation.....	25,000	
Champlain:		
<i>Flood control:</i>		
New York: Flood control.....	15,000	
Vermont: Flood control.....	15,000	
<i>Pollution:</i>		
Vermont: Stream pollution and economic usefulness of remedial measures.....	25,000	
2. Construction Projects		
Superior:		
<i>Navigation:</i>		
Keweenaw waterway, Mich.: Deepen waterway to 25 feet.....	1,985,000	Under construction. Sum needed to complete.
Presque Isle, Mich.: Deepen harbor, supplemented by breakwater.....	350,000	Sum needed to complete. Authorized by Congress. Plans completed.
<i>Pollution:</i>		
Aurora, Minn.: Sewers.....	61,000	
Duluth, Minn.: Sanitary sewers.....	26,000	
Duluth, Minn.: Sewage treatment plant.....	1,166,000	Ready for construction.
Duluth, Minn.: Storm sewers.....	194,000	Plans completed.
Floodwood, Minn.: Sewers.....	24,000	
Hibbing, Minn.: Sewers.....	14,000	
Nopeming, Minn.: Sewage treatment plant.....	27,000	Do.
Virginia, Minn.: Sewers.....	7,000	
<i>Water supply:</i>		
Bessemer, Mich.: Additional water supply.....	124,000	Do.
Duluth, Minn.: Reservoir for water supply.....	161,000	Ready for construction.
Two Harbors, Minn.: Waterworks.....	111,000	Plans completed.
Michigan:		
<i>Navigation:</i>		
Calumet Harbor, Ind.: Breakwater construction and dredging.....	890,000	Under construction. Cost given is for next 2 years. Additional needed to complete: \$1,735,000. Authorized by Congress.
Cook County, Ill.: Channel improvement.....	1,240,000	
Indiana Harbor, Ind.: Widening and deepening Indiana Harbor Canal.....	240,000	Cost given is for first 2 years. Additional needed to complete: \$493,500. Authorized by Congress.
Kewaunee Harbor, Wis.: Deepening to 20 and 22 feet.....	60,000	Cost given is for first 2 years. Additional needed to complete, \$224,000. Authorized by Congress. Authorized by Congress.
Manistee Harbor, Mich.: Dredging to 21 feet and 23 feet.....	60,000	
Manitowoc Harbor, Wis.: Dredging to 21 feet.....	115,000	
Manitowoc Harbor, Wis.: Deepen and widen channel in harbor.....	77,000	Cost given is for first 2 years. Additional needed to complete, \$68,000. Authorized by Congress.
Menominee River and Harbor, Michigan and Wisconsin: Deepening to 21 feet.....	83,000	Authorized by Congress.
Milwaukee Harbor, Wis.: Deepening to 21 feet.....	50,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$75,000. Authorized by Congress.
Muskegon Harbor, Mich.: Repair revetment.....	28,000	Authorized by Congress.
St. Joseph, Mich.: Improving harbor.....	75,000	
Sheboygan Harbor, Wis.: Deepen and widen entrance channel.....	45,000	
South Haven, Mich.: Deepening to 21 feet.....	25,000	Cost given is for first 2 years. Additional needed to complete, \$32,000.
Sturgeon Bay and Lake Michigan: Wisconsin ship canal, deepen and widen.....	1,125,000	Cost given is for first 2 years. Additional needed to complete, \$250,000.
Two Rivers Harbor, Wis.: Deepen channel and inner basin.....	30,000	
<i>Pollution:</i>		
Benton Harbor, Mich.: Additional sewage treatment.....	180,000	Preliminary reports made.
Chicago Sanitary District, Ill.: Completion of sewage treatment construction program.....	40,940,000	Under construction. Work pursuant to Supreme Court decree.
Crown Point, Ind.: Sewage treatment plant.....	45,000	
East Chicago, Ind.: Interceptors and sewage treatment plant.....	1,330,000	
East Gary, Ind.: Sewers and sewage treatment plant.....	60,000	
Elkhart, Ind.: Interceptors and sewage treatment plant.....	1,000,000	
Gary, Ind.: Interceptors and sewage treatment plant.....	2,300,000	Plans completed.
Grand Haven, Mich.: Interceptors and sewage treatment plant.....	200,000	
Griffith, Ind.: Sewers and sewage treatment plant.....	29,000	
Hammond, Ind.: Interceptors and sewage treatment plant.....	2,950,000	
Highland, Ind.: Sewers and sewage treatment plant.....	30,000	
Hobart, Ind.: Interceptors and sewage treatment plant.....	90,000	
Kendallville, Ind.: Interceptors and sewage treatment plant.....	70,000	Plans being made.
Lansing, Mich.: Sewage treatment plant.....	900,000	
Michigan City, Ind.: Additions to sewers and sewage treatment plant.....	145,000	
Mishawaka, Ind.: Interceptors and sewage treatment plant.....	974,000	
Omro, Wis.: Sewer system and primary sewage-treatment plant.....	75,000	
Racine, Wis.: Primary sewage-treatment plant.....	450,000	Preliminary reports made.
St. Joseph, Mich.: Additional sewage-treatment plant.....	200,000	Plans completed.
Sheboygan Falls, Wis.: Complete sewage-treatment plant.....	73,000	
South Bend, Ind.: Interceptors and sewage treatment plant.....	3,000,000	
South Milwaukee, Wis.: Primary sewage-treatment plant.....	68,000	Do.
Valparaiso, Ind.: Interceptors and sewage-treatment plant.....	125,000	To prevent pollution of Lake Michigan.
Whiting, Ind.: Interceptors and sewage-treatment plant.....	335,000	

Great Lakes—St. Lawrence Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Michigan—Continued.		
<i>Water supply:</i>		
Chicago, Ill.: Filtration and metering project.....	\$20,392,000	
Huron:		
<i>Water supply:</i>		
Bay City, Mich.: Water supply or treatment.....	73,000	Plans completed.
Davison, Mich.: Water supply or treatment.....	50,000	Do.
Flint, Mich.: Water-softening plant.....	500,000	Plans being prepared.
St. Charles, Mich.: Water supply or treatment.....	25,000	Plans completed.
Erie:		
<i>Flood control:</i>		
Cuyahoga River, Ohio: Dam for flood control.....	173,000	Approved by Congress.
Cuyahoga River, Ohio: Flood control reservoir.....	749,000	
<i>Navigation:</i>		
Ashtabula Harbor, Ohio: Deepening channels and constructing breakwater, additions, etc.....	360,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$508,000. Authorized by Congress.
Black Rock Channel and Tonawanda Harbor, N. Y.: Deepening and widening channels.....	225,000	Authorized by Congress.
Buffalo Harbor, N. Y.: Construction of breakwater and deepening channels.....	1,081,000	Authorized by Congress. Sum needed to complete.
Conneaut Harbor, Ohio: Deepening harbor.....	1,104,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$113,000. Authorized by Congress.
Erie Harbor, Pa.: Deepening channels to 21 and 25 feet.....	375,000	Cost given is for first 2 years. Additional needed to complete, \$289,000. Authorized by Congress.
Lorain Harbor, Ohio: Deepening channels to 25 and 26 feet and widening 2 river bends.....	950,000	Authorized by Congress. Sum needed to complete.
Rouge River, Mich.: Deepening channels to 18, 21, and 25 feet.....	228,000	Sum needed to complete. Authorized by Congress. Partly completed.
<i>Pollution:</i>		
Akron, Ohio: Sanitary sewers.....	164,000	Plans completed.
Bedford, Ohio: Sewage-treatment plant.....	156,000	Do.
Erie, Pa.: Sanitary and storm sewers.....	787,000	Ready for construction.
Findlay, Ohio: Secondary sewage-treatment plant.....	212,000	
Fort Wayne, Ind.: Interceptors and sewage-treatment plant.....	5,000,000	Plans prepared.
Girard, Pa.: Secondary sewage-treatment plant.....	20,000	Ready for construction.
Wayne County, Mich.: 2 sewage-treatment plants.....	4,000,000	Plans completed.
<i>Water supply:</i>		
Akron, Ohio: Reservoir.....	454,000	
Albion, Pa.: Water mains.....	10,000	Do.
Ann Arbor and Waterford, Mich.: Water supplies.....	518,000	Do.
Bradner, Ohio: Water-supply system.....	45,000	Do.
Erie, Pa.: Water main to Presque Isle.....	50,000	Do.
Garfield Heights, Ohio: Water-supply system.....	44,000	Do.
Hamburg, N. Y.: Water-supply reservoir.....	122,000	Plans under way.
Lakewood, Ohio: Waterworks.....	1,629,000	Plans completed.
Toledo, Ohio: Water supply from Lake Erie.....	7,654,000	Do.
Ontario:		
<i>Navigation:</i>		
New York Barge Canal: Deepening of Oswego-Rome-Albany section to 14 feet.....		Work now under way. See Hudson River Basin, North Atlantic.
<i>Pollution:</i>		
Baldwinsville, N. Y.: Sewage-treatment plant.....	215,000	Plans completed.
Boonville, N. Y.: Sewage-treatment plant.....	97,000	Do.
Palmyra, N. Y.: Sewage-treatment plant and sewer system.....	194,000	Do.
Wellsville, N. Y.: Sewage-treatment plant.....	350,000	Authorized by village.
<i>Water supply:</i>		
Deferiet, N. Y.: New water supply.....	42,000	Present supply bad.
Dresden, N. Y.: New water supply system.....	54,000	
Madison Barracks, N. Y.: Water supply.....	85,000	Plans completed.
Odessa, N. Y.: New water supply system.....	70,000	Plans not approved.
Seneca Falls, N. Y.: Relocating water intake.....	100,000	
Union Springs, N. Y.: Water supply and sewer system.....	150,000	Plans completed.
St. Lawrence:		
<i>Pollution and water supply:</i>		
Norfolk, N. Y.: Water supply and sewer system.....	119,000	
<i>Water supply:</i>		
Evans Mills, N. Y.: New well and water supply system.....	60,000	
Champlain:		
<i>Flood control:</i>		
Proctor, Vt.: Channel improvement on Otter Creek.....	23,000	Authorized by Congress.
Johnson, Vt., and other points on Lamolile River: Channel improvement, bank revetment, and flood gates.....	66,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION		
Superior:		
<i>Pollution:</i>		
Ashland, Bayfield, Hurley, Mellen, Montreal, and Pence, Wis.; Sault Ste. Marie, Mich.; Superior, and Washburn, Wis.: Sewage-treatment plants.....	\$1,105,000	
Calumet, Houghton, Ironwood, L'Anse, Marquette, Munising, Newberry, Ontonagon, and Wakefield, Mich.: Sewers and sewage treatment plants.....	1,050,000	
<i>Water supply:</i>		
Hurley, Mellen, and Washburn, Wis.: Water supply systems.....	85,000	
Michigan:		
<i>Flood control:</i>		
Fond du Lac County, Wis.: Reservoir dams, etc.....	186,000	Flood control on east and west branches of Fond du Lac River.
<i>Navigation:</i>		
Frankfort Harbor, Mich.: Dredging to 18 feet.....	69,000	
Grand Calumet River, Ill.-Ind.: Extension of Illinois waterway system through Grand Calumet River to Gary.....	500,000	
Grand Haven Harbor, Mich.: Dredging channel to 18 feet.....	25,000	Recommended by Chief of Engineers.
Green Bay, Wis.: Dredging turning basin 20 feet deep.....	27,000	Recommended by Rivers and Harbors Committee.
Indiana Harbor Canal, Ind.: Construction of a guard gate across the Indiana Harbor Canal where it joins the Grand Calumet River.....	150,000	

Great Lakes—St. Lawrence Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Michigan—Continued.		
<i>Pollution:</i>		
Albion (2), Allegan, Bronson, Centerville, Constantine, Dowagiac, Eaton Rapids, Frankfort, Hart, Ionia, Kalkaska, Lake Odessa, Lawton, Manistee, Montague, Otsego, Three Rivers, Traverse City, White Cloud, and Zeeland, Mich.: Interceptors, sewers and sewage treatment plants.	\$1,162,000	
Berlin, Chilton, Fond du Lac, Hortonville, Kimberly, Montello, New London, North Fond du Lac, Princeton, Sturgeon Bay, and Waupaca, Wis.: Sewage treatment plants.	696,000	
Big Rapids, Cassopolis, Coldwater, Coopersville, East Lansing, Fennville, Grand Ledge, Hartford, Marshall, Mason, Olivet, Plainwell, Portland-Sheridan, Saugatuck, Shelby, and Three Oaks, Mich.: Sewage treatment plants.	1,019,000	
Chestertown, La Grange, Ligonier, and Syracuse, Ind.: Interceptors, sewers, and sewage treatment plants.	287,000	
De Pere, Wis.: Interceptors, sewers, and sewage treatment plant.	367,000	
Grand Rapids, Mich.: Sewage treatment plant.	725,000	
Kalamazoo, Mich.: Sewage treatment plant.	480,000	
Maackinac City, Mich.: Sewage-treatment plant.	60,000	
Kenosha, Wis.: Sewage treatment plant.	1,250,000	
Manitowoc, Wis.: Interceptors, sewers, and sewage treatment plant.	690,000	
Milwaukee, Wis.: Sewage treatment plant.	8,670,000	
Neenah, Wis.: Sewage treatment plant.	227,000	
Niles, Mich.: Sewage treatment plant.	370,000	
Port Washington and West Allis Wis.: Interceptors, sewers, and sewage treatment plants.	397,000	
Sheboygan, Wis.: Sewage treatment plant.	585,000	
<i>Water supplies:</i>		
Ashley, East Grand Rapids, Ludington, and Manistee, Mich.: Water supplies, additions, and improvements.	198,000	
Cudahy, Neenah, and Port Washington, and Two Rivers, Wis.: Water treatment plants.	498,000	
De Pere, Oconto, and Sturtevant, Wis.: Water supplies, additions, and improvements.	207,000	
Escanaba and Gladstone, Mich.: Water treatment plants.	112,000	
Kenosha, Wis.: Water treatment plant.	750,000	
Manitowoc, Wis.: Water treatment plant.	482,000	
Marinette, Wis.: Water supply, additions, and improvements.	210,000	
Milwaukee, Wis.: Water treatment plant.	5,780,000	
Negaunee, Mich.: Water supply, additions, and improvements.	240,000	
Racine, Wis.: Water treatment plant.	1,000,000	
Sheboygan, Wis.: Water treatment plant.	600,000	
Huron:		
<i>Pollution:</i>		
Alpena, Mich.: Sewage treatment plant.	80,000	Plans not available.
Bay City, Mich.: Sewage treatment plant.	850,000	Do.
Corunna, Fenton, Holly, Ithaca, Lapeer, Marlette, Montrose, St. Louis, and Vassar, Mich.: Sewage-treatment plants.	285,000	Plans completed for St. Louis. Preliminary plans completed for Vassar and Corunna. Plans not available for Fenton, Ithaca, Holly, Marlette, and Montrose.
Flint, Mich.: New sewage treatment plant enlargement.	285,000	
Grayling and Roscommon, Mich.: Sewage treatment plants.	64,000	Roscommon: Preliminary plans completed. Grayling: Plans not available.
Saginaw, Mich.: Interceptors and sewage treatment plant.	2,000,000	Preliminary estimate.
Sebewaing, and West Branch, Mich.: Sewage-treatment plants.	80,000	Plans not available.
Erie:		
<i>Drainage:</i>		
Huron County, Ohio: Drainage improvement.	30,000	Do.
<i>Flood control:</i>		
Cuyahoga County, Ohio: Creek improvement.	47,000	Do.
Erie County, Pa.: Channel improvement.	32,000	Do.
St. Marys River, Ohio: Clearing channel.	192,000	Do.
<i>Navigation:</i>		
Black River, Mich.: Deepen channel to 20 feet.	112,000	Authorized by Congress.
Erie County, N. Y.: Channel improvements, dredging, water diversion, and storage.	445,000	Plans not available.
Fairport Harbor, Ohio: Deepening channels constructing bulkhead, and extending breakwater.	462,000	Authorized by Congress.
Monroe Harbor, Mich.: Harbor improvement.	233,000	
<i>Pollution:</i>		
Adrian, Blissfield, Chelsea, Mount Clemens, Royal Oak, Royal Oak Township, Ypsilanti, Mich.: Sewers and sewage treatment plants.	1,316,000	Plans not available.
Algonac, Applegate, Brown City, Capac, Crosswell, Mich.: Sewers and sewage treatment plants.	112,000	Do.
Angola, Brocton, and Depew, N. Y.: Sewage-treatment plants.	531,000	Plans approved.
Ashtabula, Ohio: Primary sewage treatment with added chlorination.	450,000	Plans not available.
Auburn and Garrett, Ind.: Interceptors and sewage treatment plants.	140,000	Do.
Berne, Ind.: Interceptors and sewage treatment plant.	45,000	Do.
Birmingham, Melvindale, Northville, Pontiac, Plymouth, Rochester, and Wayne, Mich.: Sewage treatment plants, intercepting sewers, construction, and improvement.	514,000	Do.
Brighton, Carleton, Monroe, Rockwood, South Lyon, Mich.: Sewers and sewage-treatment plants.	233,000	Do.
Bryan, Bluffton, Ottawa, Paulding, and Wauseon, Ohio: Complete sewage-treatment plants.	288,000	Plans not completed.
Bucyrus, Carey, and Crestline, Ohio: Sewers and/or sewage-treatment plants.	474,000	Plans not available.
Conneaut, Ohio: Primary sewage-treatment plant with chlorination.	220,000	Do.
Cuyahoga Falls, Hudson, Kent, and Rocky River, Ohio: Interceptors, Cuyahoga Falls to Akron; improvement of existing plants and sewage-treatment plans for first mentioned 4 cities.	855,000	Plans not fully developed.
Decatur, Ind.: Intercepting sewers and sewage-treatment plant.	135,000	Plans not available.
Deshler, Leipsic, and North Baltimore, Ohio: Complete sewage-treatment plants.	200,000	Plans not prepared.
Detroit, Mich.: Intercepting sewers to sewage-treatment plant.	10,000,000	Plans partly made but scope of project not yet definite.
Erie, Pa.: New construction, extension, and repairs, sanitary and storm sewers.	435,000	Plans not completed.
Fremont, Tiffin, and Upper Sandusky, Ohio: Sewage-treatment plants.	395,000	Plans not available.
Grafton, Ohio: New sewers and complete sewage-treatment plant.	130,000	Do.
Hudson and Morenel, Mich.: Sewers and sewage-treatment plants.	210,000	Do.
Huron, Ohio: Interceptors and primary sewage-treatment plant.	50,000	Do.
Lochmoor, Marine City, Marysville, and Port Huron, Mich.: Sewer system and sewage-treatment plants.	830,000	Do.
Lorain, Ohio: Primary sewage treatment plant with additional chlorination.	700,000	Do.
Maumee and Toledo, Ohio: Sewage treatment plants, construction and repairs.	1,000,000	Do.
New Baltimore, Richmond, Sandusky, St. Clair, St. Clair Shores, and Yale, Mich.: Sewers and sewage treatment plants.	208,000	Do.
Painesville, Ohio: Complete sewage treatment plant.	400,000	Do.
Wellington, Ohio: Sewage treatment plant.	130,000	Do.
Willoughby, Ohio: Primary sewage treatment plant.	150,000	Do.
<i>Pollution and water supply:</i>		
Geneva and Harbor View, Lucas County, Ohio: Water mains, sewage treatment plants, and sewer systems.	190,000	Do.
Toledo, Ohio: Water mains and sanitary sewers.	185,000	Plans not completed.

Great Lakes—St. Lawrence Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Erie—Continued.		
<i>Recreation and wildlife:</i>		
Summit County, Ohio: Recreation Lake.....	\$870,000	Plans not available.
<i>Water supply:</i>		
Adrian, Birmingham, Northville, Plymouth, Pontiac, and Rochester, Mich.: Public water supply, softening and iron removal.....	609,000	Do.
Cleveland, Ohio: Supplementary water supply.....	6,000,000	Plans completed.
Grosse Isle, Highland Park, Rockwood, and Romulus, Mich.: Public water supply plants.....	470,000	Plans not available.
Monroeville, Ohio: Water purification plant.....	30,000	Do.
Ontario:		
<i>Flood control:</i>		
Black River, N. Y.: Removal of bars in River at Lyons Falls and Carthage and construction of embankments.....	75,000	
Carthage, N. Y.: Dam in Black River.....	75,000	
Owasco Lake, N. Y.: Outlet channel and control works.....	100,000	Plans completed.
Seneca River, N. Y.: Regulating outlet of Seneca River at Cayuga Lake.....	10,000	
<i>Flood control and power:</i>		
Black River, Panther Mountain, N. Y.: Reservoir for stream regulation and power.....	4,000,000	Do.
Genesee River, N. Y.: Mount Morris Reservoir for stream flow regulation.....	6,500,000	
<i>Navigation:</i>		
Great Sodus Bay Harbor: Increase depth in lake approach to 20 feet.....	148,000	Sum needed to complete.
<i>Pollution:</i>		
Caledonia, N. Y.: Sewage-treatment plant.....	120,000	
Camillus, N. Y.: Sewage-treatment plant.....	60,000	
Dansville, N. Y.: Sewage-treatment plant.....	150,000	Plans approved.
Geneseo, N. Y.: Sewage-treatment plant.....	95,000	
<i>Recreation and wildlife:</i>		
Lake Thendara, N. Y.: Recreation project.....	300,000	Plans completed.
<i>Water supply:</i>		
Gasport, N. Y.: Water-supply system.....	98,000	Do.
Oneida, N. Y.: Filtration plant.....	125,000	
Port Byron, N. Y.: Water-supply system.....	100,000	
Rochester, N. Y.: Honeoye Lake Reservoir for water supply.....	4,500,000	
St. Lawrence:		
<i>Flood control:</i>		
Newton Falls, N. Y.: Flood control reservoir.....	870,000	
Titusville Reservoir, Salmon River, N. Y.: Flood relief and low-water control.....	918,000	
<i>Water supply:</i>		
Gouverneur, N. Y.: New water supply.....	114,000	
International waters:		
<i>Navigation:</i>		
Great Lakes-St. Lawrence Deep Waterway: Including deepening of upper lake channels, navigation canal in international rapids section, and power installations on American side.....	265,000,000	Contingent upon ratification of pending international agreement.
Niagara River: Compensating works.....	700,000	This may be undertaken as soon as a suitable agreement with the Canadian Government is concluded. Approved by International Joint Commission.
St. Clair River: Compensating works.....	2,900,000	Do.
Niagara Falls: Preservation of scenic value and power.....	875,000	This may be undertaken as soon as a suitable agreement with the Canadian Government is concluded.

UPPER MISSISSIPPI—RED RIVER OF THE NORTH

I. The Upper Mississippi

The principal uses of the Mississippi River above St. Louis relate to disposal of wastes, to navigation, to municipal water supplies, and, to a limited extent, to water power.

The river serves as a sewer, and is seriously polluted below certain large cities. As a result, fish life, water-supply sources, and recreational facilities are greatly impaired. Wastes from an urban population of about 8,000,000 affect the stream from which various municipalities draw their water supplies.

The canalization of the river which is now underway will provide by 1940 a channel 9 feet in depth from Alton to Minneapolis. Some of the flowage rights required have been transferred to the Bureau of Biological Survey in connection with the development of the upper Mississippi wildlife refuge. Protection for the more valuable agricultural lands of the flood plains, not now protected by drainage and levee systems, is authorized by the Flood Control Act of 1936. Thus progress recently has been made along several lines in realizing the potentialities of the upper river and its valley.

Most existing problems of the Mississippi below St. Paul can be solved by the long-range plans for the upper river and its tributaries which are discussed in subbasin reports. All the plans contemplate adequate treatment of domestic and industrial wastes, a procedure that would maintain at all times a desirable minimum sanitary standard. Other outstanding features of the plans for the several subbasins are, in outline, as follows:

1. *Mississippi River above St. Paul.*—Flow correction to safeguard the future water supply of St. Paul and Minneapolis and to enhance natural recreational facilities is the first objective. Regulation of lake levels to aid in flow correction and to help maintain the important tourist industry is of similar importance. Flow correction is recommended as the primary purpose of existing reservoirs operated by the United States.

2. *Minnesota River.*—The chief feature is to correct stream flow by main stem and tributary storage, to protect agricultural lands subject to a periodic overflow, to improve sanitation, and to provide reliable surface sources of water supply in the event underground supplies become inadequate or unsatisfactory.

3. *Upper eastern tributaries (including the St. Croix, Chippewa, Trempealeau, Black, Buffalo, and La Crosse Rivers).*—Lake-level regulation and storage regulation to improve recreational facilities, to facilitate water-

power development, and to reduce silting are the important features. The value of recreational areas overshadows that of the agricultural lands.

4. *Minor tributaries in southeast Minnesota and northeast Iowa (including the Cannon, Zumbro, Root, upper Iowa, Turkey, Maquoketa, and Wapsipicon Rivers).*—Flood correction by small reservoirs and improvement of water-supply sources are the primary objectives.

5. *Wisconsin River.*—Possibilities of inexpensive flow regulation and the availability of power sites indicate that water-power development is of considerable importance. Flow correction by storage and lake-level regulation will be important also to the recreational facilities.

6. *Rock River.*—In this area, flow correction by storage regulation is the chief objective of the plan. It would reduce flood damage, furnish surface water to replace failing ground-water sources, and improve the primary power possibilities at potential water-power sites.

7. *Iowa-Cedar Rivers.*—Better sanitation and improved water-supply sources are the principal water needs of these basins for which the plan makes provision.

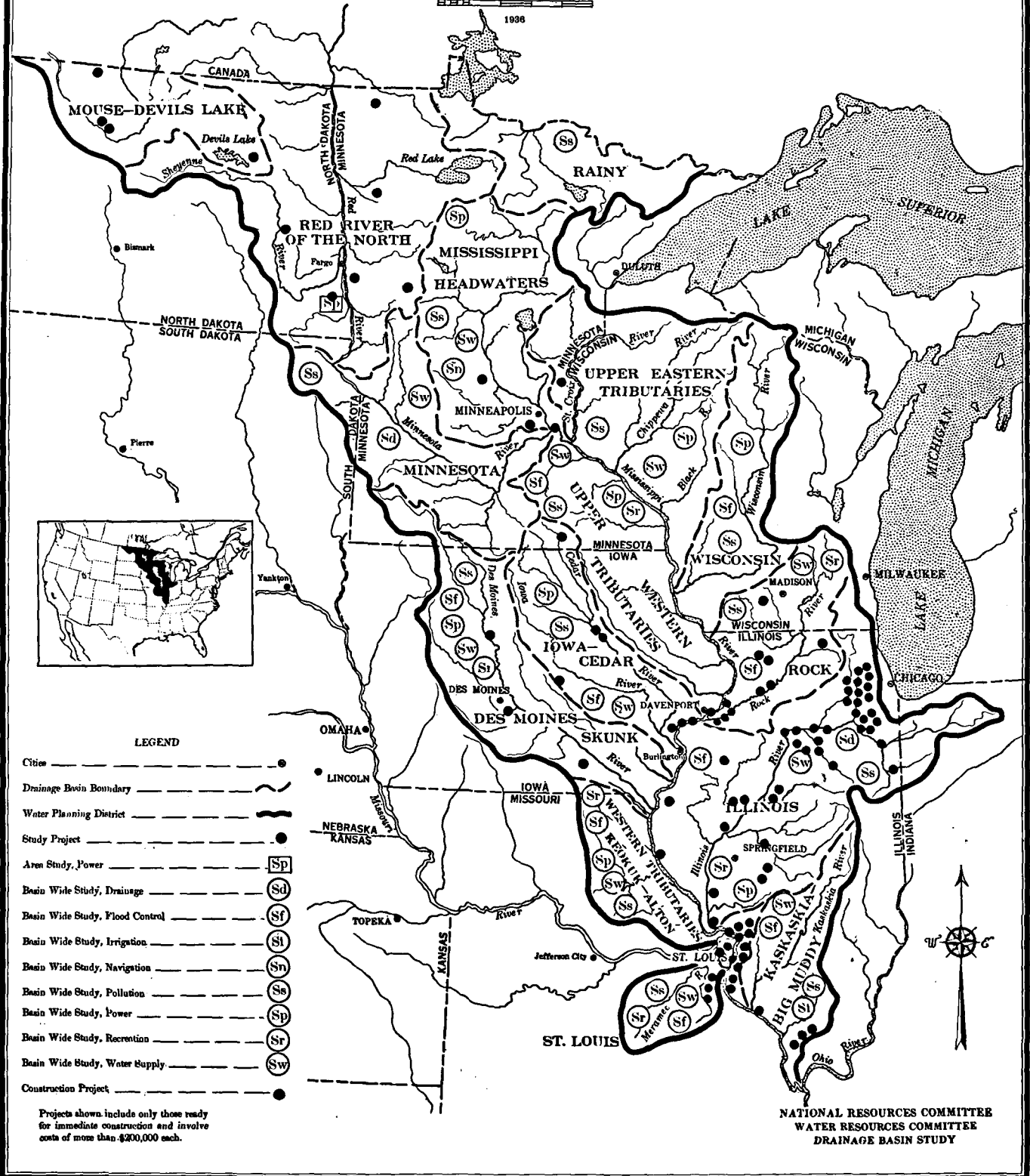
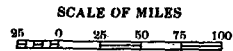
8. *Des Moines-Skunk Rivers.*—Proposed reservoir control above the city of Des Moines would reduce flood damage and improve sanitation, water-supply sources, and water-power possibilities. It would also promote the development of water-recreational facilities, now meager except near the headwaters.

9. *Minor tributaries in southeast Iowa and northeast Missouri (including the Fox, Wyaconda, Fabius, North, Salt, and Cuivre Rivers).*—The plan recognizes flow correction as a fundamental need of these basins for reduction of flood damage and for erosion control. Additional surface-water sources are also needed. The configuration of the land favors small-reservoir development.

10. *Illinois River.*—The Illinois and its tributaries drain a highly developed agricultural and manufactural area which warrants maximum realization of water-resource values. No major reservoir sites are available, but it will be desirable to investigate many small reservoir sites, which, if developed, may have an appreciable combined effect on flood flows. Other small reservoirs are recommended as recreational centers and water-supply sources.

11. *Meramec-St. Louis Basin.*—Flow correction of the Meramec, flood protection of bottomlands, improved

UPPER MISSISSIPPI RED RIVER OF THE NORTH



- LEGEND**
- City ———— ●
 - Drainage Basin Boundary ————
 - Water Planning District ————
 - Study Project ———— ●
 - Area Study, Power ———— (Sp)
 - Basin Wide Study, Drainage ———— (Sd)
 - Basin Wide Study, Flood Control ———— (Sf)
 - Basin Wide Study, Irrigation ———— (Si)
 - Basin Wide Study, Navigation ———— (Sn)
 - Basin Wide Study, Pollution ———— (Ss)
 - Basin Wide Study, Power ———— (Sp)
 - Basin Wide Study, Recreation ———— (Sr)
 - Basin Wide Study, Water Supply ———— (Sw)
 - Construction Project ———— ●

Projects shown include only those ready for immediate construction and involve costs of more than \$200,000 each.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

storm-water drainage, sanitation of congested recreational centers, and storage in small reservoirs for recreation and water supply are the outstanding features of the water plan.

Remedial measures recommended for the tributary basins would considerably increase low flows and reduce high flows in the upper Mississippi. Thus the value of the upper river to its basin would be enhanced.

II. Red River of the North

The plan for the drainage area of the Red River of the North provides for such diverse but interrelated matters as abatement of stream pollution, control of

low-water flow, improvement of municipal and rural water supplies, correction of flood flow in streams, protection against grave distress from future droughts, enhancement of recreational values in natural lakes, wildlife conservation, and promotion of the utility of water for power development, all in the common interest of the people of the basin regardless of State lines. The individual projects set forth below, together with others already under way, have the complementary and integrated relationships requisite for the accomplishment of the plan, which has the support of the three States, Minnesota, North Dakota, and South Dakota, within which the basin lies.

Upper Mississippi—Red River of the North Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
I. Investigation Projects		
Red River of the North:		
<i>Flood control:</i> Study for flood channel improvement of Red River below Ottertail River.....	\$20,000	
Surveys and plans, small conservation dams.....	20,000	
<i>Water power:</i> Study of the Ottertail, Red Lake, and Sheyenne Basins to determine the possibilities for new water-power developments and for improvement in existing developments.....	5,000	
Mouse-Devils Lake:		
<i>Flood control:</i> Collection of factual data concerning the flow of the Souris River with thorough consideration of its international aspects.....	40,000	
Minot, N. Dak.: Investigation of flood prevention.....	5,000	
<i>Water supply:</i> Burlington, N. Dak.: Investigation of further water supply.....	5,000	
Devils Lake City, N. Dak.: Investigation of possible sources of improved watersupply, including Sweetwater Lake.....	6,000	
Rainy River:		
<i>Pollution:</i> Study of pollution problems in Rainy River, Minn.....	5,000	
Mississippi headwaters:		
<i>Water power and navigation:</i> Study of flow regulation by review of existing data and reports and collection of new data to determine means for increasing the minimum stream flow and to provide for water conservation, power development, and navigation.....	25,000	
<i>Water supply and pollution:</i> Study of existing water supplies and of urban centers not now supplied with waterworks to determine needs and make recommendations to improve supplies; also to make recommendations for the abatement of pollution from domestic and industrial wastes.....	5,000	
<i>Miscellaneous:</i> Study to determine the economic value of the Minnetonka water conservation project, which plans to raise the water level of Lake Minnetonka by the diversion of water from the Crow River.....	5,000	
Minnesota:		
<i>Drainage:</i> Study and survey of State land-drainage works.....	30,000	
<i>Flood control:</i> Study of flow regulation throughout basin, including study to determine the functional utility of headwaters reservoirs in South Dakota.....	105,000	
Study of regulation of lake levels to determine most desirable development for each lake.....	25,000	
<i>Pollution:</i> Study of sanitary condition of rivers and condition of ground waters throughout entire basin.....	40,000	
Upper Mississippi, eastern tributaries:		
<i>Pollution and water supply:</i> Study of general sanitation conditions and water-supply needs in urban and rural areas.....	10,000	
<i>Water power:</i> Study of potential water-power developments and their interrelation with existing developments.....	15,000	
<i>Miscellaneous:</i> Study of lake levels and storage by review of existing data and reports and the collection of new data to form the basis for a program designed to restore lake levels and increase storage of precipitation.....	10,000	
Upper (Mississippi) western tributaries:		
<i>Pollution:</i> Study of sanitation conditions in urban and rural areas to determine needs for abatement of pollution from domestic and industrial waste.....	5,000	
<i>Water power, flood control, water supply, and recreation:</i> Study to determine the economic feasibility of works for flow improvement in combination with water power, flood control, future water supplies, and recreation throughout the basin.....	30,000	
Wisconsin:		
<i>Flood control:</i> Study to determine most practical and economical means of effecting flood control on Kickapoo and Galena Rivers.....	10,000	
<i>Pollution:</i> Study of waste disposal and pollution of water supplies in the basin to supplement existing information and to formulate a program for improved sanitary conditions throughout entire basin.....	10,000	
<i>Water power:</i> Study of flow regulation and power development problems and lake level regulation and the possibilities of diverting part of the Wisconsin flow into the Fox River to increase its low flows for sanitary purposes.....	50,000	
Rock:		
<i>Flood control, recreation, and water supply:</i> Studies of flow regulation to determine the most feasible plan for minimizing flood damages and increasing low flows in the Rock River Basin with particular emphasis on the Pecatonica River, including an investigation of tributary reservoir sites possible of development for water supply, flow regulation, and/or recreation.....	60,000	

Upper Mississippi—Red River of the North Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
1. Investigation Projects—Continued		
Rock—Continued.		
<i>Water supply and pollution:</i> Study of existing water supplies and of urban centers not now supplied with water works to determine needs and make recommendations to supplement previous study. Also studies and recommendations for the abatement of pollution from domestic, industrial, and mine wastes and aquatic growths.	\$15,000	
Iowa—Cedar:		
<i>Flood control and water supply:</i> Study to determine projects economically sound for flood control and water power; and a continuing study of water supply and sanitation; and an analysis of hydrologic data already collected on Ralston Creek.	60,000	
Des Moines—Skunk River:		
<i>Drainage:</i> Study of flow regulation in entire basin to determine economical minimum flows and storage facilities and their interrelation with water power, waste disposal, water supply and the adequacy of water for agricultural needs in dry years; and a continuing study of water supply and sanitation; and a study to determine best ultimate use of area known as Green Bay levee and drainage district.	32,000	
<i>Water power:</i> Study of possible new water-power developments and of redevelopment of existing water powers.	70,000	
Illinois:		
<i>Miscellaneous:</i> General studies as a basis for a coordinated program of sanitation, drainage, flood correction, water supply, water power, and recreation.	200,000	
Western tributaries Keokuk-Alton:		
<i>Flood control:</i> Study of all possible small reservoir sites for flow regulation and/or recreation.	20,000	
Study of flood control and water power on the Salt and Fabius Rivers in Missouri.	25,000	
<i>Water supply:</i> Study of existing water supplies and of urban centers not now supplied with waterworks to determine needs. Also studies to make recommendations for the abatement of pollution from wastes.	10,000	
St. Louis:		
<i>Recreation:</i> Study for improvement of recreational facilities throughout the entire basin to determine the feasibility of artificial lakes along the Meramec River in conjunction with flood correction and lake developments along the Mississippi.	10,000	
<i>Miscellaneous:</i> Studies to develop recommendations for the abatement of pollution from any source; and studies to ascertain present and probable future water-supply needs and to make recommendations.	20,000	
Kaskaskia—Big Muddy:		
<i>Flood control:</i> Flow regulation studies: (1) To determine the functional utility of any reservoir sites possible of development for general conservation or as specific water supplies; (2) to determine methods of flood correction for agricultural lands along the Kaskaskia; (3) to make recommendations concerning the adequacy of water for agricultural needs in dry years.	32,000	
<i>Miscellaneous:</i> General study involving procurement, correlation, and analysis of all necessary engineering, economic, and social data, including studies of urban water supply and of stream sanitation to determine needs and make recommendations.	50,000	
2. Construction Projects		
Red River of the North:		
<i>Flood control:</i>		
Ottertall, Red, and Sheyenne Rivers: Channel improvements for low-water flow.	355,000	Surveys and plans are available.
Park River levee and channel straightening for flood control.	45,000	Survey being made.
Red Lake River: Channel improvements and control works.	437,000	Plans available. Project urgent.
Sheyenne River diversion: Ditch to divert low-water flow from Sheyenne River to Dakota Wild Rice River, including diversion dam.	95,000	
<i>Pollution:</i>		
Abercrombie, N. Dak.; Ada, Argyle, Bagley, Barnesville, Battle Lake, Blackduck, Breckenridge, and Callaway, Minn.; Casselton and Cavalier, N. Dak.; Crockston, Detroit Lakes, Dilworth and Donnelly, Minn.; Drayton, N. Dak.; East Grand Forks and Elbow Lake, Minn.; Enderlin and Fairmount, N. Dak.; Fergus Falls, Fertile, Fosston, Frazee, and Graceville, Minn.; Grafton, N. Dak.; Hallock and Halstad, Minn.; Harvey, N. Dak.; Hawley and Herman, Minn.; Hillsboro, N. Dak.; Kelliher, Minn.; Kindred, N. Dak.; Lake Park, Minn.; Larimore and Maddock, N. Dak.; Mahanomen, Minn.; Mayville, Milnor, and Minto, N. Dak.; Moorhead, Minn.; Neche, N. Dak.; New York Mills and Northome, Minn.; Park River, N. Dak.; Pelican Rapids, Minn.; Pembina, N. Dak.; Perham, Minn.; Portland, N. Dak.; Red Lake Falls and Roseau, Minn.; Sheyenne and St. Thomas, N. Dak.; Thief River Falls and Twin Valley, Minn.; Wahpeton and Walhalla, N. Dak.; Warren, Minn.; West Fargo, N. Dak.; Wheaton, Minn.; Wyndmere, N. Dak.; Wolverton, Minn.; Valley City, N. Dak.; Sewer systems and sewage-treatment plants.	2,546,000	
<i>Water supply:</i>		
Abercrombie, Alice, Amenia, Aneta, Anselm, and Ardoch, N. Dak.; Argyle, Minn.; Ayr, N. Dak.; Bagley, Barnesville, and Battle Lake, Minn.; Blabon, N. Dak.; Blackduck, Minn.; Blanchard and Bowesmont, N. Dak.; Breckenridge, Minn.; Buffalo, Butteville, and Buxton, N. Dak.; Callaway and Campbell, Minn.; Casselton, Cayuga, Cavalier, Chaffee, Christine, Clifford, Cooperstown, Colgate, and Conway, N. Dak.; Crockston, Minn.; Crystal, Cummings, and Dasey, N. Dak.; Detroit Lakes and Donnelly, Minn.; Drayton, N. Dak.; Dumont, Minn.; Dwight, N. Dak.; East Grand Forks, Minn.; Eckelson, N. Dak.; Elbow Lake, Minn.; Elliott, Enderlin, Englevale, Erie, and Fairdale, N. Dak.; Fergus Falls and Fertile, Minn.; Fingal and Finley, N. Dak.; Fosston, Minn.; Fordville and Forest River, N. Dak.; Frazee, Minn.; Galesburg, Glasston, Grafton, and Great Bend, N. Dak.; Hallock and Halstad, Minn.; Hamar, Hamberg, Hamilton, Hannaford, Hansboro, and Hastings, N. Dak.; Hawley, Minn.; Heimdal and Hensel, N. Dak.; Herman, Minn.; Hope, Hoople, Hunter, Kathryn, and Kindred, N. Dak.; Lake Park, Minn.; Langdon, Lanekin, Lisbon, Litchville, Maddock, Manvel, and Martin, N. Dak.; Matton, Minn.; McCanna, N. Dak.; McIntosh, Minn.; McLeod, McHenry, Mekinock, Michigan, and Minto, N. Dak.; Moorhead, Minn.; Mooreton, Mountain, and Neche, N. Dak.; New York Mills, Minn.; Niagara and Nome, N. Dak.; Northome, Minn.; Northwood, N. Dak.; Oklee, Minn.; Oriska, Orr, Page, Park River, and Pekin, N. Dak.; Pelican Rapids, Minn.; Pembina, N. Dak.; Perham, Minn.; Pillsbury, Pisk, and Portland, N. Dak.; Red Lake Falls, Minn.; Reynolds, N. Dak.; Roseau, Minn.; Rutland, Sanborn, Sharon, Sheldon, Sheyenne, and St. Thomas, N. Dak.; Thief River Falls, Minn.; Thompson, Tolna, and Tower City, N. Dak.; Twin Valley, Minn.; Valley City, Wahpeton, and Walum, N. Dak.; Warren, Minn.; Wellsburg, Wetman, and Wheatland, N. Dak.; Wheaton, Minn.; Wimbledon, N. Dak.; Wolverton, Minn.; Wyndmere, N. Dak.; Water-supply and water-treatment plants.	2,358,000	

Upper Mississippi—Red River of the North Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Red River of the North—Continued.		
<i>Miscellaneous:</i>		
Baldhill Reservoir on Sheyenne River near Valley City for water conservation, stream regulation, and pollution reduction.	\$778,000	
Dakota Wild Rice, Goose-Pembina, Red Lake, Sheyenne, and Snake-Roseau Basins: 36 small dams and reservoirs on principal streams for water conservation, local water supply, and recreation.	436,000	
Ottertail and Pelican Rivers: Construction of 51 small dams for water conservation and control.	244,000	
Roseau Reservoir and diversion, on Roseau River for flood control, recreation, wildlife conservation and water conservation.	1,301,000	Plans ready.
<i>Mouse-Devils Lake:</i>		
<i>Irrigation:</i>		
Burlington, N. Dak.: On Des Lacs River—water storage for irrigation	90,000	
Eaton irrigation district—water storage	75,000	Plans completed.
<i>Pollution:</i>		
Berthold, Bowbells, Columbus, Dunseith, Kenmare, Portal, Towner, Velva, Westhope, and Willow City, N. Dak.: Sewer systems and sewage treatment plants.	345,000	
Bisbee, Cando, Devils Lake, Lakota, and Leeds, N. Dak.: Sewage treatment plants	190,000	
<i>Recreation and wildlife:</i>		
Ambrose, Balfour, Deering, Donnybrook, Eckman, Foxholm, Hartland, Kenaston, Logan, Marbass, Sherwood and Upham, N. Dak.; and Bottineau, Burke, McHenry, Rolette, and Ward Counties, N. Dak.: 23 small dams for recreation and water conservation.	152,000	
Burke County, N. Dak.: Water improvements in Lostwood Migratory Waterfowl Refuge	46,000	
Devils Lake City, N. Dak.: Improvement of Sullys Hill Game Preserve at Fort Totten	34,000	Do.
Lakes Metigoche and Upsilon, N. Dak.: Regulation of lake levels for recreational use, Carpenter Lake, Long Lake, and Rost Lake.	25,000	
Nelson, Ramsey, Rolette and Towner Counties in North Dakota: Minor water conservation and recreational projects: 9 North Dakota lakes.	39,000	
<i>Water supply:</i>		
Ambrose, Antler, Berthold, Balfour, Crosby, Columbus, Deering, Flaxton, Glenburn, Gardena, Larson, Loraine, Mohall, Lansford, Newburg, Noonan, Overly, Portal, Ruso, Sherwood, Souris, Tagus, Tolley, Thorne, and Velva, N. Dak.: Surveys and new wells.	26,000	
Berthold, Columbus, Dunseith, Portal, Westhope, and Willow City, N. Dak.: Urban water supply improvements and water treatment plants.	203,000	
Bisbee, N. Dak.: Water supply improvement	37,000	
Minot, N. Dak.: Water treatment plant	20,000	
<i>Miscellaneous:</i>		
Sweetwater Lake, N. Dak.: Increased tributary drainage to raise lake to higher level for better quality of water, recreational use, and possible water supply to Devils Lake City.	10,000	
Rainy:		
<i>Pollution:</i>		
Baudette, International Falls, Minn.: Sewage systems and treatment plants	41,000	Plans made.
<i>Water supply:</i>		
Bellows Lake, Grove Lake, Horseshoe Lake, Jack-the-Horse Lake, Little Turtle Lake, Maple Lake, and North Star Lake, Minn.: Water supply.	14,000	Do.
Big Falls and Warroad, Minn.: Water supply systems	15,000	Do.
International Falls, Minn.: Water supply system	187,000	Do.
<i>Miscellaneous:</i>		
Lake Vermilion, Minn.: Outlet works, water conservation	19,000	Plans made. Pending acquisition of land.
Mississippi headwaters:		
<i>Pollution:</i>		
Alexandria, Bertha, Cokato, Grove City, Glencoe, Ah Gwah Ching, Nashwauk, Little Falls, and St. Paul, Minn.: Sewer systems.	114,000	Plans completed. Ready for construction.
Anoka, Bemidji, Robbinsdale, Wadena, and Waite Park, Minn.: Storm sewers	129,000	Do.
Buffalo, Minn.: Sewage treatment plant	8,000	Plans completed.
St. Cloud, Minn.: Sewage treatment plant	420,000	Do.
<i>Water supply:</i>		
Alexandria, Anoka, Bertha, Elk River, Parkers Prairie, Pierz, Robbinsdale, St. Martin, Trommald, and Wayzata, Minn.: Water supply systems.	138,000	Plans completed and ready for construction.
St. Paul, Minn.: Additional water treatment	227,000	Do.
<i>Miscellaneous:</i>		
Aitkin, Anoka, Carlton, Cass, Crow Wing, Douglas, Hennepin, Isanti, Itasca, Stearns, and Todd Counties, Minn.: Water conservation projects at 108 points.	226,000	Ready for construction.
Minnesota:		
<i>Pollution:</i>		
Benson, Dalton, Henderson, Morris, and Walls, Minn.: Sewage treatment	76,000	Preliminary plans made.
Clara City, Clarkfield, Hancock, and Lowry, Minn.: Sewer systems and sewage treatment plants.	127,000	Do.
Danube, Delavan, Elysian, Good Thunder, and Hoffman, Minn.: Sewer systems	13,000	
New Ulm, Minn.: Sewage treatment plant	131,000	Do.
New Ulm and Willmar, Minn.: Sewer system extensions	4,000	Do.
<i>Water supply:</i>		
Benson, Browns Valley, Chaska, Clara City, Clarkfield, Cyrus, Glenwood, New Prague, Marshall, Tracy, and Triumph, Minn.: Water-treatment plants.	104,000	
Big Stone City, S. Dak.: Water-supply system	70,000	
Dalton, Minn.: Water-supply system and treatment plant	24,000	
Farwell, Hoffman, and Ruthton, Minn.: Water-supply systems	22,000	
Sisseton, S. Dak.: Waterworks system	80,000	Preliminary plans completed.
<i>Miscellaneous:</i>		
Cedar, New Ulm, Scandinavian, Sleepy Eye, and Wood Lake, Minn.: Dams and reservoirs for water conservation and recreation.	170,000	Do.
Willmar, Minn.: 6 dams and 8 channel improvement projects in chain of lakes for water conservation.	135,000	Do.
22 small dams and channel improvement for water conservation and flow correction in Minnesota	68,000	
Upper (Mississippi) eastern tributaries:		
<i>Pollution:</i>		
Askov, Minn.; Baldwin, Wis.; Bayport (State prison), Minn.; Bloomer, Clear Lake, Coon Valley, Frederic, Glenwood, Hammond, Hayward, Hudson, and Medford, Wis.; Mora and Pine City, Minn.; St. Croix Falls, Wis.; Stillwater, Minn., and Webster, Wis.: Sewers and/or sewage treatment.	666,000	Ready for construction.
<i>Recreation and wildlife:</i>		
Buffalo and Trempealeau Counties, Wis.: Trempealeau River migratory waterfowl refuge project	150,000	
<i>Water supply:</i>		
Askov, Minn.; Augusta, Dresser Junction, Wis.; Bayport (State prison), Minn.; Eau Claire, Wis.; Mora, Minn.; North Hudson, Wis.; Taylors Falls, Minn.; and Webster, Wis.: Water-supply systems and/or water treatment.	179,000	Do.
Sparta, Wis.: Water-supply system and sewage treatment, including tanks for Camp McCoy	27,000	
<i>Miscellaneous:</i>		
Bayfield, Douglas, Eau Claire, Iron, Price, Rusk, Sawyer, and Washburn Counties, Wis.: Lake-level control and water conservation in 13 lakes.	26,000	Surveys made. Plans not completed.
Bolger, Clam Lake, Lake of the Falls, Minerva, and Nancy, Wis.: Pokegama Lake (Pine County), Minn.; Round Lake, Sissabagama, St. Croix, and Totogatic, Wis.: Water conservation.	430,000	Ready for construction.
Chisago County, Minn.: Chisago Chain of Lakes project for conservation of water	260,000	Ready for construction, pending legal settlements.

Upper Mississippi—Red River of the North Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Upper (Mississippi) western tributaries:		
<i>Flood control:</i>		
Decorah, Iowa: Reservoir at mouth of Dry Run and channel enlargement on upper Iowa River.....	\$120,000	Detail plans being prepared. Authorized by Congress.
Cascade, Iowa: Cleaning and straightening channel North Fork of the Maquoketa River.....	20,000	Necessary to complete project now under way.
Green Island, Iowa: Iowa levee and drainage district no. 1, improvement to levee.....	68,000	Authorized by Congress. Plans being prepared.
McGregor, Iowa: Construction for flood control.....	115,000	
<i>Navigation:</i>		
Mississippi River from mouth of the Missouri River to Minneapolis: 9-foot navigation channel including 26 dams and locks.	35,000,000	Under construction. Estimated cost needed to complete project.
<i>Pollution:</i>		
Anamosa, Dyersville, Elkader, Independence, Manchester, Maquoketa, and Monticello, Iowa: Complete sewage-treatment plant.	297,000	Preliminary plans only are available.
Central City, Fredericksburg, Hawkeye, and Tripoli, Iowa, and Faribault, South St. Paul, and West St. Paul, Minn.: Sewage-treatment-plant extensions.	39,000	Partial only; plans completed.
Houston, Lewiston, and Owatonna, Minn.: Sewage-treatment plant for partial treatment.....	253,000	Plans completed.
Kellogg, Minn.: Sewer system and treatment plant.....	33,000	Do.
Oelwein and Waukon, Iowa: Preliminary treatment plants for industrial waste from creamery.....	10,000	Preliminary plans only are available.
Olin, and Oxford Junction, Iowa: Primary sewage-treatment plant.....	9,000	Do.
<i>Water supply:</i>		
Calamus, Comanche, Delhi, and Hazelton, Iowa; Hokah and Northfield, Minn.; Oelwein and Volga, Iowa; Waterville, Minn.; Waucoma, Iowa: Water-supply systems.	252,000	Partial plans only are available.
<i>Miscellaneous:</i>		
Houston County, Beaver Valley Dam; Le Sueur County, Volney and Dora Dams; Olmsted County, Silver Creek and Shady Lake Dams; Rice County, Cedar, Willings, Union, Mazaska, Dudley, French, and Lower Hatch Dams; Steele County, Owatonna Dam; Waseca County, Watkins Dam; Minn.: Dams for water conservation and recreation.	156,000	Preliminary plans completed.
Wisconsin:		
<i>Pollution:</i>		
Abbotsford, Colby, and Eagle River, Wis.; Galena, Ill.; Lodi, Minocqua, Prairie du Sac, Tomah, and Wonewoc, Wis.: Sewer systems and/or sewage-treatment plants.	357,000	Preliminary plans and estimates completed.
Athens, Biron, Baraboo, Cambria, and Cashton, Wis.; East Dubuque, Ill.; Elroy, Hillsboro, Lancaster, La Farge, Mauston, Mosinee, Neokoss, New Lisbon, Fort Edwards, Reedsburg, Richland Center, Rothschild, Stevens Point, Stratford, Tomahawk, Wauzeka, Wisconsin Dells, Wisconsin Rapids, and Viola, Wis.: Sewage-treatment plants.	420,000	Rough cost estimates only are available. No plans reported.
Benton, Cuba, Edgar, Gays Mills, Hazel Green, Mazomanie, Merrill, Muscoda, Necedah, North Freedom, Pittsville, Poynette, Readstown, Rhinelander, Rib Lake, Rio, Schofield, Soldiers Grove, Spring Green, Wausaw, and Wilton, Wis.: Sewer systems and sewage-treatment plants.	925,000	
Friendship and Marathon, Wis.: Sewer systems.....	28,000	
<i>Water supply:</i>		
Baraboo, Camp Douglas, Camp Williams, Edgar, Elroy, Friendship, Hillsboro, Lyndon Station, Marathon, Mosinee, Muscoda, Necedah, Pittsville, Poynette, Rib Lake, Rhinelander, Schofield, Shullsberg, and Stratford, Wis.: Water-supply systems or improvements to water supply.	644,000	Do.
East Dubuque and Galena, Ill.: Water-treatment plants.....	42,000	Field surveys not made.
<i>Miscellaneous:</i>		
Monroe County, Wis.: Dam to create new lake at Tomah Lake.....	36,000	No plans reported. Cost estimates only are available.
New Lisbon, Wis.: Dam to control lake level and restore old flowage.....	35,000	
Rock:		
<i>Drainage:</i>		
Hillsdale, Ill.: Penny Slough levees and drainage ditches to protect agricultural lands.....	109,000	Authorized by Congress.
Carroll County, Ill.: Levee and drainage district no. 1, raising and enlarging existing levee system.....	13,000	Do.
<i>Flood control:</i>		
Fort Atkinson, Wis.: Flood gates for Indian Ford and Janesville Dams on Rock River.....	29,000	Do.
<i>Pollution:</i>		
Albany, Ashton, Atkinson, Buda, Byron, Cambridge, Capron, Carbon Cliff, Chadwick, Cherry Valley, Compton, Creston, Durant, Elizabeth, Erie, Forreston, Franklin, Genoa, Hampshire, Hanover, Huntley, Kingston, Kirkland, Lanark, Leaf River, Lee, Lena, Manlius, Maple Park, Marengo, Milan, Morrison, Mount Carroll, Ohio, Orangeville, Orion and Pearl City, Ill.: Sewer systems and/or sewage treatment plants.	1,871,000	
Albany, Belleville, Beaver Dam, Blanchardville, Cambridge, Clinton, Columbus, Darlington, Delavan, Dodgeville, Horicon, Jefferson, Mineral Point, Orfordville, Palmyra, Randolph, Reeseville, Sharon, Slinger, Waterloo, and Waupun, Wis.: Sewer systems and/or sewage treatment plants.	674,000	
Amboy, Harvard, Oregon, Prophetstown, and Stockton, Ill.: Sewer systems or extensions and sewage treatment plants.	897,000	Preliminary plans are available.
Anawan, Belvidere, Fulton, Neponset, Port Byron, Rochelle, Savanna, and Winnebago, Ill.: Sewer systems and/or sewage treatment plants.	459,000	
Argyle, Beloit, Fox Lake, Johnson Creek, Juneau, Madison, Oconomowoc, Oregon, and South Wayne, Wis.: Sewer systems, extensions, or sewage-treatment plants.	698,000	Do.
Brandon, Wis.: Sewage-treatment plant.....	102,000	Plans prepared.
East Moline, Ill.: Sewer extensions and sewage-treatment plant.....	654,000	
Freeport, Ill.: Sewer extensions and sewage-treatment plant.....	1,900,000	Preliminary plans prepared.
Moline, Ill.: Sewer extensions and sewage-treatment plant.....	3,250,000	
Rock Island, Ill.: Sewer extensions and sewage-treatment plant.....	3,700,000	Do.
Sterling, Ill.: Sewer extensions and sewage-treatment plant.....	1,045,000	Do.
<i>Water supply:</i>		
Amboy, Anawan, Apple River, Ashton, Belvidere, Buda, Byron, Cambridge, Camp Grant, Carbon Cliff, Chadwick, Cherry Valley, Creston, De Kalb, Dixon, Durand, East Moline, Elizabeth, Erie, Forreston, Franklin Grove, Fulton, Geneseo, Genoa, Hampshire, Hanover, Harvard, Huntley, Kirkland, Lanark, Lena, Manlius, Marengo, Milan, Milledgeville, Morrison, Mount Carroll, Mount Morris, Neponset, Ohio, Oregon, Pecatonica, Polo, Poplar Grove, Port Byron, Prophetstown, Rochelle, Rock Island Arsenal, Rockton, Savanna, Shannon, Sheffield, Silvis, South Beloit, Stockton, Sycamore, Tampico, Walnut, Warren, West Brooklyn, Winnebago, and Winslow, Ill.: Water supplies and/or water-treatment plants.	1,208,000	
Beaver Dam and Cambridge, Wis.; Compton, Ill.; Edgerton, Elkhorn, Fort Atkinson, Horicon, and Lake Mills, Wis.; Orion and Pearl City, Ill.; Stoughton and Watertown, Wis.: Water supply improvements and/or treatment plants.	473,000	
Darlington, Orfordville, and South Wayne, Wis.: Water supply systems.....	77,000	
Freeport, Ill.: Water treatment plant and water extensions.....	609,000	
Moline, Ill.: Water treatment and extensions.....	929,000	Plans prepared.
Oconomowoc, Wis.: Water treatment plant for softening and iron removal.....	61,000	
Rockford, Ill.: Water treatment plant and water extensions.....	129,000	
Rock Falls, Ill.: Water treatment plant and water extensions.....	165,000	
Rock Island, Ill.: Water treatment plant and water extensions.....	995,000	
Sterling, Ill.: Water treatment plant and water extensions.....	283,000	

Upper Mississippi—Red River of the North Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Iowa—Cedar:		
Pollution:		
Alden, Belmont, Clarksville, Clear Lake, Forest City, North English, State Center, Waverly, West Liberty, Iowa: Treatment plants for industrial waste.	\$100,000	No plans are available. Estimates only rough.
Austin, Minn.: Sewage-treatment plant	325,000	Plans completed.
Belle Plaine, Cedar Falls, Marengo, Iowa: Sewage-treatment plants	132,000	
Columbus Junction and Gladbrook, Iowa; Glenville and Hayfield, Minn.; La Porte City, Manly, Nora Springs, Northwood, Riverside, Shellrock, and Wapello, Iowa: Sewage-treatment plants.	197,000	Preliminary plans completed.
Davenport, Iowa: Storm sewer for flood control.	358,000	Plans completed.
Davenport, Iowa: Sewage-treatment plant.	792,000	Do.
Marshalltown, Iowa: Sewage-treatment plant.	464,000	Do.
Muscatine, Iowa: Sewage-treatment plant.	200,000	No plans available.
Waterloo, Iowa: Sewage-treatment plant.	1,051,000	Plans completed.
Waterloo, Iowa: Channel improvement for sanitation.	300,000	No plans are available.
Water supply:		
Buffalo, Kalona, and Le Claire, Iowa: Water-supply systems.	140,000	
Des Moines—Skunk:		
Pollution:		
Adel, Colfax, Eldon, Lehigh, Panora, and Redfield, Iowa: Primary sewage-treatment plants.	46,000	No action has been taken. Colfax plans may call for complete sewage treatment at cost of \$35,000 instead of \$12,000.
Algona, Eagle Grove, Emmetsburg, Jefferson, and Webster City, Iowa: Sewage-treatment plants.	260,000	No action has been taken.
Bagley and University Park, Iowa: Secondary sewage-treatment or new plants.	20,000	Do.
Des Moines, Iowa: Sewage-treatment plant for domestic and industrial wastes.	2,000,000	Plant ordered by board of health; city has appealed to district court.
Fort Dodge, Iowa: Sewage-treatment plant for domestic and industrial wastes.	490,000	Plans filed with board of health.
Knoxville, Iowa: New sludge bed and drain for sewer system.	2,000	Land acquired and surveys begun.
Ottumwa, Iowa: Sewage-treatment plant for domestic and industrial wastes.	750,000	Plant ordered by board of health; city has appealed to district court. Design should include flood control features.
Perry, Iowa: Additional sewage-treatment plant, new settling tank, and additional filters.	72,000	
Water supply:		
Dallas, Eddyville, Lovilia, Melcher, Richland and Williamson, Iowa: Water supply and distribution systems.	444,000	No reports available. Surface storage probably will be developed except at Eddyville where infiltration galleries are possible. Dallas system might combine with that of Melcher.
Fairfield and Wayland, Iowa: Water-supply systems.	76,000	Plans available.
Illinois:		
Flood control:		
Baum's Levee between Shelby Bridge and Baum's Bridge on Kankakee River in Indiana: Flood protection for farm lands.	177,000	Authorized by Congress.
Illinois River in Illinois: Levee set backs and floodway improvement from Beardstown to mouth of river.	1,100,000	Do.
Sangamon River, Ill.: Levees and/or channel improvements at 15 localities on Sangamon River and its tributaries in Illinois for flood protection.	903,000	Do.
Sangamon River, Ill.: Straightening channel from mouth of Salt Creek to Roby.	773,000	Do.
Sangamon River, Ill.: Clearing and enlarging flood channel.	136,000	Do.
Navigation:		
La Grange and Peoria, Ill.: Lock and dams and channel improvement of Illinois River from mouth to Lockport, Ill.	10,391,000	Under construction. Estimated cost to complete. Authorized by Congress.
Pollution:		
Aledo, Antioch, Assumption, Astoria, Atlanta, Barry, Beardstown, Bensenville, Bloomington, Bourbonnais, Bradley, Bushnell, Canton, Carlinville, Carrollton, Cedar Point, Coal City, Crystal Lake, Cuba, Depue, Downers Grove, Dwight, East Dundee, East Peoria, Earlville, Elgin, Farmer City, Forrest, Galesburg, Galva, and Golden, Ill.; Goodland, Ind.; Hamilton, Itasca, Havana, Herscher, Jerseyville, Joliet, Kincaid, Lake Villa, LaSalle, Lemont, Lewistown, Lexington, Lincoln, Lockport, Manteno, Marselles, Mason City, Mendota, Milford, Momence, Monticello, Mount Sterling, Morris, Morton, North Utica, Oglesby, Oswego, Ottawa, Palatine, Peotone, Pekin, Peru, Petersburg, Plainfield, Plano, Quincy, Rankin, Roberts, Rochester, Rockdale, Rushville, Saint Anne, Sandwich, Shabbona, Sibley, Soldiers Home, Springfield, Spring Valley, Streator, Taylorville, Toluca, Toulon, Villa Park, Virginia, Washington, Watska, Wauconda, Wenona, West Chicago, West Dundee, Westmont, Wheaton, Whitehall, Wilmington, Wyoming, and Yorkville, Ill.; Sewer extensions and/or sewage treatment plants.	19,470,000	
Alexis, Alpha, Ashland, Athens, Auburn, Avon, Bartonville, Benson, Biggsville, Bradford, Braidwood, Buckingham, Buckley, Bureau, Cerro Gordo, Chatham, Chatsworth, Chenoa, Chenoa, wood, Buckingham, Buckley, Bureau, Cerro Gordo, Chatham, Chatsworth, Chenoa, Chenoa, Cherry, Chillicothe, Cissna Park, Colchester, Colfax, Crescent City, Crotty, Cullom, Danforth, Deer Creek, Delavan, Divernon, Donovan, Ellettsville, Elmhurst, Elmwood, El Paso, Eureka, Fairbury, Flanagan, Forest View, Fox Lake, Frankfort, Gibson City, Gilman, Girard, Glasford, Grand Ridge, Grant Park, Granville, Greenfield, Gridley, Griggsville, Gurnee, Hardin, Hebron, Hennepin, Henry, Heyworth, Hinckley, Hopedale, Hull, Ipava, Joy, Keithsburg, Kempton, Kirkwood, Knoxville, La Harpe, Lake Zurich, Lamoille, Leland, LeRoy, Little York, Loda, London Mills, Loraine, Lostant, Mackinaw, Manhattan, Maroa, Mark, McLean, Metamora, Minier, Minooka, Mokena, Monee, Montgomery, Morrisonville, Mount Prospect, Mount Pulaski, Moweaqua, New Holland, North Chillicothe, Odell, Onarga, Oquawka, Pawnee, Paw Paw, Payson, Pearl, Piper City, Plano, Rantoul, Roanoke, Roodhouse, Roseville, San Jose, Saunemin, Saybrook, Seaton, Secor, Sheldon, Somonsauk, South Jacksonville, South Pekin, South Wilmington, Standard, Stonington, Strawn, Stronghurst, Sublette, Tiskilwa, Tremont, Vermont, Viola, Virden, Washburn, Waterman, Waynesville, Weldon, Wheeling, Williamsville, Winchester, Winfield, Woodhull and Woodland, Ill.; Sewer systems and sewage-treatment plants.	10,138,000	
Water supply:		
Abington, Addison, Aledo, Alexis, Algonquin, Arlington Heights, Assumption, Atlanta, Aurora, Avon, Barrington, Bartlett, Bartonville, Beardstown, Bensenville, Berkeley, Blue Mound, Bourbonnais, Bradley, Braidwood, Brookfield, Buckley, Bushnell, Cabery, Campus, Carlinville, Carpentersville, Carrollton, Cary, Cerro Gordo, Chatsworth, Chenoa, Chillicothe, Cissna Park, Clarendon Hills, Clinton, Coal City, Colfax, Crescent City, Crystal Lake, Cuba, Cullom, Dallas City, Danforth, Danvers, Delavan, Depue, Donovan, Downers Grove, Dwight, Earlville, East Dundee, East Peoria, Elburn, Elmhurst, Elmwood, Galva, Galesburg, Galva, Gibson City, Gilman, Fox Lake, Fox River Grove, Frankfort, Franklin Park, Galesburg, Galva, Griggsville, Hamilton and Glen Ellyn, Ill.; Goodland, Ind.; Grant Park, Heyworth, Hillside, Hinckley, Hopedale, Hull, Ipava, ton, Hardin, Hebron, Henry, Herscher, Heyworth, Hillsdale, Hinckley, Hopedale, Hull, Ipava, Itasca, Jacksonville, Jerseyville, Joy, Keithsburg, and Kempton, Ill.; Kentland, Ind.; Kewanee, Kincaid, Kinsman, Kirkwood, Knoxville, Ladd, LaGrange, La Grange Park, La Harpe, Lake Zurich, Lamoille, La Salle, Leland, Lemont, Le Roy, Lewistown, Lexington, Libertyville, Lincoln, Lockport, Lombard, London Mills, Lyons, Mackinaw, Macomb, Macon, Manhattan, Manteno, Maroa, Marselles, Mason City, Maywood, McHenry, McLean, Marose Park, Mendota, Metamora, Milford, Minier, Mokena, Monmouth, and Montgomery, Ill.; Morocco, Ind.; Morris, Morrisonville, Morton, Mount Prospect, Moweaqua, Mount Pulaski, Mount Sterling, Nauvoo, Nebo, Normal, North Chillicothe, North Utica, Onarga, Oquawka, Ottawa, Palatine, Pana, Pekin, Peoria, Peoria Heights, Peotone, Peru, Petersburg, Piper City, Plainfield, Plano,	4,566,000	

Upper Mississippi—Red River of the North Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Illinois—Continued.		
<i>Water supply:</i> Continued.		
Princeville, Rankin, Rantoul, Richmond, Riverside, Roanoke, Roberts, Rockdale, Roodhouse, Rosella, Roseville, Sandwich, San Jose, Saybrook, Schiller Park, Shabonna, Sheldon, Somonauk, South Jacksonville, South Pekin, South Wilmington, Stanford, St. Anne, St. Charles, Spring Valley, Stronghurst, Sublette, Table Grove, Taylorville, Toluca, Tremont, Villa Park, Viola, Virginia, Warsaw, Washburn, Washington, Waterman, Wenona, West Chicago, West Dundee, Westmont, Wheaton, White Hall, Wilmington, Winfield, Wyand, and Wyoming, Ill.; Water treatment plants.	\$13,813,000	
Ashland, Athens, Augusta, Batavia, Bellewood, Berwyn, Blandinsville, Bloomington, Bluffs, Bowen, Bradford, Broadview, Brimfield, Camp Point, Canton, Chandlerville, Chapin, Chebanse, Cicero, Clayton, Clifton, Dalzell, DeLand, Des Plaines, East Galesburg, Edinburg, Elgin, Elliott, Elmwood Park, Fairview, Fisher, Forest Park, Forest View, Franklin, Gardner, Geneva, Golden, Gurnee, Hanna City, Hinsdale, Humpreys, Illiopolis, Industry, Joliet, Kane, and Kankakee, Ill.; Kouts, Ind.; Loda, Ill.; Lowell, Ind.; Mahomet, Manito, Mansfield, Mazon, Mendon, Meredosia, Middletown, Mokena, Murrayville, Naperville, New Berlin, New Boston, Niantic, and North Aurora, Ill.; North Judson, Ind.; North Riverside, Oak Park, Oglesby, Onida, Palmyra, Park Ridge, Pleasant Hill, Plymouth, Pontiac, and Prairie City, Ill.; Remington, Ind.; River Forest, River Grove, Riverton, Rushville, St. David, South Elgin, Sparland, Spring Forest, Stickney, Streator, Summit, Tallula, Thayer, Tiskilwa, Tonica, Vermont, Versailles, Wapella, Warrensburg, Watseka, Wauconda, Waverly, Westchester, Williamsfield, and Yates City, Ill.: Water-supply systems.		
Western tributaries Keokuk-Alton:		
<i>Flood control:</i>		
Fabius River drainage district, Marion County; Gregory drainage district, Lewis and Clarke Counties; Riverland levee district, St. Charles County; South River drainage district, Marion County; and Wiedmer chemicals drainage and levee district, St. Charles County, Mo.: Raising and enlarging existing levee systems to improve protection against floods.	314,000	Authorized by Congress.
<i>Pollution:</i>		
Bowling Green, Centralia, Clarence, Edina, Kirksville, Macon, Monroe City, Montgomery City, Palmyra, Shalbina, Troy, Wellsville, and Warrenton, Mo.: Improvement to the sewage-treatment plant.	639,000	
Canton, Hannibal, Louisiana, and La Belle, Mo.: Complete sewage treatment plant.....	208,000	
Elsberry, LaGrange, Memphis, New London, Oakwood, Paris and Perry, Mo.: Sewer systems and sewage-treatment plants.	365,000	
<i>Water supply:</i>		
Cantril and Pulaski, Iowa: Development of water supply and construction of distribution systems....	67,000	
Centralia, Montgomery City, New London, Troy, Warrenton, and Vandalia, Mo.: Improvement to existing water supplies by chlorination.	214,000	
Elsberry and Oakwood, Mo.: Development of source of water supply probably by deep well and chlorination.	85,000	
Kahoka and La Belle, Mo.: Improvement to existing water supplies by treatment and chlorination..	130,000	
Lancaster, Mo. and Milton, Iowa: Waterworks systems, including supply and distribution.....	90,000	
St. Louis:		
<i>Drainage:</i>		
Madison and St. Clair Counties, Ill.: Drainage, including control works, intercepting canals, and channel improvements in the East Side levee and sanitary district.	2,500,000	Preliminary plans completed.
<i>Flood control:</i>		
East St. Louis, Ill.: Raise and enlarge existing levees.....	1,158,000	Authorized by Congress.
Madison County, Ill.: Raise and enlarge existing levees of the Choteau, Nameoki, and Venice drainage and levee district.	154,000	Do.
St. Louis, Mo.: Raise and enlarge existing levees of the St. Louis County drainage and levee district..	279,000	Do.
<i>Pollution:</i>		
Benld, Ill.: Bonne Terre, Cuba, Desloge, Elvins, Esther, Flat River, and Leadwood, Mo.; Mount Olive, Ill.; Pacific, River Mines, St. Clair, St. James, and Salem, Mo.; Staunton, Ill.; Sullivan and Union, Mo.: Sewage treatment plants.	831,000	Preliminary plans completed.
Bismarck, Mo.: Sewer system and treatment plant.....	54,000	
Brooklyn, Ill.: Sewer system and pumping station.....	100,000	Do.
Caseyville and Signal Hill district, Ill.: Sewer system and sewage treatment plants.....	150,000	Do.
Collinsville, Ill.: Sewer extensions and sewage treatment plant.....	160,000	Do.
Crystal City, Mo.: Extension of sewer system.....	25,000	Do.
East St. Louis, Ill.: Sewer system for Edgemont district.....	200,000	Do.
East St. Louis, Ill.: Sewer system for Lansdowns area in east part of the city.....	450,000	Do.
Edwardsville and Wood River, Ill.: Sewer system extensions.....	95,000	Do.
Granite City, Madison, Nameoki, and Venice, Ill.: Combined relief sewers and pumping station....	3,000,000	Do.
St. Louis County, Mo.: Sewer system for Ladue-Deer Creek sanitary sewer district.....	435,000	Do.
St. Louis County, Mo.: Sewer system for the Lemay Ferry sanitary district.....	309,000	Petition pending to incorporate district.
St. Louis County, Mo.: Sewer system and sewage-treatment plant for the Overland sanitary sewer district.	337,000	Subject to incorporation and bond issue election.
University City, Mo.: Sewer system.....	159,000	Plans completed.
Webster Groves, Mo.: Extension of sewer system.....	200,000	Preliminary plans completed.
Wood River, Ill.: Combined sewers and pumping station.....	400,000	Preliminary plans partly completed.
<i>Water supply:</i>		
Benld, Ill.; Bonne Terre, Desloge, Elvins, Esther, Flat River, Leadwood, Pacific, Potosi, River Mines, St. Clair, St. James, and Salem, Mo.; Staunton, Ill.; Sullivan, Mo.; and Wood River, Ill.: Water supply improvement and/or treatment.	652,000	Preliminary plans completed and/or under study
<i>Water supply:</i>		
Bethalto, Brighton, Bunker Hill, Caseyville, Edwardsville, Gillespie, Glen Carbon, Maryville, Mount Olive, Roxana, Sawyerville, Wilsonville, and Worden, Ill.: Water supply systems.	1,070,000	Do.
Kaskaskia-Big Muddy:		
<i>Flood control:</i>		
Illinois: Levee construction. Protection of bottom lands.....	3,765,000	Authorized in part by Congress.
<i>Pollution:</i>		
Belleville, St. Clair County, Ill.: Extension of sewer system and additional treatment.....	1,576,000	Plans completed.
Benton, Franklin County, Ill.: Extension of sewer system and additional treatment.....	82,000	
Bethane, Carlyle, Findlay, Greenville, Lovington, Nokomis, Raymond, and Trenton, Ill.: Sewers and/or treatment plants.	465,000	
Cartersville, Williamson County, Ill.: Sewer and sewage treatment plant.....	240,000	
Columbia, Monroe County, Ill.: Sanitary sewer system.....	65,000	
Elkville, Jackson County, Ill.: Sewer and sewage treatment plant.....	145,000	
Herrin, Williamson County, Ill.: Sewer and additional sewage treatment.....	685,000	
Maessa, New Athens, O'Fallon, Percy, Poochontas, Ramsey, and Troy, Ill.: Sewers and sewage treatment plant.	489,000	
New Baden, Clinton County, Ill.: Sewer and sewage treatment plant.....	104,000	
West Frankfort, Franklin County, Ill.: Extension of sewers and sewage treatment plant.....	373,000	
<i>Water supply:</i>		
Ashley, Beckemeyer, Bresse, Buckner, Carbondale, Carlyle, Cobden, Colp, Coulterville, Cutler, Elkville, Germantown, Livingston, Mulberry Grove, Okawville, Panama, Patoka, Percy, Poochontas, Sandoval, Schram City, Sorento, Sullivan, Tamaroa, Taylor Springs, Tilden, Troy, Valler, Wamac, West City, and Willisville, Ill.: Water supply and/or improvements.	1,583,000	

Upper Mississippi—Red River of the North Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Kaskaskia—Big Muddy—Continued.		
<i>Water supply—Continued.</i>		
Ava, Evansville, Hammond, Hurst, Jonesboro, New Baden, and Pans, Ill.: Water supplies and improvements.....	\$275,000	Plans completed.
Freeburg, St. Clair County, Ill.: Development of source, treatment, and extension of system.....	122,000	
Marissa, St. Clair County, Ill.: Development of source and extension of distribution system.....	123,000	
Odin, Marion County, Ill.: Development of source and distribution system.....	102,000	
GROUP B—FOR DEFERRED CONSTRUCTION		
Red River of the North:		
<i>Flood control:</i>		
Lake Traverse—Bois des Sioux Reservoir for flood control, game refuge, and recreation.....	\$1,400,000	Authorized by Congress.
Steele County Reservoir on Goose Pembina River for water conservation and flood control.....	195,000	
Walhalla Reservoir on Pembina River for flood control and water conservation.....	395,000	
Mouse-Devils Lake:		
<i>Flood control:</i>		
Minor, N. Dak.: Straighten and improve channel of Souris River.....	250,000	
<i>Irrigation:</i>		
Sand Hill Region, N. Dak.: Minor irrigation project for 2,000 acres. Wells and equipment for small individual farm projects.	100,000	
<i>Recreation and wildlife:</i>		
Rolette County, N. Dak.: Diversion ditch to Long Lake for wild-fowl conservation.....	5,000	
<i>Water supply:</i>		
Bartlett, Brinsmade, Churches Ferry, Crary, Devils Lake, Egeland, Hampden, Hansboro, Lakota, Leeds, Minnewaukan, Mylo, Penn, Perth, Rock Lake, and Starkweather, N. Dak.: Surveys and new wells.	30,000	
Rainy:		
<i>Drainage:</i>		
Big Falls Village, Borin Creek, Little Fork River, Luoma Creek, Owens Township, Pike River, and Sturgeon Township, Minn.: Drainage by channel clearance.	67,000	
Mississippi headwaters:		
<i>Pollution:</i>		
Aitken, Albany, Annandale, Brainard, Calumet, Cambridge, Cass Lake, Cold Springs, Crosby, Deer River, Deerwood, Foley, Grand Rapids, Holdingford, Ironton, Keewatin, Long Prairie, Maple Lake, Melrose, Milaca, Monticello, Osakis, Paynesville, Princeton, Ramer, Richmond, St. Joseph, Trommald, and Watertown, Minn.: Sewage treatment plants.	769,000	
<i>Recreation and wildlife:</i>		
Cass County, Minn.: Dams at Mud and Rice Lakes for wild fowl refuges.....	20,000	
<i>Miscellaneous:</i>		
Itasca County, Minn.: Dam for water conservation and stabilization of water levels of Sugar Lake...	10,000	Would also serve as a refuge for waterfowl.
Minnesota:		
<i>Flood control:</i>		
New Ulm, Minn.: Dam on Minnesota River below the mouth of the Cottonwood River for flood control.	750,000	
Watonwan County, Minn.: 3 dams and 2 channel improvement projects for recreation and flood control.	126,000	Preliminary plans completed.
<i>Pollution:</i>		
Amboy, Blue Earth, Brisclyn, Butterfield, Canby, Easton, Hanley Falls, Henderson, Hendricks, Ivanhoe, Jordan, Lake Crystal, Lambertson, Le Center, Le Sueur, Madelia, Mankato, Mapleton, Minnesota, Minnesota Lake, Montgomery, Mountain Lake, New Prague, North Mankato, Russell, St. Peter (and State institution), Sanborn, Shakopee, Sleepy Eye, Springfield, Starbuck, Tracy, Truman, Tyler, Wabasso, Walnut Grove, Welcome, Westbrook, Winnebago, Minn.: Sewage treatment plants.	1,005,000	
Bigstone City and Wilmont, S. Dak.: Sewers and sewage treatment plants.....	48,000	
Browns Valley, Chaska, Dawson, Gaylord, Good Thunder, Granite Falls, Hopkins, Janesville, Madison, Morris, Olivia, Redwood Falls, and Renville, Minn.: Sewage treatment plants.	304,000	
Millbank, S. Dak.: Sewers and sewage treatment plant.....	50,000	
Sisseton, S. Dak.: Sewage treatment plant.....	23,000	
<i>Water supply:</i>		
Rake, Iowa: Water supply system.....	25,000	
<i>Miscellaneous:</i>		
Lincoln County, Minn.: Dam for water conservation in Lake Hendricks.....	20,000	
Upper (Mississippi) eastern tributaries:		
<i>Pollution:</i>		
Alma Center, Amery, Augusta, and Bangor, Wis.; Barnum, Minn.; Barron, Black River Falls, Blair, Cadott, Cameron, Cashton, Colfax, Cornell, Cumberland, Durand, Ellsworth, Elmwood, Fairchild, and Fall Creek, Wis.; Forest Lake, Minn.; Fountain City, Galesville, and Glidden, Wis.; Hinckley, Minn.; Independence, La Crosse, Ladysmith, Loyal, Menomonie, Merrillan, and Mondovi, Wis.; Moose Lake and Mora, Minn.; Neillsville and New Richmond, Wis.; North Branch, Minn.; North Hudson, Onalaska, Osceola, Owen, Park Falls, Pepin, Prairie du Chien, Onalaska, Prescott, Rice Lake, and River Falls, Wis.; Rush City and Sandstone, Minn.; Shell Lake, Sparta, Spooner, Spring Valley, and Stanley, Wis.; Taylors Falls, Minn.; Thorp, Viroqua, West Salem, and Whitehall, Wis.: Sewer systems and primary or secondary sewage treatment plants.	2,030,000	Plans completed.
Askov, Minn.: Clear Lake, Hayward, and Hudson, Wis.; Mora, Minn.; and St. Croix Falls, Wis.: Sewage treatment plants.	83,000	
Centuria, Clayton, Cochrane, Greenwood, Luck, Mercer, Milltown, Phillips, Taylor, Turtle Lake, and Withee, Wis.: Sewers and sewage treatment plants.	200,000	
Chippewa Falls, Wis.: Primary sewage treatment plant.....	143,000	
Eau Claire, Wis.: Primary sewage treatment plant.....	394,000	
<i>Water supply:</i>		
Altoona, Boyceville, Centuria, Cochrane, Cornell, Fairchild, Fall Creek, Fountain City, Independence, Ladysmith, Merrillan, Neillsville, Pepin, Phillips, St. Croix Falls, Taylor, Trempealeau, Westby, and Whitehall, Wis.: Water-supply systems and water-treatment plants.	635,000	
Grantsburg, Hayward, Hudson, and Mercer, Wis.: Water supply systems and water treatment plants.	60,000	
<i>Miscellaneous:</i>		
Lakes: Bashaw, Briggs, and Devils, Burnett County; Duck, Barron County; Dunham and Eagle, Burnett County; East Fork Rolling, Sawyer County; Eau Claire Lakes, Bayfield and Douglas Counties; Echo, Iron County; Fifield, Price County; Fisher Rolling, Iron County; Flambeau Rolling, Price County; Glen Flora, Rusk County; Grassy, Price County; Hawkins, Rusk County; Horseshoe, Barron County; Josie, Rusk County; Little Elk No. 1, Price County; Long and Loon, Burnett County; Mackey Brook, Washburn County; Middle, Rusk County; Mud, Burnett County; Ojibwa Rollings, Sawyer County; Or Bow, Iron County; Parks Falls, Price County; Pas Wa Wong, Sawyer County; Pike Rolling, Iron County; Potato, Rusk County; Radigan, Douglas County; Radisson Rolling, Sawyer County; Rice, Iron County; Rice, Rusk County; Sand, Sawyer County; Shell, Washburn County; Silver Creek, Taylor County; Spider, Iron County; Squaw Creek, Price County; Taber, Burnett County; West Fork Rolling, Sawyer County; Weigour, Rusk County, Wis.: Lake level control dams for water conservation.	270,000	

Upper Mississippi—Red River of the North Project List—Continued

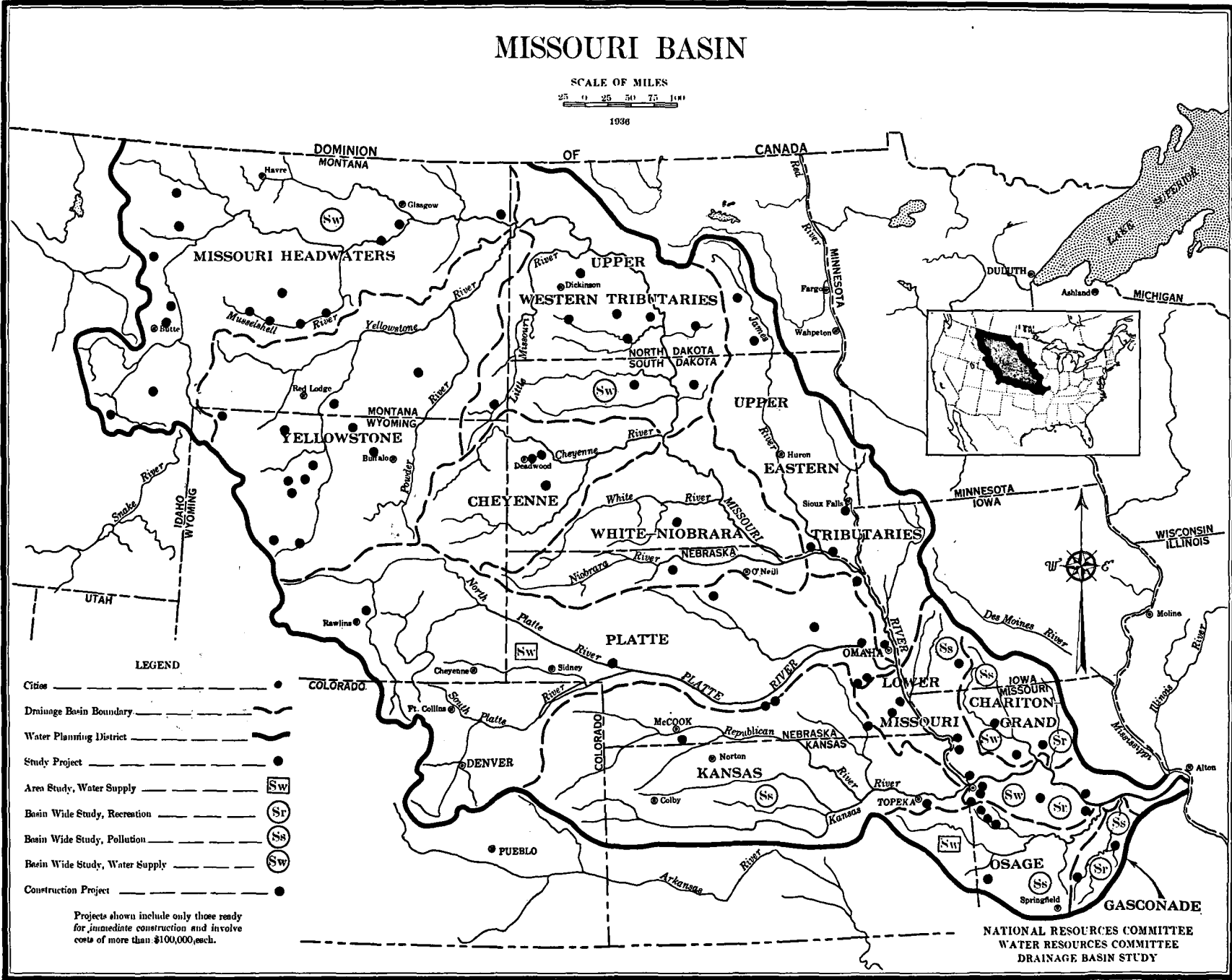
Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Upper (Mississippi) western tributaries:		
Pollution: Caledonia, Cannon Falls, Chatfield, Claremont, Dodge Center, Farmington, Hastings, Houston, Kasson, Kenyon, Lanesboro, Mabel, Mazeppa, Northfield, Pine Island, Preston, Red Wing, St. Charles, South St. Paul, Spring Grove, Spring Valley, Stewartville, Wanamingo, Waseca, and Zumbrota, Minn.: Sewage-treatment plants.	\$577,000	
Houston and Lewiston, Minn.; Oelwein and Olin, Iowa; Owatonna, Minn.; Oxford Junction and Waukon, Iowa: Secondary sewage-treatment plants.	410,000	
Wisconsin:		
Water power: Knowlton, Portage County; Little Eau Pleine, Marathon, and Portage Counties; Petenell and Table Rock, Adams County, Wis.: 4 dams and reservoirs on the Little Eau Pleine and Wisconsin Rivers.	14,300,000	Cost estimate for completion.
Water supply: Eagle River and Minocqua, Wis.: Water supply improvement.....	19,000	Rough cost estimate.
Rock:		
Pollution: Dixon, Ill.: Combined sewers.....	285,000	
Footville, Wis.: Sewage-treatment plant.....	10,000	
Rockford, Ill.: Sanitary sewers.....	137,000	
Water supply: Beloit, Wis.: Water-softening plant.....	200,000	
Iowa-Cedar:		
Erosion: Butler, Cedar, Cerro Gordo, Franklin, Winnebago, and Worth Counties, Iowa: Small dams and planting for bank protection, stream development, and provision for wildlife refuges.	70,000	
Mower County, Minn.: Improving banks of Cedar River, Dobbin Creek Lake, and Sutton Park Lake.	19,000	Preliminary plans only.
Pollution: Johnson County, Iowa: Storage dam on Iowa River above Iowa City to augment low water flow for pollution correction.	350,000	
Water supply: Albion, Britt, Cedar Rapids, Floyd, Garrison, Grafton, LeGrand, Montour, Nichols, Oakville, Princeton, Steamboat Rock, and Thornton, Iowa: Water-supply system or improvements.	463,000	
Des Moines-Skunk:		
Flood control: Ottumwa, Iowa: Des Moines River levees and channel alignment.....	600,000	Some work completed in protective works. Protection proposed as part of a sewage treatment plant system. Additional study and plans necessary.
Valley Junction, Iowa: Walnut Creek levee and channel alignment.....	25,000	Preliminary plans prepared. Petition submitted for formation of levee district in Valley Junction and Des Moines.
Pollution: Brighton, Nevada, and Story City, Iowa: Preliminary treatment plants.....	100,000	
Water supply: Agency, Barnes City, Batavia, Beacon, Birmingham, Blakesburg, Delta, Fremont, Keswick, Lacona, Lucas, Lynnville, Melrose, Menlo, Milo, Montrose, Moravia, New Virginia, Osceola, Runnells, Russell, St. Charles, Salem, Truro, Van Meter, Waukeo, and What Cheer, Iowa: Water-supply system for development of supply and constructing distribution system.	1,035,000	No action taken. Surface supply is probable in most cases. Rivers available in several cases.
Illinois:		
Drainage: Vermillion County, Ill.: Drainage projects.....	20,000	Plans complete.
Flood control: Banner special drainage and levee district; Big Lake drainage and levee district; East Liverpool drainage and levee district; East Peoria drainage and levee district; Henderson County drainage district no. 3; Hennepin drainage and levee district; Keithsburg drainage and levee district, Mississippi River; Kelley Lake drainage and levee district; Lacey, Langellier, West Matanzas, and Kerton Valley drainage and levee district; Liverpool drainage and levee district; Lost Creek drainage and levee district; Pekin and La Marsh drainage and levee district; Rocky Ford drainage and levee district; Seahorn drainage and levee district; Sny Island levee district, Mississippi River; South Quincy drainage and levee district, Mississippi River; Spring Lake drainage and levee district and Thomson drainage district, Illinois: Levee (new or additional) and channel improvements on the Illinois River and that part of Mississippi River included in this report, for flood protection.	2,040,000	Authorized by Congress.
Irrigation: Green County, Ill.: Irrigation projects.....	20,000	Plans completed.
Pollution: Algonquin, Augusta, Bladensville, Bluemound, and Bluffs, Ill.; Bremen, Ind.; Brimfield, Ill.; Brook, Ind.; Burlington, Wis.; Cabery, Camp Point, Campus, Carbon Hill, Carthage, Cary, Chandler-ville, Chapin, Cisco, Clayton, Clifton, Dallas City, Dalzell, Danvers, and De Land, Ill.; Earl Park, Ind.; East Galesburg, Edinburg, Elsie, Fairview, Farmersville, and Fisher, Ill.; Fowler, Ind.; Franklin, Gardner, Geneva, Grafton, Greenview, and Hanna City, Ill.; Hebron, Ind.; Humphreys, Iliopolis, Industry, and Kane, Ill.; Kentland, Ind.; Kewaunee and Kinsman, Ill.; Knox and Kouts, Ind.; Lake Geneva, Wis.; Lenore, Libertyville, and Lombard, Ill.; Lowell, Ind.; Macon, Mahomet, Manito, Mansfield, Mazon, Mendon, Meredosia, and Middletown, Ill.; Morocco, Ind.; Mukwonago, Wis.; Murrayville, Nauvoo, New Berlin, and New Boston, Ill.; New Carlisle, Ind.; Niantic, Ill.; North Judson and North Liberty, Ind.; Oneida and Palmyra, Ill.; Pewaukee, Wis.; Pittsfield, Pleasant Hill, and Plymouth, Ill.; Plymouth, Ind.; Prairie City, Ill.; Remington and Rensselaer, Ind.; Riverton, Shipman, South Elgin, Sparland, Spring Forest, Symerton, Tallula, Thayer, Tonica, and Versailles, Ill.; Walworth, Wis.; Wapella, Warrensburg, and Warsaw, Ill.; Waterford, Wis.; Waverly and West Dundee, Ill.; Westville, Ind.; and Wyanot and Yates City, Ill.: Sewer systems and sewage treatment plants.	5,107,000	
Water power: Kankakee River power development near Aroma Park, Ill.....	302,000	
Power development 2 miles below Wills-Kankakee County line in Illinois.....	1,473,000	
Kankakee River power development below Wilmington, Ill.....	624,000	
Water supply: Alpha, Astoria, Barry, Benson, Biggsville, Bureau, Cedar Point, Cisco, Deatur, Deer Creek, Eileen, and Elsie, Ill.; Fontana, Wis.; Glasford, Grand Ridge, Granville, Gridley, Havana, and Hennepin, Ill.; Knox and Lakeville, Ind.; Lake Geneva, Wis.; Little York, Loraine, Lostant, Mark, Minooka, Moneo, New Holland, Odell, Oswego, Paw Paw, Payson, Pearl, Seaton, Secor, Shipman, Sibley, Standard, and Toulon, Ill.; Waukesha and Williams Bay, Wis.; Williamsville, Windsor, Woodhull, Woodland, and Yorkville, Ill.: Water supplies, improvements, and sewage treatment plants.	823,000	
Western Tributaries, Keokuk-Alton:		
Flood control: Adair County, Mo.: Channel improvement and dam construction for water diversion and storage.	167,000	
Clark, Marion, and Pike Counties, Mo.: 3 flood-correction projects, levees, river improvements, etc.	76,000	

Upper Mississippi—Red River of the North Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Western Tributaries, Keokuk Alton—Continued.		
<i>Flood control—Continued.</i>		
Macon, Montgomery, Ralls, and Schuyler Counties, Mo.: 6 water conservation projects, dam construction and improvements and reservoir construction.	\$75,000	
Clark County, Mo.: Diversion of lower Fox River to protect farm lands.....	60,000	
St. Louis:		
<i>Flood control:</i>		
Big, Bourboise, and Meramec Rivers, Mo.: Channel clearance for flood correction and recreation...	20,000	
Madison County, Ill.: Improving levees of the Choteau Island drainage and levee district.....	213,000	
Madison County, Ill.: Levee construction for flood protection in the Wood River drainage and levee district.	131,000	
<i>Pollution:</i>		
Alton, Ill.: Sewer system in upper Piasa Valley.....	90,000	
Cahokia, East Carondelet, and Fairmount, Ill.; Herculaneum, Mo.; Nameoki, National City, and Washington Park, Ill., Sewer systems.	453,000	Preliminary plans completed.
Deer Creek, Huntleigh, and Kirkwood, Mo.: Sewer systems.....	260,000	
East Alton, Ill.: Storm sewers.....	25,000	
St. Louis, Mo.: Sewers for area tributary to Gravois Creek, River Des Peres and Maline Creek.....	2,800,000	
St. Louis, Mo.: Sanitary relief sewer for River Des Peres district.....	1,000,000	
St. Louis, Mo.: Sewer replacements.....	260,000	
St. Louis, Mo.: Relief sewers.....	4,800,000	
University City, Mo.: Storm sewers and channel improvements for River Des Peres area.....	2,000,000	
<i>Recreation:</i>		
Alton, Ill.: Lake development above dam no. 26; beaches, boating facilities, drives and parks.....	1,250,000	
St. Charles County, Mo.: Lake development above dam no. 26 opposite Alton, Ill.—beaches, boating facilities, drives, and parks.	1,850,000	
<i>Water supply:</i>		
Meramec River Basin, Mo.: Storage reservoirs and low dams on tributaries for rural water supplies.	400,000	
Kaskaskia-Big Muddy:		
<i>Drainage:</i>		
Alexander, Franklin, Hamilton, Jackson, Perry, Randolph, St. Clair, Union, and Williamson Counties, Ill.: Drainage for malaria control.	700,000	
<i>Pollution:</i>		
Arthur, Ashley, Atwood, Ava, Beckemeyer, Bement, Buckner, Bush, Cambria, Carbondale, Central City, Coalton, Cobden, Coffeen, Colp, Coulterville, Cowden, Cutler, De Soto, Dowell, Energy, Farina, Freeburg, Germantown, Grand Tower, Hammond, Hanford, Highland, Hillsboro, Hurst, Irving, Lovington, Johnston City, Jonesboro, Kimmunity, Lebanon, Livingston, Marine, Marion, Mascoutah, Mount Olive, Mount Vernon, Mulberry Grove, Murphysboro, North City, Odin, Okawville, Orient City, Pana, Panama, Patoka, Pinckneyville, Pittsburg, Royalton, St. Elmo, Sandoval, Schram City, Sesser, Shelbyville, Sorento, Steelville, Stewardson, Swansea, Tamaroa, Taylor Springs, Thompsonville, Tilden, Tower Hill, Valier, Vandalia, Wamac, West City, Williamson, Windsor, and Witt, Ill.: Sewers and sewage treatment plants.	5,137,000	
<i>Water supply:</i>		
Bush, Cambria, Carterville, Chester, Coalton, Coffeen, De Soto, Dowell, Energy, Farina, Grand Tower, Hanaford, Irving, Kimmunity, Lovington, Marine, Murphysboro, North City, Orient City, Pittsburg, Ramsey, Red Bud, Royalton, St. Elmo, Sesser, Shelbyville, Sparta, Stewardson, Thompsonville, Tower Hill, Trenton, Williamson, Windsor, Witt, and Ziegler, Ill.: Water supplies and improvements.	1,135,000	
Vandalia, Fayette County, Ill.: Additional treatment and additional water distribution.....	228,000	
West Frankfort, Franklin County: Water system.....	675,000	

MISSOURI BASIN

SCALE OF MILES
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- LEGEND**
- Cities — ●
 - Drainage Basin Boundary — ———
 - Water Planning District — ———
 - Study Project — ●
 - Area Study, Water Supply — (Sw)
 - Basin Wide Study, Recreation — (Sr)
 - Basin Wide Study, Pollution — (Ss)
 - Basin Wide Study, Water Supply — (Sw)
 - Construction Project — ●

Projects shown include only those ready for immediate construction and involve costs of more than \$100,000, each.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

MISSOURI BASIN

Provision of water for irrigation is uppermost among the water problems of the arid western third of the Missouri Basin. Adjustment of both water and land uses to recurring periods of drought is the pressing need of the semiarid middle section of the basin. Control of flood waters and abatement of pollution are outstanding problems in the subhumid easternmost third. Soil erosion is a serious problem in various localities of all three sections.

The irrigated valleys along the Rocky Mountain slope of the basin have prospered, in general, from the cultivation of sugar beet, vegetable and forage crops, but many of them have run short of water during recent years, and crop production has suffered sorely. Present supplies should be supplemented by additional surface storage and by transmountain diversion, with proper safeguards. Hydroelectric power installations may be combined profitably with new storage and diversion facilities in several instances. In the Jefferson, Marias, Musselshell, Gallatin, Yellowstone, and other northern tributary basins of the Missouri there is, in general, sufficient unappropriated water to allow storage adequate to care for all present needs and for some prospective needs. This is true of the Montana drainages above Fort Peck Dam if the Federal Government does not attempt to prevent further utilization of water upstream in order to maintain the flow of the Missouri River for navigation downstream. A number of relatively small reservoirs to provide supplemental water for existing enterprises are now feasible. Engineering and economic studies of proposed supplemental reservoirs, of a suggested Yellowstone-Missouri-Snake diversion, and of coordinated water-utilization programs in the Big Horn, Dearborn, and Marias Basins should be made promptly. Efficient utilization of grazing lands in the western area should be promoted by the recommended stock-watering improvements.

Water shortage is especially critical in the Platte Basin. Diversions from the Colorado Basin and storage reservoirs in the upper Platte Basin would prevent shortage in future and supply new enterprises as well, but new storage should not be undertaken until an equitable allocation of the waters of the North Platte River among Colorado, Nebraska, and Wyoming has been made, and until conflicts over available water in Nebraska have been reconciled.

Water conservation can at best play only a secondary role in the stabilization of economic life in the Great Plains section of the basin. It is an area of excessive

risk in land use; an area in which the prevailing dry-farming and grazing systems always have failed in years of severe drought. Readjustments in cropping methods, land tenure, crop-insurance structure, and farm organization are necessary prerequisites to the establishment of an agricultural economy suited to withstand recurrent periods of deficient rainfall. The extent to which measures for the use and control of water may contribute to improvement of Great Plains conditions is summarized in the following paragraphs:

1. Small dams may be constructed in certain areas devoted to grazing in order to make water available for stock on range lands that otherwise could not be grazed, or to reduce the distance which livestock must be trailed to water.

2. Springs may be improved, shallow wells may be dug, and deep wells may be drilled to supply water for livestock in favorable areas. The effect of the foregoing measures (both 1 and 2) would be to reduce overgrazing near water holes, and so to extend the effective range area.

3. In grazing areas having adequate supplies of stock water, unappropriated water may, where topographic and soil conditions permit, be stored and used for the irrigation of forage crops, thus building up feed reserves for dry years. The available surface supplies of water are meager, however, since only 5 percent of the scanty rainfall normally reaches the main river system.

4. In areas to be devoted mainly to dry farming, there are opportunities to irrigate scattered tracts of small size, in most cases, from reservoirs or by pumping. The importance of such work cannot be large in the aggregate. It is estimated that only 3 percent, at most, of the total Great Plains area can ever be irrigated at reasonable cost.

5. Construction of reservoirs for recreational use and for wildlife conservation and provision of wells for domestic use would measurably increase the comfort of Great Plains occupance but would not affect the basic problem of wresting a living from the hazardous semiarid environment.

6. Large irrigation projects are not considered feasible in most parts of the semi-arid plains because they do not yield substantial benefits in wet years and so fall into disuse. Moreover, large projects almost invariably develop independently of and yield slight benefits to dry-farming activities on adjacent lands.

Specific programs of works for the Little Missouri, Cheyenne, James, and intervening basins are shown in the accompanying tables. In general, small reservoirs

should be undertaken only after the completion of surveys indicating an economic use for the stored water, safe foundations for the dams, adequate spillway capacities, and drainage areas sufficient to supply water during dry years.

The most urgent water problem in the eastern sub-humid section of the basin is the elimination of the flood hazard at the Kansas Citys and in the lower Kansas River Basin. Studies of alternative plans for protection are nearing completion and a final plan prob-

ably will be made available during 1937. Flood control is of local importance also at a few places in the Osage and Grand Basins, and the need for reduction of Missouri River and lower Mississippi flood flows may in future warrant reservoirs on the Osage, Gasconade, and Grand Rivers. At present there is immediate justification for improvements of sanitary facilities at the commercial cities along the Missouri and in the Ozark recreational areas. The navigation project now under construction on the Missouri does not merit extension.

Missouri Basin Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Missouri Basin, general:		
Irrigation:		
Investigation of small-scale projects in Great Plains area.....	\$150,000	
Missouri headwaters:		
General:		
Study to determine extent and best use of water supply of the Dearborn River, Mont.....	25,000	
Study to determine extent and best use of water supply of the Marias River, Mont.....	50,000	
Yellowstone:		
Irrigation:		
Yellowstone-Missouri-Snake diversion project.....	150,000	
General:		
Big Horn River Basin, plan of development.....	50,000	
Platte:		
General:		
Study of water supply and use in Colorado, Wyoming, and Nebraska.....	100,000	Needed as basis for selection of projects.
Blue River diversion, Summit County, Colo.: Study of economic feasibility of diversion from Colorado Basin to Missouri Basin.....	25,000	In progress. Sum needed to complete.
Kansas:		
Pollution:		
Study of pollution throughout basin.....	20,000	
Miscellaneous:		
Study of pasture ponds throughout basin.....	10,000	
Lower Missouri:		
Pollution:		
Kansas City, Kans. and Kansas City, Mo.: Study of sewage treatment.....	20,000	
Study of stream pollution throughout basin.....	10,000	
Recreation and wildlife:		
Study of recreation, reforestation, soil conservation, and wildlife facilities of basin.....	50,000	
Water supply:		
Study of water supply for municipal, domestic, and livestock use throughout basin.....	10,000	
Chariton-Grand:		
Pollution:		
Study of stream pollution throughout basin.....	10,000	
Recreation and wildlife:		
Study of water conservation and recreation.....	20,000	
Osage:		
Pollution:		
Study of stream pollution throughout basin.....	10,000	
Water supply:		
Study of water supply for municipal, domestic, and livestock use in western section of basin.....	20,000	
Gasconade:		
Pollution:		
Study of stream pollution conditions throughout basin.....	5,000	
Recreation and wildlife:		
Study for extension of recreational facilities of basin.....	5,000	
2. Construction Projects		
Missouri headwaters:		
Flood control:		
Glasgow, Mont.: Levees on Milk River for flood protection.....	26,000	Sketch plans completed.
Harlem, Mont.: Levees on Thirty Mile Creek for flood protection.....	10,000	Do.
Havre, Mont.: For completion of Chain of Lakes Reservoir by Fresno Dam on Milk River to conserve and utilize flood waters imported from the St. Mary River.....	250,000	Sum needed to complete.
Saco, Mont.: Levees on Beaver Creek for flood protection.....	27,000	Sketch plans completed.
Irrigation:		
Ackley Lake, Mont.: Increased water storage by raising natural outlet of lake, and to fill same by feed canal (5 miles long) from Judith River for irrigation supply.....	98,000	Plans nearly ready.
Barber, Mont.: Outlet tunnel from Deadman's basin to return water to the river to supply lower Musselshell canals.....	300,000	Inlet tunnel from Musselshell River under construction. Sum needed to complete.
Durand, Forks, and Martinsdale, Mont.: Reservoirs for irrigation.....	400,000	Cost given is for first 2 years. Additional needed to complete, \$376,000.
Fairfield, Mont.: Sun River Project canals and drains to complete system.....	400,000	Cost given is for first 2 years. Additional needed to complete, \$500,000.
Fort Belknap Indian Reservation, on Milk River, Mont.: Improvements to present irrigation system.....	30,000	Storage in Chain of Lakes included with Milk River Project. Plans completed. Cost given is for first 2 years. Additional needed to complete, \$30,000.
Madison County, Mont.: Storage reservoir on Ruby River for irrigation of lands in Ruby and Jefferson Valleys.....	527,000	Plans completed.
Montana: Small reservoirs in several counties costing less than \$25,000 each, for irrigation and grazing including Little Dry Creek, Buffalo Hill, Ash Creek, and Clear Lake.....	250,000	Plans are incomplete.
Saco, Mont.: Saco Divide Pumping Division of the Milk River project for irrigating 10,000 acres of land above gravity system.....	400,000	Plans in preparation. Cost given is for first 2 years. Additional needed to complete, \$600,000.
Upper Boulder, Mont.: Dam to provide supplemental storage for irrigation.....	200,000	

Missouri Basin Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A.—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Missouri headwaters—Continued.		
<i>Irrigation and water supply:</i>		
Fort Peck, Indian Reservation, Mont.: Missouri River pumping plant for stabilizing supply for several units on reservation.	\$100,000	Cost given is for first 2 years. Additional needed to complete, \$100,000.
Jordan, Mont.: Big Dry Creek storage reservoir to be used in conjunction with Wolf Creek Reservoir for irrigation purposes. It would also serve town of Jordan.	80,000	Plans nearly ready.
<i>Navigation:</i>		
Fort Peck, Mont.: Fort Peck Dam on the Missouri River for stabilizing flow for navigation below Sioux City.	16,297,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$2,922,000.
<i>Pollution and water supply:</i>		
Helena, Mont.: Stand-by water service for veterans' hospital and Fort Harrison, including 300,000-gallon reservoir, and extension of present water and sewer systems.	35,000	Surveys started.
<i>Water supply:</i>		
Helena, Mont.: Water mains.....	379,000	
Lewiston, Mont.: Water mains.....	238,000	
Montana: General water supply development consisting of wells, springs, and reservoirs for stock grazing throughout State.	250,000	Survey to be made.
<i>Miscellaneous:</i>		
Dell, Mont.: Big Sheep Creek Reservoir for supplemental storage in Red Rock Valley.....	136,000	
Yellowstone:		
<i>Irrigation:</i>		
Big Horn and Powder River Basins, Mont.: Small reservoirs.....	200,000	Plans can be completed quickly.
Crow Indian Reservation, Mont.: Irrigation systems.....	300,000	Cost given is for first 2 years. Additional needed to complete, \$200,000.
Gooseberry Reservoir, Wyo.: Storage.....	197,000	
Grass Creek Reservoir, Wyo.: Supplemental storage.....	100,000	
Heart Mountain Division, Shoshone project, Wyo.: Irrigation.....	4,500,000	Sum necessary to complete.
Louis Lake Reservoir, Wyo.: Supplemental storage.....	31,000	
Owl Creek, Wyo.: Irrigation district; supplemental supply.....	325,000	
Riverton irrigation project, Wyo.....	750,000	Cost given is for first 2 years. Additional needed to complete, \$3,100,000.
Shell Irrigation project, Wyo.: Additional storage.....	55,000	
Sidney, Mont.: Pumping project.....	85,000	Plans nearly completed.
Tensleep Meadows Reservoir, Wyo.: Storage.....	48,000	
Tongue River, Mont.: Storage.....	820,000	Plans in progress.
<i>Miscellaneous:</i>		
Entire basin: General water development for grazing.....	250,000	
Upper (Missouri) western tributaries:		
<i>Irrigation:</i>		
Carter County, Mont.: Storage on Box Elder Creek.....	67,000	Plans ready.
Carter County, Mont., Little Missouri River: Storage and irrigation canals.....	778,000	Ready for contract.
<i>Pollution:</i>		
Ashley, Beach, Belfield, Beulah, Bowman, Golva, Dickinson, Elgin, Glen Ullin, Hazen, Hebron, Hettinger, Killdeer, Linton, Marmarth, Max, Mott, Napoleon, New England, New Salem, Ray, Richardton, Stanley, Strasburg, Turtle Lake, Watford City, Wild Rose, Wilton, and Wishek, N. Dak.: Municipal sewer systems.	1,045,000	Plans can be completed quickly for all projects except Hettinger.
Gettysburg, Glenham, Herreid, Java, and McIntosh, S. Dak., and New Leipzig, N. Dak.: Municipal sewer systems.	141,000	Plans ready for Java. Plans incomplete for New Leipzig. No plans for other projects.
Goodrich, Grenora, Hazelton, Lehr, Marshall, Plaza, Ryder, Sanish, Tioga and Underwood, and Zeeland, N. Dak.: Municipal sewer systems.	375,000	Plans can be completed quickly.
<i>Recreation and wildlife:</i>		
Steele, N. Dak.: Long Lake Bird Refuge.....	66,000	Plans completed.
<i>Water supply:</i>		
Akaska, Glenham, S. Dak.; Goodrich, Grenora, Hazelton, N. Dak.; Herreid, Hoven, Lebanon, S. Dak.; Lehr, Linton, Parshall, N. Dak.; Pollock, S. Dak.; Ryder, Sanish, Stanley, Tioga, Underwood, Washburn, Wilton, and Zeeland, N. Dak.; Municipal water-supply systems.	525,000	Plans can be prepared quickly for projects in North Dakota. Plans ready for Herreid, S. Dak. No plans for other projects.
Ashley, Bowman, Glen Ullin, Max, Napoleon, New Salem, Ray, Richardton, Strasburg, Turtle Lake, Wild Rose, Wishek, and 22 other towns in North Dakota, and Java, S. Dak.: Water-supply systems and/or wells.	480,000	Plans can be completed quickly for all projects. Plans ready for Java.
Mandan, N. Dak.: Water-treatment plant.....	115,000	Plans can be completed quickly.
New Leipzig, N. Dak.: Water distribution system and treatment plant.....	30,000	Plans incomplete.
Upper (Missouri) eastern tributaries:		
<i>Navigation:</i>		
Missouri River—Omaha, Nebr., to Sioux City, Iowa: Completion of present 6-foot channel project.....	23,000,000	Authorized by Congress.
<i>Pollution:</i>		
Decatur, Nebr.; Denison, Iowa; Dixon County, Nebr.; Dow City and Dunlap, Iowa; Edgely and Ellendale, N. Dak.; Fessenden, N. Dak.; Faulkton, S. Dak.; Hartington, Nebr.; Kulm and La Moure, N. Dak.; Missouri Valley, Iowa; Montrose, S. Dak.; Oaks, N. Dak.; Omaha, Nebr.; Plankinton, S. Dak.; South Sioux City, Nebr.; Streeter, N. Dak.; Walthill, Nebr.; Watertown, S. Dak.; Woodbine, Iowa: Sewer systems and sewage treatment plants.	3,238,000	Plans available for South Dakota projects. Plans for North Dakota projects can be completed promptly. Iowa and Nebraska plans incomplete. Iowa costs are rough estimates on per capita basis.
<i>Recreation and wildlife:</i>		
19 small reservoirs in James River drainage in North Dakota for stock watering, waterfowl, and recreation.	196,000	Plans can be completed quickly.
<i>Water supply:</i>		
Blair, Nebr.; Brandt, S. Dak.; Canton, S. Dak.; Deloit, Iowa; Huron, S. Dak.; Jackson, Nebr.; Jefferson, S. Dak.; Kiron, Iowa; Knox County, Nebr.; Kulm, N. Dak.; Lennox, S. Dak.; Maskell, Nebr.; Mitchell, S. Dak.; Omaha, Nebr.; Streeter, N. Dak.; Thurston, County Nebr.; Tripp, Valley Springs, and Vermillion, S. Dak.; Wolf Lake and Woodbine, Iowa; Yankton, S. Dak.: Water-supply systems, construction, improvement, or treatment.	638,000	Nearly all plans made. Iowa plans incomplete. All estimated costs very approximate; many on per capita basis.
<i>Miscellaneous:</i>		
James River dam: Water conservation.....	484,000	\$384,000 of this amount for land purchase.
4 small reservoirs in South Dakota—construction or repairs.....	15,000	Plans ready.
Cheyenne:		
<i>Irrigation:</i>		
Niobrara and Weston counties, Wyoming: Constructing 4 dams and reservoirs to provide storage of water for irrigation purposes.	25,000	Plans nearing completion.
<i>Irrigation and water supplies:</i>		
Indian reservations, South Dakota: Improvements to water systems for domestic use, stock, and irrigation purposes.	50,000	Preliminary plans completed. Cost given is for first 2 years. Additional needed to complete, \$50,000.
<i>Pollution:</i>		
Sturgis, S. Dak.: Sewage-disposal plant.....	136,000	Plans completed.
<i>Recreation and wildlife:</i>		
Wind Cave National Park, S. Dak.: Diversion dam and pipe line to fill dry lake bed for recreational purposes and to supply water for game refuge.	30,000	Preliminary plans made.
<i>Water supply:</i>		
Edgemont, Deadwood, Nisland, Sanator, South Dakota State School of Mines, Vale, Wall, and Whitewood, S. Dak.: Improvements to water-supply systems.	191,000	Preliminary plans completed.
Rapid City, S. Dak.: Improvements to water-supply system.....	125,000	Plans completed.

Missouri Basin Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
White-Niobrara:		
<i>Irrigation:</i> Whitney irrigation district, Nebraska: Reservoirs for supplemental storage.....	\$81,000	Plans are ready.
<i>Pollution:</i> Burke, Midland, New He-Dog School, Philip, Pine Ridge Agency, Pukwana, and Wagner, S. Dak.: Sewer systems.....	167,000	
Sewer systems and sewage-treatment plants for each of several communities in Nebraska.....	275,000	Plans can be completed quickly.
<i>Water supply:</i> Armour, Belvidere, Fort Pierre, Hammill, Kadoka, Kennebec, Lake Andes, Midland, Oacoma, Onida, Pine Ridge Agency, Platte, Reliance, White River, and Winner, S. Dak.: Water supply for municipal distribution systems for each of above 15 communities.....	368,000	Further investigation of all projects necessary.
Water supply for domestic and stock use on Indian reservations in South Dakota.....	50,000	
Water supply for municipal developments for each of several communities in Nebraska.....	377,000	Plans can be completed quickly.
Platte River:		
<i>Irrigation:</i> Goshen County, Wyo.: Ray Reservoir on Horse Creek to furnish supplemental water supply for 10,640 acres.....	315,000	
Development of wells, springs, and storage facilities for stock watering on the public range in several counties in Platte basin in Wyoming.....	75,000	
<i>Irrigation and power:</i> Casper-Alcova project, Wyoming.....	2,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$4,800,000.
Platte Valley public power and irrigation district ("Sutherland"): Power and irrigation project on North Platte River in Lincoln County, Nebr.....	465,000	Nearly completed. Sum given is rough estimate of additional amount necessary to complete. This sum already allotted subject to compliance with certain conditions. Total cost estimated at \$10,165,000.
Central Nebraska public power and irrigation district ("Tri-County"): Project on Platte River in central Nebraska.....	3,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$17,000,000. Certain construction pertaining to power is restrained temporarily pending court hearing. Adjustments to irrigation plans may be necessary because of recent court decisions.
<i>Water power:</i> Loup River public power district ("Columbus"): Power project on Loup River, Platte County, Nebr.....	5,200,000	Under construction. Certain construction pertaining to transmission lines is restrained temporarily pending court hearing. Sum given is rough estimate of additional amount necessary to complete. Total cost estimated at \$16,200,000.
<i>Pollution:</i> Arlington, Broadwater, Columbus, Fremont, Fullerton, Kearney, Lincoln, Meadow Grove, Norfolk, North Bend, Ogallala, Oshkosh, Osmond, Overton, Sargent, Schuyler, Stanton, Wayne, West Point, and Wolback; Dixon and Lancaster Counties, Nebr.: Sewer systems and/or sewage treatment.....	905,000	
Brighton, Fort Lupton, Fort Morgan, Colo.: Sewer systems.....	64,000	
Lincoln, Nebr.: Sewage channel to Platte River.....	200,000	Plans can be completed quickly.
<i>Water supply:</i> Albany County, Wyo.: Near Pole Mountain, reconstruction of water system.....	16,000	
Albion, Alliance, Alvo, Bridgeport, Bruno, Clarks, Columbus, Craig, Elba, Ericson, Fremont, Hickman, Hyannis, Kearney, Madison, Norfolk, O'Neill, Overton, Page, Pender, Prague, Rockville, Sargent, and Tilden; Knox and Thurston Counties, Nebr.: Waterworks extensions.....	632,000	
Castle Rock, Central City, Frederick, Fort Morgan, Golden, Idaho Springs, Keenesburg, La Salle, Louisville, Loveland, and Nederland, Colo.: Municipal water supplies.....	251,000	Plans incomplete.
Eric and Lafayette, Colo.: Municipal water supplies.....	142,000	
Intercepting ditches on Ranch Creek and St. Louis Creek in Grand and Boulder Counties, Colo., to provide additional water for diversion through Moffat tunnel.....	2,250,000	Surveys in progress.
Kansas:		
<i>Pollution:</i> Bertrand, Elwood, McCook, and Superior, Nebr.: Sewage disposal plants.....	161,000	Plans completed.
Campbell, Davenport, Hastings, Imperial, Indianola, Osceola, Seward, and Sutton, Nebr.: Sewer systems.....	344,000	Do.
Cheyenne Wells and Flagler, Colo.: Sewer systems and sewage treatment plants.....	49,000	Do.
Nelson and Superior, Nebr.: Storm sewers.....	43,000	Do.
Topeka, Kans.: Sewer extensions and improvements.....	307,000	Do.
<i>Water supply:</i> Alma, Beatrice, Nebr.; Cheyenne Wells, Colo.; Dwight, Exeter, Grafton, Nelson, Nebr.; Olathe, Kans.; Stockville and Swanton, Nebr.: Waterworks improvements.....	318,000	Do.
Clifton, Delia, Dorrance, Ellis, Fort Riley, Lebanon, Leonardville, Longford, McLouth, Palco, Eudora, Shawnee, Soldier, Vermillion, Wallace, and Wetmore, Kans.: Municipal water supplies.....	689,000	Do.
Kansas City, Kans.: Waterworks improvement.....	200,000	Do.
Topeka, Kans.: Waterworks improvement.....	219,000	Do.
Lower Missouri:		
<i>Drainage:</i> Richardson County, Nebr.: Channel enlargement, Big Nemaha River, for drainage improvement.....	252,700	
<i>Navigation:</i> Omaha, Nebr., to mouth of Missouri River: Construction of navigation channel of 6 foot depth....	9,200,000	Sum needed to complete present project.
<i>Pollution:</i> Adams, Nebr.; Anita and Atlantic, Iowa; Booneville, Burlington Junction, California; and Carrollton, Mo.; Carson and Clarinda, Iowa; Columbia, Concordia, and Eldon, Mo.; Elliott and Essex, Iowa; Excelsior Springs and Fairfax, Mo.; Farragut, Iowa; Fayette, Fulton, Gilliam, and Glasgow, Mo.; Glenwood, Griswold, and Hamburg, Iowa; Hermann, Higginsville, Hopkins, Independence, Jefferson City, and King City, Mo.; Lennox, Iowa; Lees Summit, Lexington, Liberty, and Maryville, Mo.; Melvern, Iowa; Mound City, Mount Washington, New Franklin, New Haven, Norborne, North Kansas City, Odessa, Oregon, Pilot Grove, and Plattsburg, Mo.; Red Oak, Iowa; Richmond, Rockport, and Sedalia, Mo.; Shenandoah, Iowa; Skidmore, Slater, Smithville, St. Charles, St. Joseph, Sugar Creek, Sweet Springs, Tarkio, and Tipton, Mo.; Villisca, Iowa; Warrensburg, Washington, and Weston, Mo.: Sewage treatment plants.....	930,000	
St. Joseph, Mo.: Sewage-system.....	930,000	
<i>Water supply:</i> Belton, Booneville, Burlington Junction, California, and Concordia, Mo.; Corning, Iowa; Eldon Excelsior Springs, Fulton, and Hermann, Mo.; Lennox, Iowa; Lexington, Maitland, Marshall, Mound City, New Franklin, New Haven, Norborne, North Kansas City, Oregon, Richmond, Skidmore, Sweet Springs, Tipton, and Washington, Mo.: Water treatment plants.....	627,000	
Atlantic, Avooca, Defiance, Elkhorn, Elliott, Glenwood, Hastings, Hamburg, Lewis, Oakland, and Pacific Grove, Iowa; Pilot Grove, Mo.; Riverton, Silver City, and Templeton, Iowa: Waterworks systems and improvements.....	288,000	
Kansas City, Mo.: Improvements to waterworks system.....	527,000	

Missouri Basin Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Chariton and Grand:		
<i>Pollution:</i>		
Alton, Iowa; Albany, Bevier, Breckenridge, Brunswick, Bucklin, Cainsville, Cameron, Chilli-cothe, Mo.; Corydon, Iowa; Gallatin, Grant City, Green City, Hamilton, Huntsville, Keytes-ville, La Plata, Linneus, Maysville, Milan, Novinger, Pattonsburg, Princeton, Salisbury, Tren-braymer, Mo.: Sewer treatment plants.....	\$767,000	Preliminary plans completed.
<i>Water supply:</i>		
Bevier, Mo.: Sewer system and sewage treatment plant.....	49,000	Plans ready.
Allerton and Murray, Iowa: Municipal water supplies.....	133,000	
Bethany, Cameron, and Marceline, Mo.: Improvement of water supplies.....	215,000	
Bevier, Braymer, Breckenridge, Bucklin, Cainsville, Green City, Linneus, Novinger, and Pattons-burg, Mo.: Municipal water supplies.....	348,000	
Osage:		
<i>Pollution:</i>		
Appleton City, Ash Grove, Bolivar, Buffalo, Camdenton, Clinton, Cole Camp, Drexel, Eldorado Springs, Greenfield, Harrisonville, Humansville, Iberia, Liberal, Lockwood, Marshfield, Nevada, New Linn Creek, Osceola, Pleasant Hill, Rich Hill, Sheldon, Stockton, Versailles, Warsaw, Westphalia, and Windsor, Mo.: Sewage-treatment plants.....	923,000	Final plans needed.
Arcadia, Eskridge, Gardner, Louisburg, Moran, Mound City, Pomona, Quenemo, Scranton, and Waverly, Kans.: Sewer systems and sewage-treatment plants.....	314,000	Do.
Mulberry, Kans.: Sewer system and sewage-treatment plant.....	70,000	Do.
Osawatomie, Kans.: Sewage-treatment plant.....	65,000	Do.
<i>Recreation and wildlife:</i>		
Near Nevada, Mo.: Waterfowl refuge.....	96,000	Plans being prepared.
<i>Water supply:</i>		
Drexel, Mo.: Eskridge, Kans.; Fair Play, Garden City, Liberal, and Hume, Mo.; Louisburg, Kans.; New Linn Creek, Mo.: Pomona, Quenemo, and Scranton, Kans.; Sheldon, Mo.; Spring Hill, Kans.; Tusculumbia and Westphalia, Mo.: Water-supply systems.....	310,000	Final plans needed.
Harrisonville, Mo.; Melvern, Kans.; Morrisville and Pleasant Hill, Mo.: Addition to water-supply system.....	329,000	
Gasconade:		
<i>Pollution:</i>		
Cabool, Houston, Mountain Grove, and Richland, Mo.: Sewage-treatment plants.....	255,000	Final plans required.
<i>Pollution and water supply:</i>		
Crocker, Hartville, Lane, Licking, Newburg, and Waynesville, Mo.: Municipal water-supply systems and sewage-treatment plants.....	155,000	Do.

GROUP B—FOR DEFERRED CONSTRUCTION

Missouri headwaters:		
<i>Irrigation:</i>		
Bainville, Mont.: Supplemental supplies from Little Muddy and Shot Gun Creeks for irrigation....	\$254,000	Plans nearing completion.
Beaverhead County, Mont.: Dam on Red Rock Creek to provide supplemental water supply for irrigation.....	860,000	
Daniels County, Mont.: Storage reservoir for irrigation on East Fork Poplar River.....	205,000	Requires clearance of rights from Fort Peck Indian Reservation. Plans nearing completion.
Havr, Mont.: Beaver Creek storage for irrigation.....	184,000	Plans incomplete.
Jefferson County, Mont.: Diversion project, water to be stored at Beaverhead Rock Dam for irriga-tion of Pipestone benchlands.....	200,000	Do.
Plentywood, Mont.: Reservoir on Upper Big Muddy for irrigation.....	478,000	Requires clearance of rights from Fort Peck Indian Reservation. Plans nearing completion.
Richland, Mont.: Storage reservoir for irrigation purposes on West Fork Poplar River.....	359,000	Plans not complete. Cost given is for first 2 years. Additional needed to complete, \$870,000.
Townsend, Mont.: Broadwater-Missouri dam and reservoir for irrigation.....	250,000	
<i>Recreation and wildlife:</i>		
Medicine Lake, Mont.: Migratory waterfowl refuge; additional water development.....	15,000	Should not conflict with principal uses of water.
Yellowstone:		
<i>Drainage:</i>		
Drainage on irrigation projects in Yellowstone and Clarks Fork Valleys.....	350,000	To be planned as required.
<i>Irrigation:</i>		
Buffalo Rapids project, Custer County, Mont.....	1,000,000	Cost given is for first 2 years. Additional needed to complete, \$5,100,000.
Wind River Indian Reservation, Wyo.: Storage.....	100,000	Cost given is for first 2 years. Additional needed to complete, \$1,205,000.
Upper (Missouri) western tributaries:		
<i>Irrigation:</i>		
Montana, North Dakota, South Dakota: Small reservoirs for stock water and irrigation on Knife River, Heart River, Cannonball River, Grand and Moreau Rivers. Minor tributaries of Mis-souri River.....	250,000	Plans can be prepared quickly. Cost given is for first 2 years. Additional needed to complete, \$750,000.
Upper (Missouri) eastern tributaries:		
<i>Navigation:</i>		
Sioux River channel improvement from Elmwood Park to Brandon, Minnehaha County, S. Dak.....	240,000	Plans ready.
<i>Pollution:</i>		
Alexandria, Alpena, Beresford, Bristol, Canton, Dell Rapids, Flandreau, Flandreau Industrial School, Frederick, Groton, Hartford, Humboldt, Iroquois, Leola, Mount Vernon, Plankinton, Roscoe, School District No. 3, Tripp, Vermillion, Volga, Waubay, Willow Lakes, and Woon-socket, S. Dak.: Sewer systems and/or sewage-treatment plants.....	561,000	Plans available for Flandreau.
<i>Recreation and wildlife:</i>		
McCook County, S. Dak.: Ramsey Lake recreation project, in Vermillion River drainage.....	154,000	Plans prepared.
6 recreational lakes in Big Sioux and Vermillion Basins, S. Dak.....	54,000	Plans available for 2. No plans for others.
<i>Water supply:</i>		
Aberdeen, Northern Normal School, Brandt, Bruce, Carthage, Castlewood, Clifton School District No. 4, Cresbord, Flandreau Industrial School, Florence, Goodwin, Humboldt, Langford, Letcher, Roscoe, Roswell, Seneca, unnamed place, and Volga, S. Dak.: Water-supply systems.....	215,000	Plans available for Florence, Castlewood, Bruce, and Flandreau Industrial School. No plans for others.
Bowden, Cathay, Cleveland, Courtenay, Ellendale, Fessenden, Gackle, Hamberg, Kensal, Kulm, Ludden, Medina, Montpelier, Monango, Pingree, Streeter, and Verona, N. Dak.: Wells for municipal water supply.....	22,000	Plans can be completed quickly.
Sioux Falls, S. Dak.: Addition to filtration plant.....	300,000	No plans.
<i>Miscellaneous:</i>		
Small reservoirs for water conservation in Nebraska.....	200,000	Plans incomplete.
54 reservoirs for water conservation at various places in South Dakota.....	600,000	Plans available for 18 of these projects. No plans for others. Cost given is for first 2 years. Addi-tional needed to complete, \$631,000.
Cheyenne:		
<i>Flood control:</i>		
Belle Fourche, Hermosa, Hot Springs, Keystone, New Underwood, Rapid City, and Spearfish, S. Dak.: Small reservoirs and improvements for flood control.....	29,000	Partial plans only.

Missouri Basin Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Cheyenne—Continued.		
<i>Irrigation:</i> Belle Fourche, S. Dak.: Supplemental storage for Belle Fourche Irrigation project.....	\$100,000	Investigations under way. Plans not completed. Cost given is for first 2 years. Additional needed to complete, \$300,000.
Butte, Custer, Meade Counties, S. Dak.: Small reservoirs, wells, and tanks for watering stock.....	150,000	Preliminary plans only. Cost given is for first 2 years. Additional needed to complete, \$150,000.
<i>Irrigation and power:</i> Rapid City, S. Dak.: Dam and reservoir for storage and power on Pactola project and to supplement irrigation water below Rapid City.	100,000	Preliminary plans only. Cost given is for first 2 years. Additional needed to complete, \$2,900,000.
<i>Pollution:</i> Belle Fourche, Deadwood, Edgemont, Lead, Newell, Spearfish, Wall, and Wasta, S. Dak.: Sewage-treatment plants and sewer systems.	129,000	
<i>Recreation and wildlife:</i> Belle Fourche, S. Dak.: Water-control structures and fencing of Belle Fourche Migratory Waterfowl Refuge.	22,000	Plans completed.
Custer and Pennington Counties, S. Dak.: 13 reservoirs for storage of water and recreational purposes. All small except Beaver Creek, \$100,000.	179,000	Do.
<i>Water supply:</i> Ardmore, Fairburn, Oelrichs, Owanka, Quinn, Rapid City, Sturgis, Wall, Wasta, and Whitewood, S. Dak.: Improvements and extensions to the water-supply systems.	300,000	Preliminary plans only.
White-Niobrara:		
<i>Flood control:</i> Midland and Philip, S. Dak.: Small flood-control projects.....	20,000	
<i>Irrigation:</i> Small reservoirs in various locations in Nebraska.....	125,000	Plans can be completed quickly.
Stock watering dams for each of 39 individual projects in South Dakota.....	150,000	
<i>Pollution:</i> Avon, Delmont, Draper, Gregory, Kennebec, Lake Andes, Onida, Pukwana, Quinn, Rosebud, Winner, and White River, S. Dak.: Sewer systems.	105,000	Each of these projects should be investigated before funds are allocated to them.
<i>Recreation and wildlife:</i> Bonesteel (dam), Delmont (city lake), Lake Burke (spillway), Oscoma (ditch), Sully County (diversion to fill dry lake), Sully Lake, and Witten (dam), S. Dak.: Recreational projects in these 7 locations.	61,000	
Recreational and wildlife refuge projects in various localities in Nebraska.....	150,000	Some projects are ready for immediate construction. Nebraska State Planning Board is recommended to program same into individual projects.
<i>Water supply:</i> Burke, Delmont, Draper, Murdo, and Pierre, S. Dak.: Municipal water supplies.....	152,000	Further study of these projects necessary.
<i>Water supply and recreation:</i> Storage projects for the combined purpose of recreation and increased percolation to ground water for domestic and stock water use in 38 localities in South Dakota.	400,000	
Platte:		
<i>Irrigation:</i> Colorado-Big Thompson transmountain diversion of water from Colorado Basin to Missouri Basin for supplemental irrigation supply.	3,000,000	Feasible and badly needed to supply water for lands now under cultivation. Estimate includes a definite provision for compensating reservoirs fully sufficient to protect rights of water users on western slope. Cost given is for first 2 years. Additional needed to complete, \$22,000,000.
Frances March McDonald Reservoir on Horse Creek, in Goshen County, Wyo., for supplemental irrigation supply.	450,000	Further study needed.
8 small storage projects for irrigation in Wyoming.....	72,000	Plans can be completed quickly.
Garden County, Nebr.: Blue Creek public power and irrigation district project.....	400,000	Plans incomplete.
<i>Pollution:</i> Arvada, Central City, Deer Trail, Fort Collins, Georgetown, Golden, Idaho Springs, Johnstown, Julesburg, Kersey, La Salle, Longmont, Loveland, Merino, Mountain View, Ovid, and Platteville, Colo.: Sewage treatment plants.	274,000	Do.
Lower Missouri:		
<i>Pollution:</i> Hardin, Higbee, Overland, St. Ferdinand, and Waverly, Mo.: Sewage treatment plants.....	202,000	
Kansas City, Mo.: Sewage treatment plant.....	3,000,000	
<i>Water supply:</i> Bloomton, Clearfield, College Springs, Prescott, and Gravity, Iowa; Hardin and Higbee, Mo.; New Market, and Orient, Iowa; St. Ferdinand, Overland, and Waverly, Mo.: Municipal water supply systems.	494,000	
Chariton-Grand:		
<i>Flood control:</i> Flood levees for such land units as may be protected at relatively low cost.....	225,000	
<i>Water supply:</i> Exline, Garden Grove, Grand River, Kellerton, Lineville, Lorimor, Numa, Tingley, and Van Wert, Iowa: Water supply systems.	377,000	Improvements of supplies.
Cincinnati and Mystic, Iowa: Water supply systems.....	220,000	

SOUTHWEST MISSISSIPPI BASINS

(Basins of the Arkansas, White, Black, and St. Francis)

The Arkansas River is a typical "through river", possessing dissimilar characteristics in its upper, middle, and lower sections, each of which presents distinctive water problems.

1. Its headwaters rise at altitudes of some 14,000 feet in the Rocky Mountains amid heavy snows and under abundant rains. It flows eastward from the mountains across the semiarid Great Plains, losing volume on the way. Its principal tributary, the Canadian, has similar attributes. Most of the smaller streams tributary to the upper Arkansas and the upper Canadian are on the high plains and are flashy. These headwater streams contribute practically no sustained flow to their eastern extensions.

The prime water need of the upper section of the basin is more water for lands now irrigated. More water may be made available by further conservation of existing supplies and by transmountain diversion from drainage on the western slopes of the Rocky Mountains. Storage of water on the Canadian River, in New Mexico, ultimately will put under irrigation some 60,000 acres, most of which is new land. Proposals for storing floodwaters on the Cimarron in New Mexico and Oklahoma involve smaller irrigation developments, which, if used for production of forage and subsistence crops, may harmonize satisfactorily with the best comprehensive land-use economy.

2. The middle Arkansas flows through the gently rolling prairie plains of eastern Kansas and Oklahoma. The lower Canadian, lower Cimarron, Neosho, and Verdigris tributaries rise rapidly and flood good agricultural lands several times a year during periods of thunderstorms. The middle section of the basin, with its diversified industries and relatively concentrated population, has important problems of providing an adequate urban water supply and insuring stream flow regulation for sanitary purposes.

3. The lower Arkansas occupies a broad flood plain in a trough entrenched in the rugged hilly area between the Boston and Ouachita Mountains. Here there are problems similar to those of the middle basin, and, in addition, the problems of serious and frequent floods. Tributaries of the lower Arkansas afford numerous opportunities for the development of recreational facilities and of hydroelectric power.

The White, Black, and St. Francis Rivers rise in the Boston Mountains and Ozark Plateau. A considerable part of their base flow comes from large springs. Violent rains on the steep rocky slopes cause numerous

floods. These basins possess many beauty spots for recreational development, and several power sites for development in an integrated power system. The extensive tracts of rocky wooded hills with their numerous watercourses are potential game and wildlife refuges.

The regional plan formulated to meet the foregoing conditions and problems may be summarized as follows:

1. In the Rocky Mountain and Great Plains sections the available water resources would be completely conserved and applied primarily to crop production in a grazing economy, but with full consideration of the urban water supply and sanitary needs. The consummation of such a plan would also correct flood flows, reduce soil erosion, and improve recreational facilities.

2. In the Prairie Plains and the lower Arkansas Basin an ample and reliable sustained flow would be secured in the main stream and the principal tributaries through storage of flood waters, thus making available a water supply of satisfactory quantity and quality for urban centers. Such a development would so reduce the frequency of floods on the bottom lands that it would be unnecessary to provide complete protection by levees, except for small areas of high value.

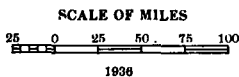
3. In both the Prairie Plains and lower Arkansas Valley sections complete protection from great and infrequent floods is not practicable for agricultural lands any more than it would be for urban property in connection with municipal storm drainage.

4. On the streams of the Ozark uplift, hydroelectric power will ultimately be developed in large blocks, but for a long time the cost of such power, if used for base-load purposes, will exceed that of equivalent steam-power production from gas and oil and even from coal. Such projects should be developed when it proves economical to use hydroelectric power for peak-load purposes in large interconnected systems.

5. In the sandy shifting channel of the Arkansas River, projects cannot be carried out that would provide water transportation except at a cost far greater than that of transportation by other means.

The foregoing matters are reflected in the list of projects. Proposals are there made for further study of several dams authorized by the Congress and for additional reservoirs. It is suggested that these reservoirs be fitted to a program of water control that would improve low water stream flow and reduce the frequency of floods. Hydroelectric power production is proposed on the Verdigris-Neosho-Illinois systems.

SOUTHWEST MISSISSIPPI BASINS



- LEGEND**
- Cities _____ ○
 - Drainage Basin Boundary _____
 - Water Planning District _____
 - Study Project _____ ●
 - Area Study, Flood Control _____ Sf
 - Area Study, Irrigation _____ Si
 - Area Study, Water Supply _____ Sw
 - Basin Wide Study, Recreation _____ Sr
 - Basin Wide Study, Flood Control _____ Sf
 - Basin Wide Study, Irrigation _____ Si
 - Basin Wide Study, Power _____ Sp
 - Basin Wide Study, Water Supply _____ Sw
 - Basin Wide Study, Pollution _____ Ss
 - Construction Project _____ ●

Projects shown include only those ready for immediate construction and involve costs of more than \$500,000 each.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

SOUTHWEST MISSISSIPPI BASINS

(Basin of the Red River)

In this drainage area the underground water resources of the Texas high plains are at present adequate for municipal supplies and for supplementary application through pumping for improvement of agricultural production, but in some sections the water is not fit for drinking purposes, because of its high fluoride content.

Below the high plains escarpment, rainfall is inadequate for satisfactory crop production. The streams have high flood-flow peaks and are nearly or quite dry during long periods in summer. Storage is needed to make water available for supplementary application to maturing crops on lands now under cultivation, for improvement of very unsatisfactory urban water supplies, and for improvement of stream flow for sanitary purposes. Such storage may reduce appreciably the frequency of flooding of fertile lands.

For the part of the basin below Denison, Tex., there is ample rainfall for crops, but the valley lands are flooded so frequently as to impair greatly their value. In this section, flood flows on the tributaries are more damaging than in the western area, but, as in the west, the streams dwindle and disappear in summer. There is a definite deficiency of surface water for urban supplies in various localities and a seriously unsanitary condition in the streams every summer. Storage of water is indicated for correction of low water stream flow on the tributaries, and for reduction of the frequency with which valley lands are flooded. In certain areas reservoirs for these purposes would have further value for production of water power and for recreation.

Studies by the Corps of Engineers demonstrate clearly that the cost of producing reliable conditions for navigation on the Red River above Shreveport would be far in excess of any prospective benefits. Accordingly navigation alone is not considered as a possible part of a long-range water plan. The same studies also show that protection of agricultural lands and of improvements on the lowlands against great and infrequent floods could be secured only at a cost far in excess of benefits. It appears, however, that the best use of the fertile bottom lands is impaired to much greater extent by frequent overflow from small and moderate floods than by great floods, and it is thought that the cultivation of these lands can be stabilized reasonably well if the frequency of overflow is

reduced from once in 1 or 2 years, the present situation, to once in 5 years. The best form of protection is through detention reservoirs; it may be flexible as to the degree secured. There is urgent need for an engineering investigation of a possible system of relatively small reservoirs in the upper parts of the tributary valleys, supplemented by local channel improvements of moderate scope. The investigation should determine whether or not such a system could be operated to reduce the frequency of flooding to the extent suggested. The recent drought indicated clearly that conservation of flood water in the part of the area above Denison is essential to the establishment of good sanitary conditions and to the best use of agricultural lands.

For the section below Denison, a similar type of water improvement is indicated, except that no supplemental water is needed for agricultural purposes. These statements apply also to the lower part of the Washita Basin. In the Ouachita Basin, additional water storage and stream-flow regulation are needed somewhat urgently, and if combined with the development of hydroelectric power they may be warranted in the near future. Water-storage projects in parts of the Little River and Kiamichi Basins should provide for ultimate production of hydroelectric energy.

There apparently is a need for flood protection on the Sulphur River. It will require channel and floodway improvement, possibly supplemented by the impounding of flood waters.

The plan outlined in preceding paragraphs is tentative. An extensive and detailed engineering investigation will be required to determine whether or not it is feasible in all its phases.

In the Red River Basin as a whole there is need for the improvement of municipal water-supply facilities and for the installation and extension of sewage-treatment works.

The extension of forests on the submarginal areas of the uplands would have important value for the long-range water plan. There is definite need for the wider practice of soil-conservation measures on cultivated lands and for the improvement of the vegetal cover on other lands over much of the area. Reduction of soil erosion would simplify the operation of water-conservation facilities. Recommendations with respect to these collateral needs and problems are made elsewhere.

Southwest Mississippi Basins Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Arkansas (general): Studies: (1) In the Cimarron and Canadian sub-basins to determine reservoir developments to achieve the best flow regulation for irrigation, augmentation of low flows, reduction in frequency of overbank flows and water supplies; (2) of the Central Arkansas, Verdigris, Neosho (Grand), and Illinois Rivers with special emphasis on multiple use reservoirs for flow regulation, water supply, water power, or recreation; (3) to determine what changes could be made in the design or operation of flow regulation projects in other sub-basins to increase benefits to the Lower Arkansas without materially lessening the local benefits; a determination of the benefits primarily to the main stem of possible reservoir projects on the Poteau, Petit Jean, and Fourche La Pave Rivers; a determination of levee projects which might supplement the reservoirs.	\$825,000	All these studies are to determine what combination of projects and operation will attain a considerable increase in low flows and a material reduction in frequency of overbank flows. All studies of tributary reservoirs should include consideration of any incidental benefits to the lower Arkansas.
Upper Arkansas: Flood control: Study to determine measures for flood control on the Apishapa, Cuchara, Huerfano, and Purgatoire Rivers in Colorado.	100,000	Authorized by Congress. In addition to studies now being made by Bureau of Reclamation.
Irrigation: Colorado River-Arkansas River diversion: Study to determine the practicability and desirability of diverting the headwaters of the Gunnison and Frying Pan Rivers to the Arkansas River Basin and the feasibility of Tennessee Pass tunnel for irrigation.	215,000	Study in progress.
Cimarron: Flood control, recreation, and wildlife: Study of possible sites for small reservoirs for flow correction, water supply, and recreation.....	10,000	
Study of lake in Grant County, Kans., to determine its usefulness in flood correction in connection with its primarily intended use for recreation and wildlife conservation.	5,000	
Canadian: Irrigation: Study of possibilities of irrigation systems corollary to Optima and Fort Supply Reservoirs in Texas, Beaver, and Woodward Counties, Okla.	50,000	
Central Arkansas: Pollution: Arkansas City and Hutchinson, Kans.; Ponca City, Okla.; Wichita and Winfield, Kans.: Study and preparation of plans for sewage treatment plants.	25,000	
Study of salt-water disposal in the oil fields in Kansas and Oklahoma.....	25,000	
Study of stream pollution in Kansas and Oklahoma.....	20,000	
Study of ground-water resources in Kansas and effects of oil brines.....	10,000	
Neosho-Verdigris: Pollution: Study and survey of sources and extent of stream pollution in Kansas, Oklahoma, and Missouri....	20,000	Quantitative knowledge of pollution is seriously lacking.
Lower Arkansas: Pollution: Study of stream pollution to ascertain its extent and character and to make recommendations.....	15,000	
Upper White-Black-St. Francis: Pollution: Study to determine the extent and source of stream pollution throughout the basin.....	25,000	
Recreation, wildlife, and water power: Study to determine the relative values of water resources for power or recreation throughout the basin.	15,000	
Upper Red River: Irrigation and water supply: Studies of reservoirs throughout the subbasin in Oklahoma and Texas for water supply, irrigation, and flow regulation; including a study of methods to minimize silting in reservoirs.	175,000	These studies may indicate the desirability of altering the proposed Denison project.
Pollution: Study and survey of stream pollution in Texas and Oklahoma. Chemical and biological analyses of surface water to determine extent and seriousness of pollution. Should include fluoride analyses.	25,000	
Washita: Flood control, irrigation, pollution, and water supply: Study of proposed plan to construct 25 reservoirs on tributaries of Washita River for flood control, irrigation, water supply, and maintenance of adequate dry-season flow for dilution of sewage and other wastes, in the Washita Basin, Oklahoma.	180,000	
Irrigation: Study of practicability of irrigation in the basin in Oklahoma and Texas.....	50,000	
Lower Red: Flood control and water power: Arkansas, Louisiana, Oklahoma, and Texas; Blue River, Boggy Creek, Kiamichi River, Little River, Sulphur River, Cypress Creek, Bayou Bodcau, and Bayou Dorcheat: Study of reservoirs for partial flood control in connection with water power.	200,000	
Study of reservoir possibilities at Denison, Tex., in connection with tributary reservoirs in the basin, for flood control and power.	50,000	Further development of studies now in progress, under authority of 1936 Flood Control Act.
Pollution: Pollution survey in Arkansas, Louisiana, Oklahoma, and Texas.....	20,000	
Water supply: Atoka, Bryan, Choctaw, and Coal Counties, Okla.; Fannin and Hunt Counties, Tex.; Johnston, Latimer, Le Flore, and McCurtain Counties, Okla.; Miller County, Ark.; Pittsburg and Pushmataha Counties, Okla.; Sevier County, Ark.: Study of small water-conservation projects.	25,000	For summer supply in areas lacking adequate ground water.
Ouachita: Pollution and water supply: Studies to collect and analyze data on water resources to draw up a water plan, including consideration of sanitation and water supply.	80,000	
2. Construction Projects		
Upper Arkansas: Flood control and irrigation: Taylorville, Colo.: Earth dam and reservoir at the Caddoa site on the Arkansas River for flood control and to supplement water supply for irrigation.	10,000,000	Plans near completion. Authorized by Congress
Irrigation: Chivington, Colo.: Completion and rehabilitation of the Chivington Public Irrigation District....	86,000	Plans completed.
Hugo, Colo.: Diversion dam on Big Sandy Creek, reservoir, and canals for the Hugo Public Irrigation District.	180,000	Preliminary plans made.
Las Animas, Colo.: Rehabilitation of Apishapa Public Irrigation District by replacement of dam which failed in flood.	300,000	Plans completed. Appurtenant works completed
Pollution: Bazine, Kans.; Buena Vista, Camp Martin, Canon City, Cripple Creek, Eads, Florence, Fountain, Fowler, Holly, La Junta, Lamar, Las Animas, Manzanola, Monument, Rocky Ford, Salida, Sugar City, Victor, and Wiley, Colo.: Sewage-treatment plants for partial or complete treatment.	396,000	Plans completed.
Pueblo, Colo.: Complete sewage-treatment plant.....	500,000	Do.
Walsenberg, Colo.: Complete sewage-treatment plant.....	50,000	Do.

¹ Per year.

Southwest Mississippi Basins Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Upper Arkansas—Continued.		
<i>Water supply:</i>		
Camp Martin and Kit Carson, Colo.: Water supply systems.....	\$40,000	Plans completed. Camp Martin project authorized by Congress.
Canon City, Colorado Springs, and La Junta, Colo.; Lakin, Kans.; Lamar and Mansanola, Colo.; Ness City, Kans.; Rocky Ford, Swink, and Trinidad, Colo.: Improvements and repairs to water supply systems.....	190,000	Preliminary plans made.
Colorado and Kansas: Approximately 4,500 small farm ponds throughout the basin.....	655,000	Rough preliminary plans only; further study to disclose location and type.
<i>Cimarron:</i>		
<i>Pollution:</i>		
Carman, Fairview, Hennessey, Jennings, Oilton, O'Keene, Stillwater, Waynoka, and Yale, Okla.: Sewer system improvements and/or sewage-treatment plants.....	109,000	
Guthrie, Okla.: Sewage treatment plant.....	150,000	
<i>Water supply:</i>		
Buffalo, Okla.; Enid, Okla.; Goltry, Okla.; Kismet, Kans.; Langston, Okla.; Meade, Kans.; O'Keene, and Stillwater, Okla.: Water supply systems or improvements.....	616,000	Preliminary plans made.
<i>Canadian:</i>		
<i>Drainage:</i>		
Hughes County, Okla.: Drainage for farm lands.....	84,000	Awaits authorization.
Lincoln County, Okla.: Drainage for farm lands.....	72,000	Do.
Mora County, N. Mex.: Eradication of malarial mosquito breeding areas by fill and drainage.....	32,000	
<i>Flood control:</i>		
Texas County, Okla.: Optima Reservoir on Beaver River.....	1,530,000	Authorized by Congress. Irrigation study recommended in A-1.
Woodward County, Okla.: Fort Supply Reservoir on Wolf Creek.....	2,585,000	Do.
<i>Flood control, irrigation, and water supply:</i>		
Tucumcari, N. Mex.: Conchas Dam and Reservoir.....	6,500,000	Under construction. Estimated cost is amount necessary to complete project.
<i>Irrigation:</i>		
Colfax County, N. Mex.: Completion of Miami Dam to insure cultivation of about 6,500 acres of fertile farm land.....	60,000	Preliminary plans and surveys made. Approximately \$50,000 already spent by farmers' development company.
Colfax County, N. Mex.: Dam and reservoir at Maxwell site for storage of waste water and for irrigation purposes.....	23,000	Plans completed.
La Cueva, N. Mex.: Earth fill dam on the Mora River for retention of floodwaters.....	91,000	Plans completed. Core drillings have been made.
Mora County, N. Mex.: Improvement of Colmar irrigation system.....	23,000	Plans completed.
<i>Pollution:</i>		
Ada, Chandler, and Jones City, Okla.: Improvements to sewage systems and sewer treatment plants.....	210,000	
Allen, Beaver, Blanchard, Depew, Enfield, Haileyville, Hartshorne, Konawa, McAlester, McLoud, Morris, Norman, and Purcell, Okla.; Roy, N. Mex.; Seminole, Shattuck, Stratford, Thomas, Watonga, Weleetka, Wewoka, and Woodward, Okla.: Improvements to sewer systems and sewage treatment plants.....	448,000	
Shawnee, Okla.: Sewage treatment plant.....	250,000	No treatment facilities at present.
<i>Water supply:</i>		
McAlester, Okla.: Water supply improvements.....	193,000	Preliminary plans made.
Oklahoma City, Okla.: Improvements to supplement present supply.....	1,000,000	
Whitedeer, Tex.: Water supply system.....	9,000	Do.
<i>Central Arkansas:</i>		
<i>Flood control, recreation, and wildlife:</i>		
Alfalfa County, Okla.: Great Salt Plains Reservoir on Salt Fork River for flood control and wildlife refuge.....	1,233,000	Project authorized by Congress.
<i>Pollution:</i>		
Alva, Cherokee, Cleveland, Shidler, and Tonkawa, Okla.: Complete sewage treatment plants.....	180,000	
Arkansas City, Kans.; Ponca City, Okla.; Winfield, Kans.: Complete sewage treatment plants.....	550,000	
Attica, Burnton, Galvo, and Mount Hope, Kans.; and Pawnee, Okla.: Sewer systems and/or sewage treatment plants.....	234,000	Preliminary plans made.
Blackwell, Billings, Kaw City, Pond Creek, and Ralston, Okla.: Improvements to existing sewage treatment plants.....	61,000	
Hutchinson, Kans.: Extensions to sewer system.....	120,000	Do.
Hutchinson, Kans.: Complete sewage treatment plant.....	400,000	
Wichita, Kans.: Secondary sewage treatment plant.....	1,000,000	
<i>Water supply:</i>		
Alva, Lamont, and Nash, Okla.: Waterworks or waterworks improvements.....	55,000	Do.
Arkansas City, Kans.: New water supply.....	751,000	Money needed for completion of a project already underway.
Braman, Okla.: Dam and storage reservoir for water supply of Blackwell, Okla.....	50,000	Preliminary plans made.
Eldorado, Kans.: Improvements to waterworks system.....	144,000	
Fairfax and Ralston, Okla.: Improvements to existing waterworks systems.....	115,000	
Hutchinson, Kans.: Improvements to waterworks system.....	1,422,000	Do.
Isabel, Kans.; Kaw City, Okla.; Lorraine, Mount Hope, and Norwich, Kans.; Osage, Okla.; Sharon and Sylvia, Kans.: Waterworks systems or improvements to existing systems.....	360,000	Do.
Perry, Okla.: Improvements to existing waterworks system.....	210,000	Do.
<i>Neosho-Vardigris:</i>		
<i>Drainage:</i>		
Ottawa, Tulsa, and Wagoner Counties, Okla.: Malaria control.....	689,000	
<i>Flood control:</i>		
Osage County, Okla.: Dam and reservoirs at Hulah site on Caney River for flood control and stream stabilization.....	2,343,000	Authorized by Congress.
<i>Pollution:</i>		
Atton, Okla.; Alba, Mo.; Altamont and Altoona, Kans.; Anderson, Mo.; Arma and Buffalo, Kans.; Carl Junction and Cartersville, Mo.; Cherokee, Kans.; Claremore and Collinsville, Okla.; Colony, Kans.; Commerce, Okla.; Decatur, Ark.; Edna and Elk City, Kans.; Gravette, Ark.; Hartford, Kans.; Hominy, Okla.; Jasper, Mo.; LaHarpe, Kans.; Lanagan, Mo.; Lebo and Longton, Kans.; Marionville, Mo.; McCune and Mound Valley, Kans.; Neck City, Neosho, and Noel, Mo.; Nowata, Okla.; Oronogo, Mo.; Peru, Kans.; Picher, Okla.; Pierce City and Pineville, Mo.; Pryor, Okla.; Purcell, Mo.; Rogers, Ark.; Sarcoux, Mo.; Seaman, Kans.; Seneca, Mo.; Severy, Kans.; Skiatook, Okla.; Southwest City, Mo.; Strong and Treece, Kans.; Wagoner, Okla.; Webb City, Mo., and White City, Kans.: Sewer systems and/or primary, secondary, or complete treatment plants or reconditioning of existing systems.....	636,000	
Chanute, Kans.; Joplin and Lamar, Mo.; LeRoy, Kans.; Lincoln, Prairie Grove, and Sulphur Springs, Ark.; Vinita, Okla.: Sewage-treatment plants.....	81,000	
<i>Pollution and water supply:</i>		
St. Paul, Kans., and Springdale, Ark.: Waterworks and sewer system for the former; extensions to sewer system for the latter.....	81,000	

Southwest Mississippi Basins Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Neosho-Verdigris—Continued.		
<i>Water supply:</i>		
Altamont, Americus, Buffalo, and Chautauqua, Kans.; Copan and Dawson, Okla.; Dearing, Kans.; Diamond and Duenweg, Mo.; Dunlap, Durham, Dwight, Edna, Elk Falls, and Fall River, Kans.; Goodman, Mo.; Grenola, Gridley, Havana, Hepler, Lebo, Lehigh, Liberty, and Lincolnville, Kans.; Miller, Mo.; Neosho Falls, Neosho Rapids, and Olpe, Kans.; Purdy and Seigman, Mo.; Siloam Springs, Ark.; Sperry, Okla.; Tampa, Thayer, Tyro, and Wilsey, Kans.: Complete water supply systems or extensions.	\$468,000	Rough estimated cost, with allowance for possibility that some of the projects may not be constructed.
Barnsdall and Catoosa, Okla.; Cherryvale, Kans.; Golden City and Joplin, Mo.; Le Roy, Kans.; Monett, Mo.; Mount Valley, Kans.; Oronogo and Pineville, Mo.; Salina, Okla.; Severy, Kans.; Southwest City, Mo.; Springdale, Ark.; Strong, Kans.; Vinita and Wagoner, Okla.; Walnut and White City, Kans.: Waterworks, improvements, extensions, or construction to secure additional supply.	733,000	
Chanute, Eureka, and Fredonia, Kans.: Filtration or water treatment plants.	216,000	
Greenwood County, Kans.: Dam and reservoir near town of Fall River for stream flow stabilization, for improvement of municipal water supplies.	1,276,000	Preliminary studies made. Additional study necessary to determine size of reservoir.
Morris County, Kans.: Dam and reservoir near Council Grove on Neosho River for stream flow stabilization and for improvement of municipal water supplies.	1,330,000	Preliminary studies made. Additional study needed to determine size of reservoir.
Lower Arkansas:		
<i>Drainage:</i>		
Faulkner County, Ark.; Haskell, Le Flore, McIntosh, Muskogee, and Pittsburg Counties, Okla.; Pope, Pulaski, and Saline Counties, Ark.; Tulsa and Wagoner Counties, Okla.: Malaria control.	1,665,000	
<i>Flood control:</i>		
Clarksville, Ark.: Flood protection levees on Spadra Creek	70,000	
Little Rock, Ark.: 2 miles of levees on Arkansas River for flood protection	111,000	Authorized by Congress. Detailed plans in preparation.
North Little Rock, Ark.: 4.3 miles of levees and walls on Arkansas River for flood protection	401,000	Do.
<i>Pollution:</i>		
Danville, Fort Smith, Hartford, Mansfield, Mulberry, and Waldron, Ark.: Sewer system and/or sewage treatment plants or intercepting sewer.	200,000	Preliminary plans made.
North Little Rock, Ark.: Intercepting sewers	269,000	Do.
Tulsa, Okla.: Sewage treatment plant	971,000	Do.
<i>Water supply:</i>		
Camp Pike, Dover, and Plumerville, Ark.; Stigler and Taft, Okla.: Water supply systems and/or extensions.	139,000	Preliminary or complete plans available.
Upper White-Black-St. Francis:		
<i>Drainage:</i>		
Bollinger, Butler, and Cape Girardeau Counties, Mo.; Independence and Lawrence Counties, Ark.; Perry County, Mo.; Randolph County, Ark.; Ripley and St. Genevieve Counties, Mo.; and White County, Ark.: Malaria control.	439,000	
<i>Pollution:</i>		
Berryville, Ark.; Cassville, Mo.; Green Forest and Hardy, Ark.; Ironton, Mo.; Pangburn, Ark.; Perryville, Piedmont, and Thayer, Mo.: Sewer systems and sewage-treatment plants.	441,000	Plans completed.
Doniphan, Mo.; Eureka Springs, Ark.; Poplar Bluff, West Plains, and Willow Springs, Mo.: Sewage treatment plants.	192,000	Preliminary plans made.
Huntsville, Leslie, Marshall, and Mountain View, Ark.: Sewer systems	176,000	Plans completed.
<i>Recreation and wildlife:</i>		
Ava, Mo.: Lake for recreational purposes	50,000	Plans not completed.
<i>Water supply:</i>		
Arkansas and Missouri: 200 small dams to augment adjacent rural water supply	1,000,000	
Doniphan, Mo.; Eureka Springs, Huntsville, Imboden, Jasper, Leslie, Mammoth Springs, Marshall, Melbourne, and Mountain Home, Ark.; Mountain View, Mo.; Pangburn, Ark.; Springfield, Mo., and Yellville, Ark.: Waterworks or improvements.	578,000	Plans completed.
Upper Red:		
<i>Drainage:</i>		
Wichita Falls, Tex.: Drainage of irrigated land	345,000	Preliminary plans made.
<i>Pollution:</i>		
Indian and public lands: Sealing of abandoned mine shafts and drill holes	10,000	
<i>Pollution and water supply:</i>		
Claude, LeFors, Petrolia, and Nacona, Tex.: Water supply and sewer systems	238,000	
<i>Water supply:</i>		
Indianola, Okla., Iowa Park, and Wheeler, Tex.: Water supply or improvements	162,000	
Wichita Falls, Tex.: Water supply, 5 miles of 42-inch pipe line and treatment plant	1,500,000	Do.
Washita:		
<i>Pollution:</i>		
Alex, Binger, Carnegie, Cement, Chickasha, Davis, Fort Cobb, Hammon, Leedey, Lindsay, Madill, Maysville, Mountain View, Rush Springs, and Verden, Okla.: Secondary sewage-treatment plants.	107,000	
Anadarko and Paul's Valley, Okla.: Complete sewage-treatment plants	65,000	
Byars, Okla.: Sewage-treatment plant	31,000	
Wayne, Okla.: Sanitary sewers	29,000	
<i>Water supply:</i>		
Anadarko, Byars, Chickasha, Cordell, and Marlow, Okla.: Water supply	174,000	
Lower Red:		
<i>Drainage:</i>		
Arkansas, Oklahoma, Louisiana, and Texas: Malaria control	1,000,000	
<i>Flood Control:</i>		
Bossier Parish, La.: Bayou Bodcau diversion floodway involving 33.5 miles of levee and 3 miles of ditches to carry waters of Bayou Bodcau and Cypress Bayou to Red River. For protection against headwaters floods.	1,893,000	Authorized by Congress. Detailed plans in preparation.
DeSoto, Natchitoches, and Red River Parishes, La.: Enlargement of drainage channels through Bayou Pierre and Bayou Pierre Lake from Bayou Wincoy to the north at Grand Ecore for protection against headwaters floods.	300,000	Do.
<i>Pollution:</i>		
Antlers, Okla.; Ashdown, Ark.; Atoka, Caddo, and Coalgate, Okla.; Cove, DeQueen, Foreman, Fulton, Garland, Hope, and Horatio, Ark.; Hugo, Okla.; Lewisville, Lockesburg, McNeill, and Nashville, Ark.; Pittsburg, Okla.; Stamps, Ark.; Talihina, Okla.; Texarkana and Washington, Ark.: Sewer systems and sewage-treatment plants or improvements.	477,000	
Avery, Tex.: Barksdale Field, La.; Blossom, Tex.; Dierks, Ark.; Gilmer, Tex.; Magnolia and Mineral Springs, Ark.; New Boston, Tex.; Shreveport, La.; Wascom, Tex.: Sewer systems and sewer treatment plants or improvements.	357,000	Preliminary plans made.
<i>Pollution and water supply:</i>		
Atlanta, Daingerfield, Detroit, Omaha, Pecan Gap, Pittsburg, and Texarkana, Tex.: Water supply and sewage systems or improvements.	968,000	Plans made.
<i>Water supply:</i>		
Ashdown, Cove, DeQueen, Foreman, Fulton, Garland, Hope, Horatio, and McNeill, Ark.; Pittsburg, Okla.; Stamps, Ark.; Talihina, Okla.; and Washington, Ark.: Water supply systems and water improvements.	234,000	

Southwest Mississippi Basins Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Lower Red—Continued.		
Water supply—Continued.		
Atoka, Okla.: Bailey, Bloomburg, Commerce, and Cooper, Tex.; Dierks, Ark.; Dodd City, Tex.; Durant, Okla.; Ector and Hallsville, Tex.; Lewisville and Magnolia, Ark.; Mooringsport, La.; Mount Pleasant, Tex.; Ringgold and Robeline, La.; Sherman and Trenton, Tex.; Valliant, Okla.; and Waskom, Tex.: Water supplies.	\$706,000	Preliminary plans made.
Ouachita:		
Drainage:		
Malaria control project throughout basin.....	100,000	10-year program.
Pollution:		
Amity, Ark.; Farmerville and Jonesboro, La.; Murfreesboro, Sparkman, and Stephens, Ark.: Sewer systems and sewage treatment plants.	234,000	Preliminary plans made.
Water supply:		
Amity and Benton, Ark.; Bernice and Chatham, La.; Delight, Ark.; Farmerville, La.; Fountain Hill and Hampton, Ark.; Hodge, Jena, and Jonesboro, La.; Okalona, Ark.; and Pollock, La.: Waterworks and water supply systems or improvements.	358,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION		
Upper Arkansas:		
Flood control and irrigation:		
Trinidad, Colo.: Construction of 5 reservoirs and intake canal for flood control and irrigation.....	\$652,000	Plans nearing completion.
Cimarron Basin:		
Recreation and water supply:		
Construction of small reservoirs for flow correction, water supply, and recreation throughout the basin.	500,000	Exact locations and details to be determined by study project.
Water supply:		
Logan County, Okla.: Dam and reservoir at Crescent site for storage for increasing low flows.....	1,260,000	Subject to further study.
Canadian:		
Flood control:		
Canadian County, Okla.: Reservoir on North Canadian River for flood control and storage of water.	6,032,000	Cost estimate is approximate. Report on selection of exact site in preparation by Corps of Engineers.
Irrigation:		
Cimarron, Harper, and Texas Counties, Okla.: Wells near Boise City, Guyman, and Laverne, Okla., for irrigation purposes.	50,000	
Clay and San Miguel Counties, N. Mex.: Canal and lateral system on Conchas Irrigation project, to irrigate 35,000 acres in vicinity of Tucumcari.	1,000,000	Reconnaissance surveys have been made. Cost given is for first 2 years. Additional needed to complete, \$2,980,000.
Colfax County, N. Mex.: Improvements to Colfax irrigation district.....	75,000	Preliminary plans made.
Mora County, N. Mex.: Structures for the Watrous irrigation system to irrigate about 10,000 acres in Mora River Valley.	400,000	Do.
Irrigation and water supply:		
Woodward County, Okla.: Reservoir and water mains for irrigating nurseries and for fire protection at Bureau of Plant Industry Field Station.	50,000	Present water supply inadequate. Sketch plans have been completed.
Water supply:		
Borger and Dalhart, Tex.: Water supply.....	915,000	
Clayton, N. Mex.: Storage reservoir to augment urban water supply.....	150,000	Preliminary plans only.
Greenfield, Indianola, Morris, Okfuskee, and Wetumka, Okla.: Water-supply improvement.....	261,000	
Central Arkansas:		
Flood control:		
Augusta, Kans.; Blackwell and Kaw City, Okla.; Winfield, Kans.: Levees to protect property.....	319,000	Authorized by Congress. Plans in preparation.
Belle Plaine, Kans.: Levees from the mouth of Big Slough Floodway along Arkansas River to mouth of Ninnescah River and along the Ninnescah River for protection of agricultural lands.	1,882,000	Authorized by Congress.
Hutchinson, Kans.: Diversion of Cow Creek around Hutchinson for flood control.....	1,400,000	Do.
Wichita, Kans.: Big Slough Floodway, Chisholm Creek Improvement and Diversion, Little Arkansas and Arkansas Rivers Diversion for flood control.	4,200,000	Do.
Flood control and pollution:		
Chickaskia River, Cole Creek, Little Walnut and Ninnescah Rivers, Slate Creek and Whitewater River, Kans.: Construction of 6 reservoirs on the above streams.	14,000,000	
Pollution:		
Argonia, Arlington, Burden, Chase, Clafin, Clearwater, Conway Springs, Cunningham, Haviland, Holyrood, Leon, Little River, South Hutchinson, Turon, and Whitewater, Kans.: Sewage treatment plants.	455,000	
Recreation and wildlife:		
Cowley and Sedgwick Counties, Kans.: 2 small lakes on Otter and Clear Creeks for recreational development.	490,000	Preliminary plans made.
Water supply:		
Alden, Andale, Bluff City, Cambridge, Chase, Coats, Garden Plain, Latham, South Hutchinson, Sun City, Whitewater, and Wilmore, Kans.: Waterworks or waterworks improvements.	225,000	
Neosho-Verdigris:		
Flood control:		
Benedict, Kans.; Chautauqua County, Kans.; Cherokee, Elk City, and Fredonia, Kans.; Lyon and Montgomery Counties, Kans.; Washington County, Okla., and Wilson County, Kans.: and Levee system to protect agricultural lands along Caney Creek and the Elk, Fall, Neosho, and Verdigris Rivers.	1,246,000	Authorized by Congress. Contingent upon study under A-1.
Cherokee County, Okla.: Dam and reservoir at Tenkillers Ferry on Illinois River for flood control.	9,692,000	Study authorized by Congress.
Oklahoma and Kansas: Channel clearance on Verdigris River from its mouth to Madison, Kans., for flood relief.	232,000	Authorized by Congress.
Flood control and water power:		
Delaware County, Okla.: Dam and reservoir near Pensacola on Neosho River for partial control of floods on the Arkansas River, stream flow regulation and ultimate development of water power.	9,000,000	Study authorized by Congress. Oklahoma has created the Grand River Dam Authority to sponsor this project. Cost estimate is reduced from that of Corps of Engineers to provide for reduced scope.
Lower Arkansas:		
Flood control:		
Dardanelle, Faulkner County levee district no. 1, Gillett to North Little Rock, Morrilton, Ark.: Levees on Arkansas River.	1,763,000	Authorized by Congress. Detailed plans in preparation. Estimate includes \$884,000 for part of the Little Rock-Gillett levee system, balance of which is in Lower Mississippi list.
Pollution:		
Altus, Atkins, and Belleville, Ark.; Birby, Okla.; Booneville, Ark.; Boynton, Okla.; Clarksville, Coal Hill, and Conway, Ark.; Coweta, Okla.; Dardanelle, Dover, Dyer, and Hartman, Ark.; Heavener, Jenks, and Keifer, Okla.; Lamar, Levy, Magazine and Morrilton, Ark.; Mounds and Muskogee, Okla.; Ola, Osark, Paris, Plainview, and Plumerville, Ark.; Poteau, Okla.; Russellville, Ark.; Sand Springs, Sapulpa, Stigler, Spiro, and Sallisaw, Okla.; and Van Buren, Ark.: Sewer systems and/or sewage-treatment plants.	820,000	

Southwest Mississippi Basins Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Lower Arkansas—Continued.		
<i>Recreation and wildlife:</i>		
Big Piney, Cass, Cedar Creek, Gaylor, Hurricane Fork, Maumelle, Middle Fork, Rough Hollow, Shores Lake, and Trace Creek, Ark.: Dams to develop recreational reservoirs in Ozark and Ouachita National Forests.	\$1,745,000	Cedar Creek Reservoir partly completed.
<i>Water supply:</i>		
Altus, Atkins, Belleville, Clarksville, Coal Hill, Conway, Dardanelle, Dyer, and Hartman, Ark.; Heavener and Keifer, Okla.; Lamar, Magazine, and Morrilton, Ark.; Mounds, Okla.; Paris and Plainview, Ark.; Poteau, Okla.; Russellville, Ark.; Sand Springs, Sapulpa, and Sallisaw, Okla.; and Van Buren, Ark.: Water-supply systems and/or improvements.	683,000	
Upper White-Black-St. Francis:		
<i>Flood control and water power:</i>		
Baxter and Marion Counties, Ark.: Wild Cat Shoals Dam and Reservoir on White River near Cotter.	25,712,000	Preliminary plans made.
Taney County, Mo.: Table Rock Dam and Reservoir on White River near Branson.	15,208,000	Do.
<i>Irrigation:</i>		
Cleburne County, Ark.: Greers Ferry Dam on Little Red River near Heber Springs to impound water for irrigation of rice in Grand Prairie region.	2,050,000	Do.
<i>Pollution:</i>		
Ava and Branson, Mo.; Calico Rock and Cotter, Ark.; and Crane, Mo.: Sewage system and sewage-treatment plants.	184,000	Do.
Farmington, Fredericktown, and Jackson, Mo.: Sewage-treatment plants.	87,000	Do.
<i>Water power:</i>		
Carter County, Mo.: Mill Creek Dam on Current River near Van Buren.	5,075,000	Do.
Ripley County, Mo.: Hargus Eddy Dam and Reservoir on Current River near Doniphan.	7,141,000	Do.
Shannon County, Mo.: Blair Creek Dam on Current River below Eminence.	6,728,000	Do.
<i>Water supply:</i>		
Fayetteville, Harrison, and Salem Ark.: Water supply and/or waterworks systems or improvements.	205,000	Do.
Upper Red:		
<i>Drainage:</i>		
Grayson and Hall Counties, Tex.: Malaria control.	117,000	
<i>Flood control:</i>		
Farmer County, Tex.: Dam on Friona Draw for flood control and flow regulation for benefit of town of Friona and Paloduro Canyon Park.	40,000	
<i>Pollution:</i>		
Altus, Apache, Comanche, Davidson, Devol, Eldorado, Fletcher, and Grandfield, Okla.; Hedley, Tex.; Hollis, Mangum, Marietta, Ringling, Ryan, Sayre, Temple, Tipton, Walters, and Waurika, Okla.: Construction of sewage-treatment plants or improvements to existing plants.	243,000	
Clarendon, Dimmitt, Happy, Henrietta, St. Joseph, Shamrock, and Vernon, Tex.: Sewage-treatment plants.	204,000	Additional treatment needed.
<i>Water power:</i>		
Baylor County, Tex.: Lake Kemp power plant. Installation of 1,400 kilowatt generating capacity to make use of water now wasted.	170,000	Project dependent on agreement of water users not to expand acreage under irrigation and on analysis of flow during recent dry years.
<i>Water supply:</i>		
Archer City, Childress, Crowell, Electra, Henrietta, and Holliday, Tex.: Water treatment plants.	200,000	All towns have surface supplies which are unsatisfactorily treated.
Canyon, Harrold, Matador, and Pottsboro, Tex.: Water supply systems or improvements.	216,000	
Washita Basin:		
<i>Flood control, irrigation, and water supply:</i>		
Oklahoma: 25 reservoirs for flood control, irrigation, flow equalization, and water supply.	1,500,000	Subject to confirmation or modification after completion of study project. Cost given is for first 2 years. Additional needed to complete, \$9,268,000.
<i>Irrigation:</i>		
Caddo, Canadian, Comanche, and Washita Counties, Okla.: Small irrigation projects for Arapaho, Cheyenne, and Kiowa Indian Reservations. Water supply from wells and Washita River.	57,000	
Washita River Basin, Okla.: Irrigation of 300,000 acres of bottom land.	7,500,000	Do.
<i>Pollution:</i>		
Cheyenne, Okla.: Sewer system and sewage treatment plant.	100,000	
Lower Red:		
<i>Flood control:</i>		
Caddo Parish, La.: Black Bayou Dam and Reservoir.	125,000	Authorized by Congress.
Caddo Parish, La.: Wallace Lake Dam for storage of floodwaters.	400,000	Do.
<i>Pollution:</i>		
Cumby, De Kalb, Denison, Honey Grove, Hughes Springs, Linden, Mount Vernon, and Sulphur Springs, Tex.: Sewage treatment plants.	198,000	
<i>Recreation and wildlife:</i>		
Bienville Parish, La.: Construction of earth filled dam across Bayou Dorcheat, for restoration of Lake Bistenau for fish and game preserve.	71,000	
<i>Water supply:</i>		
Antlers, Broken Bow, and Isabel, Okla.; Sulphur Springs, Tex.: Water supply improvements.	95,000	
Arkansas, Oklahoma, and Texas: Small water conservation projects in 14 counties in these States.	500,000	Locations and plans dependent on study project in group A-1.
Ouachita:		
<i>Drainage:</i>		
Bradley, Dallas, Drew, Hot Springs, Jefferson, and Union Counties, Ark.: Malaria control.	96,000	On authorized program of W. P. A.
<i>Flood control:</i>		
Hot Springs, Ark.: Improvement of storm water sewers for flood control.	250,000	
<i>Flood control and water power:</i>		
Hot Springs, Ark.: Dam at Blakely Mountain for power, flood control, and improvement of downstream water supplies.	13,442,000	Preliminary plans only.
<i>Pollution:</i>		
Arkadelphia, Benton, Camden, Crosssett, El Dorado, Huttig, Louann, Malvern, Mena, Monticello, Norphlet, Prescott, Sheridan, and Warren, Ark.: Sewage treatment plants and/or improvement and extension of sewer systems.	382,000	
Delight, Fountain Hill, Graysonia, Hampton, Hermitage, Mount Ida, Okolona, Rosboro, Strong, Thornton, and Wilmar, Ark.: Sewer systems.	228,000	
<i>Recreation and wildlife:</i>		
Corn Lake and Dugdemons Bayou, La.; Hot Springs, Ark.; Iatt Lake, La.; and Mena, Ark.: Park development and improvement of streams and lakes for recreational purposes.	470,000	
<i>Water power:</i>		
Malvern, Ark.: Increase of installed capacity of generating plant at Rammel Dam to utilize draw-down from Blakely Mountain Reservoir.	760,000	Do.
<i>Water supply:</i>		
Graysonia, Hermitage, and Wilmar, Ark.: Water supply systems.	62,000	
Huttig, Louann, Malvern, Mena, Monticello, Norphlet, and Prescott, Ark.: Improvement to water supply systems.	104,000	

LOWER MISSISSIPPI

Water problems in the lower Mississippi Valley relate chiefly to protection against surplus waters and to their disposal, rather than to the conservation of water for man's use. Nevertheless, storage of water is now receiving consideration in certain areas partly because of recent droughts, and further expansion of the rice-growing industry is contingent upon the development of additional supplies. There are no water power sites of commercial value in the area. Navigation has increased of late, but it raises no technical problems beyond those of channel improvement and stabilization.

The lower Mississippi district may be divided into three distinct parts: (1) the narrow section of the valley from St. Louis to Cairo, (2) the wide alluvial valley below Cairo, and (3) the uplands east of the Mississippi River which stretch from the Ohio River to the Gulf coast.

1. The narrow valley between St. Louis and Cairo afforded no suitable lowland sites for towns and little land for cultivation. It accordingly always has had a small population and has presented no flood problem of magnitude. The river channel is here in good navigable condition, but its further improvement and stabilization probably are warranted by recent trends in traffic and particularly by the functional relation of this section of the river to the whole system of inland waterways now under unified development.

2. Below Cairo, the flood problem is of paramount importance. There the Mississippi channel and flood plain, as developed by natural processes, formed a huge trough by which storm waters from the Ohio River, the upper Mississippi, the Missouri, and numerous southern tributaries, both large and small, were conveyed to the Gulf of Mexico. In order to occupy and utilize parts of the rich flood plain, the construction of levees was begun early in the eighteenth century and has continued to the present. Until 1917 it was carried on by many diverse interests. In 1883, a tentative grade line was established for the top of the levees all the way from Cairo to the mouth of the river. In 1898, a new grade line, averaging some 5 feet higher, was established. After the floods of 1912 and 1913 demonstrated its inadequacy with tragic force, a third line was adopted in 1914 several feet higher than the 1898 grade. In 1927 the levees, which had been brought almost everywhere to the standard 1914 grade line, were again broken in many places and the greater part of the valley was flooded with appalling loss of life and property. In 1928 the Congress adopted a new plan of protection involving still higher levees supplemented by a system

of emergency floodways. Additional works provided in the act approved June 15, 1936, are designed to afford protection against floods from lower tributaries and, by means of a floodway system of more generous capacity, to care for floodwaters in excess of the safe carrying capacity of the leveed course of the main river. Security appears now to be reasonably assured. Reservoir systems on the Tennessee, Ohio, and other tributaries of the Mississippi will add to the security otherwise in prospect by increasing the freeboard on the levee system along the lower Mississippi and by reducing the frequency and duration of floodway use.

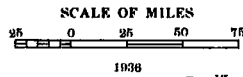
Marked improvement of land-drainage conditions, involving the redesign and reconstruction of hundreds of independent drainage works and their integration into a few well planned, unified systems is a need of prime importance from the standpoints of agriculture and the elimination of malarial conditions. The magnitude of the task involved has made local endeavor ineffectual in most sections. Cooperation is necessary between adjoining districts and between States.

There are large areas normally subject to backwater from the Mississippi at high stages which cannot be made safe and suitable for human occupancy through flood protection, drainage, and associated measures. Most of these lands are forested and they function effectively during floods as huge natural retarding basins. This represents their best use for the greater good of the greater number. They might well be incorporated in national forests to insure perpetuity of the important service they render, to form wildlife refuges, and to obviate further ill-advised attempts at their reclamation and agricultural occupation. It may be added that flood control and drainage for any other partially developed or undeveloped portions of the alluvial valley should be associated with a program of land development, occupation, use, and ownership that will insure a notably higher standard of living than now prevails there. The mode of life now dominant in the lower valley, characterized particularly by a pernicious tenant system, should not be extended.

Irrigation by pumping from deep wells in the rice fields of eastern Arkansas has depleted underground waters to an alarming extent. The remedy apparently lies in storing flood waters in local reservoirs, but a careful study of the situation in both its technical and economic aspects is needed.

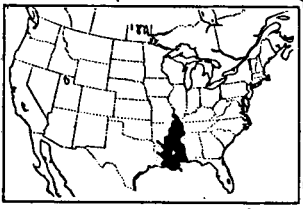
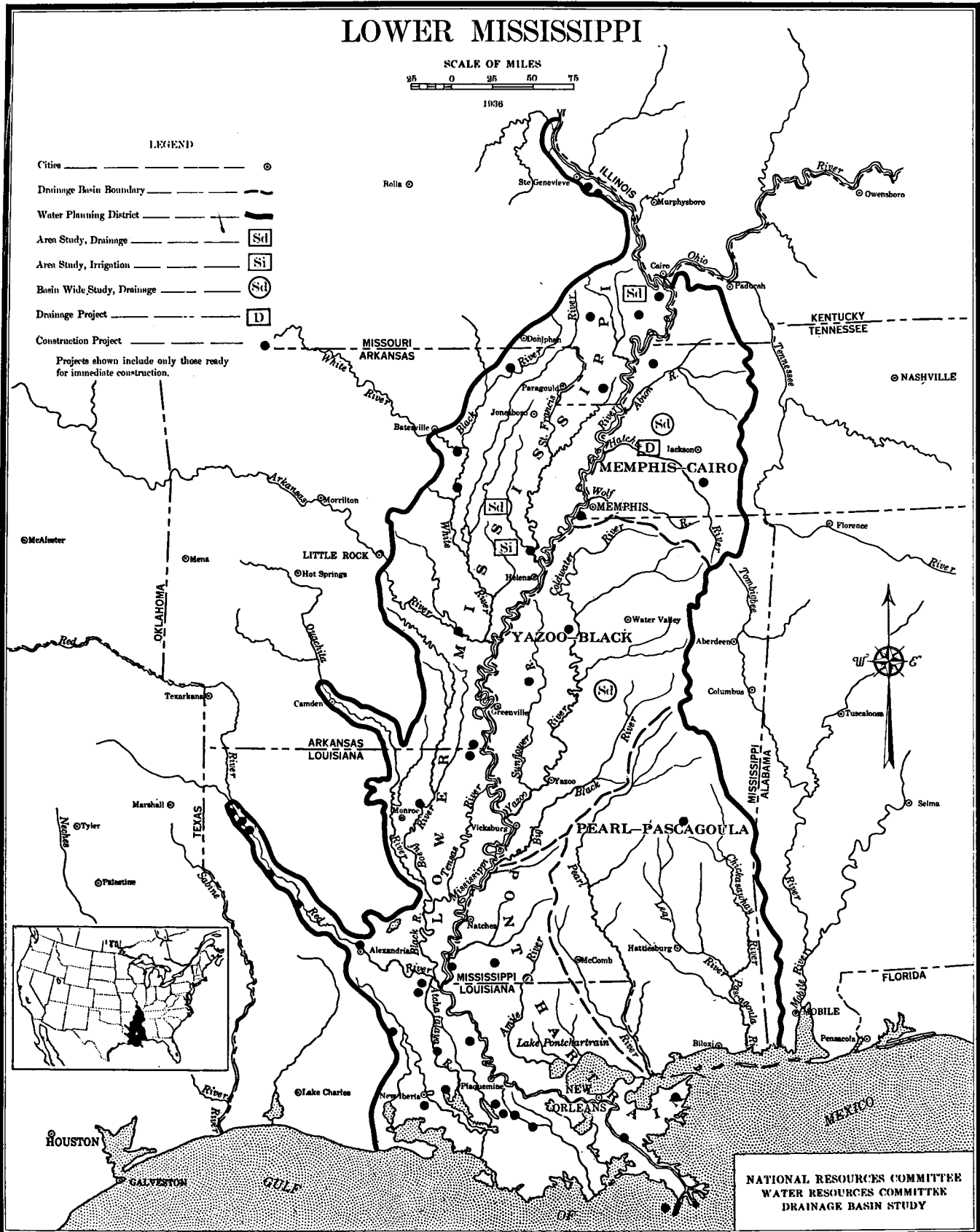
3. The associated water and land problems of the uplands east of the Mississippi River relate especially

LOWER MISSISSIPPI



- LEGEND**
- Cities _____ ○
 - Drainage Basin Boundary _____
 - Water Planning District _____
 - Area Study, Drainage _____ [Sd]
 - Area Study, Irrigation _____ [Si]
 - Basin Wide Study, Drainage _____ (Sd)
 - Drainage Project _____ [D]
 - Construction Project _____ ●

Projects shown include only those ready for immediate construction.



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

to poor drainage in the tributary valleys, malarial conditions of grave proportions, an advanced state of soil erosion, and progressive retirement of farm lands from cultivation. These interlocking problems exist with little variation from end to end of the upland belt. Vigorous and comprehensive measures are essential,

and Federal assistance is needed in planning them in detail to the advantage of all concerned.

Systematic general studies of underground water supplies are needed in both the lowlands and uplands of the district. Wasteful use is bringing the available supplies of certain localities close to exhaustion.

Lower Mississippi Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Cairo-Memphis:		
<i>Drainage:</i>		
Study to devise a coordinated plan of upland drainage. Plan provides for malaria control.....	\$100,000	Surveys, investigation and report, in line with similar recommendations by the Planning Commissions of Kentucky and Tennessee, but more comprehensive.
Lower Mississippi:		
<i>Drainage:</i>		
Study to devise a coordinated plan of drainage for alluvial valley counties in Arkansas.....	100,000	To be coordinated with a similar study in Missouri.
Study to devise a coordinated plan of drainage for 9 alluvial valley counties in Missouri.....	50,000	To be coordinated with a similar study in Arkansas.
<i>Irrigation:</i>		
Study project for water supply for irrigation of rice fields in alluvial valley counties in Arkansas.....	75,000	Extension of previous studies.
Yazoo-Black:		
Study to devise a coordinated plan of drainage for the entire lowlands area known as the Yazoo Delta, and to improve agricultural conditions and plantation methods.	150,000	
2. Construction Projects		
Cairo-Memphis:		
<i>Drainage:</i>		
Memphis, Tenn.: 9 drainage projects including street drainage.....	1,704,000	
Memphis, Tenn.: 9 drainage projects involving levee construction, stream improvement, and drainage ditches for flood protection and malaria control.	414,000	
<i>Recreation and wildlife:</i>		
Chester and McNairy Counties, Tenn.: Creation of lakes for county fish and game preserves.....	14,000	Plans completed.
Lake and Obion Counties, Tenn.: Water control structures to create water-fowl refuge at Lake Isom.....	103,000	Plans completed. 45 percent of purchase area optioned.
Lower Mississippi:		
<i>Drainage and flood control:</i>		
Sikeston, Mo.: Construction of concrete storm sewer and riprapping river bank.....	31,000	Final plans completed.
<i>Flood control:</i>		
Continuation of flood-control project for lower Mississippi River as modified in act of June 15, 1936. The project comprises the following work:	100,000,000	Cost given is for next 2 years. \$210,000,000 additional needed to complete. Authorized by Congress.
1. Avoyelles, Iberia, Iberville, Pointe Coupee, St. Martin, and St. Mary Parishes, La.: Atchafalaya Basin floodways to relieve Mississippi River floodwaters in excess of its safe carrying capacity. Includes guide levees, control works for Morganza floodway, land rights, drainage, clearing, railroad and highway changes.		
2. Atchafalaya River improvements in Louisiana. For flood control and navigation. Includes new outlet from Grand Lake into Gulf of Mexico.		
3. Chicot and Desha Counties, Ark.; East and West Carroll, Madison, and Tensas Parishes, La.: Eudora floodway and control works. To relieve the Mississippi River of floodwaters in excess of its safe discharge capacity. Includes guide levees, drainage, clearing, railroad and highway changes, land rights and utility changes.		
4. St. Francis River flood-control works in Arkansas: To protect against headwater floods above the backwater of the Mississippi River, involves construction of levees and drainage structures.		
5. Desha and Phillips Counties, Ark.: White River Emergency Reservoir. Levee construction to protect 152,400 acres against all but very great floods. During latter, area is available for flood storage for protection of lower Mississippi Valley.		
6. Arkabutla, Coffeeville, Coldwater, Enid, Granada, and Holcomb Counties, Miss.: Flood-control reservoirs for protection of Yazoo Delta lands against headwater floods.		
7. Dredging, channel contraction and revetment on main river.		
Field examination, appraisal, and acquisition by the United States of lands in the Eudora and Morganza floodways in order to withdraw them from human occupancy, and to convert them into national forest and game preserves. These are permanently exposed to occasional flood overflows.	17,000,000	Cost estimate roughly approximate. Acquisition to be considered under provisions of the Weeks Act by establishment of land-purchase units.
Avoyelles Parish, La.: Bayou des Glaisses Diversion Canal. Excavation of a drainage canal 6 miles long from Bayou des Glaisses at Moreauville to a borrow pit of West Atchafalaya levee at Lake Bayou. To reduce overflow and improve drainage.	285,000	Authorized by Congress. Detailed plans in preparation.
Columbia, La.: Construction of levees on Ouachita River, including bulkhead and interior drainage works to protect town from flooding by Ouachita and Mississippi Rivers.	395,000	Do.
Grant and Rapides Parishes, La.: Extension of existing levees along left bank of Red River from Colfax, La., to north bank of Bayou Darro. To protect lands along left bank of Red River from overflow.	71,000	Preliminary plans completed.
Jackson and Woodruff Counties, Ark.: Village Creek, White River, and Mayberry district. Construction of 197 miles of levees along east bank of White River. For flood protection.	1,154,000	Authorized by Congress.
Jefferson, Lincoln, and Pulaski Counties, Ark.: North Little Rock to Gillette, improvement of existing levees and construction of new levees on north bank of Arkansas River for flood protection.	1,845,000	Authorized by Congress. Remainder of project, \$984,000, is included in southwest Mississippi list.
Natchitoches Parish, La.: Construction of 21 miles of levee on right bank of Red River from head of Cave River to and across mouth of Cave River; includes low dam, flood gates, and drainage structures. For protection against headwater floods.	355,000	Authorized by Congress. Detailed plans in preparation.
Newport on White River, Ark.: In Jackson County. Improvement on 6.2 miles of existing levees and construction of flood wall. For flood protection.	261,000	Authorized by Congress.
Ferry County drainage and levee districts, nos. 1, 2, and 3, Missouri. Improvement of existing Mississippi River front and back levees.	913,000	Do.
Red River Parish, La.: Enlargement and extension of existing levee system on right bank of Red River below Shreveport. For protection against headwater floods.	180,000	Authorized by Congress. Detailed plans in preparation.
Skaggs Ferry on Black River east of Pochahontas, Ark., in Randolph County. Construction of 8.2 miles of levee including drainage works for flood protection.	80,000	Authorized by Congress.
<i>Navigation:</i>		
Assumption and La Fourche Parishes (Bayou La Fourche) near Napoleonville, La.: Dredging channel 6 feet deep and 60 feet wide for improvement of navigation.	351,000	Cost figure needed to complete. Surveys and preliminary plans completed.
Mississippi River between the Ohio and Missouri Rivers: Consists of dredging and channel contraction work to provide navigable channel 9 feet deep, 300 feet wide, for a length of 195 miles—part of Lakes to the Gulf Waterway.	2,000,000	Cost given is for first 2 years. Additional needed to complete, \$10,100,000. Surveys completed.
Southwest Pass, Mississippi River: Construction of dikes and regulating works to maintain a more stable channel and improve navigation conditions.	300,000	Cost given is for first 2 years. Additional needed to complete, \$420,000. Surveys completed.

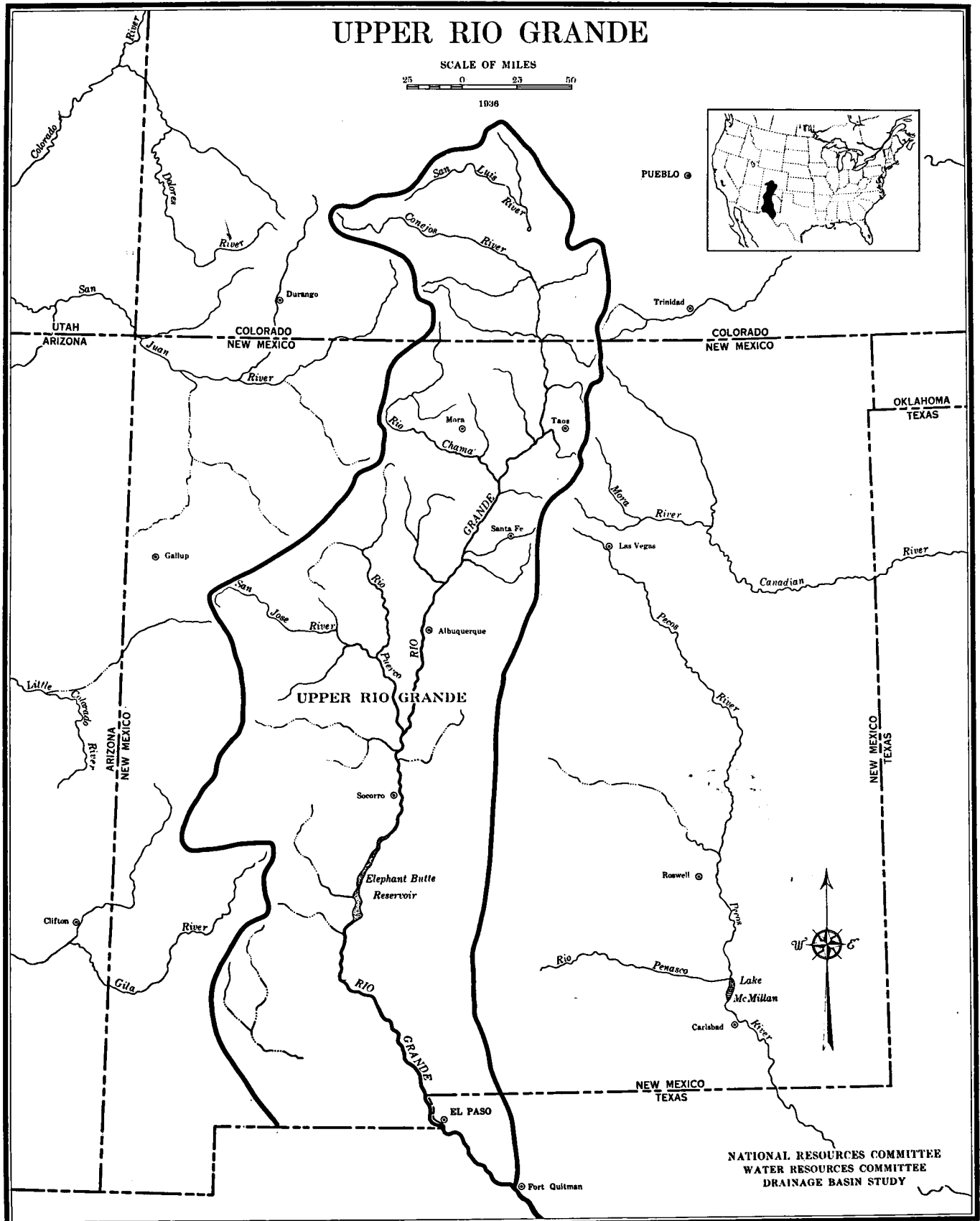
¹ Approximately.

Lower Mississippi Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Lower Mississippi—Continued.		
<i>Pollution and Water Supply:</i> Monroe, La.: Sewer system; extension of water supply system; storm sewers and pumping plant; drainage canal and pumping plant.	\$1,068,000	Preliminary plans made.
Pineville, La.: Sewers.....	50,000	
<i>Recreation and wildlife:</i> Avery Island Game Reserve, Iberia Parish, La.: General improvements urgently needed.....	21,000	Plans completed.
Mingo Migratory Waterfowl Refuge in Stoddard County, Mo.: Several miles of dikes to restore swamp status, including structures for water-level control.	82,000	Preliminary plans made. Lands optioned and under condemnation.
<i>Water supply:</i> Napoleonville, Assumption Parish, La.: 33 wells, average depth 200 feet to obtain uncontaminated drinking water for communities throughout parish.	12,000	Plans completed.
Harrisonburg, La.: Water supply system.....	22,000	
Port Allen, La.: Extension of waterworks system and deep well.....	21,000	Detailed plans and specifications available.
Steele, Mo.: 2 settling basins and water-treatment plant; also necessary appurtenances to existing water system.	22,000	Final plans completed.
Sunset, La.: New waterworks, including deep well.....	28,000	Detailed plans and specifications available.
Thibodaux, La.: Desilting basin and treatment plant for water supply from Mississippi River.....	29,000	Plans completed.
Yazoo-Black:		
<i>Pollution:</i> Cleveland, Miss.: Sewer system and sewage treatment plant.....	227,000	Final plans and specifications are in progress.
Pontchartrain:		
<i>Flood control:</i> Adams and Wilkinson Counties, Miss.: Headwater dams and channel improvements on Homochitto River.	50,000	Detail plans in preparation. Authorized by Congress.
Wilkinson County, Miss.: Channel improvements on Buffalo River.....	35,000	Plans completed. Authorized by Congress.
<i>Recreation and wildlife:</i> Plaquemines County, La.: Delta migratory waterfowl refuge—Opening canals, repairing dikes, and restoring existing structures.	125,000	Plans completed. Lands acquired by the Biological Survey.
<i>Water supply:</i> St. Bernard, La.: Water supply for livestock and other purposes, and mosquito control, involving clearing channel of Bayou Terre Aux Bouefs and building bulkheads.	41,000	Plans completed.
Pearl Pasca goula:		
<i>Water supply:</i> Hickory, Miss.: Complete waterworks, including deep well.....	27,000	Plans 75 percent completed.
GROUP B—FOR DEFERRED CONSTRUCTION		
Lower Mississippi, general:		
<i>Flood control:</i> Field examination, appraisal, and acquisition by the United States of lands which cannot be economically protected from overflow, with the view to converting them into national forest and game preserves and for use as natural flood storage area. This would include selected areas between the Mississippi River and its bluffs.	\$19,300,000	Cost estimate roughly approximate. Acquisition to be considered under provision of the Weeks Act by establishment of land-purchase units.
Cairo-Memphis:		
<i>Flood control:</i> Dyer, Lake, and Obion Counties, Tenn.: Levee from Tiptonville to mouth of Obion River to protect lowlands east of Mississippi River, including towns of Tiptonville, Ridgley, and other smaller communities.	730,000	Authorized by Congress. Construction contingent upon procurement of land, settlement of damages and maintenance of structures, by local authorities. Negotiations not completed. Detailed plans not completed.
<i>Navigation:</i> Memphis, Tenn.: Completion of dredging 9-foot navigable channel in Wolf River for Memphis harbor to Hindman Ferry Road.	628,000	Authorized by Congress. Construction contingent upon local authorities furnishing right-of-way. Survey completed.
<i>Pollution:</i> Collierville, Tenn.: Sewer system with partial sewage treatment plant.....	71,000	Preliminary plans completed.
Huntingdon, Tenn.: Sewer system.....	45,000	Do.
<i>Pollution and water supply:</i> Dyersburg, Tenn.: Additional water supply treatment plant and extension of mains; extensions of sewer system and partial sewage treatment plant.	127,000	Plans completed.
Newbern, Tenn.: Extension of water supply and sewer systems.....	115,000	Do.
Union City, Tenn.: Extension of water supply and sewer systems and construction of partial sewage treatment plant.	75,000	Do.
<i>Water supply:</i> South Fulton, Tenn.: Extension of water supply system.....	80,000	Preliminary plans completed.
Lower Mississippi:		
<i>Flood control:</i> Big Bottom, Independence County, Ark.: Construction of 9.8 miles of levee along north bank of White River at mouth of Black River.	148,000	Authorized by Congress.
Butler County, Mo., and Clay County, Ark.: Construction of a leveed floodway to divert flood waters of Black River by building 88 miles of levees.	2,604,000	Do.
Butler and Ripley Counties, Mo., and Clay County, Ark.: Construction of 22.5 miles of levee along Little Black River.	820,000	Do.
Lee County, Ark.: Construction of 3.3 miles of levee on Big Creek and L'Anguille River.....	97,000	Authorized by Congress. Preliminary plans complete. Requires further study.
Monroe, Prairie, and Woodruff Counties, Ark.: Construct 74 miles of levees on east bank of White River and west bank of Cache River between Augusta and Clarendon, Ark.	8,100,000	
<i>Navigation:</i> Bayou Grand Caillou and Le Carpe in Terrebonne Parish, near Houma, La.: Dredging channel 5 feet deep and 40 feet wide a distance of 18.3 miles as feeder to intracoastal waterway, for improvement of navigation. Local interests to furnish right of way.	56,000	Sum needed to complete. Survey and preliminary plans completed.
Bayou Grossetete in Iberville Parish at Maringouin, La.: Widening to full width of 60 feet to a depth of 5 feet to improve navigation.	101,000	Do.
Bayou Teche in Iberia Parish at New Iberia, La.: Widening channel to full project dimensions of 60 feet and 80 feet for a depth of 8 feet to improve navigation.	141,000	Do.
<i>Pollution:</i> Cape Girardeau and St. Genevieve, Mo.: Sewage treatment plants.....	120,000	Preliminary plans completed.
<i>Recreation and wildlife:</i> Ashley, Crittenden, Cross, Lonoke, Monroe, and Woodruff Counties, Ark.: Stream improvements and construction of reservoirs in 8 existing and proposed game refuges. Improvements to fish and game preserves.	145,000	
<i>Water supply:</i> St. Genevieve, Mo.: Water treatment plant.....	27,000	

Lower Mississippi Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Yazoo Black:		
<i>Pollution and water supply:</i>		
Louise, Miss.: Waterworks and sewer system.....	\$18,000	Final plans are in preparation.
<i>Water supply:</i>		
Blue Mountain, Isola, Maben, Mathiston, Pickens, and Raymond, Miss.: Waterworks systems or improvements.....	133,000	Final plans and specifications are in progress for all except Raymond, on which preliminary plans only are prepared.
Pontchartrain:		
<i>Pollution and water supply:</i>		
Baton Rouge, La.: Additional water-supply and sanitary sewers to supplement existing facilities....	110,000	Preliminary plans completed.
<i>Recreation and wildlife:</i>		
Brushy, Clear Springs, Molls, and Pretty Creeks in Homochitto National Forest, Miss.: Creation of small lakes for recreational purposes.....	83,000	No plans prepared; lands being acquired.
<i>Water supply:</i>		
Gonzales, Independence, and Jackson, La.; Liberty, Miss.; Lutchter and Slaughter, La.: New waterworks or extensions.....	195,000	
Pearl-Pascagoula:		
<i>Drainage:</i>		
Leake County, Miss.: Drainage ditch 4¼ miles long, for malaria control.....	65,000	Preliminary plans completed.
Weir, Miss.: Drainage canal for Yockanookany drainage district.....	29,000	Do.
<i>Drainage and pollution:</i>		
Jackson, Miss.: Storm sewers to correct drainage.....	30,000	Do.
Meridian, Miss.: Drain swamps and ponds and build sanitary sewers.....	67,000	Do.
<i>Pollution:</i>		
Picayune, Miss.: Sanitary sewer system, 15 miles of main sewers.....	112,000	Do.
Poplarville, Miss.: Sanitary sewer system.....	37,000	Do.
Raleigh, Miss.: Sanitary sewer system.....	38,000	Do.
<i>Recreation and wildlife:</i>		
Beaver Dam Creek, Miss.: 72 acre-lake for recreational purposes and mosquito control.....	27,000	Do.
Seminary, Miss.: 480-acre fish hatchery.....	146,000	Do.
Winston County, Miss.: 30-acre lake for migratory water fowl refuge.....	37,000	Do.
<i>Water supply:</i>		
Ellisville, Miss.: Extension of existing waterworks.....	8,000	Plans 25 percent completed.
Forest, Miss.: Extension of existing water supply; includes deep well.....	8,000	Do.
Gulfport, Miss.: Artesian well to supplement existing water supply.....	15,000	Detailed plans and specifications in preparation.
Taylorville, Miss.: Waterworks, including deep well.....	40,000	Plans 20 percent completed.



UPPER RIO GRANDE

(Above Fort Quitman, Tex.)

Life in the Upper Rio Grande Valley depends on water, and the outlook for the valley through many years depends fundamentally on decisions likely to be reached in the immediate future with respect to its water problems. At present the question of where the water shall be used is more urgent than the question of how it shall be used. No construction projects are recommended for the valley in the present report, pending early completion of the Rio Grande Joint Investigation. The background and nature of this investigation may be outlined briefly, since it constitutes a promising approach to one of the more serious types of problems in western development.

A long-standing controversy over the waters of the upper river between the States of Colorado, New Mexico, and Texas and their respective water claimants reached a critical stage in 1935. A special board of review appointed by the National Resources Committee at the suggestion of the Bureau of Reclamation found (1) that a situation existed in the area which was inimical to public and private interests, (2) that the available water resources were apparently fully appropriated, and (3) that Federal funds were being sought for new projects which might not only create conflicts of Federal investments utilizing waters of the river, but also violate the Rio Grande Compact, which provides in essence that further depletions of the waters of the river shall not be made before June 1, 1937. Shortly thereafter, the President issued an Executive order instructing the appropriate Federal officials not to approve any application for a project involving the use of Rio Grande waters without securing from the National Resources Committee a prompt opinion on it from all relevant points of view.

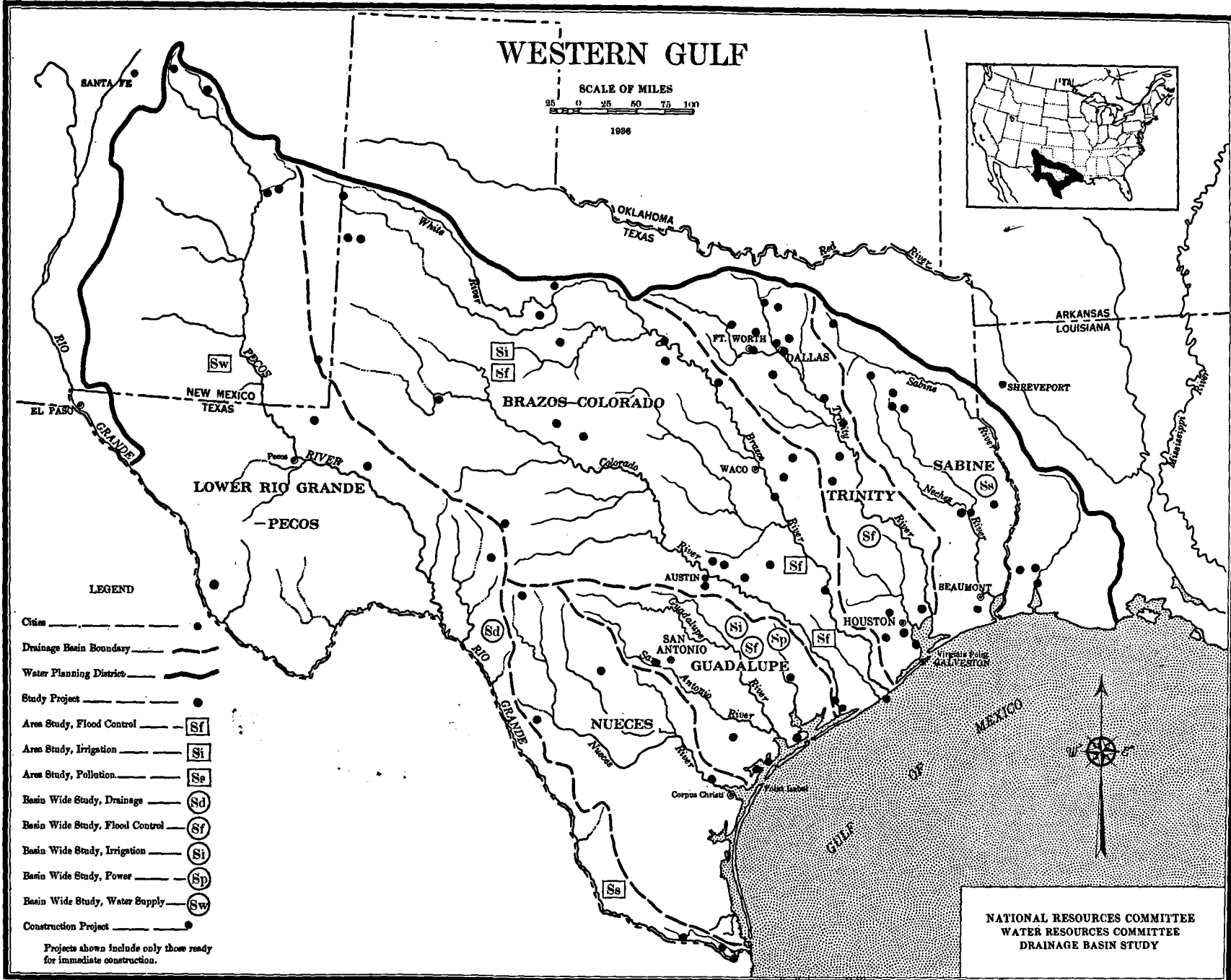
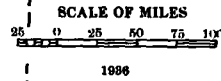
Early in December the Rio Grande Compact Commission adopted a resolution requesting the National Resources Committee, through its Water Resources Committee, to arrange immediately for a cooperative fact-finding investigation of the water resources of the Rio Grande Basin above Fort Quitman; of the past, present, and prospective uses and consumption of water in that basin in the United States; and of the opportunities for conserving and augmenting such water

resources by all feasible means. It was recognized that the facts with regard to these matters are indispensable prerequisites to the successful negotiation of a permanent compact for the equitable apportionment of the waters of the upper basin among the several States involved, and that these facts should be established by an impartial organization. The National Resources Committee accepted the responsibility of guiding the investigation, the requisite funds were provided through Federal and State contributions, and complete plans were promptly agreed upon by the Federal and State agencies concerned with the investigation. All field work must be completed in the 1936 season and the findings of the investigation are to be available early in the spring of 1937.

Most of the work has been assigned to three Federal bureaus. The United States Geological Survey is investigating stream flow at all essential points on the main river and its tributaries, all diversions and return flows of water, underground waters, and the chemical quality of water. The Bureau of Agricultural Engineering is dealing with the problems of consumptive use, vegetative cover on all irrigated lands and water-consuming areas, and the water requirements of irrigable lands. The Bureau of Reclamation is carrying on surveys concerning the possibilities of storage and of importation of water by transmountain diversions. In addition, the Soil Conservation Service, the Resettlement Administration, the Bureau of Indian Affairs, and various other Federal, State, and local agencies are giving assistance in services, materials, records, office and laboratory space, and the like.

The Rio Grande Joint Investigation is blazing a trail that should lead to collective security in the form of a permanent compact under which the rights and equities of the several States and their citizens in the life-giving water of the valley will be firmly established through voluntary cooperation. It is seeking to substitute fact for opinion, cooperation for controversy. It will establish a sound basis for a water plan involving meritorious construction projects and a program for carrying them out in an orderly, balanced manner. It may well serve as an example of great importance in western life.

WESTERN GULF



- LEGEND**
- Cities ———— ●
 - Drainage Basin Boundary ————
 - Water Planning District ————
 - Study Project ———— ●
 - Area Study, Flood Control ———— [Sf]
 - Area Study, Irrigation ———— [Si]
 - Area Study, Pollution ———— [Se]
 - Basin Wide Study, Drainage ———— (Sd)
 - Basin Wide Study, Flood Control ———— (Sf)
 - Basin Wide Study, Irrigation ———— (Si)
 - Basin Wide Study, Power ———— (Sp)
 - Basin Wide Study, Water Supply ———— (Sw)
 - Construction Project ———— ●

Projects shown include only those ready for immediate construction.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

WESTERN GULF

The problems of the western Gulf drainage areas include (1) flood control; (2) provision of fresh-water supplies for irrigation, municipal, and industrial purposes along the coast; (3) conservation of water for irrigation in the subhumid section; (4) development of underground water supplies where there is little surface run-off; (5) correction of pollution from sewage, and from oil well and refinery wastes; and (6) settlement of conflicts over the waters of some of the streams. Improvement and extension of existing navigation facilities also are important.

1. Intense local storms and flashy, violent floods are characteristic of much of the region. Thus in June 1935 the Nueces River developed a peak flow estimated at 600,000 second-feet as a result of intense precipitation over a drainage area of 400 square miles. The provision of adequate flood-control works in the Trinity, Brazos, Colorado, Guadalupe, Nueces, and Lower Rio Grande Basins is important.

Local interests have built a disconnected, inadequate system of levees along the Trinity and Brazos Rivers for the protection of agricultural lands. Additional reservoirs and a coordinated system of levees are needed in both basins. Some 13 reservoirs have been proposed by the Brazos River Conservation and Reclamation District to provide flood control and to generate hydroelectric power. One dam is ready for construction, and the proposed sites for the others are being investigated. Four of the dams, located at strategic points, should be constructed as soon as the investigation is completed.

The Lower Colorado River Authority, with the aid of the United States Bureau of Reclamation, is constructing three dams on the Colorado River for flood control and power generation. Additional funds are needed to enlarge one of these dams to provide greater storage capacity. In addition to the reservoirs, levees will be required from Columbus to the Gulf to afford protection for the agricultural lands of the valley. More water for the irrigation of rice near the mouth of the river would be provided incidentally by the reservoirs.

Reservoirs hitherto suggested for tributaries of the Guadalupe River are believed to be inadequate to control floods in the entire basin. Large floods originate below the sites of some of the proposed dams, and a restudy of the flood problem of the basin is recommended.

It will become important in time to achieve maximum conservation of all water in the Nueces River Basin,

both from underground and surface sources, for use in irrigation. More land there is adaptable to irrigated agriculture than can be served by the water now available. The flow of the streams is erratic, and much water is lost in crossing the Balcones Fault zone. The preliminary examination of the basin now being made should be followed by a complete study to devise the most effective means not only of controlling floods but also of conserving water for irrigation.

A comprehensive system of levees and floodways for flood control along the lower Rio Grande has been designed and laid out by the International Boundary Commission. Approximately half the system has been constructed. Funds should be made available for completion of the works.

2. Much rice is grown by irrigation in the eastern part of the district, both in Louisiana and Texas. During frequent periods of low-stream flow, salt water from the Gulf causes heavy losses of rice. The construction of projects to supply fresh water for rice culture and other purposes near the mouths of the Mermentau, Sabine, and Neches Rivers is recommended.

3. In the parts of the Colorado and Brazos River Basins which lie below the High Plains and above the 25-inch annual rainfall line, conservation of water for irrigation will become important soon or later. A study should be made of this section to devise the most logical plan of water development for that purpose.

4. In the High Plains areas, and to considerable extent in the Pecos River Basin, similar studies are needed in connection with underground water supplies.

5. The most serious pollution problem in the entire district is along the Trinity River. During periods of low flow, the river below Dallas is virtually an open sewer. This condition should be corrected by improvement and enlargement of the sewage-disposal plant at that city. Additions also should be made to the sewerage systems of Houston and many smaller municipalities.

6. The use of the water of the lower Rio Grande is a matter of international concern. A large part of the water originating in the basin below Fort Quitman comes from tributaries in Mexico. A very small part of the unused water passing from the river into the Gulf originates in the United States. Rapid development of irrigation in Mexico foreshadows serious depletion of supplies of water necessary for the 400,000 acres of land in Texas already irrigated in the lower valley. Prospective shortages can be obviated only by major reservoir construction on the main stream. Such con-

struction cannot be undertaken, however, without international agreement and cooperation. Meanwhile, an essential fact-finding study is recommended to determine water uses and water supplies in Texas along the river below Fort Quitman.

A compact should be negotiated between New Mexico and Texas to provide for the most efficient use of the waters of the Pecos River. A fact-finding inves-

tigation is recommended to form a basis for compact negotiations.

Due largely to the great quantities of oil produced in the district, its ports rank among the more important of the country. Improvements already authorized by the Congress should be made on the Houston Ship Channel and the Sabine-Neches Waterway. The Intra-coastal Canal should be extended to Corpus Christi.

Western Gulf Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Sabine:		
<i>Pollution:</i>		
Study to devise means for control of stream pollution by salt water from oil wells.....	\$50,000	
<i>Water Supply:</i>		
Rockland Dam Project: Tyler County, Tex.: Study for supplemental water supply in Jefferson County.	50,000	Preliminary report prepared. Study to consist of dam site exploration and water supply and economic studies.
Trinity:		
<i>Drainage:</i>		
Chambers and Liberty Counties, Tex.: Study for drainage.....	50,000	Preliminary plans for mapping project completed.
<i>Flood Control:</i>		
Houston, Tex.: Study for protection from flood damages due to high waters of Buffalo Bayou.....	60,000	Two projects undertaken by W. P. A. Coordinated plan needed. Estimate approximate. Study authorized by Congress.
Trinity River, Tex.: Plan to protect 750,000 acres fertile alluvial land and reduce present damages from high waters.	500,000	Extension of preliminary examination by Corps of Engineers.
Brazos-Colorado:		
<i>Flood control:</i>		
Brazos River, Tex.: Study of flood control by means of levees, also topographic mapping for the Lower Brazos.	175,000	Plans made.
Matagordo and Wharton Counties, Tex.: Topographic mapping and study of levee design for flood control of the lower Colorado River.	175,000	Do.
Study to devise plans for flood control and irrigation through topographic surveys, examination of reservoir sites, water supply studies, etc., in area between Caprock and the 25-inch annual rainfall line in this basin.	250,000	Corps of Engineers authorized to make examination and report on part of this area in the Colorado River Basin. Study to expand scope and area of preliminary examination. Estimated cost approximate.
Guadalupe:		
<i>Flood control, irrigation, navigation, and water power:</i>		
Study of the coordinated utilization of the water resources of the Guadalupe, San Antonio, and Lavaca Basins for flood control, water power, irrigation, and navigation.	100,000	Continuation of study made by Corps of Engineers.
Lower Rio Grande-Pecos:		
<i>Drainage:</i>		
Study of the lower valley of the Rio Grande River to form basis for design of needed drainage system, including topographic mapping, and water table and seepage investigations.	75,000	Preliminary plans for study completed.
<i>Water supply:</i>		
Study to determine the interstate phases of the Pecos River and the facts in regard to water supply and uses, which will form a basis for compact negotiations between New Mexico and Texas.	75,000	Estimated cost approximate.
Study of water uses and water supply in Texas along the lower Rio Grande (below Fort Quitman).	200,000	Factual data now in hand should be supplemented and extended in cooperation with State of Texas.
2. Construction Projects		
Sabine:		
<i>Navigation:</i>		
Sabine-Neches Waterway, Jefferson and Orange Counties, Tex.: Channel enlargement from Sabine Pass to Port Arthur, Beaumont, and Orange.	1,790,000	Plans completed to complete immediate project.
<i>Pollution:</i>		
Lake Charles, La.: Intercepting sewer and sewage treatment plant.....	160,000	Preliminary plans made.
Sulphur, La.: Sewer system and sewage treatment plant.....	86,000	Do.
<i>Pollution and water supply:</i>		
Cushing, Tex.: Waterworks, sewer system, and sewage treatment plant.....	60,000	Do.
<i>Recreation and wildlife:</i>		
Boykin Springs, Tex.: Dam for recreation purposes.....	19,000	
Lake Charles, La.: Sabine migratory waterfowl development; dikes to keep out salt waters; buildings and equipment.	144,000	Surveys in progress.
<i>Water supply:</i>		
Brownsboro, Commerces, Garrison, Lindale, Newton, and Tatum, Tex.: Water supply or improvements.	120,000	Preliminary plans made.
Trinity:		
<i>Navigation:</i>		
Cedar Bayou, Tex.: Channel dredging.....	12,000	Work in progress. Sum needed to complete.
Houston, Tex.: Ship channel to Galveston Bay, to be dredged to 34 feet in depth and width increased.	2,900,000	Cost given is for first 2 years. Additional needed to complete, \$614,000. Authorized by Congress.
<i>Pollution:</i>		
Dallas, Tex.: Sewer and sewage treatment improvements.....	1,320,000	Preliminary plans made.
Houston, Tex.: Sewer and sewage treatment improvements.....	909,000	Do.
Jewett, Tex.: Sewage treatment plant.....	16,000	Do.
<i>Pollution and water supply:</i>		
Centerville, Mesquite, and Oakwood, Tex.: Waterworks and sewer system improvements.....	121,000	Do.
<i>Water Supply:</i>		
Eustace, Grapevine, Lancaster, Pilot Point, Prosper, and Rhome, Tex.: Waterworks improvements..	133,000	Do.
Highland Park, Tex.: Water system improvements.....	285,000	Do.
Houston, Tex.: Water system improvements.....	1,000,000	Do.
Brazos-Colorado:		
<i>Erosion (coastal):</i>		
Freeport, Tex.: Concrete mat revetment.....	44,000	Do.
<i>Flood control, irrigation, and water power:</i>		
Marshall Ford, Tex.: Reservoir dam to be raised to provide extra capacity for flood control, power, and irrigation.	8,000,000	Plans practically complete. Cost given is for next 2 years. Additional needed to complete, \$13,750,000.
<i>Flood control and water power:</i>		
Palo Pinto County, Tex.: Possum Kingdom Dam for flood control and power.....	6,600,000	Amount needed to complete.

Western Gulf Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Brazos-Colorado—Continued.		
<i>Pollution:</i>		
Hobbs and New Hobbs, N. Mex.: Sewer system and sewage treatment plant.....	\$159,000	Preliminary plans made.
Muleshoe, Tex.: Sewer system.....	32,000	Preliminary plans made. System needed but cost excessive. Requires restudy.
Round Rock, Tex.: Sewer system with sewage treatment plant.....	47,000	Do.
<i>Pollution and water supply:</i>		
Aspermont, Benjamin, Burleson, Calvert, Hempstead, Lexington, Sudan, Taylor, and Tehuacana, Tex.: Water supply and sewer systems.....	230,000	Preliminary plans made.
Bangs, Tex.: New filtration galleries and pumps for water supply; sanitary sewers and sewage treatment plant.....	31,000	Preliminary plans made. Requires restudy because of excessive cost.
Eldorado, Tex.: Waterworks and sewer system including sewage treatment plant.....	105,000	Preliminary plans made.
Kosse, Tex.: Water supply from well; sewer system and sewage treatment plant.....	58,000	Do.
<i>Recreation and wildlife:</i>		
Bay City, Tex.: Wild fowl refuge; facilities and water control works.....	42,000	Plans completed.
Muleshoe, Tex.: Muleshoe wild fowl refuge; housing facilities and water control works.....	33,000	Do.
<i>Water supply:</i>		
Big Spring, Tex.: Water supply reservoir, pipe line; tanks and filtration plant.....	500,000	Preliminary plans made.
Elgin, Tex.: Water supply system.....	13,000	Do.
Hamlin, Tex.: Reservoir, additional filters and improvement of present filters.....	145,000	Preliminary plans made. Requires further study.
Temple, Tex.: Extension of mains and new storage reservoir for water supply.....	65,000	Sketch plans made.
Winters, Tex.: Dam, pumping equipment, and treatment plant for domestic water supply.....	84,000	Preliminary plans made. Requires restudy.
Guadalupe:		
<i>Drainage:</i>		
San Antonio, Tex.: Drainage of flying field.....	120,000	Preliminary plans made.
<i>Pollution and water supply:</i>		
Ganado, Tex.: Waterworks and sewer system.....	54,000	Preliminary plans made. Requires restudy.
<i>Recreation and wildlife:</i>		
Rockport, Tex.: Migratory bird refuge: Improve existing facilities.....	56,000	Preliminary plans made.
<i>Water supply:</i>		
Kyle, Tex.: Waterworks.....	38,000	Preliminary plans made. Requires restudy.
Nueces:		
<i>Navigation:</i>		
Sabine River to Corpus Christi, Tex: Intracoastal waterway.....	3,900,000	Cost given is for first 2 years. Additional needed to complete, \$1,500,000. Authorized by Congress.
<i>Pollution:</i>		
Devine and Odem, Tex.: Sewer systems and sewage treatment plants.....	67,000	Preliminary plans made.
<i>Water supply:</i>		
Alice, Tex.: New well and improvements to water supply system.....	98,000	Do.
Carrizo Springs, Tex.: Deep well and extensions to water supply system.....	46,000	Do.
Rocksprings, Tex.: Water supply system.....	26,000	Do.
Lower Rio Grande-Pecos:		
<i>Flood control:</i>		
Lower Rio Grande Valley, Tex.: Flood control by levees and floodways.....	3,290,000	Levees and flood ways more than half completed. Amount needed to complete.
<i>Irrigation:</i>		
Fort Sumner, N. Mex.: Alamogordo dam on Pecos River 15 miles above Fort Sumner to replace capacity of Lake McMillan depleted by silt. Lining of irrigation canals to prevent seepage losses.....	400,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$200,000.
<i>Pollution:</i>		
Fort Sumner, N. Mex.: Replacement of old sewer system.....	60,000	Plans being prepared.
Santa Rosa, N. Mex.: Replacement of old sewer system.....	35,000	Do.
Wink, Tex.: Sewer system and sewage treatment plant.....	51,000	Preliminary plans in preparation.
<i>Water supply:</i>		
Fort Isabel, Tex.: Water supply purification plant and extension of mains.....	75,000	Preliminary plans made.
Rankin, Tex.: Improvements to water supply system.....	40,000	Do.
Sonora, Tex.: Water supply system.....	93,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION		
Sabine:		
<i>Flood control:</i>		
Sabine-Neches conservation district: Study of flood control and water conservation by means of dams and reservoirs and by channel improvements.....	\$250,000	General study project authorized by Congress. Directed at specific construction project proposed by Sabine-Neches Authority. To be an expansion of preliminary examination now under way by Corps of Engineers.
<i>Irrigation:</i>		
Mermentau River fresh water project, Louisiana: Stream control, and channel improvement for irrigation. Locks for control of salinity.....	1,400,000	Preliminary report made by Corps of Engineers.
<i>Pollution:</i>		
Beckville, Tex.: Sewer system and sewage treatment plant.....	18,000	Preliminary plans made. Requires further study.
<i>Pollution and water supply:</i>		
Celeste, Tex.: Water supply system, sewer system and sewage treatment plant.....	65,000	Do.
<i>Water supply:</i>		
Beckville, Caddo Mills, Joaquin, and Mount Enterprise, Tex.: Water supply systems.....	126,000	Do.
Tenaha, Tex.: Water supply system.....	56,000	Do.
Trinity:		
<i>Pollution:</i>		
Bryson, Dawson, Normangee, Roanoke, and Seagoville, Tex.: Sewer systems.....	145,000	Preliminary plans should be revised before construction.
<i>Pollution and water supply:</i>		
Alvord, Athens, and Rice, Tex.: Waterworks and sewer system improvements.....	203,000	Do.
Cleveland, Tex.: Waterworks system and sewage treatment plant.....	129,000	Preliminary plans made. Proposed water system requires further study.
<i>Water supply:</i>		
Blue Ridge, Tex.: Waterworks system.....	29,000	Preliminary plans should be revised before construction.
Waxahachie, Tex.: Water supply reservoir and pipe line.....	273,000	Preliminary plans made. Excessive cost requires further study.
Brazos-Colorado:		
<i>Flood control:</i>		
Bell County, Tex.: Lampasas Reservoir.....	1,355,000	Under study. Estimate of cost approximate.
Bell County, Tex.: Leon Reservoir.....	2,382,000	Do.
Madison County, Tex.: Navasota Reservoir.....	2,143,000	Do.
Stephens County, Tex.: Breckenridge Reservoir.....	2,385,000	Do.
<i>Irrigation:</i>		
Coleman, Tex.: Central Colorado Authority project; 3 small reservoirs for domestic stock, and irrigation use.....	567,000	Preliminary plans made.

Western Gulf Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Brazos-Colorado—Continued.		
<i>Water supply:</i>		
Abilene, Tex.: Domestic water supply improvements.....	\$614,000	Preliminary plans made. Requires further study.
Colorado, Tex.: Reservoir, filtration plant, pipe line, and pumping station for water supply.....	184,000	Preliminary plans made. Requires restudy because of excessive cost.
Hempstead, Tex.: Water supply system.....	60,000	Preliminary plans made. Requires further study.
Smithville, Tex.: Deep well, surface reservoir, elevated tank, and distribution system for water supply.	185,000	Preliminary plans made. Requires restudy because of excessive cost.
Guadalupe:		
<i>Water supply:</i>		
Rockport, Tex.: Water supply system, sewer system and sewage treatment plant.....	102,000	Do.
Nueces:		
<i>Pollution and water supply:</i>		
San Diego, Tex.: Water supply system, sewer system and sewage treatment plant.....	158,000	Do.
<i>Miscellaneous:</i>		
Study to provide plan for control and development of water resources throughout entire basin.....	500,000	Preliminary examination under way.
Lower Rio Grande-Pecos:		
<i>Navigation:</i>		
Harlingen, Tex.: Completion of light draft channel between Port Isabel and Harlingen.....	300,000	Plans completed.
<i>Water supply:</i>		
Barstow, Tex.: Water supply.....	51,000	Preliminary plans made. Requires restudy.

COLORADO BASIN

The basin of the Colorado River embraces parts of seven States, together with a small area in Mexico. The mountainous rim of the upper basin has a moderately heavy precipitation, cold winters, and a short, hot growing season. The lower basin is very arid, has mild winters and hot summers, and is favored by a growing season that lasts throughout the year. No crops can be grown successfully anywhere in the basin without the artificial application of water. The urban population of the basin in 1930 was 225,000; the rural, 552,000. A population of 1,120,000, urban and rural, has been predicted for 1960.

Recreational opportunities within the basin are excellent. The mountainous northern country contains natural parks and forests, with clear, fish-stocked lakes and rivers, and with national monuments and varied resorts for the summer months. The southland invites the tourist to its national parks of unsurpassed grandeur—Zion and Bryce Canyons, Cedar Breaks, and the superb Grand Canyon of the Colorado.

The annual discharge of the Colorado River system varies between 4 and 26 million acre-feet. Storage of water is necessary to make this highly variable supply available for human use through river regulation. In order to provide for such regulation, six of the seven States entered into a compact which makes blanket apportionments of Colorado River waters to the upper and lower basin States. The Boulder Canyon Project Act, supplementary to the Colorado River compact, authorized the construction of the Boulder Canyon Dam and power plant and the excavation of the All-American Canal. This multiple-purpose project, involving river regulation for navigation and flood control, provision of water for municipal use and for irrigation, and the development of power, is the key to future development in the basin.

The silt problem continues to be one of the more serious problems of the basin. The Colorado River has carried annually 200 million tons of sediment to the Gulf, and every reservoir built upon the system will be slowly robbed of its storage space unless remedial measures are applied. The cost of handling silt in the lower irrigation projects has run into millions of dollars each year; from this cost, however, Lake Mead will afford material relief. The Colorado Basin affords an excellent opportunity for an exhaustive study of the silt problem in all of its phases. Such a study should extend over a period of years and should be carried on under cooperative arrangements made by the various Federal and State agencies concerned

with the problem. The findings of the investigation would be of great value, not in this basin alone, but wherever silt problems exist.

The Colorado River compact makes the consumptive use of water (diversions less return waters) the measure and limit of allocations of the waters of the river. The several States involved must allot among themselves the blanket apportionments specified by the compact. This cannot be done without full knowledge of the water consumed in irrigation, of evaporation from reservoirs, of the water that can be economically exported from the basin, and of the contributions and consumptive uses by each State under past, present, and final conditions of development. Data essential for the solution of the many problems involved must come from studies and measurements of erosion, the quality of water, stream flow, underground waters, the consumptive use of water, the effect of forests on water supply, and from surveys for reservoirs, irrigation projects, power sites, and transmountain diversions.

The water resources of the Colorado Basin have been studied heretofore largely in terms of State and municipal interests. They should be studied likewise in terms of the basin as a whole, in terms of interbasin relationships, in terms of national welfare, and in terms of international relations, with due regard to the various interests involved and in the light of all relevant economic and cultural conditions. The fact, for example, that diversions of water from the basin that have been made or proposed amount to several million acre-feet annually, raises questions of inter-regional and national scope.

The projects listed for the Colorado Basin are divisible into three groups. The first is the Boulder Canyon group, those pertaining to the main Colorado and those downstream from Boulder Dam. They constitute a well-coordinated system, supplemental to and dependent upon the Boulder Canyon project.

The second group relates to municipal improvements, irrigation, flood control, and recreational projects that are situated away from the main stream and that are related only remotely to the Boulder Canyon project. They are dependent upon the general social developments within the basin, which the first group will stimulate.

The third group is concerned with the procurement of physical data so essential in character that the general development of the basin cannot proceed along rational and economic lines without them.

COLORADO BASIN

SCALE OF MILES



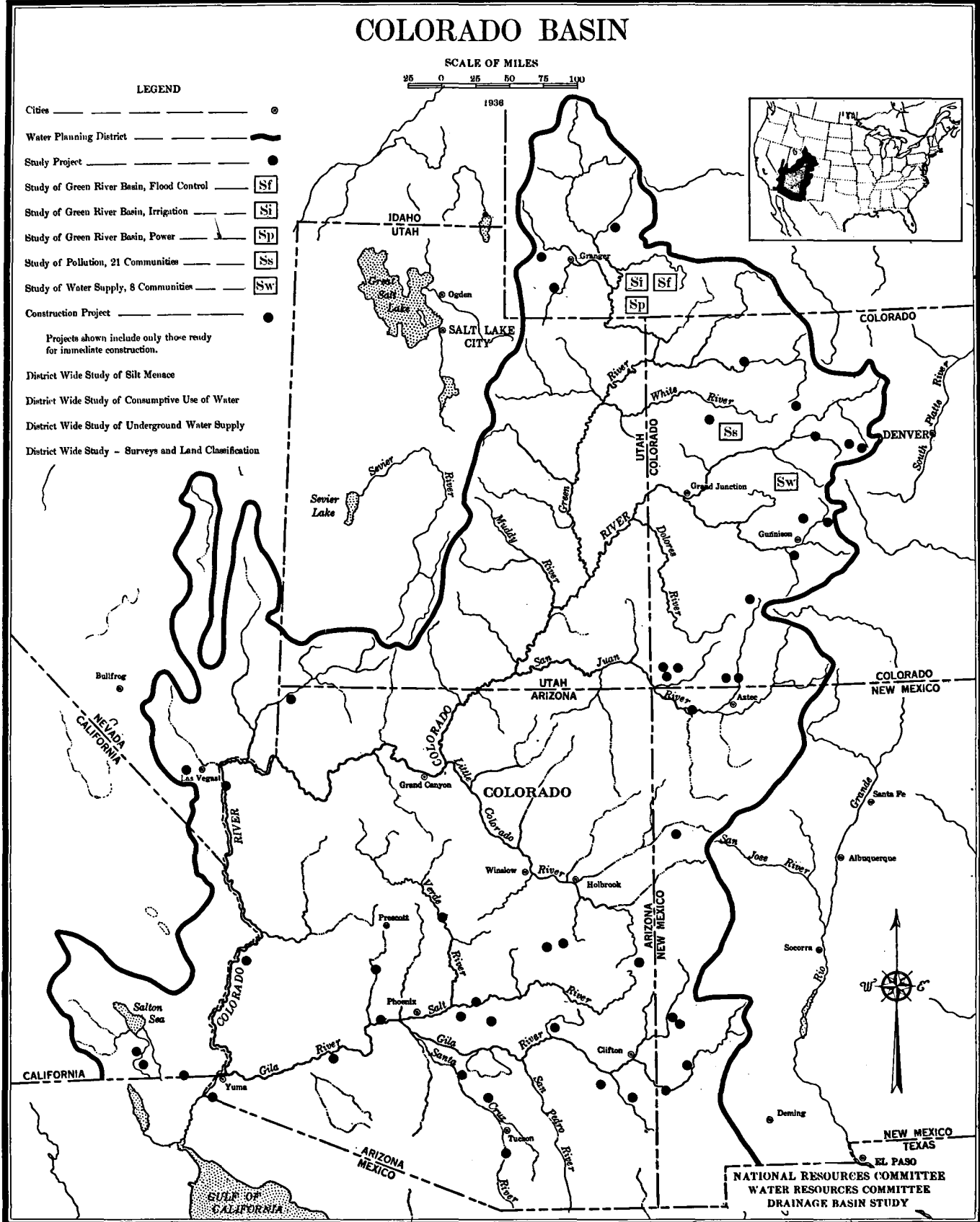
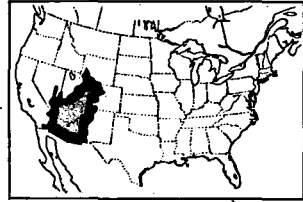
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LEGEND

- Cities ———— ●
- Water Planning District ————
- Study Project ———— ●
- Study of Green River Basin, Flood Control ———— [Sf]
- Study of Green River Basin, Irrigation ———— [Si]
- Study of Green River Basin, Power ———— [Sp]
- Study of Pollution, 21 Communities ———— [Ss]
- Study of Water Supply, 8 Communities ———— [Sw]
- Construction Project ———— ●

Projects shown include only those ready for immediate construction.

- District Wide Study of Silt Menace
- District Wide Study of Consumptive Use of Water
- District Wide Study of Underground Water Supply
- District Wide Study - Surveys and Land Classification



NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

The proper sequence of development for the Boulder Canyon group of projects is apparent. When power demands increase sufficiently, Bullshead Reservoir will be necessary to hold water released from Lake Mead solely for power purposes until it is required for irrigation later in the season. Parker Reservoir, now under construction, will also be used for reregulation. Upstream flood-storage reservoirs will preserve space in the reservoir above Boulder Dam and make that space

available for storage of silt. Other upstream reservoirs on silt-laden tributaries will be built primarily for storage of silt to preserve the integrity of Lake Mead. Dependent also upon the Boulder Canyon project are the developments downstream from Lake Mead, including the Metropolitan Aqueduct, the Imperial, Coachella, and Palo Verde irrigation projects in California, and the Colorado River Indian, Yuma, and Lower Gila developments in Arizona.

Colorado Basin Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Colorado:		
<i>Erosion, flood control, and irrigation:</i> Little Colorado River in New Mexico and Arizona: Comprehensive investigation for irrigation, flood control, silt, storage, soil conservation, and forestry.	\$75,000	Preliminary data available.
<i>Flood control:</i> Sentinel Reservoir: Study of effect of Gila floods on lands of Colorado River delta.....	30,000	Preliminary plans and some foundation explorations made.
<i>Flood control and irrigation:</i> Santa Cruz and San Simon River Basins, Ariz.: Investigations for flood control and irrigation.....	75,000	Preliminary data available.
<i>Flood control, irrigation, and power:</i> Complete the physical and economic investigations of Cliff Reservoir, Grant County, and Alma Reservoir, Catron County, N. Mex., for storage required to reduce floods, provide water for irrigation, and develop power.	20,000	A study and report was made by Bureau of Reclamation but without final conclusion; it recommended further investigations.
Tri-State investigations on Green River in Wyoming, Utah, and Colorado: Study for irrigation, power, and flood control, prior to creation of Ladore Game Preserve.	50,000	This area proposed as a game preserve.
<i>Irrigation:</i> Colorado-Arkansas River diversion: Study to determine practicability of diverting headwaters of Gunnison and Frying Pan Rivers to the Arkansas River Basin and feasibility of Tennessee Pass tunnel, for irrigation.	-----	This study with its estimated cost is listed among southwest Mississippi Basin projects.
Green River and Bear River, southwest Wyoming and north Utah: Study of diversion from Green River in Colorado Basin to supplement supply for irrigation along Bear River in the Great Basin.	-----	See the Great Basin list, for cost estimate.
Queen Creek irrigation, eastern Maricopa County, Ariz.: Queen Creek to be spread to replenish ground waters.	20,000	Project studied 30 years ago by Bureau of Reclamation.
Round Valley Water Users Association, Arizona: Repairs and construction for irrigation system.	3,000	Preliminary plans completed.
Upper Colorado River: Continuing investigations, surveys, and land classification, as contemplated in sec. 15 of the Boulder Canyon Act.	500,000	
<i>Irrigation and water supply:</i> Blue River diversion, Summit County, Colo.: Study needed of economic feasibility of diverting water from Colorado Basin to Missouri Basin.	-----	Sum needed to complete this study is listed among Missouri Basin projects.
<i>Pollution:</i> Aspen, Breckenridge, Delta, Fruita, Glenwood Springs, Grand Junction, Gypsum, Hayden, Hotchkiss, Ignacio, Meeker, Montrose, Oak Creek, Olathe, Ouray, Palisade, Paonia, Red Cliff, Rifle, Silverton, and Telluride, Colo.: Investigations for sewage-treatment plants.	25,000	Sewage treatment ordered by State board of health.
<i>Water supply:</i> DeBeque, Colo.: Fredonia, Ariz.: Fruita, Ignacio, New Castle, Norwood, Nucla, Pagosa Springs, and Palisade, Colo.; and Mogollon, N. Mex.: Investigation for sources of supply, purification, and improvements to domestic water supplies as may be required.	15,000	Some towns are without adequate fire protection, some require new supplies, others desilting and purification works.
Investigation of underground waters (quantity and chemical quality) in various areas scattered throughout the basin.	300,000	A study extending over a period of years and probably costing a million dollars.
<i>Miscellaneous:</i> Mesquite Reservoir near Littlefield, Mohave County, Ariz.: Reservoir to store floods for supplemental irrigation use and to retain silt from Lake Mead.	8,000	Preliminary studies made.
Silt study, Colorado River drainage area: Study of origin of silt and alleviation of silt menace in basin.	1,000,000	Total cost will run to several millions and extend over 25 years or more.
Research on consumptive use of water in Colorado River Basin.....	200,000	A 20-year study to cost a million dollars or more.
2. Construction Projects		
Colorado:		
<i>Drainage:</i> Malaria control, San Juan County, N. Mex.: Draining and filling mosquito breeding areas, San Juan Valley.	43,000	Plans completed.
<i>Irrigation:</i> All-American Canal, Calif., including Coachella main canal.....	3,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$8,500,000.
Colorado River Indian Reservation project: Diversion dam, irrigation canals, and pumping unit.....	3,000,000	General plans completed and lands classified. Cost given is for next 2 years. Additional needed to complete, \$7,000,000.
Eden irrigation project, Sweetwater County, Wyo.: Reservoir for supplemental supply.....	1,000,000	General plans and land classification completed.
Lower Gila irrigation project, Yuma County, Ariz.: First unit of project, including Parker power plant. Pumping from main canal to irrigate 150,000 acres.	3,500,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$13,950,000.
Lyman irrigation project, Uinta County, Wyo.: Reservoir for supplemental supply.....	1,000,000	General plans and land classification completed.
Montezuma irrigation project, Montezuma County, Colo.: Diversion by present tunnel from Dolores River. Reservoir for supplemental supply.	2,000,000	General study completed.
Pine River irrigation project, La Plata County, Colo.: Storage reservoir for supplemental supply..	1,300,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$300,000.
Roosevelt irrigation district, Maricopa County, Ariz.: Lining canals, flumes, and spillways with granite.	605,000	Plans completed.
Salt River irrigation project, Ariz.: Bartlett Storage Dam on Verde River and canal improvements.	1,200,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$494,000.
White Mountain Apache Reservation in Navajo, Apache, Gila, and Graham Counties, Ariz.: Rehabilitation of irrigation system.	35,000	Cost given is for first 2 years. Additional needed to complete, \$75,000.
San Carlos Indian irrigation project, Gila County, Ariz.: Canal improvements.....	25,000	Plans completed.
Saopeke County, Utah: Diversion tunnel to divert Cottonwood Creek from Colorado Basin to San Pitch Watershed in the Great Basin for irrigation.	-----	This project with its estimated cost is listed among the Great Basin projects.
Viridan Dam, Grant County, N. Mex.: Diversion dam to supplement supply for irrigation in New Mexico and Arizona.	50,000	Preliminary plans completed.
San Xavier, Pima County, Ariz.: Wells, pumps, and irrigation distribution system.....	288,000	Plans completed.

Colorado Basin Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Colorado—Continued.		
<i>Irrigation and water supply:</i> Papago Indian domestic and stock-water development, Pinal and Pima Counties, Ariz.: Sink 8 wells, install pumps, and improve irrigation structures.	\$53,000	Plans completed. Cost given is for next 2 years. Additional needed to complete, \$79,000.
<i>Pollution:</i> Durango, Colo.: Partial sewage-treatment plant.....	50,000	Plans completed.
Eagle, Colo.: Sewage-treatment plant.....	11,000	Do.
Gunnison, Colo.: Partial-treatment plants.....	12,000	Do.
Wickenburg, Ariz.: Pipe line and sewage-treatment plant.....	38,000	Do.
<i>Pollution and water supply:</i> Imperial, Calif.: Outfall sewer and filtration plant.....	111,000	Preliminary plans made.
<i>Water supply:</i> Breckenridge, Colo.: Storage reservoir and supply system.....	17,000	General plans completed.
Cortez, Colo.: Waterworks improvements.....	100,000	Detailed plans and specifications completed.
Craig, Colo.: Filter plant.....	20,000	Detailed plans completed.
Crested Butte, Colo.: Storage reservoir.....	11,000	Plans completed.
Dolores, Colo.: Waterworks improvement.....	100,000	Do.
Gallup, N. Mex.: Water supply.....	218,000	Preliminary plans made.
Meeker, Colo.: Replacement of old wooden pipe line.....	54,000	Do.
Mesa, Ariz.: Water mains.....	74,000	Plans completed.
North Las Vegas, Nev.: Waterworks improvement.....	35,000	General plans completed. Details lacking.
Ridgway, Colo.: Replacement of pipe lines.....	43,000	Plans completed.
Safford, Ariz.: Purchase of privately owned system and construction of supplementary works.....	496,000	Preliminary plans completed. Final plans 50 percent completed.
Yampa, Colo.: Filter plants and replacement of old pipe.....	40,000	Surveys and detail plans completed.
<i>Water power:</i> Boulder Canyon Dam, Arizona-Nevada.....	4,000,000	Dam is finished. Power plant under construction. Cost given is for next 2 years. Additional needed to complete, \$2,740,000.
Imperial Irrigation district, Calif.: Power plants and distribution system. Foundations being built at drops in All-American Canal.	2,000,000	Plans 90 percent completed. Cost given is for next 2 years. Additional needed to complete, \$2,662,000.
GROUP B—FOR DEFERRED CONSTRUCTION		
Colorado:		
<i>Flood control:</i> Meadow Valley flood diversion project near Overton, Clark County, Nev.: Earth dam to divert floods over wide plain.	\$100,000	Plans completed.
<i>Irrigation:</i> Colorado-Big Thompson transmountain diversion of water from Colorado Basin to Missouri Basin for supplemental irrigation supply.	-----	This project, with its estimated cost, is listed among Missouri Basin projects.
Duncan Valley irrigation project, Greenlee County, Ariz.: Improvements of system by wells and pumping equipment.	80,000	Preliminary plans completed.
Florida Mesa irrigation project near Durango, La Plata County, Colo.: Storage reservoir for supplemental supply.	1,000,000	Land classification completed. Cost given is for first 2 years. Additional needed to complete, \$1,000,000.
La Plata Irrigation project, La Plata County, Colo.: Building 2 dams and enlarging third to supplement supply.	1,039,000	Plans nearly completed.
Mancos irrigation project, Montezuma County, Colo.: Storage reservoir for supplemental supply....	600,000	Investigations and land classification nearly completed.
Paonia Irrigation project in Delta and Gunnison Counties, Colo.: Storage reservoir for supplemental supply.	1,000,000	Plans in preparation. Cost given is for first 2 years. Additional needed to complete, \$3,000,000.
Roan Creek irrigation project near DeBeque, Garfield County, Colo.: Supplemental water for irrigation.	500,000	Final plans in preparation. Cost given is for first 2 years. Additional needed to complete, \$500,000.
Smith Fork Irrigation project near Hotchkiss, Delta County, Colo.: Reservoir for supplemental supply.	500,000	Plans in preparation.
Upper Yampa Reservoirs near Yampa, Colo.: Supplemental supply and new land irrigation.....	1,000,000	General plans completed.
Utah and Wasatch Counties, Utah: Diversion works to divert Duchesne River from Colorado Basin to Provo River in the Great Basin, for irrigation and water supply.	-----	This project, with its estimated cost, is listed among the Great Basin projects.
<i>Irrigation and water supply:</i> Camelback water conservation district, Maricopa County, Ariz.: Irrigation works, pumping plant, power and pipe line for irrigation and domestic purposes.	335,000	Plans completed.
<i>Water supply:</i> Globe, Ariz.: Replacement of pipe line.....	68,000	General plans completed.
Tucson, Ariz.: Waterworks improvements.....	504,000	Preliminary plans completed. Final plans in preparation.

THE GREAT BASIN

Scarcity of water has limited the utilization of the land resources of the Great Basin. The stabilization of agricultural and manufactural activities in this arid, intermontane area and its further economic development both will hinge in large measure upon the degree to which meager surface supplies of water can be conserved, new underground supplies can be discovered and utilized, and additional supplies can be imported from the Colorado Basin.

Although no water which falls in the Great Basin flows to the sea, the volume of water flowing in streams to inland lakes and alkali "sinks", or accumulating in valley fills, is insufficient to serve many current needs, not to mention prospective needs. The normal flows in most of the streams which together drain the numerous small basins are utilized completely or almost completely for irrigation and for municipal purposes. The waters of Provo River and of other streams draining into Great Salt Lake are fully appropriated. The streams naturally tributary to Humboldt Sink are entirely diverted for irrigation in normal years; some of their water reaches the sink only in rare years of excessive rainfall. Various streams in southeastern Oregon, western Nevada, and southeastern California likewise are put to complete use for the irrigation of cash crops or of forage for livestock grazed on adjacent pastures. In many subbasins more land is irrigated than can be served adequately with water in some years, and farmers are subject to recurring shortages and crop losses. In various valleys, such as Malad Valley in Idaho, a precarious financial condition has resulted from the overexpansion of farming in years of relatively plentiful stream flow. Grazing of livestock in the scant pastures of the long, barren valleys of the desert floor and on the slopes of the intervening mountain ranges is restricted in many places by lack of suitable water holes. From time to time, Salt Lake City, Ogden, and other municipalities have experienced a shortage of water for domestic purposes. Lack of fresh water for condensing purposes has prevented large-scale generation of power from Utah coal. Even feeding grounds for migratory waterfowl are at a premium. A population only equal in number to that of Rhode Island finds barely enough water to meet current needs in an area comprising one-fifteenth of the United States.

The practicable means of obtaining more water in the Great Basin at reasonable expense include (1) additional surface storage, (2) reduction of losses from river channels and lakes, (3) elimination of waste in apply-

ing water to land, (4) utilization of underground waters, and (5) diversion of water from other basins having superabundant supplies.

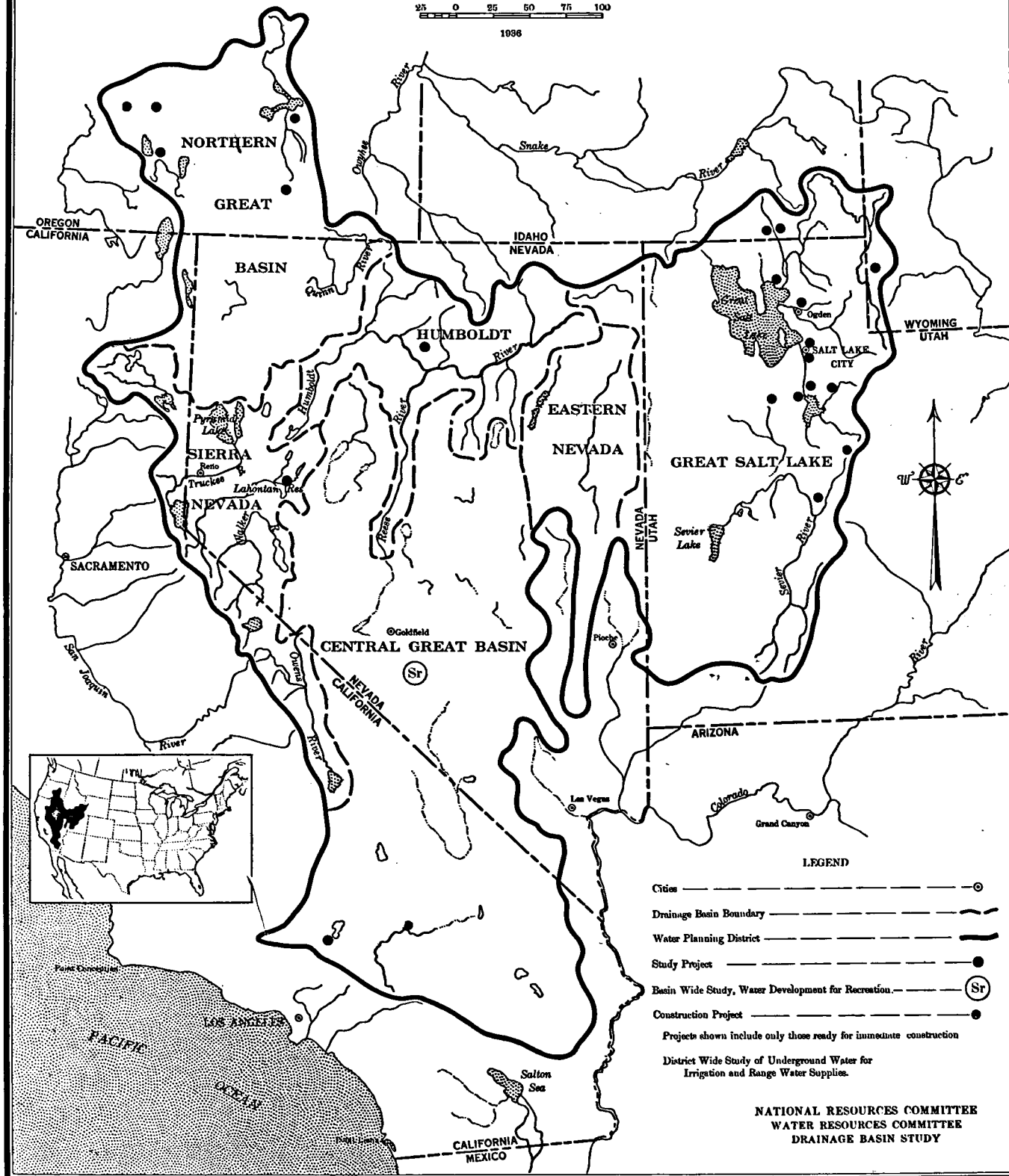
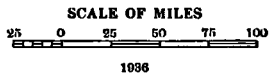
1. With the completion of Boca Reservoir on Little Truckee River, only a small number of economically feasible storage projects will remain. They are of small size and only a few in the Wasatch Mountains and the Sierra Nevada have possible collateral use for generation of power.

2. There are, however, fruitful possibilities of increasing the available supply of surface water by improving stream channels to reduce seepage losses and by constricting lake areas to reduce evaporation losses. Studies of channel improvement plans for the Humboldt and Little Humboldt Rivers should be completed. The Utah Lake diking project is needed to prevent undue loss of fresh water from the Provo drainage, where a large storage reservoir (the Deer Creek Reservoir) is planned for early construction. It would conserve water as part of a comprehensive program to supplement supplies for Salt Lake City and adjacent areas by storage works combined with diversion from the Colorado Basin. A similar diking project of larger size for Great Salt Lake would create a fresh-water embayment, the waters of which would be used in whole or in part for cooling purposes in a proposed steam-electric power plant. This project should be studied further, in conjunction with several alternative measures that might accomplish similar ends. The quality of available water supplies in the vicinity of Ogden, Utah, may be improved by the construction of sewage-treatment plants.

3. A more important method of increasing the effective supply of water is through salvage of water now wasted or lost by seepage and evaporation from irrigation canals and by its untimely or excessive application to the land. The individual savings from improvements in irrigation practices are small, but in the aggregate they are large. In some basins they may eliminate threatened shortages. Improvements of this type may be attained only through action by individual farmers and by irrigation districts, stimulated by State and Federal agricultural extension workers.

4. The underground waters which accumulate in varying quantities beneath the floors of the intermontane valleys are possible sources of additional supply in most parts of the Great Basin. In many valleys they are the only undeveloped source. They have been used profitably in a few valleys, but their extent, quality, and volume in the remainder of the district are largely

THE GREAT BASIN



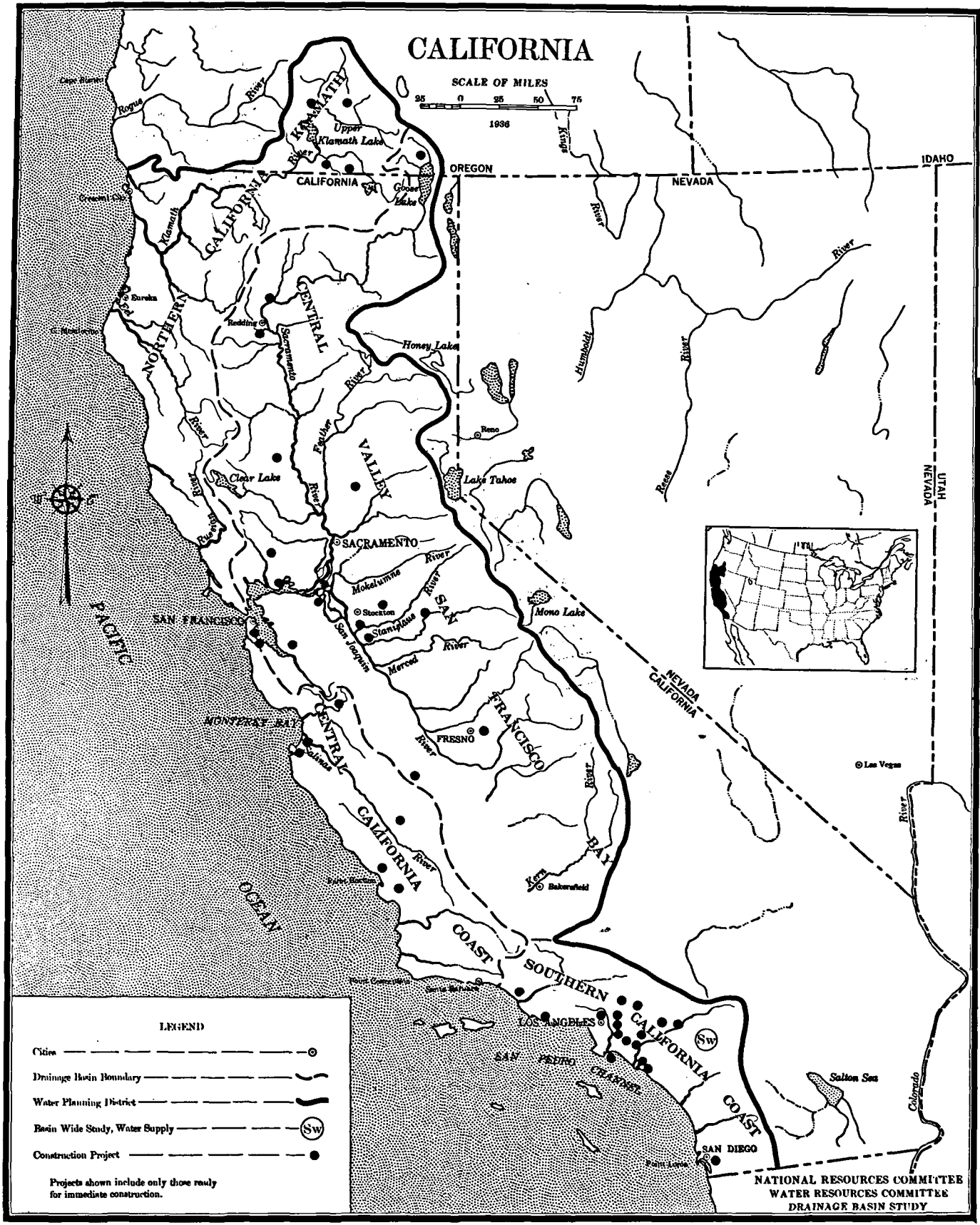
unknown. Surveys are much needed to determine the degree to which underground waters may be drawn upon with confidence for irrigation, stock water supply, and domestic use.

5. Even if all surface waters and all economically available underground waters within the district were utilized effectively, there would still remain a pressing need for more water. This need can be met only by importation from the Colorado Basin. Because of com-

plex legal and economic questions such diversions commonly require special study and long negotiations, but the construction of the Huntington Creek-San Pitch diversion tunnel in Utah may be undertaken immediately. The Green River-Bear River diversion possibilities should be investigated promptly. Action on the Duchesne River-Provo River diversion should await a settlement concerning the participation of Salt Lake City in the Deer Creek project.

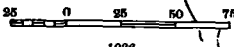
The Great Basin Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
General district:		
<i>Irrigation:</i> Study to ascertain location and extent of the underground water resources of the Great Basin, especially in those areas not heretofore investigated for use in irrigation. Study to determine methods for avoidance of losses in distribution and application of irrigation waters.....	\$200,000 50,000	Preliminary plans made.
Northern Great Basin:		
<i>Irrigation:</i> Callow Valley, Harney County, Oreg.: Study to determine the extent and development of underground water. Fort Rock-Christmas Lake Valley: Study to determine extent of underground water in valley and the possible effect its development will have on supplies now utilized on north end of Summer Lake, Lake County, Oreg.	9,000 14,000	Investigation can be started immediately. Do.
Great Salt Lake:		
<i>Irrigation:</i> Green River and Bear River, southwest Wyoming and north Utah. Study of diversion from Green River in Colorado Basin to supplement supply for irrigation along Bear River in the Great Basin. <i>Water power:</i> Davis County, Utah: Study of project for dams to form embayment in Great Salt Lake and for construction of steam electric power plant.	200,000 50,000	
Humboldt:		
<i>Irrigation:</i> Study to determine plans for improvement of channels in Little Humboldt River, Nev., and tributaries, including necessary engineering and legal details. Study to determine the value and feasibility of channel improvements of Humboldt River, Nev., to reduce water losses, including necessary engineering and legal details.	8,000 18,000	Preliminary plans complete. No plans developed.
Central Great Basin:		
<i>Irrigation:</i> Lancaster, Calif. Study of Little Rock Dam, Little Rock Creek, and Palmdale irrigation districts, to devise method of repairs to dam and to determine economies of project and plans of financing. <i>Recreation and wildlife:</i> Study of water development for recreational facilities throughout the basin.....	15,000 30,000	No plans have been prepared. Complete engineering, legal, and financial investigations necessary. Preliminary plans made.
2. Construction Projects		
Northern Great Basin:		
<i>Irrigation:</i> Lake County, Oreg.: Repairs to dam and reservoir, Silver Lake irrigation district..... Lake County, Oreg.: Repairs to dam and canal system, Summer Lake irrigation district..... <i>Recreation and wildlife:</i> Harney County, Oreg.: Dikes for flooding of Malheur migratory water-fowl refuge.....	6,000 7,000 117,000	Preliminary plans completed. Do. Plans completed.
Great Salt Lake:		
<i>Irrigation:</i> San Pete County, Utah: Diversion tunnel to divert Cottonwood Creek from Colorado River Basin to San Pitch River watershed in the Great Basin for irrigation. Utah County, Utah: Dike and outlet control to decrease evaporating surface of Utah Lake..... Weber County, Utah: Pineview Reservoir on Ogden River for irrigation of lands near Ogden, Utah..... Utah and Wasatch Counties, Utah: Construction of Deer Creek Reservoir and enlargement of Weber-Provo and Provo Reservoir canals. <i>Pollution:</i> Central Park, Salt Lake City, Utah: Improvements to sewer system..... Ogden, Utah: Sewage-treatment plant..... <i>Recreation and wildlife:</i> Boxelder County, Utah: Dam and dikes to enlarge Bear River migratory bird refuge..... <i>Water supply:</i> Bingham, Bountiful, and Manti; Improvements to water-supply system.....	30,000 800,000 450,000 2,000,000 365,000 100,000 290,000 89,000	Work under way. Sum indicated needed for completion. Preliminary study completed. Cost given is for first 2 years. Additional needed to complete \$1,574,000. Under construction. Sum indicated is needed for completion. Under construction. Cost given is for first 2 years. Additional needed to complete, \$1,800,000. Plans completed. Do. Preliminary plans completed. Plans completed.
Sierra Nevada:		
<i>Irrigation:</i> Nevada County, Calif.: Earth-fill dam in Little Truckee River near Boca for irrigation in Reno Valley and Newlands Project. <i>Recreation and wildlife:</i> Churchill County, Nev.: Water-fowl refuge near Fallon.....	250,000 52,000	Under construction. Sum indicated is needed for completion. Preliminary plans prepared. Land acquired.
Central Great Basin:		
<i>Pollution:</i> Barstow, Calif.: Sewage-treatment plant.....	87,000	Plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION		
Great Salt Lake:		
<i>Irrigation and water supply:</i> Malad Valley, Idaho: Construction of dams for irrigation, including exploratory work..... Utah and Wasatch Counties, Utah: Diversion works to divert Duchesne River from Colorado River Basin to Provo River, in the The Great Basin, for irrigation and water supply. <i>Water supply:</i> Preston, Idaho: Water-supply system..... Salt Lake City, Utah: Aqueduct from Deer Creek Reservoir, for water supply.....	\$170,000 500,000 333,000 500,000	Deferred pending decision by Salt Lake City on question of participation in Deer Creek project. Cost given is for first 2 years. Additional needed to complete, \$1,600,000. Plans completed. Cost given is for first 2 years. Additional needed to complete, \$4,100,000.
Central Great Basin:		
<i>Recreation and wildlife:</i> Current, Nev.: Wild-fowl refuge in Railroad Valley.....	16,000	Plans completed.



CALIFORNIA

SCALE OF MILES



1966

NORTHERN CALIFORNIA

CENTRAL VALLEY

SACRAMENTO

SAN FRANCISCO

MONTEREY BAY

FRESNO

SAN FRANCISCO BAY

SOUTHERN CALIFORNIA

LOS ANGELES

SAN PEDRO CHANNEL

SAN DIEGO

- LEGEND**
- Cities ———— ○
 - Drainage Basin Boundary ————
 - Water Planning District ————
 - Basin Wide Study, Water Supply ———— (SW)
 - Construction Project ———— ●

Projects shown include only those ready for immediate construction.

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

CALIFORNIA

The California district, as delimited in this study, comprises all of the State of California except the desert area lying east of the Sierra Nevada, together with a small part of southern Oregon. The outlook for this large area, with its fast-growing population of more than 6,000,000, depends chiefly upon the supply of water that can be made regularly available for essential purposes. In the future, as now, the extent of its agriculture will be limited by the supply of water for irrigation. In the future, even more than now, its industries will depend for power on hydroelectric energy. The future of its cities, no less than that of its farm lands and factories, will be influenced greatly by the supply of water available to them. In comparison with the need for more water, the need for better water through abatement of pollution, the need for additional river improvements in behalf of navigation, the need for further development of water bodies for recreational use, and the like, all are of minor importance. Even the flood problem, though urgent in some localities, is less fundamental than the requirement for more water to replenish or replace underground supplies for irrigation and to provide adequate domestic supplies for the areas of denser urban population.

Realizing years ago that the future of California was tied up with the future of its water supply, the legislature directed the State engineer to conduct a State-wide investigation of water needs and water resources and to formulate a comprehensive plan for water development. The resultant "State Water Plan" was completed in 1931. It involves a long-range projection of the California water problem into the future, and an outline, with some of the detail sketched in, of a program to implement the plan. The investigation upon which the plan is based disclosed the fact that the more serious water shortages of California were in the Los Angeles metropolitan area and the San Joaquin Valley.

To solve the difficulties of the Los Angeles metropolitan area, the plan proposed to divert water from the Colorado River through an aqueduct 249 miles in length. Several years ago the metropolitan water district of southern California was formed to construct this aqueduct at an estimated cost of more than \$200,-

000,000. The great aqueduct is now far advanced toward completion.

To solve in conjunction the difficulties of the San Joaquin Valley and various other water problems of central California, the plan proposed the multiple-purpose Central Valley project. This project is designed to secure the following interlocking benefits: (1) Regulation of the flow of the Sacramento River by means of the Kennett Reservoir, thus assuring Sacramento irrigation projects adequate supplies of water at all seasons. (2) Provision through the Friant Reservoir of an adequate amount of irrigation water for the upper San Joaquin Valley, where a falling water table was depriving a large acreage of fertile and highly developed farm land of its old source of irrigation water. (3) Provision, by pumping surplus water from the Sacramento to the lower San Joaquin Basin, for replacing water distributed in the upper San Joaquin Basin from the Friant Reservoir. (4) Improvement of the navigability of the lower Sacramento and San Joaquin Rivers. (5) Amelioration of flood conditions along both rivers. (6) Control of salinity in the Sacramento-San Joaquin Delta and assurance of an adequate supply of fresh water in the delta area for agricultural, industrial, and domestic purposes. (7) Generation of power in a 260,000-kilowatt installation at the Kennett Reservoir.

The Central Valley project is the outstanding incomplete project of the district, overshadowing all others. It is designed to meet the complex requirements of the great Central Valley, in which 900,000 people live. It has been adopted by the United States Bureau of Reclamation, which is now engaged in detailed engineering studies preparatory to the early initiation of construction. The cost of the project, estimated at about \$170,000,000, is to be repaid to the Federal Government by the revenue from sale of power and by the sale of water under the National Reclamation Act. Completion of the project as soon as practicable is of prime importance.

Forest destruction by fire has adversely affected stream flow in parts of California. Forest protection in critical watershed areas is essential.

California Project List

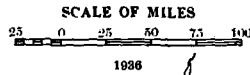
Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Southern California Coast:		
<i>Irrigation:</i> Los Angeles and Orange Counties, Calif.: Study of salt intrusion into wells.....	\$30,000	Preliminary plans made.
2. Construction Projects		
Northern California-Klamath:		
<i>Drainage, flood control, and irrigation:</i> Klamath, Oreg.: Construction of Tule Lake division of Klamath Federal Reclamation Project.....	120,000	Plans completed. Cost given is for first 2 years. Additional needed to complete, \$480,000.
<i>Irrigation:</i> Klamath Indian Reservation, Oreg.: Irrigation improvements.....	26,000	Do.
<i>Pollution:</i> Klamath Falls and Malln, Oreg.: Extensions to sewer systems.....	103,000	Do.
<i>Water supply:</i> Oregon: Stock water development, conservation of range, utilization of ungrazed areas.....	19,000	Do.
Central Valley-San Francisco Bay:		
<i>Irrigation:</i> Goose Lake Valley, Oreg.: Improvement and rehabilitation of irrigation works.....	92,000	Plans completed.
Stanislaus County, Calif.: Modesto irrigation district service ditch improvement.....	380,000	Do.
<i>Navigation:</i> Santa Clara County, Calif.: Dredging deep sea channel and turning basin in Lower San Francisco Bay and Guadalupe River.....	560,000	Authorized by Congress.
Stockton, Calif.: Dredging 9-foot feeder channel.....	112,000	Sum needed to complete.
<i>Pollution:</i> San Francisco, Calif.: Extension and repairs to water, sewer and drainage systems of Letterman General Hospital.....	24,000	Plans completed.
<i>Recreation and wildlife:</i> Glenn and Colusa Counties, Calif.: Sacramento Valley Bird Refuge; Wild Fowl Concentration Refuge on Sacramento River.....	369,000	Sum needed to complete.
<i>Water supply:</i> Napa County, Calif.: Supplemental domestic water supply to State institutions in Napa Valley; reservoir and pipe line.....	1,000,000	Plans completed.
Pittsburg, Calif.: Replacements and extensions to water distribution system.....	140,000	Do.
<i>Miscellaneous:</i> American, Bear and Yuba Rivers, Calif.: 4 debris storage dams to control gravel waste from placer mining.....	6,945,000	Authorized by Congress.
Central Valley project of California: Comprehensive irrigation, navigation, flood and salinity control, domestic and industrial water supply, and hydroelectric power project covering entire Central Valley. Project consists of these engineering features:	40,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$115,000,000. Construction program will require about 8 years. Authorized by Congress.
<i>Estimated cost</i>		
Kennett Dam, reservoir and power plants.....	\$34,000,000	
Kennett transmission line and substation.....	14,000,000	
Contra Costa conduit.....	2,500,000	
San Joaquin pumping system.....	18,500,000	
Friant Dam and Reservoir.....	14,000,000	
Friant-Kern Canal.....	26,000,000	
Madera Canal.....	3,000,000	
Rights of way, water rights and general expense.....	8,000,000	
Central California Coast:		
<i>Irrigation:</i> Santa Clara and San Benito Counties, Calif.: Supplemental water supply involving construction of 3 reservoirs and 4 canals for irrigation and recharge of underground basins in Pacheco water district.....	335,000	Plans completed.
<i>Pollution:</i> Carmel sanitary district, Calif.: Complete sewage treatment.....	50,000	Do.
San Luis Obispo, Calif.: Partial sewage treatment.....	24,000	Do.
<i>Water supply:</i> San Luis Obispo, Calif.: Supplemental water supply involving intra-basin diversion, collection reservoir, tunnel and pipeline, regulating reservoir, and mains.....	980,000	Do.
<i>Miscellaneous:</i> Basin-wide project to protect forest and brush cover against fire, with attendant benefits to grazing, soil erosion, and flood control.....	1,226,000	Plans have been prepared by Forest Service for a continuous construction and maintenance program.
Southern California Coast:		
<i>Flood control:</i> Los Angeles County, Calif.: Flood control and water conservation on Los Angeles and San Gabriel Rivers by Los Angeles County flood control district.....	35,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$37,000,000. Authorized by Congress.
<i>Navigation:</i> Los Angeles and Long Beach Harbors, Calif.: Breakwater.....	1,375,000	Sum needed to complete immediate project. Authorized by Congress.
<i>Pollution:</i> Azusa, Calif.: Sewers and complete sewage treatment.....	180,000	Plans completed.
Laguna Beach, Calif.: Sewers and complete sewage treatment.....	190,000	Do.
Monterey Park, Calif.: Sewers and complete sewage treatment.....	200,000	Do.
Newport Beach, Calif.: Sewers, outfall and complete sewage treatment.....	230,000	Do.
San Diego, Calif.: Sanitary sewer system and sewage treatment plant.....	2,000,000	Do.
San Gabriel, Calif.: Sewer system and sewage treatment plant.....	450,000	Do.
<i>Water supply:</i> Bell, Calif.: Extension and improvement of water-supply system.....	314,000	Do.
Rosemead, Calif.: Waterworks.....	242,000	Do.
Ventura, Calif.: Reservoir on Coyote Creek for supplemental water supply.....	844,000	Do.
<i>Miscellaneous:</i> Basin-wide project to protect forest and brush cover against fire, with attendant benefits to grazing, soil erosion and flood control.....	1,393,000	Plans have been prepared by Forest Service for a continuous construction and maintenance program.

1 Annually.

California Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION		
Northern California-Klamath:		
<i>Flood control:</i>		
Eel River, Calif.: Retards, bank protection, and levees.....	\$144,000	Authorized by Congress. Construction set for 1939. Plans in preparation.
<i>Irrigation:</i>		
Beaver Creek, Oreg.: Dam for irrigation.....		See Pacific Northwest (Oregon-Pacific basin) project list for cost.
<i>Pollution:</i>		
Healdsburg, Calif.: Outfall sewer and partial sewage treatment plant.....	15,000	Preliminary plans completed.
<i>Recreation and wildlife:</i>		
Lower Klamath Lake, Oreg.: Bird refuge.....	1,500,000	Do.
<i>Water supply:</i>		
Merrill, Oreg.: Improvement to water supply system.....	30,000	Plans incomplete.
Yreka, Calif.: Improvement to water supply system.....	235,000	
Central Valley-San Francisco Bay:		
<i>Flood control, irrigation, and water power:</i>		
Sacramento County, Calif.: Folsom Reservoir in American River.....	4,000,000	Preliminary plans completed. Cost given is for first 2 years. Additional needed to complete, \$8,000,000.
<i>Irrigation:</i>		
Butte County, Calif.: Supplemental water and improvements for Paradise Irrigation district.....	300,000	Plans completed.
El Dorado County, Calif.: Supplemental water and improvements for El Dorado irrigation district.....	360,000	Do.
Fresno County, Calif.: Pine Flat Reservoir to control seasonal peak flows of the Kings River for supplemental water supply.....	3,000,000	Preliminary plans completed. Cost given is for first 2 years. Additional needed to complete, \$7,000,000.
Modoc and Lassen Counties, Calif.: Supplemental water for Big Valley Irrigation project.....	325,000	Plans under way.
<i>Navigation:</i>		
San Francisco Harbor: Remove 3 rock shoals.....	45,000	Survey completed.
Solano County, Calif.: Dredging and straightening Suisun Channel to 8-foot depth from Suisun Bay to town of Suisun.....	140,000	Do.
<i>Pollution:</i>		
Bakersfield, Calif.: Partial sewage treatment.....	100,000	Preliminary plans completed.
North Sacramento, Calif.: Complete sewage treatment.....	20,000	Do.
Palo Alto, Calif.: Sewage disposal plant for veterans' hospital.....	32,000	Survey in progress.
Petaluma, Calif.: Outfall sewer and complete sewage treatment.....	316,000	Preliminary plans completed.
Piacerville, Calif.: Outfall sewer and partial sewage treatment.....	50,000	Do.
Willows, Calif.: Partial sewage treatment.....	10,000	Do.
<i>Miscellaneous:</i>		
Nevada County, Calif.: Water for hydraulic mining, Black Rock placer mining district.....	249,000	Plans under way.
Central California Coast:		
<i>Flood control and irrigation:</i>		
Santa Barbara and San Luis Obispo Counties, Calif.: Irrigation and flood control in Santa Maria Valley; dam and reservoir on Cuyama River and main canals.....	1,500,000	Preliminary engineering work completed. Cost given is for first 2 years. Additional needed to complete, \$2,500,000.
<i>Irrigation:</i>		
Monterey County, Calif.: Storage on the Salinas River system for irrigation, recharging of underground water supplies, and power.....	1,000,000	Plans incomplete. Cost given is for first 2 years. Additional needed to complete, \$1,700,000.
San Benito County, Calif.: Supplemental water supply for Hollister irrigation district, involving construction of 3 dams, 2 canals, and spreading grounds for underground percolation; the Pacheco project covers part of this plan.....	500,000	Plans incomplete. Cost given is for first 2 years. Additional needed to complete, \$800,000.
<i>Pollution:</i>		
King City, Calif.: Outfall sewer and partial sewage treatment.....	20,000	Preliminary plans completed.
Pacific Grove, and Santa Maria, Calif.: Sewer systems.....	50,000	Plans incomplete.
Southern California Coast:		
<i>Drainage:</i>		
Oxnard, Calif.: Drainage district no. 3. Drainage to remove alkaline salts.....	318,000	Preliminary plans completed.
<i>Flood control:</i>		
Orange County, Calif.: Flood control and water conservation.....	16,500,000	Authorized by Congress.
<i>Irrigation:</i>		
San Diego County, Calif.: Fallbrook irrigation district, water supply from San Luis Rey River for irrigation of 5,000 acres.....	250,000	Preliminary plans completed. Cost given is for first 2 years. Additional needed to complete, \$536,000.
Ventura County, Calif.: Conservation of waste water of Santa Clara River for irrigation and recharging underground basin.....	1,000,000	Investigation under way. Cost given is for first 2 years. Additional needed to complete, \$2,200,000.
<i>Navigation:</i>		
San Diego Harbor, Calif.: Dredging.....	4,184,000	Survey completed.
<i>Pollution:</i>		
Arcadia, Calif.: Sewer system and sewage treatment plant.....	271,000	Plans completed.
San Diego, Calif.: Outfall sewer and 2 sewage treatment plants.....	500,000	Preliminary plans completed.
San Jacinto, Calif.: Sewers and partial sewage treatment.....	20,000	Do.
Sunset Beach sanitary district, Calif.: Sewers and partial sewage treatment.....	60,000	Do.

PACIFIC NORTHWEST



LEGEND

- Cities _____ ●
- Drainage Basin Boundary _____
- Water Planning District _____
- Study Project _____ ●
- Area Study, Drainage _____ [Sd]
- Area Study, Irrigation _____ [Si]
- Area Study, Water Supply _____ [Sw]
- Basin Wide Study, Erosion _____ (Se)
- Basin Wide Study, Irrigation _____ (Si)
- Basin Wide Study, Pollution _____ (Ss)
- Basin Wide Study, Water Supply _____ (Sw)
- Construction Project _____ [W]
- Construction Project _____ ●
Water Supply for Stock Raising in Snake River Basin.
- Construction Project _____ ●
Projects shown include only those ready for immediate construction.
- District Wide Study of Effect of Forest Cover on Stream Flow.
- Study of Spawning Areas throughout the Columbia River Basin.
- Study of Pollution throughout the Columbia River Basin.



NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

● SALT LAKE CITY

PACIFIC NORTHWEST

The Pacific northwest district comprises all drainage areas of the United States tributary to the Pacific Ocean north of Smith River near the California-Oregon line. The regional water problems of the district are differentiated by natural and cultural conditions. West of the Cascades, precipitation is heavy on the mountain slopes and adequate for various crops on the lowlands, irrigation is chiefly supplemental in type, floods are frequent along many streams, navigation is important and tied intimately to ocean shipping, and the population of the lowlands is relatively dense. East of the Cascades, precipitation in most places is very light, irrigation is indispensable to successful agriculture in many localities, floods are less frequent, navigation is unimportant, and the population of most of the area is sparse. Both west and east of the mountains, natural conditions are favorable for the development of large amounts of water power.

The most pressing problem at present in relation to power is the development, through stimulation of power-consuming industries and otherwise, of markets for the output of projects now under construction, particularly those at Grand Coulee and Bonneville. The proposal to add greatly to the height of the dam under construction at Grand Coulee is intended not only to increase the output of power, but also to promote irrigation and in so doing create a market for power. Some of the power made available by the higher dam could be used to pump water to irrigate ultimately 1,200,000 acres of fertile land above the proposed reservoir and otherwise to serve settlers on the land reclaimed. The long-term relationships of the High Dam should receive further study.

The dams at Grand Coulee and Bonneville are the uppermost and lowermost members of a system of 10 dams by which it is proposed to utilize ultimately 92 percent of the 1,300-foot fall of the Columbia River in its 750-mile course from the Canadian border to the sea for power plants with an aggregate installed capacity of more than 10,000,000 horsepower. The

objective challenges admiration, but construction of additional units of the system should not get out of step with the regional requirements for power. The system of dams proposed would provide, with associated channel improvements, for seagoing ships to The Dalles, 190 miles inland, and for modern barges to Priest Rapids, 400 miles inland. Decades undoubtedly will pass before the development of the Columbia River for power, irrigation, and navigation is completed.

Some irrigation projects now in operation east of the Cascades suffer at times from serious shortages of water. This is particularly true in southern Idaho, where there is much need for supplemental supplies. A comprehensive investigation is recommended to determine all practicable sources from which the water that is needed may be obtained.

Some 24 short streams west of the Cascades are subject to floods that cause damages averaging approximately \$1,000,000 annually to lowland property. Flood control, involving erosion control, is the outstanding water need of the Puget Sound area. Large amounts of cheap hydroelectric power are being developed, particularly by Seattle on the Skagit River. It is important that the coastal power programs be harmonized with those at Grand Coulee and Bonneville in the interest of economical marketing.

The Corps of Engineers is conducting a comprehensive investigation of the entire Willamette drainage in Oregon. It is expected that the resulting program will provide for several large upstream reservoirs that will afford much-needed flood protection, improve the navigability of the Willamette to Eugene, improve the quality of river water by dilution, and develop incidental hydroelectric power. Sewage and industrial treatment plants at Portland and other communities should not, however, await completion of the integrated plan. Drainage of about three-quarters of a million acres in the valley by progressive step development also is desirable.

Pacific Northwest Project List

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION		
1. Investigation Projects		
Columbia River (general problems):		
<i>Irrigation:</i>		
Big Blackfoot Valley: Reconnaissance survey for irrigation.....	\$10,000	
Bitterroot Valley: Reconnaissance survey of water supply for irrigation.....	20,000	
Camas Prairie: Reconnaissance survey of water supply for irrigation.....	50,000	
Irrigation and drainage surveys other than Columbia Basin projects.....	100,000	
Missoula Valley: Reconnaissance survey of water supply for irrigation.....	50,000	
Upper Flathead Basin: Reconnaissance survey of water supply for irrigation.....	30,000	
<i>Pollution:</i>		
Stream-pollution studies throughout basin.....	120,000	
<i>Recreation and wildlife:</i>		
Fishery survey of streams and spawning areas throughout basin.....	50,000	
<i>Water supply:</i>		
Oregon: Municipal water supply investigation.....	16,000	
<i>Miscellaneous:</i>		
Forest cover—Stream flow studies.....	475,000	
Oregon: Irrigability classification of project lands.....	50,000	
Washington: Preliminary surveys of likely demonstration areas for soil and water conservation.....	4,000	
Washington and Idaho: Silt load measurements.....	53,000	
Snake:		
<i>Irrigation:</i>		
Clearwater River Basin in Idaho: Study and surveys to determine the irrigation possibilities.....	30,000	
Salmon River and tributaries in Idaho: Study and survey to determine the irrigation possibilities.....	50,000	Necessary for construction of project under Group B.
Snake River Basin in Oregon: Study and surveys of the irrigation and drainage conditions.....	100,000	
Snake River Basin in Oregon: Classification of project lands for irrigation.....	15,000	
<i>Pollution:</i>		
Snake River Basin: Study of stream pollution.....	59,000	
<i>Recreation and wildlife:</i>		
Snake River Basin: Fishery survey of streams and spawning areas throughout basin.....	11,000	
<i>Water supply:</i>		
Snake River Basin in Oregon: Study of municipal water supply.....	4,000	
Study of water supply and storage including trans-mountain diversions.....	300,000	Continuation of present studies.
<i>Miscellaneous:</i>		
Snake River Basin: River-utilization surveys.....	15,000	
Snake River Basin: Study of the data obtained by a geological and geophysical survey.....	185,000	Plans completed by U. S. Geological Survey.
Upper Columbia:		
<i>Irrigation:</i>		
Columbia Basin project, Washington: Classification of irrigable lands for best use of water made available by Grand Coulee Dam.....	500,000	Sum needed to complete.
Flathead County, Mont.: Investigation of Hungry Horse Reservoir project.....	150,000	
Lower Columbia-Willamette:		
<i>Pollution:</i>		
Stream-pollution study.....	50,000	
<i>Recreation and wildlife:</i>		
Fishery survey of streams and spawning areas throughout basin.....	17,000	
Puget Sound:		
<i>Pollution:</i>		
Stream-pollution study: Public health and protection to fish life.....	120,000	
<i>Recreation and wildlife:</i>		
Fishery survey of streams and spawning areas throughout basin.....	50,000	
<i>Miscellaneous:</i>		
Aero mapping of river channels and their drainage areas.....	30,000	
River utilization surveys: To obtain river and reservoir topography.....	43,000	
Oregon coast:		
<i>Drainage:</i>		
Oregon: Study of diking and drainage for reclamation of marsh lands along coast.....	30,000	Plans not made.
<i>Irrigation:</i>		
Classification of irrigable lands: To determine best lands and cull out inferior lands.....	13,000	No plans; begin immediately.
Surveys to determine best means of irrigating 65,500 acres.....	25,000	Do.
<i>Pollution:</i>		
Stream-pollution surveys.....	10,000	
<i>Recreation and wildlife:</i>		
Fishery survey of streams and spawning areas throughout basin.....	30,000	
<i>Water supply:</i>		
Municipal water-supply investigations: Improve domestic water supply and sewage works.....	8,000	
<i>Miscellaneous:</i>		
River-utilization surveys: To obtain river and reservoir topography.....	20,000	
Silt-gaging stations: To determine quantities of soil actually eroded.....	169,000	
Washington coast:		
<i>Pollution:</i>		
Stream-pollution studies.....	24,000	Plans completed.
<i>Recreation and wildlife:</i>		
Fishery survey of streams and spawning areas throughout basin.....	25,000	Begin immediately.
<i>Miscellaneous:</i>		
River-utilization surveys: To obtain river and reservoir topography.....	15,000	Plans completed.
2. Construction Projects		
Columbia River:		
<i>Drainage:</i>		
Levee improvements, with drainage at some points to reclaim land subject to overflow of Columbia River or its backwaters from Bonneville to the sea at 4 districts near Portland, at districts 1, 3, 4, and Skamokawa, Upper Gray and Day Rivers in Wahkiakum County at Deer Island, Prescott, Westland, and Sauvie Island and along Cowlitz, Longview, Wallcut, and Lewis Rivers in Washington and Oregon.....	5,521,000	Sum needed to complete. Sketch plans completed and detailed plans in preparation for some projects.
<i>Irrigation and power:</i>		
Grand Coulee Dam, Columbia Basin project, west of Spokane, Wash.: High dam for irrigation storage reservoir and power plant.....	40,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$84,250,000. Total cost \$124,250,000. Construction will cover a period of years.
<i>Navigation:</i>		
Columbia River, Oreg. and Wash.: Navigation channel from Celile to Umatilla.....	287,000	Cost given is for next 2 years. Additional needed to complete, \$450,000. Surveys completed. Authorized by Congress.
St. Helens Channel: Dredge 30-foot channel, Columbia River to St. Helens.....	50,000	Surveys completed. Authorized by Congress.
Youngs Bay and River, Oreg.: Dredge 10-foot channel, Columbia River to Havens Island.....	5,000	Surveys completed.
<i>Navigation and power:</i>		
Bonneville Dam, Columbia River, Oreg. and Wash.: Navigation and power dam.....	5,650,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances. Total cost is \$46,065,700.

Pacific Northwest Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Columbia River—Continued.		
<i>Water supply:</i>		
Idaho, Oregon, and Washington: Reservoirs, springs, and wells on the public range and national forest, for watering stock.	\$222,000	Can be started at once. Needed to arrest decline of herds and spotted overgrazing.
<i>Snake:</i>		
<i>Irrigation:</i>		
Arco, Idaho: Diversion dam on Big Lost River.....	55,000	Sketch plans completed.
Ashton, Idaho: Squirrel Meadows storage reservoir for irrigation in Idaho.....	200,000	Survey not completed.
Custer County, Salmon River Drainage, Idaho: Challis irrigation canal improvements.....	44,000	Investigations completed.
Driggs, Teton County, Idaho: Storage on Teton River for irrigation.....	1,050,000	Under construction. Cost given is for next 2 years.
Emmett, Idaho: Diversion canal for Black Canyon irrigation district.....	2,500,000	Additional needed to complete, \$1,300,000.
Fort Hall, Idaho: Indian reservation irrigation project.....	150,000	Preliminary plans in progress. Cost given is for first 2 years. Additional needed to complete, \$235,000.
Indian Valley, Weisen River Drainage, Idaho: Reservoir for irrigation.....	128,000	Sketch plans completed.
Jackson, Wyo.: Irrigation system for elk refuge.....	49,000	Preliminary plans completed.
Lincoln County, Wyo.: Star Valley Reservoir for supplemental storage for irrigation.....	57,000	Plans completed.
Malheur County, Oreg.: Owyhee irrigation project.....	800,000	Under construction. Cost given is for next 2 years. Additional needed to complete main canals and laterals, \$300,000.
<i>Pollution:</i>		
Boise, Idaho: Sewage treatment plant.....	273,000	Sketch plans completed.
Colfax, Wash.: Sewage treatment plant.....	97,000	Plans completed.
Grangeville, Idaho: Sewage treatment plant.....	11,000	Preliminary plans completed.
Lostine, Oreg.: Sewage treatment plant.....	11,000	Do.
McCall, Idaho: Sewer system.....	32,000	Sketch plans completed.
<i>Water supply:</i>		
New Plymouth, Idaho: Water supply system.....	40,000	Plans completed.
Snake River Basin, Idaho: Development of supplemental water supply by well drilling, for stock raising in Taylor grazing districts.....	113,000	General plans completed.
Snake River Basin, Idaho, Oregon, and Washington: Development of water supply for stock raising.....	258,000	Do.
Twin Falls, Idaho: Storage for water supply.....	144,000	Sketch plans completed.
Upper Columbia:		
<i>Drainage:</i>		
Latah Creek, near Spokane, Wash.: Drainage improvements to prevent stagnant pools.....	81,000	Plans completed.
Yakima near Toppenish, Wash.: Improvements to drainage system.....	87,000	Do.
<i>Irrigation:</i>		
Flathead irrigation project, Lake Sanders, Missoula, Mont.: Complete Indian reservation irrigation project, pumping, storage, and drainage.....	1,000,000	Detail plans in preparation. Cost given is for first 2 years. Additional needed to complete, \$1,096,000.
Inchelium City, Wash.: Diversion dam for storage in Twin Lakes to irrigate Indian lands.....	35,000	Under construction.
Nespelem River, Nespelem, Wash.: Complete diversion and dam for irrigation storage in Owhi Lake.....	24,000	Sum needed to complete. Total cost \$216,000.
Nevada Creek, Powell County, Mont.: Irrigation dam and reservoir for supplemental water.....	248,000	
Race Track Creek, Powell County, Mont.: Irrigation dam and reservoir for supplemental water.....	254,000	
Wapato, Wash.: Complete irrigation project.....	350,000	Preliminary plans made. Cost given is for first 2 years. Additional needed to complete, \$750,000.
West Fort Bitterroot, Ravalli County, Mont.: Irrigation dam and reservoir for supplemental water.....	450,000	
Wheeler Dam, near Wenatchee, Wash.: Raise dam to increase irrigation storage.....	21,000	Plans completed.
<i>Irrigation and power:</i>		
Rosa project, near Yakima, Wash.: Irrigation canal and power plant.....	11,500,000	Sum needed to complete. Total cost \$15,000,000.
<i>Pollution:</i>		
Coeur d'Alene City, Idaho: Improve existing sewer system.....	69,000	Plans completed.
Spokane, Wash.: Additions to sewer system and sewage treatment plant.....	909,000	Do.
Wapato City, Wash.: Sewage treatment plant.....	22,000	Do.
<i>Recreation and wildlife:</i>		
Fish screens and ladders on existing Federal irrigation projects throughout basin.....	345,000	
<i>Water supply:</i>		
Kennewick, Wash.: Improvements and extensions to water system.....	31,000	Do.
Spokane, Wash.: Install 1,800 horsepower pumping plant for city supply.....	330,000	Do.
Twisp, Wash.: Water system.....	36,000	Do.
Whitestone City, Wash.: Water system, including repairs to irrigation system.....	37,000	Do.
Middle Columbia:		
<i>Flood control:</i>		
Pendleton, Oreg.: Flood channel improvements in Umatilla River.....	200,000	Detail plans in preparation.
<i>Irrigation:</i>		
Warm Springs Indian Reservation, near Mitchell, Wheeler County, and near Bend and Sisters, Deschutes County, Oreg.: Irrigation and stock watering dams.....	78,000	Surveys completed only for Warm Springs Indian Reservation.
<i>Pollution and water supply:</i>		
Dayton, Wash.: Sewer system and sewage treatment plant.....	50,000	
<i>Water supply:</i>		
Dayton, Wash.: Improvements to water system.....	35,000	Plans completed.
White Salmon, Wash.: Reconstruct water system.....	90,000	Do.
Lower Columbia—Willamette:		
<i>Flood control:</i>		
Willamette River Basin: Bank protection and clearing flood channels on Willamette River and tributaries.....	2,430,000	Detailed plans in preparation authorized by Congress.
<i>Pollution:</i>		
Beaverton, Oreg.: Outfall sewer and sewage treatment plant.....	79,000	Preliminary plans made.
Gladstone, Oreg.: Intercepting sewer and sewage treatment plant.....	35,000	Do.
Milwaukee, Molalla, Oregon City, and West Linn, Oreg.: Sewer system extensions and sewage treatment plants.....	450,000	
Oregon City, Oreg.: Intercepting sewer and sewage treatment plant.....	106,000	Do.
Portland, Oreg.: Sewage treatment plants and interceptor sewers to improve Willamette River.....	9,575,000	Only preliminary plans made.
Salem, Oreg.: Intercepting sewer and primary sewage treatment plant.....	360,000	Preliminary plans made.
Puget Sound:		
<i>Flood control:</i>		
Mud Mountain Reservoir on White River for flood control of White and Puyallup River.....	3,205,000	Detailed plans in preparation. Includes estimated cost of land.
Skagit River, cut-off channel.....	4,798,000	Do.
Tacoma, Wash.: Channel improvement of Puyallup River.....	1,558,000	Do.
<i>Flood control and erosion:</i>		
Stillacumish River channel for flood and erosion control.....	261,000	Detailed plans in preparation.
<i>Flood control and navigation:</i>		
Seattle Harbor: Settling basin for flood relief and navigation.....	10,000	Surveys completed.
<i>Navigation:</i>		
Olympia Harbor: Widen entrance channel.....	98,000	Do.
Tacoma Harbor, Hylebos Waterway: Dredging turning basin and channel.....	112,000	Do.

Pacific Northwest Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued		
2. Construction Projects—Continued		
Puget Sound—Continued.		
<i>Pollution:</i>		
Bellingham, Wash.: New outfall sewer and sewer system additions.....	\$103,000	Plans completed.
Bremerton, Wash.: Extension of sewer system.....	174,000	Do.
Seattle, Wash.: Oregon and Henderson Street sewer system and sewage treatment plant.....	500,000	Do.
Tacoma, Wash.: Trunk sewers and sewage treatment plant.....	631,000	Do.
<i>Water supply:</i>		
King County, water district, 49\ Domestic waterworks system.....	128,000	Do.
Oregon Coast:		
<i>Irrigation:</i>		
Medford, Oreg.: Diversion dam for Rogue River Valley.....	25,000	Right of way acquired; no plans made.
Talent City, Oreg.: Line irrigation water tunnel.....	10,000	No plans required.
<i>Navigation:</i>		
Reedsport, Oreg.: Extension of south jetty, Umpqua River.....	600,000	Authorized by Congress. Survey and plans completed.
<i>Pollution:</i>		
Roseburg, Oreg.: Sewer system and sewage treatment.....	86,000	Plans completed.
Washington Coast:		
<i>Navigation:</i>		
Grays Harbor, Wash.: Reconstruction of harbor entrance jetties.....	3,155,000	Work under way. Sum needed to complete.
Port Gamble, Wash.: Deepen entrance to bay.....	20,000	Surveys completed.
GROUP B—FOR DEFERRED CONSTRUCTION		
Columbia River:		
<i>Navigation:</i>		
Columbia River: Dredge 27-foot channel Vancouver to Bonneville.....	\$2,380,000	Survey completed.
Elokomin Slough: Dredge 10-foot channel to Columbia River for navigation.....	16,000	Do.
Vancouver, Wash.: Extension of lower turning basin.....	22,000	Do.
Snake River:		
<i>Drainage:</i>		
Caldwell, Idaho: Drainage system in drainage district no. 6.....	131,000	Sketch plans completed.
<i>Irrigation:</i>		
Boise County, Idaho: Jerusalem Valley Dam and reservoir on Porter Creek.....	35,000	Preliminary plans completed.
Butte County, Idaho: Bypass irrigation canal on Big Lost River.....	96,000	
Council, Idaho: Lost Valley Dam and storage reservoir.....	20,000	
Elgin, Oreg.: Diversion dam.....	18,000	
Gooding County, Idaho: Irrigation storage reservoir on Clover Creek.....	66,000	
Leadore, Salmon River Drainage, Idaho: Texas Creek dam for irrigation.....	189,000	Sketch plans completed.
Lincoln County, Idaho: Bypass canal on Big Wood River.....	39,000	No plans.
Lawiston, Idaho: Replacements to existing irrigation system.....	160,000	Detail plans in preparation.
Picabo, Idaho: Irrigation storage reservoir on Silver Creek.....	206,000	Sketch plans completed
Roseberry, Idaho: Additional irrigation storage in Boulder Lake reservoir.....	24,000	Preliminary plans completed.
Rupert, Idaho: Diversion canal to the Salmon tract.....	61,000	Do.
Teton County, Wyo.: Upper Slide Lake reservoir for Teton irrigation project.....	10,000	Do.
Valley County, Idaho: Irrigation storage in Upper Payette Lake.....	186,000	Do.
Valley County, Idaho: Clear Creek Dam and storage reservoir.....	25,000	Do.
Washington County, Idaho: Dam and irrigation canal on Lower Manns Creek.....	100,000	Do.
Washington County, Idaho: Irrigation storage reservoir on Upper Manns Creek.....	101,000	Do.
<i>Irrigation and power:</i>		
Baker, Oreg.: Storage reservoir on Powder River for irrigation and power.....	3,665,000	Preliminary surveys completed.
<i>Recreation and wildlife:</i>		
Idaho, Oregon, Washington, and Wyoming: Fish screens and ladders for Snake River Basin at Federal projects for protection of fish life.....	355,000	
<i>Water supply:</i>		
La Grande, Oreg.: Improvements to water supply system.....	194,000	Preliminary plans completed.
Ontario, Oreg.: Improvements to water supply system.....	94,000	Do.
Teton, Idaho: Replacements to existing water supply system.....	48,000	Sketch plans completed.
Upper Columbia:		
<i>Irrigation:</i>		
Columbia Basin project: Irrigation works.....	1,000,000	Construction may require 50 years. Cost given is for first 2 years. Additional needed to complete, \$196,000,000.
Kootenai Creek project, Ravalli County, Mont.: Irrigation storage dams.....	36,000	
Post Falls, Idaho: Improvement to irrigation system, pumps, and canals.....	100,000	Sketch plans completed.
Swamp Creek, Sanders County, Mont.: Irrigation storage dam for supplemental water.....	60,000	
Talley Lake project, Flathead County, Mont.: Irrigation dam, canal, and tunnel.....	600,000	
<i>Irrigation and water supply:</i>		
Rattlesnake Creek near Missoula, Mont.: Irrigation storage dams, and city water supply.....	22,000	
<i>Pollution:</i>		
Ellensburg, Wash.: Sewage treatment plant.....	80,000	
Prosser, Wash.: Sewage treatment plant.....	20,000	
Toppenish, Wash.: Sewage treatment plant.....	30,000	
<i>Water supply:</i>		
Kennewick, Wash.: Water purification plant.....	30,000	
Pasco, Wash.: Water purification plant.....	40,000	
Sandpoint, Idaho: Improvements to city water system.....	88,000	Do.
Middle Columbia:		
<i>Flood control:</i>		
Mill Creek near Walla Walla, Wash.: Construction flood control works, including storage and flood channel improvements.....	1,794,000	Detail plans completed.
Touchet River, near Dayton, Wash.: Channel improvements.....	22,000	Plans completed.
<i>Irrigation:</i>		
Madras, Oreg.: Canal and dam for irrigation of Deschutes north district.....	3,000,000	Surveys completed. Cost given is for first 2 years. Additional needed to complete, \$5,000,000.
Prineville, Oreg.: Improvements to existing Ochoce irrigation system.....	85,000	Surveys completed.
Warm Springs Indian Reservation: Addition to irrigation works.....	50,000	Surveys completed. Cost given is for first 2 years. Additional needed to complete, \$215,000.
<i>Recreation and wildlife:</i>		
Oregon and Washington: Fish ladders and screens at dams and irrigation ditches to prevent destruction of fish life at Federal projects on tributaries in middle Columbia Basin.....	125,000	Estimate is approximate. Survey needed to supply accurate information as to location and cost.
<i>Water supply:</i>		
The Dalles, Oreg.: City water system.....	551,000	Preliminary plans completed.
Lower Columbia-Willamette:		
<i>Water supply:</i>		
Maplewood water district, Multnomah County, Oreg.: Reconstruction of waterworks system.....	22,000	Do.

Pacific Northwest Project List—Continued

Drainage basin and project description	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued		
Puget Sound:		
<i>Flood control:</i>		
Black River: Channel improvement.....	\$23,000	
Hatt Slough: Reconstruction and repair of dikes.....	26,000	Plans completed.
Sauk River Channel: Revetments.....	53,000	Do.
<i>Flood control and drainage:</i>		
Skagit County drainage district no. 17: Flood control and drainage.....	107,000	Do.
<i>Water supply:</i>		
Alderwood Manor, Wash.: Extension of water distribution system.....	102,000	Do.
Oregon coast:		
<i>Irrigation:</i>		
Beaver Creek, Oreg.: Dam for irrigation.....	425,000	Preliminary plans completed.
Jackson County, Oreg.: Line Eastside Canal, Talent irrigation district, and main canal.....	125,000	
<i>Pollution:</i>		
Jacksonville, Oreg.: Sewer system.....	24,000	
<i>Water supply:</i>		
Bay City, Oreg.: Water supply system.....	40,000	
Coquille, Oreg.: Water mains.....	35,000	
Port Orford, Oreg.: Water supply system.....	26,000	
Toledo, Oreg.: Water supply system.....	130,000	
Washington coast:		
<i>Water supply:</i>		
Centralia, Wash.: Pumps for domestic water supply system.....	176,000	Plans completed.
Willapa Valley, Wash.: Diversion dam on Stringer Creek and water main extension.....	69,000	

METHOD OF STUDY

A large portion of the work in the field was carried out through the State planning organizations working in conjunction with field officers of interested Federal and State agencies. In many States, the State planning boards appointed special committees on water resources. State planning consultants, State engineers, State health officers, State geologists, municipal engineers, and numerous other officials participated in organizing basic materials for the use of the Regional Water Consultants.

The following Federal agencies participated in the study:

- Bureau of Agricultural Engineering
- Bureau of Biological Survey
- Bureau of Fisheries
- Bureau of Mines
- Bureau of Reclamation
- Corps of Engineers
- Division of Grazing
- Federal Emergency Administration of Public Works
- Federal Power Commission
- Forest Service
- International Boundary Commission, American Section
- International Joint Commission
- National Park Service
- Office of Indian Affairs
- Soil Conservation Service
- Tennessee Valley Authority
- United States Geological Survey
- United States Public Health Service
- Works Progress Administration

All of these supplied data for the preparation of the consultants' reports. Many of them contributed generously in technical assistance in the review of consultants' reports. The Water Resources Committee is

indebted especially to the Bureau of Reclamation for assistance furnished by the Denver office of the Bureau; to the Public Health Service for loan of personnel from the Office of Stream Pollution Investigations at Cincinnati; to the Public Works Administration for technical assistance in the Washington office; and to the Corps of Engineers for personnel detailed from the office of the Mississippi River Commission at Vicksburg.

The subcommittee of the Water Resources Committee which reviewed the individual basin reports was assisted by O. L. Hooper of the Federal Power Commission, C. S. Jarvis of the Soil Conservation Service, and Capts. Thomas Stanley and William W. Wanamaker of the Corps of Engineers, each of whom represented committee members at various times.

The study was handled as part of the National Resources Committee administration under Charles W. Eliot 2d, executive officer, and Harold Merrill, assistant executive officer. Cooperation of State planning boards and their staffs, financed from the National Resources Committee and from State and Works Progress Administration project funds, was organized under the direction of Robert H. Randall, consultant on State planning. The facilities of the Information and Publication Division, under Lloyd George, editor, and Martin E. Janson, his assistant, were utilized. Charles P. Dake was in charge of administrative arrangements, Charles Faunce supervised the drafting, and Ethel F. Fealy supervised the stenographic work. The special arrangements for temporary personnel and office space were facilitated through the cooperation of the Office of the Secretary of the Interior. The U. S. Geological Survey aided in the drafting of maps.

Clerical and stenographic assistance for the regional water consultants was contributed in part through State planning board projects financed through the Works Progress Administration.

PROBLEMS AND PROGRAMS OF INDIVIDUAL BASINS

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NEW ENGLAND DRAINAGE BASINS

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1. MAINE RIVERS

The water problem of chief importance at present in the Maine river basins is the abatement of stream pollution in the interest of sanitation and to preserve the recreational assets of the State. Problems of less immediate importance include the extension of water supplies for domestic and industrial purposes, improvement in the navigation facilities and flood control. Consideration should also be given to the orderly development of water power and storage in the several basins.

General Description

This region includes all of Maine and the small portion of New Hampshire containing the headwaters of rivers which have their outlets along the Maine coast. The principal streams are the Androscoggin, Kennebec, Penobscot, and St. John Rivers; lesser streams are the St. Croix, Machias, Union, Presumpscot, Kennebunk, Saco, and Salmon Falls (Piscataqua) Rivers. The St. John and St. Croix Rivers are international and the Androscoggin, Saco, and Salmon Falls Rivers are interstate streams.

The headwaters of the rivers lie in mountainous regions which are heavily wooded, particularly in the northern areas. The central and southern portions are hilly, but the altitudes are moderate. The rivers, with their many falls and rapids, are important sources of water power, developed and potential.

The total area of the region is about 34,900 square miles, of which 32,600 square miles are in Maine and 2,300 square miles in New Hampshire. Forest growth, covering more than 70 percent of the area, is located principally in the upper or northern, two-thirds of the drainage basins. The water area is more than 1,460 square miles, provided by 1,400 rivers and 2,200 ponds and lakes.

The population of the basin is in excess of 900,000, the largest portion of which is in the southern part. Many square miles of the northern area are uninhabited wild lands. The population density reaches a maximum of 160 per square mile in the lower Androscoggin Basin and falls to 30 in the Penobscot Basin. The urban population ranges from 9 percent of the total in the St. John Basin to 60 percent in the Androscoggin Basin.

The principal commercial centers are Portland, Bangor, and Augusta, Maine; and Portsmouth, N. H.; the larger industrial cities are Saco, Biddeford, Lewiston and Rumford, Maine, and Berlin, N. H. Bath is important for its ship building and Rockland and

Eastport are centers of fishing; Bar Harbor and Poland Springs are prominent among the many recreational communities.

The leading industries and commercial enterprises are lumbering, pulp and paper manufacture, textiles, ship building, agriculture, fisheries, and public utilities. Recreational enterprises occupy a prominent place in the list of economic assets in the State, producing a revenue of nearly 100 million dollars annually.

The annual rainfall is adequate, being well distributed throughout the year. It ranges from about 44 inches in the southern portion along the coast to about 35 inches in the northern section, averaging about 42 inches. The annual run-off averages around 20 inches. The average temperature for the year is about 42°. The growing season is short and cool; the winters are long and severe.

Liberal expenditures by the Federal Government in dredging and maintaining greater depths and straighter channels, together with modern navigation aids, have made possible reasonably safe passage along an otherwise dangerous coast.

Recommended Plan

Control of river pollution is needed to protect the natural recreational assets of this region.

For the most part, the rivers are large in relation to the moderate-sized cities in their drainage basins and, in general, the amount of water available for dilution of sewage has been sufficient to prevent the development of extensive nuisances. However, there are places where the concentration of pollution has reached or nearly reached objectionable limits, and there is immediate need for the construction of treatment works at some of the larger communities.

The pollution problem becomes serious when municipal sewage is combined with industrial wastes, particularly from the manufacture of paper and pulp. There are numerous large paper and pulp mills and also textile mills and other waste-producing plants situated along most of the principal rivers. Because of the divided responsibility for the maintenance of satisfactory sanitary conditions along these rivers, abatement and control of pollution become difficult of attainment. Practicable methods of treatment of wastes by the industries, particularly those manufacturing pulp and paper, have not yet been developed. Furthermore, the cost of constructing and operating disposal works may handicap many industries in competition

with similar industries which can cheaply dispose of their wastes.

Of the larger rivers in this region, the Androscoggin presents the most serious pollution problems. With about 20 percent of its watershed in New Hampshire, where considerable quantities of sewage and of industrial waste enter the river, the problem calls for cooperative action by Maine and New Hampshire. Using as a basis the results of joint studies made in 1930 on this and the other principal rivers of Maine by a committee of paper manufacturers and the State department of health, an investigation of the Androscoggin pollution problem should be made to formulate a program of river sanitation. This investigation should be of sufficient scope to include the evaluation of the effects of pollution, the determination of tentative rational limits of pollution, the formulation of appropriate methods of control, and the consideration of suitable legislation. The results of such an investigation would serve as a guide for all future anti-pollution measures on this river and also would furnish a model for later studies on other important rivers in this region.

Following the studies of the Androscoggin River, it would be desirable to undertake a State-wide survey of rivers, lakes and coastal waters primarily for the purpose of determining the effect of pollution on recreational developments. Using as a starting point the studies made in 1930 and the results of the intensive investigations of the Androscoggin River, a long range program of pollution abatement and control could then be prepared for the State as a whole.

Unless the proposed comprehensive investigation of the Androscoggin River proceeds at once, specific studies of sewage disposal problems at Berlin and Gorham, N. H., and Lewiston and Auburn, Maine, should be undertaken. There are a number of other important municipal sewerage and sewage-disposal projects in this region for which the needs are evident at the present time. Among these are Old Orchard, Portland, Sanford, Winthrop, and Bangor, Maine. The proposed State-wide survey of rivers and coastal waters would probably show that similar facilities are needed in many other communities in this region.

Water-supply needs are confined chiefly to extensions and improvements of existing works and are for the most part of local significance only. The present sources of supply in the basin are adequate to meet requirements and the development of new sources either from surface or underground waters is not at present a problem. The protection of industrial water supplies against excessive pollution is a significant problem in the area, as the quality of such supplies has

an important bearing upon the successful operation of many large industries.

Navigation.—With few exceptions, the present facilities for the accommodation of vessels are adequate. Improvements to navigation are needed in Corea Harbor.

Flood control had not been considered a serious problem prior to the flood of March 1936. Until then no floods had occurred on the Maine rivers causing damages in excess of \$500,000. In the "308" reports of the Corps of Engineers for these rivers no flood-control projects were recommended, on the ground that the cost of such projects would far exceed the benefits. The modification of existing power storage reservoirs to provide for flood storage did not appear justifiable.

The floods of March 1936 were far greater than any before experienced and the damages will be found to be several times the previous damages, although, as yet, the total amount of the recent damages on the rivers has not been compiled. This compilation is being made by the Corps of Engineers, which is also making a thorough reinvestigation of the problem.

Water power in excess of 1,000,000 horsepower is available on the rivers for economical development. Of this approximately 670,000 hp. is now utilized.

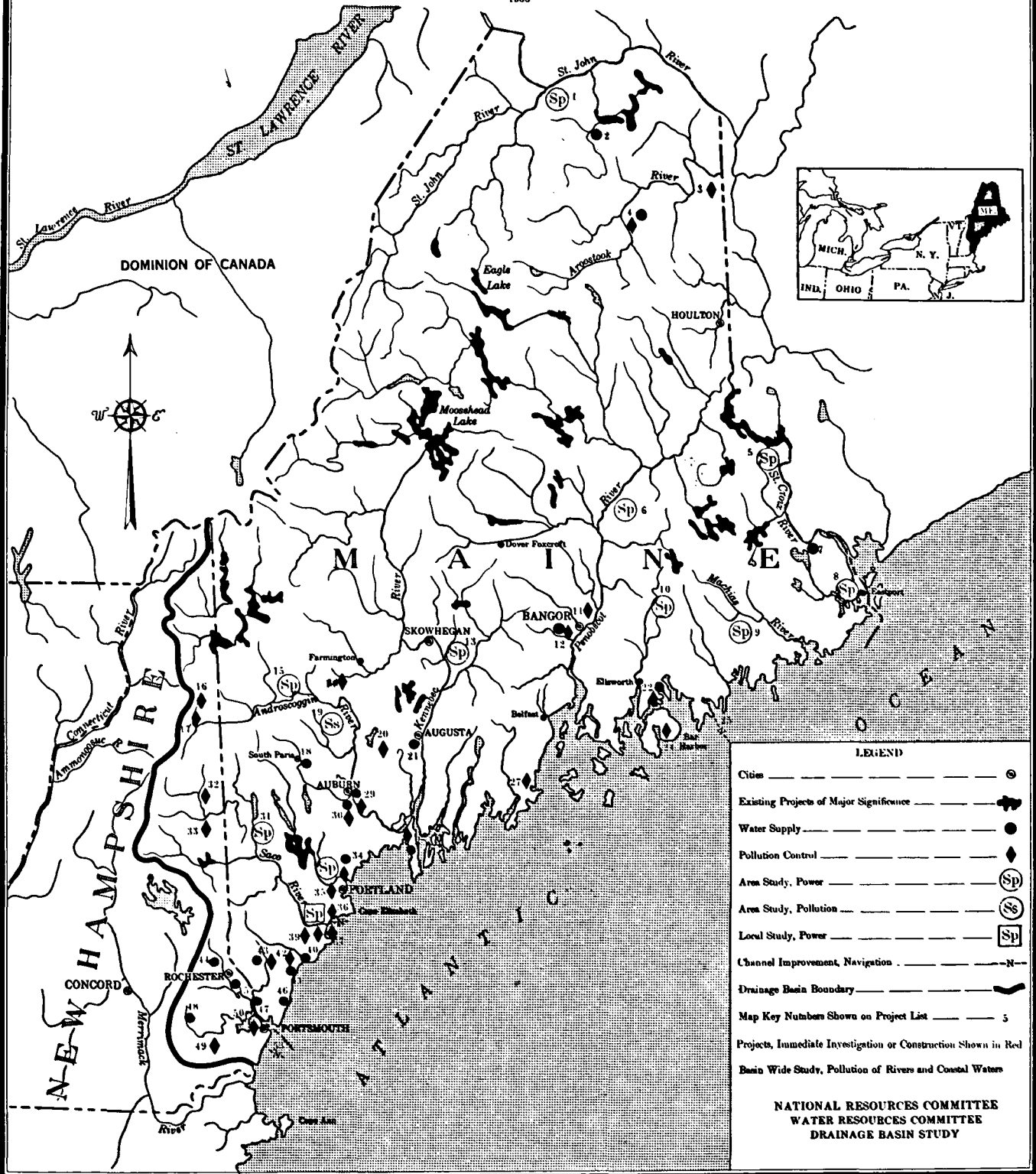
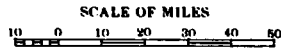
Investigations of the undeveloped power and storage in Maine were made in 1918 by the Public Utilities Commission of Maine, and in 1920 by the Maine Water Power Commission. These investigations served as a basis for the reports of the Corps of Engineers on the navigable streams. Of the many sites investigated, 48 were selected as being feasible for economic development when markets warrant.

There is opportunity for excellent regulation of the rivers due to the large number of ponds and lakes in the region. More than 50 natural and artificial reservoirs are now used for storage with a total capacity of approximately 4,700,000 acre-feet.

Although there is no present demand for the construction of these projects, it is desirable, in view of the fact that the basic reports on these developments were made nearly 20 years ago, that a comprehensive investigation be made for power and storage developments and their effect on recreation, stream flow, and pollution control.

The Passamaquoddy tidal power project is at Eastport, Maine, on the international boundary. Construction was started in 1935 and stopped in 1936 due to lack of Congressional appropriations. Because of various relevant engineering and economic problems and because of the international aspects of the undertaking, additional studies should be made before the project is carried to completion.

MAINE RIVERS



LEGEND

- Cities ———— ●
- Existing Projects of Major Significance ———— ■
- Water Supply ———— ●
- Pollution Control ———— ◆
- Area Study, Power ———— (Sp)
- Area Study, Pollution ———— (Sp)
- Local Study, Power ———— [Sp]
- Channel Improvement, Navigation ———— -N-
- Drainage Basin Boundary ———— ————
- Map Key Numbers Shown on Project List ———— 5
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution of Rivers and Coastal Waters

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Maine Rivers Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
8	Passamaquoddy, Eastport, Maine: Investigation and negotiation of international construction costs and market aspects of proposed tidal power development.	\$100,000	Contingent upon international cooperation.
(1)	Maine: Study of power and storage projects on the Androscoggin (15), Kennebec (13), Machias (9), Penobscot (6), Saco (31), St. Croix (5), St. John (1), and Union (10) Rivers.	200,000	
19	Engineering investigation of stream pollution, covering both industrial and domestic wastes, in Androscoggin River, Maine and New Hampshire.	25,000	Survey to develop comprehensive plan and costs for abatement of pollution.
	Study of all other rivers in Maine as well as coastal waters for pollution control.....	40,000	
24	Portland, Maine: Study of sanitary conditions in Portland Back Bay district.....	5,000	
37	Study for sewage treatment plant at Old Orchard, Maine.....	5,000	
43	Sanford, Maine: Extensions to water system.....	126,000	Preliminary study made.
43	Sanford, Maine: Extensions to sewer system, new pumping station and treatment plant.....	1,000,000	Preliminary plans made and some construction already started.
(1)	Portland (34) and South Portland (35), Maine: Extensions to sewer systems.....	1,068,000	Preliminary studies made.
(1)	Conway (33) and North Conway (32), N. H.: Sewer systems.....	185,000	
(1)	Exeter (49) and Portsmouth (50), N. H.: Extensions to sewer systems.....	75,000	Do.
(1)	Bangor (12) and Old Town (11), Maine: Improvements to sewer systems.....	330,000	
34	Portland, Maine: Extensions to water-supply system.....	2,088,000	Plans made.
48	Epping, N. H.: New water-supply system.....	40,000	Preliminary study made.
44	Dover and Rochester, N. H.: Extension to water supply systems.....	287,000	Preliminary studies made.
(1)	Auburn (30), Augusta (21), Bath (28), Kennebunkport (40), Lewiston (29), Wells (41), and York (46), Maine: Extensions and improvements to water-supply systems.....	648,000	Do.
(1)	Bar Harbor (24), Bath (28), Biddeford (39), Kennebunk (42), Old Orchard (37), Rockland (27), and Scarborough (36), Maine: Extensions to sewer systems.....	227,000	
(1)	Ashland (4), Fort Fairfield (3), and Mount Desert Island (22), Maine: Sewer systems.....	201,000	
25	Corea Harbor, Maine: Dredging anchorage basin.....	44,000	Authorized by Congress.
(1)	Auburn (30), Maine; Berlin (16) and Gorham (17), N. H.; and Lewiston (29), Maine: Sewage treatment plants.....	800,000	Construction to await completion of Androscoggin River pollution study.
(1)	Wilton (14) and Winthrop (20), Maine: Sewer systems.....	120,000	Preliminary studies made.
(1)	Ashland (4) and Eagle Lake (2), Maine: New water supplies.....	65,000	
(1)	Elliot (47), Mount Desert Island (22), and South Paris (18), Maine: Extensions to water-supply systems.....	201,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
53	Hampton, N. H.: Construction of jetties and dredging of Rye Harbor.....	\$202,000	Plans and surveys made.
37	Old Orchard, Maine: Sewage treatment plant.....	100,000	Construction should await completion of study.
12	Bangor, Maine: Waterworks improvements.....	235,000	Preliminary study made.
7	Calais, Maine: New water supply.....	226,000	Do.

¹Map key number shown following name of river or community.

2. MERRIMACK

Water problems of the Merrimack Basin, which includes part of the important White Mountains recreational area, are of two types. One involves abatement of pollution of the basin's water; the other, conservation by storage for additional utilization of the streams and for flood control.

Stream pollution has reached the point at which sewage and industrial wastes combine to constitute a gross nuisance along the lower river. In other sections it causes serious menace in one of the more attractive vacation areas of New England.

A storage reservoir system, properly integrated, would decrease the pollution menace by increasing the low flow of the streams, would facilitate additional power production, and would ameliorate flood conditions. In addition, however, plans should be made at once to reduce the amount of sewage and wastes entering the streams, particularly in Massachusetts.

General Description

The Merrimack Basin comprises an area of approximately 5,000 square miles, with about 3,800 square miles in New Hampshire and 1,200 square miles in Massachusetts. The main river is formed at Franklin, N. H., by the confluence of the Pemigewasset and Winnepesaukee Rivers. Its principal tributaries are the Contoocook, Piscataquog, Suncook, and Souhegan Rivers, whose drainage areas lie wholly in New Hampshire; the Nashua River, whose area is mostly in Massachusetts; and the Concord River, which is wholly within Massachusetts.

The rugged hills and mountains in this area generally have a cover of second- and third-growth forests. Dairying, poultry raising, fruit growing, and small farming are the principal agricultural activities. Lumbering has declined and is confined to cuttings under Federal and State supervision at the northern end of the basin. In the northern section, recreation activities support an important industry.

The total basin population of 811,000 includes about 247,000 in New Hampshire and 564,000 in Massachusetts. More than nine-tenths of the population is urban and about three-quarters of the total is in the southern industrialized area. The principal industrial centers are along the main river and include the Massachusetts cities of Lowell, 100,000; Lawrence, 85,000; Haverhill, 49,000; and the New Hampshire cities of Manchester, 77,000; Nashua, 31,000; and Concord, 25,000. Fitchburg, Mass., on the Nashua River, has a population of 41,000. Textile manufacturing is the

principal industry in Manchester, Lowell, and Lawrence. Shoe manufacturing and miscellaneous lines are active throughout the lower half of the basin.

Power generation on the river has a long history. Lowell and Lawrence, where there are extensive canal systems, were the pioneers. Lake Winnepesaukee, in New Hampshire, with a water surface of 72 square miles and 160,300 acre-feet of storage, is the principal water body in the basin and serves for power storage, flood control, and recreational purposes.

Recommended Plan

Reservoir sites of sufficient capacity are available upon the various tributaries to provide for reasonable flood control, for power use, and for other advantages, although the complex pollution problem will make additional works necessary.

Water-power studies involving search for reservoir sites have been made in detail on the Pemigewasset, Suncook, and Blackwater Rivers by the State of New Hampshire and they are under consideration by the Water Resources Board of that State. Preliminary studies, without surveys, have been made as a part of this investigation for several other reservoir sites. The Corps of Engineers "308" Report gave no conclusive data in this respect.

From the information now available, nine reservoirs with a total capacity of about 620,000 acre-feet, controlling, together with present available storage chiefly on Winnepesaukee River, about 70 percent of the area above Franklin, can be constructed for about \$18,000,000.

The determination of the final plan in detail must await further investigations which are now under way by the Corps of Engineers. A system of reservoirs is recommended for immediate construction following the completion of current investigations.

The Merrimack River for many years has been highly developed for water power, with upward of 200,000 horsepower. The main river below the junction of the Pemigewasset and Winnepesaukee Rivers has a total fall of about 250 feet, of which 168 feet is developed. One site of 25 feet head remains. There are both developed and undeveloped heads on the various tributaries.

Opportunities for substantial further development of water-power sites in connection with proposed reservoir sites are found on the Pemigewasset River, the Contoocook River and its tributaries, and on Souhegan River.

Flood control.—Until the flood of March 1936, flood damages in the Merrimack Valley had not been noteworthy. A flood in 1927 caused damages aggregating perhaps a million dollars above Franklin, but was not seriously damaging on the lower river.

The flood of March 1936 caused damages totaling about \$15,000,000, with about \$7,000,000 in New Hampshire. Damage in Massachusetts was confined principally to Lowell, Lawrence, and Haverhill. Of the total damages, about 40 percent was to highways and bridges.

Basic data for studies of flood frequency and damage on the Merrimack are inadequate. From the results of several different analyses, however, it appears that perhaps \$8,000,000 to \$16,000,000 is warranted for the construction of reservoirs for flood protection alone. As in the case of the Connecticut River Basin, the desirable procedure is to operate the reservoirs primarily for power, and at the same time to provide flood protection.

Pollution problems here are as pressing as any in New England. The situation is particularly acute along the main stem of the river in Massachusetts. Here, the river is used as the source of water supply for the city of Lawrence after purification by sand filters and chlorination. It is also used by a considerable number of the industries in the valley. However, the river receives untreated sewage and large volumes of industrial wastes from the cities of Lowell, Lawrence, and Haverhill and a number of smaller cities and towns scattered from Chelmsford, above Lowell, to the mouth of the river at Newburyport.

The worst conditions, from a sanitation standpoint, are found in the vicinity of Haverhill, where the combined effects of sewage brought down from the upstream cities result in a gross nuisance at times. Under the direction of the Massachusetts State Department of Public Health investigations of the sanitary condition of the lower Merrimack were made in 1908 and again in 1923. As a result of the studies in 1923 a trunk sewer was recommended from a point above Lowell to the mouth of the river with an outfall in deep water in Newburyport harbor. The works recommended by the health department were estimated to cost about \$10,000,000. This project has been discussed from time to time since 1923, but no definite action has been taken. It seems evident now that disposal by dilution at sea will be opposed by communities in the vicinity of the mouth of the river and that primary-treatment works involving a construction cost of several million dollars will be required even if the trunk-sewer project is undertaken.

For several reasons it is desirable that a new investigation be made of this pollution problem. As an alternative to the trunk sewer, individual disposal plants

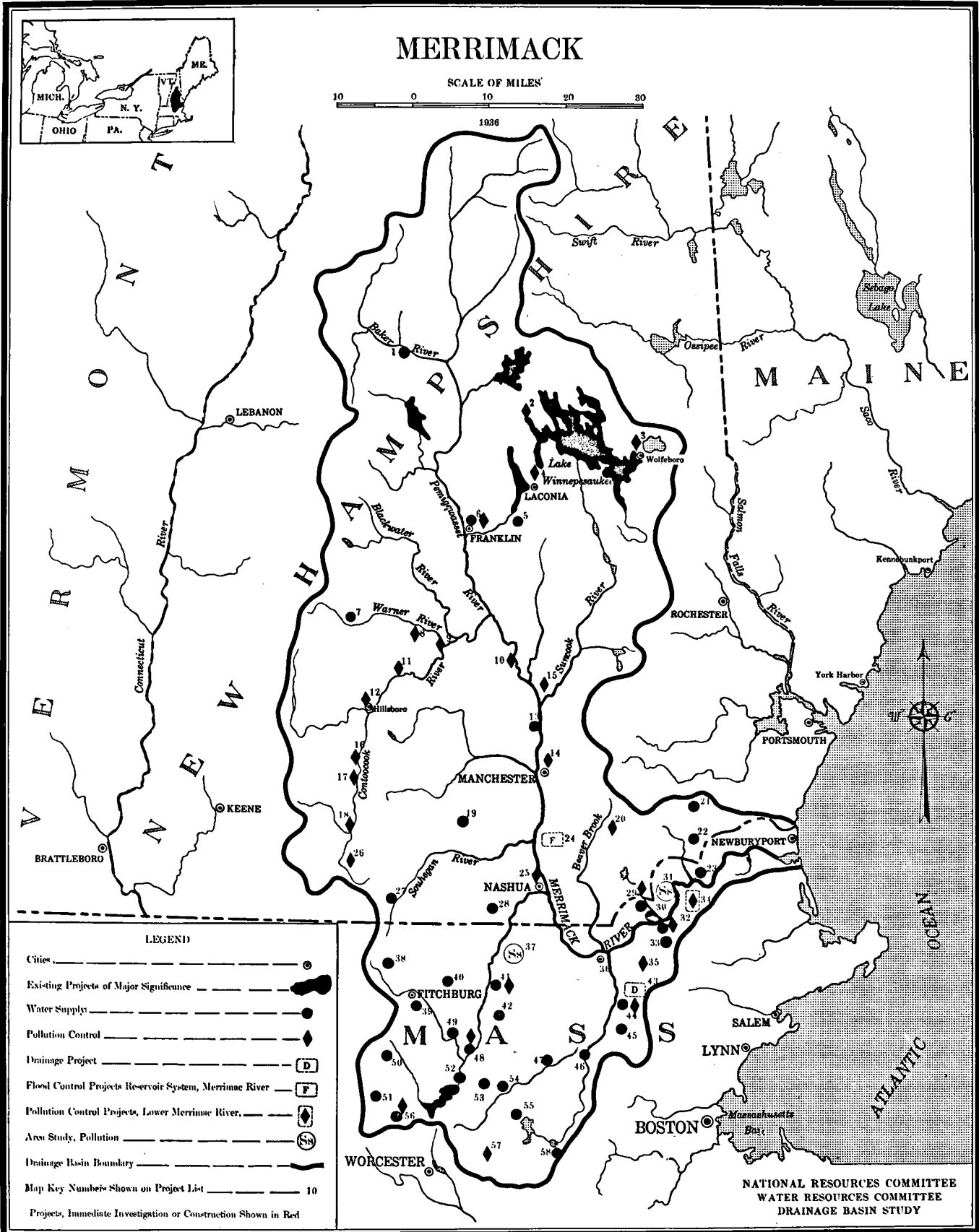
at the principal cities in the valley were considered in 1923, but they were rejected chiefly because the cost of such works would have been greater than that of the trunk-sewer. If a treatment plant is necessary even with the trunk-sewer project, the balance, so far as cost is concerned, might be swung the other way. The growth of population in the valley has been considerably less than predicted in 1923. This will require a revision of the basic data upon which the recommendations for a trunk sewer were based. Another element which should now be considered is the effect of proposed flood-control reservoirs in the upper basin on the general problem of pollution of the main stem of the river.

On the upper Merrimack, the cities of Nashua, Manchester, and Concord, with an aggregate population of about 133,500, now dispose of untreated sewage in the river. While the sanitary conditions of the river in Massachusetts are not seriously affected by the lack of upstream treatment facilities, investigations to determine the effect of the sewage and wastes discharged at these New Hampshire cities should be undertaken within the next few years and plans should be made for the abatement of any unsatisfactory conditions disclosed. Since the immediate problem is the improvement of the lower river in Massachusetts, the New Hampshire cities should not be expected to construct treatment works, except for their own protection, until there is definite assurance that in Massachusetts local conditions will be rectified.

Most of the tributaries of the Merrimack River receive pollution in one form or another. On the Nashua River the problem is chiefly one of disposal of industrial wastes. Data on the sanitary conditions on this river are now being assembled by the Works Progress Administration. Using these data, further studies should be undertaken in the near future. These studies should be directed toward the development of a general plan and program for the improvement of the river.

Improvements in sanitary conditions are also needed on the Concord River, particularly in the vicinity of Lowell. In New Hampshire the Contoocook River has been studied comprehensively and general plans developed for sanitation. In general, sewage treatment facilities in the upper basin are required chiefly to preserve the unusual recreational advantages of this section, which is one of the most popular summer playgrounds in New England.

A considerable number of the towns and villages in the Merrimack Basin are without public sewer systems. Some of the systems now in use, moreover, should be improved and extended. In general, the construction of new sewer systems and extensions of existing systems are problems for the individual com-



munities. The benefits of such works are local for the most part.

Public water supplies in the region are, on the whole, reasonably adequate. Except in a few places, water of good quality can be readily obtained from upland surface sources or from wells. Filtration is not generally necessary except for improving the physical characteristics of the water. There are a few cities, especially in Massachusetts, where either the protection of the quality of the supplies or the development of supplementary sources will require improvements. Lawrence, which takes its supply from the Merrimack River, should be provided with adequate purification facilities immediately.

Scattered over the basin are numerous small communities where public water supplies are entirely lacking. Construction of new supplies for the principal villages probably is justified from the standpoint of protection of health and property.

Navigation is confined to the tidal portion of the Merrimack River from the mouth to Haverhill, a distance of 20 miles. Commerce is chiefly in coal and petroleum products. It is declining rapidly due to the limited channel depth and the competition of motor and rail transportation from deep water terminals. However, no further improvements seem justifiable at this time.

Merrimack Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
37	Nashua River: Continuation of investigation of problem of sewage disposal of towns and industries on the Nashua River.	\$15,000	
31	Merrimack River: Pollution study from Massachusetts line to mouth.....	25,000	To be made prior to construction project.
30	Lawrence, Mass.: Extension to water filtration plant.....	600,000	Preliminary plans made.
29	Methuen, Mass.: Water supply extensions and filtration.....	470,000	Do.
13	Hooksett, N. H.: Waterworks system.....	93,000	Do.
6	Franklin, N. H.: Dike around water filtration plant.....	25,000	Do.
24	Merrimack Valley: Reservoir system for flood control and stream regulation.....	11,250,000	Cost estimate rough and preliminary.
36	Lowell, Mass.: Additions to water supply and filtration plant.....	651,000	Preliminary plans made.
40	Lunenburg, Mass.: Water supply system.....	150,000	Do.
67	Westboro, Mass.: Sewage treatment system for Lyman School for Boys and State Hospital.....	83,000	Do.
35	Tewksbury, Mass.: Extensions to sewer system.....	100,000	Do.
48	Lancaster, Mass.: Extension of sewage treatment system at State Industrial School for Girls.....	75,000	Do.
56	Holden, Mass.: Sewer system.....	125,000	Do.
46	Concord, Mass.: Water treatment plant.....	60,000	Do.
4	Leonia, N. H.: Sewage treatment plant.....	400,000	Preliminary study made.
(1)	Antrim (16), Bennington (17), Contoocook (9), East Jaffrey (26), Henniker (11), Hillsboro (12), Peterboro (18), and Warner (8), N. H.: Sewer systems and treatment plants.	344,000	Preliminary studies made.
(1)	Andover (33), Clinton (52), Fitchburg (39), Framingham (58), and Leominster (49), Mass.: Extensions to water systems.	663,000	Preliminary plans made.
(1)	Franklin (8), Manchester (14), Nashua (25), and Pembroke (15), N. H.: Extensions to sewer systems.	105,000	Do.
29	Methuen, Mass.: Extensions to sewer system.....	45,000	Do.
43	Middlesex County, Mass.: Swamp drainage for mosquito control and to improve sanitation.....	170,000	Preliminary studies made.
34	Merrimack Valley communities in Massachusetts: Sewage disposal facilities for communities between State line and mouth of river.	15,000,000	Should await completion of study project. Cost estimate is rough and preliminary.
(1)	Concord (10), Manchester (14), and Nashua (25), N. H.: Intercepting sewers and sewage treatment works.	4,301,000	Cost estimate rough and preliminary.
(1)	Bedford (45), Bolton (53), Harvard (42), Holden (56), Lancaster (48), Princeton (50), Rutland (51), Tewksbury (35), and Westminster (35), Mass.: Water supplies, extensions, and improvements.	500,000	Do.
23	Haverhill, Mass.: Water supply extension and improvement.....	200,000	Do.
(1)	Amherst (19), Belmont (5), Bradford (7), Franklin (6), Hollis (28), Kingston (21), New Ipswich (27), Plastow (22), and Rumney (1), N. H.: Water supplies, extensions, and improvements.	400,000	Do.
(1)	Derry (20), Meredith (2) and Wolfeboro (3), N. H.: Sewer systems and/or sewage treatment.....	416,000	Cost estimate is rough and preliminary.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Ayer (Fort Devens) (41), Billerica (44), Concord (46), Hudson (54), Marlborough (55), Maynard (47), and North Andover (32), Mass.: Extensions and improvements to water supply systems.	\$765,000	Cost estimates rough and preliminary.
	Ayer (41), Billerica (44), and North Andover (32), Mass.: Sewer system extensions and improvements.	386,000	Do.

1 Map key number shown following community name.

3. EASTERN MASSACHUSETTS

Needs of the eastern Massachusetts basins for the utilization of their water resources are: first, the control of serious pollution in the rivers and along the beaches of this densely populated region; second, the deepening and protection of numerous important harbors and channels for navigation; third, additions or improvements to existing water-supply works; and fourth, the improvement of water facilities for recreational use. Important recreational benefits will accompany many of the projects recommended to fill other needs.

General Description

This coastal region comprises several sub-basins draining generally into Massachusetts Bay on the east and into Buzzards Bay on the south. The area, 2,330 square miles, covers most of the eastern end of the State or about 30 percent of its surface. The principal streams are the Ipswich, Mystic, Charles, Neponset, Weymouth Fore, and Weymouth Back Rivers.

To the north and west of Boston there are low undulating hills. Southward the topography is gently rolling with occasional areas nearly flat. Although the region is not primarily agricultural, it contains much fertile land which is cultivated as truck gardens and small farms. In the southeast a considerable acreage is devoted to cranberries. The average annual rainfall is about 42 inches, well distributed throughout the year.

The population is about 2,485,000, of which at least 90 percent is in cities or villages. The northern portion is highly industrialized with a wide variety of manufacturing. Greater Boston is the fifth largest metropolis in the United States, a major port, and a leading center of commerce. Other cities in the basin of more than 100,000 population are Lynn, New Bedford, Cambridge, and Somerville.

Recommended Plan

Pollution of the rivers by sewage and industrial wastes is serious. New and additional sewer systems or treatment plants are recommended for construction or study. Many of the excellent beaches need protection from sewage contamination.

In the territory draining into Boston Harbor and Quincy Bay, including the Mystic, Charles, and Neponset River valleys, many of the intercepting and trunk sewers are now inadequate for the increased population. In some of the outlying areas of the Boston metropolitan district there are towns of considerable size without sewer systems. Relief trunk sewers

must be constructed in many places to reduce the volume of sewage which now overflows into the rivers and tidal estuaries and along the water front of the harbor and bay.

Disposal of sewage by long outfall sewers into the waters of Boston Harbor without treatment other than coarse screening and dilution is not wholly satisfactory, and eventually works will have to be constructed for more nearly complete treatment. An immediate purpose of most of the construction planned for the Boston district is to make the waters clean enough for recreational use. Boston Harbor and nearby waters are used extensively by large numbers of people for bathing and boating. For this thickly populated area every reasonable measure should be taken to protect such excellent recreational opportunities from impairment by contamination.

The cities of Salem, Peabody, Beverly, and Danvers are served by jointly operated sewer systems. The waters of Salem and Beverly harbors are objectionable at times, owing chiefly to industrial wastes carried by an outfall sewer into them, with damage to bathing facilities along the Beverly shore. The North River has become decidedly offensive through the discharge at Salem of industrial wastes, chiefly from tanneries in Salem and Peabody.

The movement of population from urban to suburban areas has not been accompanied in various instances by extensions of sewer facilities. In consequence, a number of towns need sewer extensions to prevent further contamination of the water resources.

Except for districts within reach of the Boston and Salem collection works, problems of pollution abatement must, in general, be solved independently by each community. Most of the communities are relatively small, however, with little serious conflict of interest pertaining to the pollution of rivers and coastal waters. In many places an engineering study is needed to determine the requirements and to specify a method by which the waters may be protected.

Navigation improvements, by dredging of channels and anchorages, are needed in various harbors for the safer passage and better accommodation of ocean and coastwise ships, fishing vessels, and pleasure craft. The main ship channel for Boston is being deepened to 40 feet, and other improvements are being made, in connection with an existing project of the Corps of Engineers.

A project to provide safe passage for the increasing traffic through the Cape Cod Canal between Buzzards Bay and Cape Cod Bay has been under way since 1933.

Harbor improvements by channel deepening are needed at Lynn, at Weymouth Fore River, at Weymouth Back River, and at Edgartown Harbor on Martha's Vineyard.

The importance of boating in these waters is indicated by the existence of more than 80 yacht clubs along the shore. Shallow harbor depths and tidal fluctuations limit the utilization of remarkable opportunities for such recreation. Approach channels should be deepened and widened, and anchorages dredged to permit increased use of the harbors.

The Department of Public Works of Massachusetts is considering the improvement of the Merrimack River for commercial and recreational purposes by a canal from the mouth of the Merrimack southward back of Plum Island and Castle Neck to the Essex River. This waterway would afford a safe passage for pleasure craft and fishing boats between the many harbors along the north shore of Massachusetts.

Sea walls, jetties, and other protective works are needed along the south shore of Massachusetts Bay and on Cape Cod and Buzzards Bay. From Boston Harbor southward most of the shore line is sandy and subject to continuous erosion by waves and wind. Cape Cod is especially vulnerable to these forces.

Water supply requirements of the area involve principally the extension or improvement of existing works to meet growing demands for water of better

quality. Sources of supply are in general adequate for present needs. Many communities should increase the capacity of their distribution systems and storage facilities, chiefly for fire protection. In a few places purification works are needed to improve the quality of existing supplies. Studies should be made of potential sources of supply for some of the smaller towns not now equipped with public water systems.

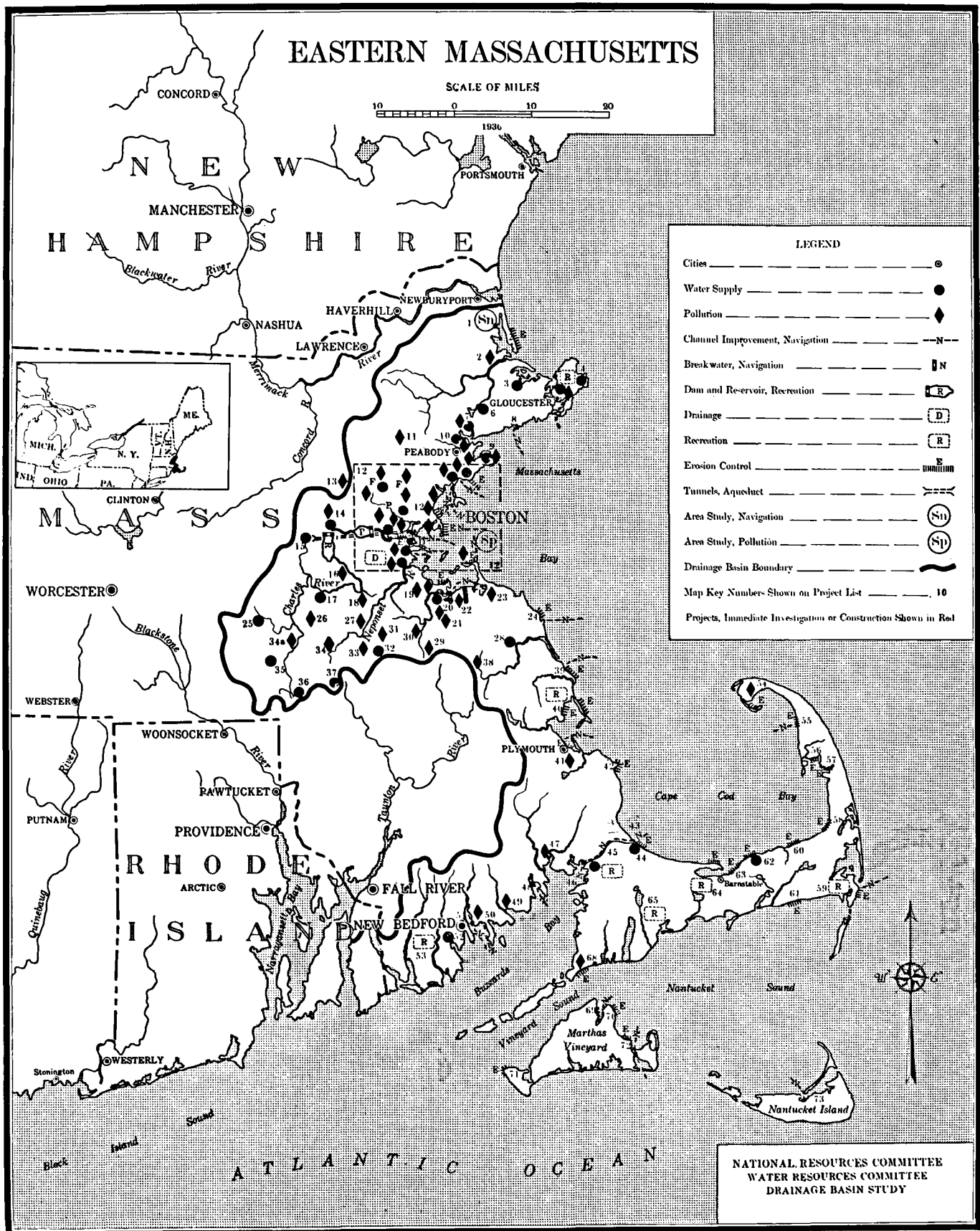
Boston and a number of its suburbs obtain their water supply from impounding reservoirs on the Sudbury and Nashua Rivers, tributaries of the Merrimack. New supplies are now being developed in the Connecticut River Basin. Under present conditions the water from the Nashua River and also from the new sources to the west must pass through reservoirs of the older system. Investigations are being made to determine the feasibility of bypassing these reservoirs with pressure tunnels, holding the reservoirs for standby or emergency service. This would safeguard the quality of the water and might eventually release the older reservoirs for recreational or other purposes.

Drainage is needed to eliminate mosquito-breeding places in the swamps of the city of Boston and in fresh-water and salt-water marshes bordering on the Neponset River.

Recreation on the numerous lakes, ponds, rivers, and beaches is limited somewhat by pollution, although there are as yet few places where conditions are so bad that bathing is actually unsafe. It would be the part of wisdom to safeguard by every practicable means the remarkable recreational opportunities with which the region is endowed.

Eastern Massachusetts Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
12	Boston, Mass.: To determine a plan and program for relief trunk sewers and appurtenant works.....	\$75,000	To precede construction project.
12	Boston, Mass.: High-pressure service mains to outlying districts.....	650,000	Plans made.
28	Norwell, Mass.: Water-supply system.....	200,000	Preliminary plans made.
3	Essex, Mass.: Water-supply system.....	140,000	Do.
7	Danvers, Mass.: Sewer system.....	415,000	Do.
14	Waltham, Mass.: Waterworks treatment plant.....	150,000	Preliminary study made.
7	Danvers, Mass.: Water filtration plant.....	185,000	Do.
10	Salem, Mass.: Sewage treatment plant and pumping station additions.....	375,000	Do.
10	Salem, Mass.: Closed conduit for North River.....	649,000	Do.
12	Cambridge, Mass.: Water filtration plant improvement.....	165,000	Construction plans made.
45	Cape Cod Canal, Mass.: Deepening and widening channel from Cape Cod Bay to Buzzards Bay.....	6,714,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$3,100,000.
12	Boston, Mass.: Dredging and rock removal in main channel in Boston Harbor.....	1,800,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$1,629,000.
12	Boston, Mass.: Removal of ledge in channel from main ship channel to drydock at Army base.....	660,000	Preliminary plans made.
12	Saugus, Mass.: Sewer system and trunk sewer to city of Lynn.....	750,000	Preliminary plans and cost estimates made.
22	Weymouth, Mass.: Sewer system.....	1,550,000	Plans and cost estimates made.
41	Plymouth, Mass.: Intercepting sewers and outfall works.....	750,000	Do.
30	Randolph, Mass.: Sewer system.....	300,000	Preliminary study commenced.
68	Falmouth, Mass.: Sewer system.....	100,000	Preliminary plans made.
22	Boston, Mass.: Dredging channel in Weymouth Fore River from Hingham Bay to river bridge at Quincy Point.....	233,000	Authorized by Congress.
22	Boston, Mass.: Dredging channel in Weymouth Back River.....	60,000	Do.
51	New Bedford, Mass.: Dredging and ledge removal in New Bedford and Fairhaven Harbors.....	142,000	Do.
12	Boston, Mass.: Extensions to water mains.....	750,000	Preliminary plans made.
4	Rockport, Mass.: Water supply extension.....	35,000	Do.
35	Medway, Mass.: Water supply extension.....	25,000	Do.
25	Holliston, Mass.: Water supply extension.....	50,000	Do.



Eastern Massachusetts Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
(1)	Dartmouth (52), Everett (12), Marblehead (9), Quincy (20), Salem (10), Stoughton (32), Swampscott (12), Winchester (12), and Wrentham (36), Mass.: Extensions to water supply systems.	\$1,023,000	Preliminary plans made.
5	Gloucester, Mass.: Reservoir, filtration plant, and water mains.....	325,000	Do.
37	Foxboro, Mass.: Extension to water supply system.....	80,000	Do.
20	Quincy, Mass.: Dredging of Town River.....	550,000	Do.
1	Study of canalization project between Hampton Harbor, N. H., and Gloucester Harbor, Mass.....	25,000	
12	Lynn, Mass.: Deepening channel in Lynn Harbor.....	336,000	Authorized by Congress.
72	Edgartown, Mass.: Dredging channel from Nantucket Sound to deep water of inner harbor.....	21,000	Recommended in report of Chief of Engineers.
(1)	Barnstable (64), Brewster (60), Chatham (59), Dennis (62), Duxbury (40), Edgartown (72), Falmouth (68), Harwich (61), Hull (12), Ipswich (2), Marshfield (39), Oak Bluffs (70), Orleans (58), Plymouth (41), Provincetown (54), Quincy (20), Revere (12), Sandwich (44), Scituate (24), South Wellfleet (57), Truro (55), Wellfleet (56), Winthrop (12), and Yarmouth (63), Mass.: Beach protection.	3,002,000	Preliminary surveys under way.
(1)	Barnstable (64), Bourne (46), Chatham (59), Duxbury (40), Gloucester (5), Mashpee (65), and Westport (53), Mass.: Public beaches.	850,000	For purchase of beaches and necessary adjacent property.
12	Boston, Mass.: Drainage of fresh and salt water marshes along Neponset River and at other places in city of Boston.	236,000	
17	Dover, Mass.: Water supply system.....	130,000	Cost estimate rough and preliminary.
12	Boston, Mass.: Sea wall along Charles River, Boston Harbor.....	210,000	Preliminary survey made.
(1)	Ipswich (2), Rockland (38), and Sharon (33), Mass.: Sewer systems and sewage-treatment plants....	725,000	Cost estimate rough and preliminary.
(1)	Fairhaven (50), Hingham (23), Holbrook (29), Mattapoisett (49), Medfield (26), Millis (34a), Provincetown (54), and Wareham (47), Mass.: Sewer systems.	2,500,000	Do.
(1)	Dennis (62), Hamilton (6), and Sandwich (44), Mass.: Water-supply systems.....	400,000	Do.
12	Swampscott, Mass.: Breakwater.....	220,000	Preliminary surveys made.
(1)	Sagamore (43), Mass.: Riprap shore at Manomet Point (42).....	576,000	Preliminary study made.
71	Gay Head, Martha's Vineyard, Mass.: Riprap cliffs along shore.....	336,000	No plan adopted.

GROUP B—FOR DEFERRED CONSTRUCTION

72	Edgartown, Mass.: Dredging channel.....	\$45,000	Surveys and plans prepared.
12	Boston, Mass.: Removal of ledge in channel to pier no. 5 of the Commonwealth of Massachusetts....	100,000	Preliminary plans made.
12	Boston, Mass.: Dredging harbor along Atlantic Ave. water front.....	155,000	Final check survey needed.
(1)	Boston (12), Chatham (59), Dorchester (12), East Boston (12), Fairhaven (50), Gloucester (5), Manchester (8), Marion (48), Marshfield (39), Nantucket (73), Orient Heights (12), Plymouth (41), Quincy (20), Revere (12), South Boston (12), Tisbury (69), Truro (55), and Winthrop (12), Mass.: Dredging projects.	1,631,000	
24	Scituate, Mass.: Dredging Scituate Harbor.....	350,000	Preliminary plans made.
	Saugus, Mass.: Dredging Saugus River.....	350,000	Survey and estimates made.
12	Boston, Mass.: Relief sewers and appurtenant works for metropolitan area.....	28,000,000	To be constructed after completion of study project.
46	Bourne, Mass.: Water supply system.....	66,000	Preliminary plans ready. Legislation required.
12	Boston, Mass.: Relief sewer for Charles River Valley.....	1,000,000	Construction plans not ready.
12	Boston, Mass.: Enlargement of culverts at outlet of Spot Pond and improvement of Spot Pond Brook.	160,000	Do.
12	Boston, Mass.: Relief and outfall sewers and pumping station improvements for north metropolitan district at East Boston and Deer Island.	3,970,000	Do.
12	Boston, Mass.: Reconstruction and relief sewer for Alewife Brook section of north metropolitan district.	705,000	Do.
12	Malden, Mass.: Relief sewer for Malden River for metropolitan district commission.....	675,000	Do.
12	Arlington, Mass.: Relief sewer from north metropolitan sewerage district.....	290,000	Do.
12	Cambridge, Mass.: Relief sewer and additional pumps for metropolitan district commission.....	2,427,000	Do.
12	Charlestown, Mass.: Extension to main discharge sewer system for metropolitan district commission....	420,000	Do.
12	Boston, Mass.: New reservoir to improve sanitary conditions in Charles River Valley.....	242,000	Do.
12	Boston, Mass.: Dredging of Mystic River to improve sanitary conditions.....	1,075,000	Do.
12	Hull, Mass.: Sewer system and sewage treatment plant.....	2,200,000	Do.
12	Winchester, Mass.: Dredging upper Mystic Lake.....	30,000	Plans partially prepared.
14	Waltham, Mass.: Dam and sluiceway.....	35,000	Do.
(1)	Arlington (12), Cambridge (12), Lexington (13), Melrose (12), Reading (11), Revere (12), Somerville (12), and Waltham (14), Mass.: Extensions and improvements to sewer systems.	2,480,000	Preliminary plans made.
(1)	Braintree (21), Canton (31), Dedham (18), Milton (19), Needham (16), Norwood (27), Quincy (20), Stoughton (32), and Walpole (34), Mass.: Extensions and improvements to sewer systems.	2,661,000	Do.
(1)	Gloucester (5), Lynn (12), Marblehead (9), Salem (10), and Swampscott (12), Mass.: Extensions to sewer and storm drainage systems.	3,523,000	Do.
12	Boston, Mass.: Sewage treatment works at the main outfalls into Boston Harbor.....	16,000,000	Investigation now under way.
15	Weston, Mass.: Extensions to waterworks system.....	100,000	Preliminary cost estimates made.
12	Lynn, Mass.: New reservoir to supplement present system.....	3,000,000	Cost estimate rough and preliminary.

GROUP C—TIME OF CONSTRUCTION INDETERMINATE

15	Boston, Mass.: Pressure tunnels to bypass the Sudbury Reservoir of the Boston metropolitan water supply district.	\$4,500,000	Investigations now under way.
15	Boston, Mass.: Pressure tunnel from Sudbury Reservoir to Weston Reservoir of Boston metropolitan water supply district.	14,000,000	Do.
15	Boston, Mass.: Pressure tunnel from Weston Reservoir to East Boston—Boston metropolitan water supply district.	21,000,000	Do.
12	Boston, Mass.: Filling in South Bay.....	6,821,000	Preliminary estimate.

1 Map key number shown following community name.

4. THAMES-BLACKSTONE-TAUNTON

The principal water problem in this area is the abatement of stream pollution. Another problem of less immediate importance is the control of annual spring freshets and infrequent serious floods. Ultimately, consideration must be given to furnishing additional water supplies for industrial and domestic purposes, to the utilization of the remaining power sites, and to providing additional facilities for navigation in harbors and the tidal sections of rivers. The problems are mainly local, and conflicts of use do not involve the basins as a whole, particularly since the sources of clean water for domestic and industrial use are ample.

General Description

The basins under discussion include all of Rhode Island, the eastern part of Connecticut, and the south-central portion of Massachusetts. They are drained southward through the Thames, Blackstone, and Taunton Rivers and several smaller streams into Narragansett and Mount Hope Bays. Their combined area is two-thirds as large as Connecticut.

Undulating hills characterize the greater portion of the basins, with highest elevations and greatest ruggedness in the northwestern part where the land rises to an altitude of 1,200 feet along the divide between the Thames and Connecticut Valleys. To the east and south, the hills gradually diminish in height, finally disappearing in the sandy plains of the coastal lowlands, where the lower reaches of the rivers are tidal estuaries.

The population of the basins, approximately 1,500,000, is slightly less than that of the entire State of Connecticut. One-third of the inhabitants live in the Blackstone Valley, another third in the Taunton and Thames Valleys, and the remaining third in the minor basins. The average density is more than three times that of New England as a whole. About three-fourths of the people live in cities and towns, for most of which recent trends indicate a slow future growth.

The central portion, lying within the Worcester-Providence-Fall River metropolitan area, is heavily industrialized. The natural advantages of abundant water power stimulated the early development of textile mills in this area, which has become one of the leading textile centers of the United States. Agriculture is a minor activity, although there is good land, particularly in the Blackstone Valley. Agricultural activities include subsistence and part-time farming, poultry raising, and dairying. The average annual

rainfall is about 46 inches and is well distributed throughout the year.

Recommended Plan

Pollution by domestic sewage and industrial wastes from the many thickly settled industrial communities has destroyed most of the fish life in the main streams as well as in some of the tributaries. The sewage can be treated by municipal disposal plants, but the treatment of industrial wastes is generally a matter for each plant to handle in accordance with the particular chemical composition of its wastes.

In the upper tributaries where the streams are used mainly for domestic water supply and recreation, pollution is generally under reasonable control, but it is important that no new sources of contamination be permitted. In the lower river valleys, now chiefly devoted to industry, the cost of purifying the waters appears to be out of proportion to the value. There is little or no economic justification at this time for attempting to make these waters fit for domestic use and recreation. A reasonable program will attempt only to prevent such gross pollution as would interfere with industrial use of the streams. Along the seacoast, however, the recreational areas and shellfish beds have values that justify a program of protection against bacterial contamination. The conservation of wildlife, while not constituting a separate problem, is naturally involved in the general plan for pollution control.

Flood control is desirable, but investigations of the principal rivers of these basins by the Corps of Engineers have indicated that the cost of control reservoirs would not be warranted by the prospective benefits. However, further studies are now under way by the Corps of Engineers, and flood control may prove to be practicable if combined with various uses of water, such as navigation and the regulation of stream flow for the benefit of power generation and for dilution of wastes. Several reservoirs which have been destroyed by recent floods might be rebuilt as part of such a coordinated plan. In some of the river valleys there is need for the reconstruction or removal of structures which obstruct the channel and unnecessarily increase the heights of major floods.

Water-power development is outstanding among the uses of water in this area. Many natural falls exist, the best of which were long ago developed for power purposes. Subsequently much of the remaining fall in the streams has been utilized and only a few sites of importance remain undeveloped.

Water supply for both industrial and domestic purposes is adequate for practically the entire region. Nearly 90 percent of the total population of the area is served by organized systems. Supplies for the remainder of the population and extensions to the present systems may be obtained from headwaters in western Rhode Island and eastern Connecticut, or from underground waters which in most places are of good quality.

Navigation along the ocean front, and in the many bays and tidal rivers that indent the shore line of Connecticut and Rhode Island, is increasing in number and size of craft. In consequence, there is a growing need for further improvement of channels and anchorages.

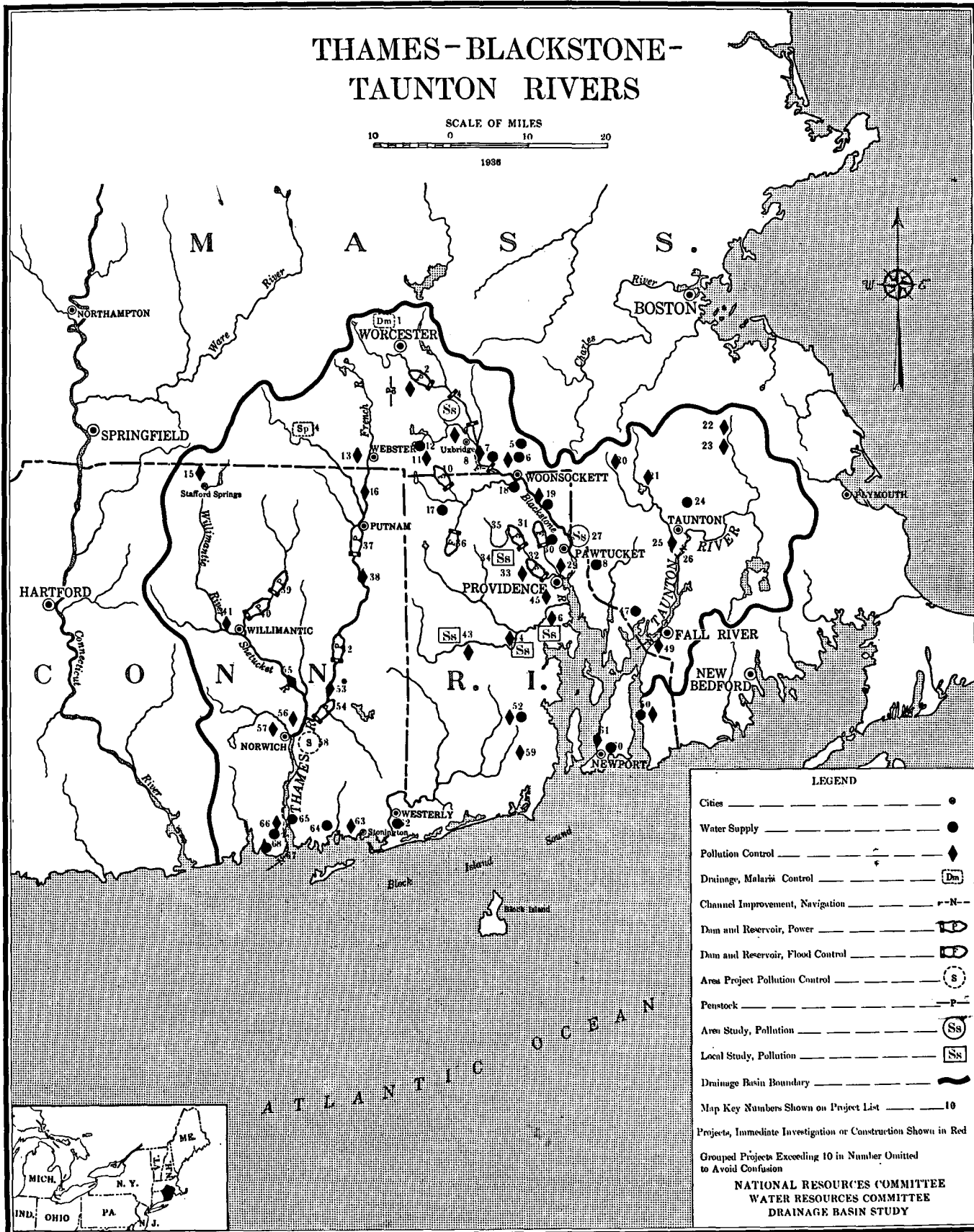
Drainage is of little importance. Most of the large areas in the basins that formerly were swampy have been drained recently to abate the mosquito nuisance.

Thames-Blackstone-Taunton Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
27	Central Falls, Cumberland, East Providence, and Pawtucket, R. I.: Study to determine relative merits of individual and district sewage-treatment plants.	\$10,000	Related to construction projects.
4	Blackstone River Valley: Study of sanitation and pollution.	25,000	
(1)	Coventry (43), Johnston (34), Warwick (46), and West Warwick (44), R. I.: Study for sewer systems and sewage-treatment plants.	10,000	
30	Pawtucket, R. I.: Water-treatment plant.	400,000	Preliminary study made.
18	Woonsocket, R. I.: New water-supply reservoir to supplement existing sources.	2,180,000	Preliminary plans made.
17	Harrisville and Pascoag, R. I.: Joint waterworks system.	325,000	Plans being prepared.
(1)	East Lyme (64), Groton (65), and Waterford (68), Conn.: Extensions and improvements to water-supply systems.	270,000	Preliminary plans made.
47	Swansea, Mass.: Water-supply system.	290,000	Do.
52	North Kingston, R. I.: Waterworks construction.	210,000	Preliminary study made.
50	Tiverton, R. I.: Waterworks construction.	85,000	Preliminary plans made.
(1)	Bellingham (5), Blackstone (18), Manchaug (12), and Millville (7), Mass.: Waterworks systems.	345,000	Preliminary studies made.
24	Raynham, Mass.: Water-supply system.	45,000	Preliminary study made.
45	Cranston, R. I.: Sewer system and sewage-treatment plant.	4,000,000	Do.
25	Taunton, Mass.: Sewage-treatment works.	950,000	Preliminary plans made and land purchased.
49	Fall River, Mass.: Intercepting sewers, treatment works, and outfall sewer.	2,500,000	Preliminary plans made.
13	Webster, Mass.: Sewage-treatment plant.	600,000	Do.
41	Willimantic, Conn.: Sewage-treatment plant extensions.	125,000	Do.
38	Danielson, Conn.: Sewage-treatment plant extensions.	135,000	Do.
57	Norwich, Conn.: Sewage-treatment plant extensions.	225,000	Do.
66	New London, Conn.: Sewage treatment.	250,000	Preliminary study made.
61	Newport, R. I.: Sewer-system extensions and sewage-disposal improvements.	2,000,000	Preliminary plans made.
(1)	Blackstone (6), East Douglas (11), Milbury (2), Millville (7) and Uxbridge (9), Mass.: Sewer systems and sewage-treatment works.	2,235,000	Preliminary studies made.
(1)	North Kingston (52) and South Kingston (59), R. I.: Sewer systems.	300,000	Do.
50	Tiverton, R. I.: Sewer system.	100,000	Preliminary studies made.
(1)	Baltic-Oocum (55), Jewett City (53), North Grosvenor Dale (16), Stafford Springs (15), Stonington (63), and Taftville (56), Conn.: Sewage-treatment works.	600,000	
1	Worcester County, Mass.: Drainage for mosquito elimination.	150,000	
	Little Narragansett Bay, Newport Harbor, Pawtuxet Yacht Basin, Providence Harbor, Sakonnet Point Harbor, and Seekonk River, R. I.: Investigation of costs of dredging harbors.	25,000	Dredging is necessary, but no investigations yet made.
67	Thames River, Conn.: Deepening channel for navigation.	820,000	Authorized by Congress.
48	Fall River Harbor, Mass.: Widening channel for navigation.	65,000	Do.
26	Taunton River, Mass.: Dredging channel for navigation.	600,000	Do.
29	Central Falls, Cumberland, East Providence and Pawtucket, R. I.: Intercepting sewers and treatment works for these communities individually or as a district.	2,000,000	Rough estimate. Should await completion of study project of Pawtucket-Central Falls district.
GROUP B—FOR DEFERRED CONSTRUCTION			
9	Uxbridge, Mass.: Reconstruction of Rice City Dam.	\$200,000	Dam weakened by March 1936 flood.
8	Blackstone, Millville, and Uxbridge, Blackstone River, Mass.: Channel improvement.	430,000	Allotment for project made. Start of project awaiting action of towns involved.
60	Newport, R. I.: Additional water supply.	500,000	Further study needed.
28	Seekonk, Mass.: Water supply system.	100,000	Do.
(1)	Coventry (43), Johnston (33), Warwick (46), and West Warwick (44), R. I.: Initial construction of sewers and sewage treatment plants.	1,500,000	Cost estimate rough and preliminary.
(1)	Abington (22), Easton (23), Mansfield (21), and Whitman (20), Mass.: Sewer systems and sewage treatment for village centers.	1,500,000	Further study needed.
67	New London, Conn.: Dredging a straight channel to State pier.	16,000	Surveys completed.

¹ Map key number shown following community name.

THAMES - BLACKSTONE - TAUNTON RIVERS



LEGEND

- Cities _____ ●
 - Water Supply _____ ●
 - Pollution Control _____ ◆
 - Drainage, Malaria Control _____ [Dm]
 - Channel Improvement, Navigation _____ -N-
 - Dam and Reservoir, Power _____ [D]
 - Dam and Reservoir, Flood Control _____ [F]
 - Area Project Pollution Control _____ [S]
 - Penstock _____ P
 - Area Study, Pollution _____ [Ss]
 - Local Study, Pollution _____ [Ss]
 - Drainage Basin Boundary _____
 - Map Key Numbers Shown on Project List _____ 10
- Projects, Immediate Investigation or Construction Shown in Red
- Grouped Projects Exceeding 10 in Number Omitted to Avoid Confusion

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Thames-Blackstone-Taunton Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
3	Sutton, Worcester County, Mass.: Construct penstock between 2 canals and repair canals.....	\$25,000	
31	Lincoln, R. I.: Construct Butterfly Factory Dam to provide better storage and aid in flood control.	90,000	Investigations of storage on Branch River should be made first.
32	North Providence, R. I.: Construct Lymansville Pond Dam to replace dam destroyed in March 1936.	50,000	Do.
35	Smithfield, R. I.: Repair Georgiaville Pond Dam and raise height 7 feet to increase storage.....	140,000	Do.
36	Glocester, R. I.: Construct new dam to raise water level in Smith and Sayles' Reservoir to that in Keach Reservoir.	195,000	Do.
2	Millbury, Worcester County, Mass.: Redevelop and combine 2 power sites on Blackstone River.....	30,000	
10	Burrilville, R. I.: Construct 2 dams on Round Top River to provide increased storage.....	210,000	Do.
4	Grafton, Worcester County, Mass.: Repair canal tailrace and install appurtenances at site.....	25,000	
7	Millville, Worcester County, Mass.: Rebuild dam to utilize power formerly developed at site.....	58,000	
62	Westerly, R. I.: Water-works extensions.....	150,000	Plans not ready.
19	Cumberland, R. I.: Water-main extensions.....	200,000	Do.
66	New London, Conn.: Additions to present water-supply system.....	887,000	Do.
58	Thames Valley, Conn.: Industrial wastes disposal and other pollution abatement.....	550,000	Based on studies made by State water commission.
	Central Village, Dayville, Hanover, Gargo, Goodyear, Hallville, Mechanicsville, Montville, Moosup, Pomfret, South Coventry, Sterling, Voluntown, and Wauregan, Conn.: Sewer systems and sewage-treatment plants.	453,000	Preliminary studies made.
37	Pomfret Landing, Conn.: Hydropower development, capacity, 1,277 kilowatts.....	275,000	Studies and estimates made. Further studies needed.
14	Study of power development and water storage at East Brimfield, Mass., to determine effects and advantages to present power users of storage.	10,000	Preliminary studies and estimates made. Detailed investigation needed.
40	Marshfield Hollow, Conn.: Hydropower development, capacity 2,230 kilowatts.....	531,000	Studies and estimates made. Further studies needed.
42	Canterbury, Conn.: Hydropower development, capacity 3,274 kilowatts.....	577,000	Do.
54	Shetucket, Conn.: Hydropower development, capacity 3,999 kilowatts.....	600,000	Do.
39	Chaplin, Conn.: Hydropower development, capacity 1,430 kilowatts.....	588,000	Do.

5. CONNECTICUT-HOUSATONIC

The outstanding water problem in this area is that of stream-flow regulation—on the one hand to reduce waste of water and danger of floods and on the other hand to increase the quantity of stream flow at low water. Abatement of pollution, increased power production, improved navigation, and better opportunities for recreation, are benefits to be obtained through increased low-water flow. A comprehensive system of storage and control reservoirs is recommended and concurrently with such developments, requisite measures to control soil erosion as a means of maintaining their capacity. Certain projects are listed for immediate construction, others cannot yet be definitely scheduled. Details of the complete plan await further investigation, which should also include the study of power possibilities at reservoir sites and elsewhere and a program for their development.

Measures to control the pollution of the streams by sewage and industrial wastes are other widespread needs of this populous region. Additional or improved water supplies or sewer systems will be needed soon or later in some communities.

The general problems of the basin are interstate and their adequate solution will require joint effort in design, in construction, and in operation. Large interests are involved. Legislation has been enacted authorizing negotiation of an interstate compact. State agencies and the New England Regional Planning Commission are now at work planning cooperative action for the proper development of the water resources of the basin. Vermont and New Hampshire authorities have made investigations and selected reservoir sites.

General Description

The region here considered comprises the drainage areas of the Housatonic and Connecticut Rivers and the adjacent lowlands on Long Island Sound, covering large portions of New Hampshire, Vermont, Massachusetts, and Connecticut, as well as small sections of New York and of Canada. The total area of 13,670 square miles includes 11,205 for the Connecticut River Basin, 1,950 for the Housatonic River Basin, and about 400 for the coastal lowlands.

The Connecticut rises in Canada near the international boundary, flows southward between New Hampshire and Vermont, crosses Massachusetts and Connecticut, and discharges into Long Island Sound about 30 miles east of New Haven. The length of the main stream is about 392 miles. The Housa-

tonic rises in the southwestern corner of Massachusetts and flows southward through Connecticut to the Sound at Bridgeport, 20 miles west of New Haven. The principal tributaries of the Connecticut are the Ashuelot, Sugar, Mascoma, West, White, and Passumpsic Rivers in New Hampshire and Vermont; the Westfield, Deerfield, Chicopee, and Millers Rivers joining the main stem in Massachusetts; and the Farmington River in Connecticut. The principal tributaries of the Housatonic are the Naugatuck, Shepaug, and Tenmile Rivers. The latter drains a small area in New York.

Toward the north and west the country is wooded and mountainous with altitudes of 3,000 to 4,500 feet. The ruggedness decreases progressively toward the south. There are large areas of rich bottom lands between the hills along the main stream from central Massachusetts through part of Connecticut. The mean annual precipitation ranges from about 38 inches at the northern stations to about 45 inches in the south.

The population of the combined watersheds in 1930 was 2,027,000, nearly one-fourth of the total population of New England. It is about two-thirds urban. The section in Connecticut and Massachusetts, slightly more than one-third of the total area, contains nearly 90 percent of the population; in the southern end of the region the population density is almost 800 per square mile, compared with 11 per square mile in the extreme north.

The larger cities and their 1930 populations are: Hartford 164,000, New Haven 163,000, Bridgeport 147,000, Waterbury 100,000, New Britain 68,000, in Connecticut; Springfield 150,000, and Holyoke 57,000, in Massachusetts. There are also seven cities or towns between 25,000 and 50,000 population and numerous smaller industrial communities. Manufacturing activity dates back to colonial days; the southern portion of the region has had a steady growth and increased in population between 1920 and 1930 more rapidly than New England as a whole. Industries are well diversified and are close to large markets. There are important and densely populated industrial districts centering at Springfield and Holyoke, Hartford, Waterbury, New Haven, and Bridgeport.

Manufactured products cover a wide range and include tools and other metal products, machinery, textiles, paper, and many other lines. The Naugatuck Valley leads the United States in the fabrication of copper and brass. Hartford, New Britain, New Haven, Greenfield, and several other cities are famous

for high-grade machinery and tools. Holyoke is noted for fine papers, and Springfield is an important center for a wide variety of manufactures. The value of manufactured products for the region in 1929 was about \$1,600,000,000, or one-fourth of the New England total.

Agricultural activities contribute a large revenue, amounting to about \$65,000,000 in 1929 for the Connecticut Valley alone. Tobacco is an important and valuable crop in the lower part of the valley. Fruit growing, poultry raising, and truck farming also provide occupations for a large number of people. Part-time farming is increasingly practiced near the industrial centers.

Past growth indicates a continued increase in population for the industrial districts, especially in the Hartford-Springfield district, in the Naugatuck Valley, and along the coast. The slow rate of growth and in some cases the loss of population in certain rural communities suggest that only a slight increase in farm population may be expected. Recreational activities are important in various parts of the region and they will probably increase, especially in the northern Housatonic and Connecticut Valleys and in the coastal section playgrounds of more than regional interest.

The total water power capacity already developed in the basin is about 600,000 horsepower in 63 plants, which in 1932 generated about 1,500,000,000 kilowatt-hours of electric energy. The main river has a total fall of about 1,600 feet from First Connecticut Lake in northern New Hampshire to tidewater at Hartford. About 450 feet of this fall is being utilized for power, including seven major stations with 428,000 horsepower installed. The Deerfield River in Vermont and western Massachusetts is the most highly developed tributary, with about 130,000 horsepower installed in eight plants utilizing nearly 1,200 feet of head. There are a considerable number of undeveloped waterpower sites, particularly on the Vermont and New Hampshire tributaries including the White and Black Rivers in Vermont and the Ashuelot in New Hampshire.

Recommended Plan

Stream-flow regulation.—In November 1927 an unusual flood caused damages aggregating, for the whole basin, about \$15,000,000, mostly upon tributary streams in Vermont. In March 1936 a much greater flood caused damages totaling nearly \$50,000,000, about \$41,000,000 on the main river and \$9,000,000 on tributaries. About 60 percent of the damage occurred in Massachusetts and 25 percent in Connecticut.

A study of flood frequency and damage on the lower river in Massachusetts indicates that the average yearly flood damage is about \$850,000 for the entire

basin. There should be some additional allowance for indirect damages; but on the other hand, in both the 1927 and 1936 floods much of the loss covered injuries to highways and bridges which will be raised during repair and will not be seriously affected in the future. Reservoir storage capacity large enough to provide an adequate degree of control would cost about \$40,000,000. It appears that flood protection alone will not justify such an expenditure.

But other benefits would accrue from regulation of the stream flow. Chief among these in monetary value is the increase in power output. The solution of the problem appears to lie in an extensive system of storage reservoirs, designed and operated for economic power production but providing flood protection as a large accompanying benefit. Increased low-water flow would automatically result from the operation of the system for power.

The yearly cycle of water use for power begins about March 1–15, with the reservoirs normally empty; they would be filled usually by June 1 and thereafter gradually drawn until the next March. Practically all of the great flood-producing storms have occurred in September, October, or November, when the reservoirs would be drawn down one-third or more in volume stored. The extreme flood of 1936 occurred in March when nearly all of the storage capacity would have been available. The existing Harriman-Somerset power reservoir system on the Deerfield River in southern Vermont furnished an example of such flow regulation during both of the recent major floods. In November 1927 the Harriman Reservoir was about one-third filled at the beginning of the flood and filled about another third; in March 1936 it was almost fully drawn down, filled completely, and wasted only a relatively small amount of water.

There is already considerable power-storage capacity in the basin, including the two large reservoirs just mentioned on the Deerfield River and the Connecticut Lakes and Lower Fifteen Mile Falls Reservoir on the upper main stream.

Many other sites are available, mainly in Vermont and New Hampshire. Investigations of Connecticut River tributaries have been made by the State of Vermont in 1928–30, by New Hampshire in 1934–35, and by the Corps of Engineers as reported in 1936. Several different possible systems of reservoirs have been studied, ranging from an initial group of 8 reservoirs costing about \$13,000,000 and controlling about 12 percent of the area above Holyoke, to a fairly complete group of all sites investigated, 59 in number, costing about \$56,000,000 and controlling about 57 percent of the drainage area above Holyoke.

For estimating purposes in this report a system of 37 reservoirs, with about 1,120,000 acre-feet or 49 bil-

lion cubic feet of storage capacity, controlling about 53 percent of the area above Holyoke and costing about \$40,000,000, is recommended subject to modification on the basis of further investigation. Some of these projects are listed for immediate construction, but further studies of flood routing, reservoir operation, available power output, etc., are required before the final selection of the number and location of all reservoir sites in a comprehensive system can be made. Surveys or test borings are needed for more accurate cost estimates. Further investigation as a basis for the final plan is under way by the Corps of Engineers.

Hydroelectric power.—The increase in the low-water flow obtained through this system of regulating reservoirs is estimated at 2,400 cubic feet per second on the lower river. A study of the effect of the flow regulation on power production shows that at existing stations on the main stream and the tributaries there would be an increase in capacity of about 170,000 kilowatts on a 25-percent load factor, and an increase in annual output of about 340 million kilowatt-hours of energy.

Detailed calculations should be made to determine figures more accurately from the operating experience of these stations, and to ascertain the value of the increases in capacity and output in terms of their costs if obtained from present or alternative sources. Such studies would furnish a basis for determining the share of the cost of the control-reservoir system that may be justified by increased power production at existing stations.

The region is believed to be capable of absorbing immediately the estimated increase in output of 340 million kilowatt-hours per year.

In addition to such benefits to power production at existing stations, the recommended reservoir system will provide storage and head for the development of large amounts of power by new installations. A preliminary review based on the available information indicates that some 300,000 kilowatts or more of capacity can be developed, including the site at Upper Fifteen Mile Falls where about 135,000 kilowatts are projected; the yearly output would be more than 1 billion kilowatt-hours and much of it would be primary power with the comprehensive reservoir system in operation. The possibilities of developing power at the reservoir sites and at other sites should be investigated and a detailed plan for future power development should be formulated, to be given effect as the need for power grows.

It is noted that the complete plan for stream-flow regulation and power development involves large interests on the part of four States and many private organizations, and that its success will require coordinated effort in its design, financing, and operation.

Pollution by sewage and industrial waste.—The most serious pollution problems in this region are found along the tributaries of the Connecticut River in Massachusetts and Connecticut and in the valley of the Housatonic River. In addition to untreated sewage, many of these streams receive large volumes of trade wastes resulting from the manufacture of paper and textiles and a wide variety of specialty products.

Along the main stem of the Connecticut River through Massachusetts most of the cities discharge their sewage into the river without treatment. Sanitary conditions are often objectionable immediately below the principal outfall sewers and there are some evidences of sewage pollution at considerable distances downstream, but so far the dilution obtained even at low water has apparently been enough to postpone a popular demand for sewage-treatment works in this section of the basin.

The policies already adopted by the State of Connecticut will probably be of primary importance in encouraging antipollution measures in the other States upstream. In Connecticut recent statutes give broad powers to the water authorities with the apparent intent of preventing the disposal of any sewage or wastes into the waters of the State without some form of treatment. However great may be the volume of water available for dilution, municipalities or industries may be compelled to install some prescribed form of treatment. Partly as a result of a reasonable application of these powers, substantial progress has been made in the construction of sewage and waste treatment facilities in Connecticut.

In Massachusetts, unless the degree of pollution is shown to be such as to result in a nuisance or a definite menace to the public health, it is difficult under existing statutes to compel municipalities to construct sewage treatment works. When Connecticut has completed its program of pollution abatement it will have reasonable grounds for urging that the communities and industries in Massachusetts and possibly in Vermont and New Hampshire construct whatever works may be necessary so that the waters entering Connecticut shall be free from objectionable pollution.

In anticipation of future requirements it is important that investigations be made by the larger communities in Massachusetts, especially, to determine the methods of sewage treatment best adapted to their needs. Under a W. P. A. project information has been collected which may be used as a basis for future studies. Such cities as Springfield, Westfield, Chicopee, Holyoke, and Northampton, and several of the larger towns in this region, should undertake investigations of their sewage disposal problems. Similar investigations should be made in the Housatonic River Valley by such communities as are now without ade-

quate sewage disposal facilities. Studies of industrial waste disposal should be continued with a view to setting up reasonable requirements for the guidance of the industries.

Along the Connecticut coastal waters several important sources of pollution are now causing injury to the shellfish industry and to beaches and resorts of more than local interest. Additional sewage treatment works should be constructed as soon as practicable at New Haven, Bridgeport, and other communities.

In Vermont and New Hampshire the population within the Connecticut Basin is for the most part scattered through numerous rural communities, and problems of stream pollution are generally of local significance only. However, the waters of these States are used extensively for recreational purposes and reasonable measures should be taken to preserve the recreational advantages of their rivers and lakes. Increased low-water flow to be obtained through the operation of the regulating reservoirs already described would go far toward such protection.

Water supply problems in the Connecticut Basin are principally those of extensions and improvements to existing works. In general there is no lack of satis-

factory sources of supply. Filtration is usually needed only to improve the physical characteristics of the water. A considerable number of towns and smaller communities need adequate distribution facilities, mainly in the interest of fire protection. There are many communities without public water supplies, but in only a few of them would the cost of such public supplies be justified.

Navigation on the Connecticut is limited to 52 miles of tidal river where the Corps of Engineers maintain a channel 300 feet wide and 15 feet deep across the bar at the mouth and thence 100 feet wide and 12 feet deep to Hartford. The existing project adopted by Congress in 1935 for the river below Hartford authorizes a channel 15 feet deep at mean low water, 300 feet wide, from the mouth to Lyme railroad bridge and thence 150 feet wide to Hartford. When this project is completed, navigation needs apparently will be adequately served.

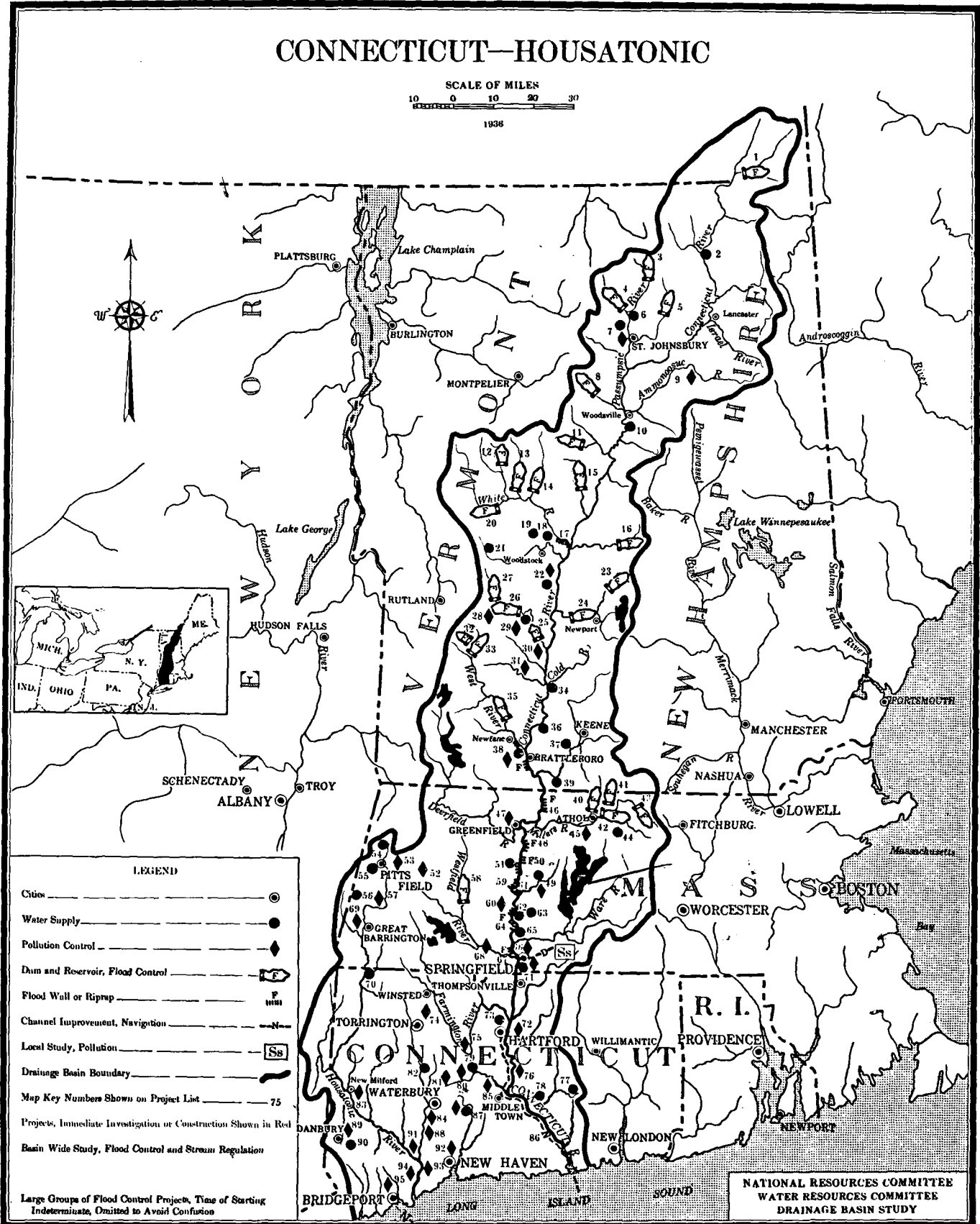
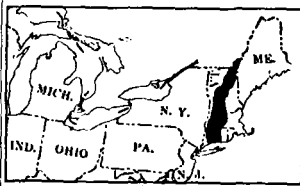
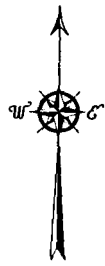
An existing project for the tidal portion of the Housatonic River provides for a channel 18 feet deep and 200 feet wide in the lower 5 miles of the river. No further improvements are necessary at the present time.

Connecticut-Housatonic Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
1	Pittsburg, N. H.: Dam and reservoir for flood control and stream regulation.....	\$1,700,000	Plans completed.
5	Victory, Vt.: Dam and reservoir for flood control and stream regulation.....	379,000	Preliminary study made.
66	Springfield, Mass.: Study for sewage treatment works.....	15,000	
92	New Haven, Conn.: Extensions and improvements to present sewage disposal facilities.....	1,400,000	Preliminary plans made.
95	Bridgeport, Conn.: Extensions and improvements to present sewage treatment facilities.....	1,700,000	Do.
95	Bridgeport sanitary district (Bridgeport, Stratford, Trumbull, Easton, Fairfield, and Westport, Conn.): Sewage treatment plants.....	3,300,000	
95	Bridgeport, Conn.: Completion of Pequonnock River channel.....	20,000	Sum needed to complete. Authorized by Congress.
(1)	Ansonia (91), Derby (93), and Shelton (94), Conn.: Sewer extensions and sewage treatment works.....	1,435,000	Preliminary study made.
87	Meriden, Conn.: Enlargement of sewage treatment facilities.....	240,000	Preliminary plans made.
79	New Britain, Conn.: New water treatment works.....	599,000	Do.
2	North Stratford, N. H.: New water mains.....	24,000	Do.
10	North Haverhill, N. H.: Water supply system.....	49,000	Do.
37	North Swansey, N. H.: Water supply extension from Keene, N. H., system.....	30,000	Do.
50	West Stockbridge, Mass.: Complete new water system.....	93,000	Do.
7	St. Johnsbury, Vt.: Filtration plant and water supply extensions.....	108,000	Preliminary study made.
(1)	Farmington (75) and Kensington (55), Conn.: Sewer systems and sewage treatment plants.....	200,000	Preliminary plans made.
49	Amherst, Mass.: Sewer extensions, including pumping station.....	170,000	Do.
52	Hinsdale, Mass.: Sewer system.....	52,000	Do.
(1)	Brattleboro (38) and Chester (31) Vt.: Extensions to sewers and new sewage treatment plants.....	314,000	Cost estimate rough and preliminary.
(1)	Bethel (90), Canaan (70), Meriden (87), and Windsor (73), Conn.: Extensions and improvements to water supply systems.....	309,000	
71	East Long Meadow, Mass.: Water system extensions.....	39,000	Preliminary plans made.
86	Connecticut River: Dredging 15-foot channel from mouth to Hartford, Conn.....	200,000	Cost given is for first 2 years. Additional needed to complete, \$50,000. Authorized by Congress.
38	Brattleboro, Vt.: Water supply extensions.....	218,000	Preliminary plans made.
62	South Hadley, Mass.: Water supply additions and improvements.....	98,000	Do.
66	Springfield, Mass.: Sewage treatment plant.....	2,000,000	Cost estimate rough and preliminary.
	Connecticut River: Study of flood control and stream regulation.....	100,000	Preliminary study made, but further investigation necessary.
84	Waterbury, Conn.: Intercepting sewers and sewage treatment works.....	1,100,000	
89	Danbury, Conn.: Sanitary sewers, industrial waste, collecting sewers and treatment.....	500,000	
96	Fairfield, Conn.: Sewers and sewage treatment for Fairfield-Stratford district.....	267,000	
49	Amherst, Mass.: Completion of water system for State college and State sanitarium.....	46,000	
83	New Milford, Conn.: Sewage treatment plant.....	318,000	
72	East Hartford, Conn.: Sewage treatment plant.....	125,000	
81	Forestville, Conn.: Sewers and sewage treatment plant.....	185,000	
80	Plainville, Conn.: Sewers and sewage treatment plant.....	425,000	
88	Naugatuck, Conn.: Sewage treatment plant.....	125,000	
29	Cavendish, Vt.: Water supply system for Proctorsville village.....	50,000	
22	Hartland, Vt.: Water supply system.....	35,000	
6	Lyndonville, Vt.: Additions and improvements to water system.....	30,000	
63	Granby, Mass.: Water system.....	30,000	
51	Whately, Mass.: Water supply system including reservoir and distribution system.....	130,000	
49	Amherst, Mass.: Reinforcement of water distribution system.....	150,000	
22	Hartland, Vt.: Drainage, sewer system, and sewage treatment plant.....	40,000	

1 Map key number shown following community name.

CONNECTICUT—HOUSATONIC



- LEGEND**
- Cities ———— ●
 - Water Supply ———— ●
 - Pollution Control ———— ◆
 - Dam and Reservoir, Flood Control ———— F
 - Flood Wall or Riprap ———— P
 - Channel Improvement, Navigation ———— N
 - Local Study, Pollution ———— Ss
 - Drainage Basin Boundary ————
 - Map Key Numbers Shown on Project List ———— 75
 - Projects, Immediate Investigation or Construction Shown in Red
 - Basin Wide Study, Flood Control and Stream Regulation
 - Large Groups of Flood Control Projects, Time of Starting Indeterminate, Omitted to Avoid Confusion

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Connecticut-Housatonic Project List—Continued

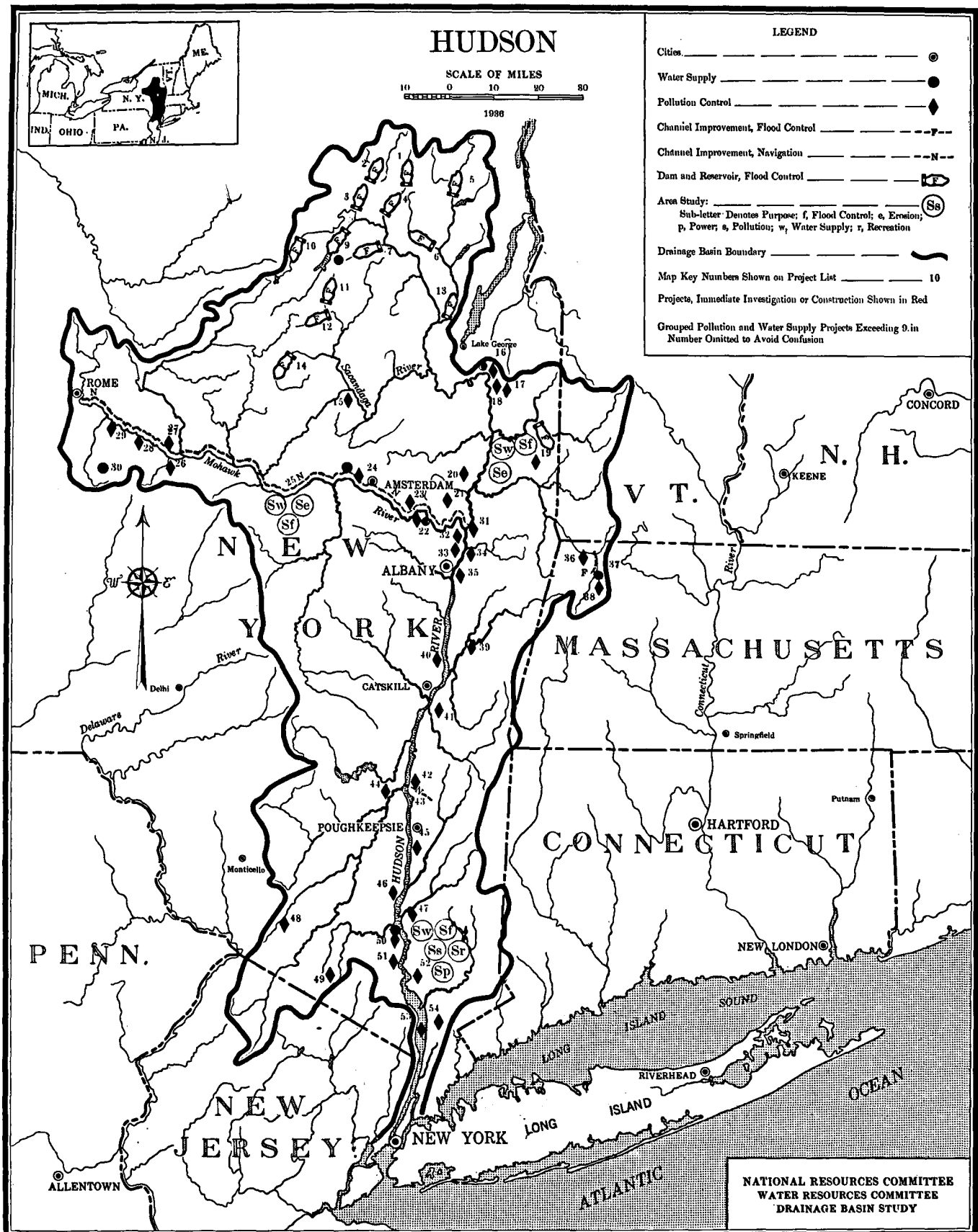
Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
(1)	Amherst (49), Athol (45), Chicopee (65), Dalton (53), E. Longmeadow (71), Great Barrington (69), Greenfield (47), Lee (57), Northampton (60), and Westfield (68), Mass.: Sewer system and sewage disposal facilities.	\$2,000,000	Cost estimates rough and preliminary.
(1)	Colchester (77), East Hampton (78), and Plymouth (82), Conn.: Water supply systems.....	300,000	Do.
(1)	Lanesboro (51), and Templeton (44), Mass.: Water supply systems.....	175,000	Do.
(1)	Rochester (21), Sharon (18), and Tunbridge (19), Vt.: Water supplies and improvements.....	300,000	Do.
(1)	Alstead (34), Westmoreland (36), and Winchester (39), N. H.: Water supply systems.....	250,000	Do.
(1)	Cavendish (29), Ludlow (28), and Springfield (30), Vt.: Sewer systems and treatment plants.....	200,000	Do.
76	Glastonbury, Conn.: Sewage treatment plant.....	237,000	
74	Winsted, Conn.: Sewage treatment plant.....	285,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Ashburnham (43), Mass.; Cavendish Township (26), Vt.; Claremont (24), N. H.; East Haven (3), and Gayesville (20), Vt.; Grantham (23), N. H.; Groton (8), Vt.; Huntington (58), and Hydeville (42), Mass.; Londonderry (33), Ludlow (27), Lyndonville (4), Newfane (35), North Landgrove (32), North Springfield (25), and Randolph Township (12), Vt.; Royalston (40) and Winchendon (41), Mass.; South Corinth (11), South Randolph (13), South Tunbridge (14), and Thetford Township (15), Vt.; and West Canaan (16), N. H.: Reservoirs for flood control and river regulation.	\$25,328,000	Preliminary study made. Sites not acquired and legislation needed.
9	Bethlehem, N. H.: Sewer system extensions.....	100,000	
7	St. Johnsbury, Vt.: Storm sewers.....	33,000	
55	Pittsfield, Mass.: Water main extensions.....	75,000	
(1)	Connecticut River: Riprap for protection of banks at Agawam (67), Hadley (61), Hatfield (59), Holyoke (64), Montague (48), Northampton (60), Northfield (46), Sunderland (50), and Whately (51), Mass.	290,000	Preliminary plans made.
38	Brattleboro, Vt.: Flood walls to protect industrial property.....	213,000	Do.
71	Longmeadow, Mass.: Drainage channel to Connecticut River—cleaning and extending.....	60,000	
17	Hartford, Vt.: Protection of banks of White River against erosion.....	45,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Berlin, N. H.; Bethel Township, Vt.; Bethlehem Junction, N. H.; Bloomfield, Bridgewater Corners, and Chester, Vt.; Croyden, Dummer Township, Franconia Center, and Franconia Township, N. H.; Hartland Township, and Jamaica, Vt.; Kenne and Roxbury Township, N. H.; Lyndville, Vt.; Lyman Township, N. H.; Marlow Township, North Randolph, Quechee Village, Reedville, St. Johnsbury, and Sherburne, Vt.; Stratford Township, Sullivan Township, and Surry Township, N. H.; Stratford Township and Thetford Township, Vt.; Washington Township, N. H.; and West Fairlee, Vt.: Construction of reservoirs for flood protection and regulation of stream flow.	\$24,379,000	Should await completion of studies. Adequate degree of control may not require construction at all these sites.
49	Amherst, Mass.: Water filtration plant.....	50,000	

¹ Map key number shown following community name.

NORTH ATLANTIC DRAINAGE BASINS

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2. New Jersey—New York Coast	133
3. Delaware	137
4. Susquehanna	142



1. HUDSON

Coordination of water uses in the Hudson Basin is especially needed to resolve conflicting requirements while providing urgently needed abatement of pollution and control of damaging floods. Other problems include future water supplies and improvements for navigation. The streams are already highly developed, but better utilization is possible for the benefit of a large population and of important economic interests.

General Description

The Hudson River drainage area of 13,366 square miles lies mainly in New York, overlapping into Vermont, Massachusetts, Connecticut, and New Jersey. Important tributaries are the Mohawk from the west and the Hoosic from the east. The headwaters of the main stream rise in the mountainous and heavily wooded Adirondack region devoted mainly to recreation. Farther south the valleys of the Mohawk and the Hudson are occupied by farms and by concentrated industrial areas. Excluding New York City the population is about 1,600,000, mainly in the industrial areas.

The central and southern portions of the basin are traversed by many railroads and main highways, and contain the great tidal waterway of the Hudson and the canalized Mohawk connecting through the New York State Barge Canal with the Great Lakes. The Champlain Canal connects the upper Hudson with Lake Champlain and Canada.

The average annual precipitation of 42 inches is ample for agricultural purposes. Temperatures in the Adirondacks sometimes run as low as 30° F. or 40° F. below zero. The yearly average in the northern part of the basin is 40° F.

Recommended Plan

Coordination of water use is essential to harmonize the requirements of water supply, flood relief, pollution abatement, water power, and recreation. In the Mohawk Basin navigation should be coordinated with stream regulation, flood control, and water power. Recreation needs are related to sanitation and to the problems of local finance. Soil conservation is related to the cost of channel dredging. The comprehensive study of the Mohawk Basin now being carried on by the State Planning Council should be pushed to completion. Similar investigations are needed for the

lower Hudson, the upper Hudson, and the Hoosic Valleys.

Flood control should be provided through a general plan, including reservoirs, retarding basins, and channel improvements. Multiservice possibilities should be studied. Property damage has been caused near Troy and Albany, N. Y., by high flood discharge and ice jams. The Sacandaga reservoir reduced the flood height at Albany about 4 feet in its first test in March 1936. Three large storage reservoirs in the Mohawk Valley, one used for New York City water supplies and two for the Barge Canal, have been effective in reducing floods. On the Hoosic River there have been flood damages at North Adams, Mass., Bennington, Vt., and Hoosic Falls, N. Y. The coordination studies recommended above are intended to lay the basis for an effective attack on these problems.

Pollution of the Hudson and its tributaries by municipal and industrial wastes has reached a degree that endangers water supplies, recreation facilities, and aquatic life. In many places the condition is an active nuisance. Most of the waste is discharged into the streams without any treatment. Millions of people are affected, including a large part of the metropolitan New York City population. Treatment plants are recommended for many communities immediately and for others later. Coordination studies should include consideration of these matters.

Navigation requirements in general are adequately provided for, but improvements are needed in the Barge Canal for additional water supplies and for a deeper and wider channel. The proposed deep-water channel from the Hudson to the St. Lawrence by way of Lake Champlain is under study.

Water supply in the lower Hudson Valley is a problem that will become serious with further growth of population. The supply for this area should be investigated with a view to developing a comprehensive plan. Development of a new supply for New York City from the headwaters of the Delaware River is discussed in connection with that basin.

Water power sites for the most part are already in use, but with better river regulation the output can be improved. These possibilities should be investigated in the course of the recommended studies of the coordination of water resources.

Hudson Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Mohawk River Basin, N. Y.: Study for development of water resources, including flood protection, erosion control, and multiservice reservoirs.	\$25,000	
	Lower Hudson River Basin, N. Y., and N. J.: Study for coordinated development of water resources, including water supply, flood control, pollution abatement, water power, and recreation.	100,000	
	Upper Hudson River Basin, including Hoosic River in New York, Massachusetts, and Vermont: Study for development of water resources, including flood protection, erosion control, and multi-service reservoirs.	25,000	
25	Great Lakes to Hudson River Waterway, N. Y.: Deepening and widening New York State Barge Canal from the Hudson River to Oswego on Lake Ontario.	15,000,000	Cost given is for next two years. Additional needed to complete, \$2,165,000. Authorized by Congress.
22	Schenectady, N. Y.: Additional water supply.	200,000	Plans completed.
16	Glens Falls, N. Y.: Water-treatment plant.	175,000	
9	Indian Lake, N. Y.: Water-supply system.	60,000	
38	Adams, Mass.: Reservoir for fire district.	200,000	Do.
28	Utica, N. Y.: Sewage-treatment plant.	1,150,000	Do.
22	Schenectady, N. Y.: Improvement to sewage-treatment plant.	170,000	Do.
38	Adams, Mass.: Sewage-treatment plant and trunk sewer extension.	155,000	Preliminary plans completed
18	Fort Edward, N. Y.: Sewage-treatment plant.	77,000	Plans completed.
29	Whitesboro, N. Y.: Sewage-treatment plant.	169,000	Do.
23	Scotia, N. Y.: Sewage-treatment plant.	95,000	Do.
31	Cohoes, N. Y.: Sewage-treatment plant.	500,000	
33	Menands, N. Y.: Sewage-treatment plant.	35,000	Do.
26	Mohawk, N. Y.: Sewage-treatment plant.	27,000	Do.
34	Troy, N. Y.: Sewage-treatment plant.	1,500,000	Do.
39	Chatham, N. Y.: Sewage-treatment plant.	178,000	Do.
40	Hudson, N. Y.: Sewage-treatment plant.	250,000	Do.
48	Middletown, N. Y.: Sewage-treatment (secondary) plant.	210,000	Do.
47	Beacon, N. Y.: Sewage-treatment plant.	150,000	Do.
54	Pleasantville, N. Y.: Sewage treatment plant.	70,000	Do.
50	West Point, N. Y.: Sewage treatment plant.	49,000	Dg.
41	Greenburgh, N. Y.: Sewage treatment plant.	230,000	Do.
36	Williamstown, Mass.: Trunk sewer and sewage treatment plant.	100,000	Rough estimate.
37	North Adams, Mass.: Clearing of channel and construction of drift barriers in the Hoosic River above the city for flood control.	68,000	Plans not ready. Authorized by Congress.
43	Rondout, N. Y.: Deepening navigation channel in harbor.	15,000	Surveys completed. Authorized by Congress.
GROUP B—FOR DEFERRED CONSTRUCTION			
24	Amsterdam, N. Y.: Water treatment plant.	\$237,000	
30	Clayville, N. Y.: Additional water supply.	80,000	
19	Washington County, N. Y.: Shushan Dam and Reservoir on Batten Kill for flood and low flow control.	1,397,000	Preliminary plans completed.
8	Chain Lakes, Hamilton County, N. Y.: Dam and reservoir on Cedar River for flood and low flow control.	1,600,000	Do.
15	Northville, N. Y.: Sewage treatment plant.	82,000	
16	Glens Falls, N. Y.: Sewage treatment plant.	277,000	
17	Hudson Falls, N. Y.: Sewage treatment plant.	130,000	
19	Cambridge, N. Y.: Sewage treatment plant.	105,000	
20	Stillwater, N. Y.: Sewage treatment plant.	120,000	
21	Mechanicville, N. Y.: Sewage treatment plant.	167,000	
27	Ilion, N. Y.: Sewage-treatment plant.	198,000	Plans not completed.
24	Amsterdam, N. Y.: Sewage-treatment plant.	700,000	
	Bennington, Vt.; and Fonda, Fort Plain, Green Island, Greenwich, Hoosick Falls, Salem, Schuylerville, St. Johnsville, and Waterford, N. Y.: Sewage treatment plants.	473,000	
32	Watervliet, N. Y.: Sewage-treatment plant.	320,000	
35	Rensselaer, N. Y.: Sewage-treatment plant.	224,000	
44	Kingston, N. Y.: Sewage-treatment plant.	560,000	
42	Rhinebeck, N. Y.: Sewage-treatment plant.	105,000	
45	Poughkeepsie, N. Y.: Sewage-treatment plant.	800,000	
46	Newburgh, N. Y.: Sewage-treatment plant.	470,000	
49	Warwick, N. Y.: Sewage-treatment plant.	147,000	
	Athens, Castleton, Catskill, Coxsackie, Coldspring, Dobbs Ferry, Ellenville, Fishkill, Monroe, New Paltz, and Valatie, N. Y.: Sewage-treatment plants.	785,000	
51	Highland Falls, N. Y.: Sewage-treatment plant.	232,000	
52	Peekskill, N. Y.: Sewage-treatment plant.	340,000	
53	Haverstraw, N. Y.: Sewage-treatment plant.	110,000	
50	West Point, N. Y.: Military Academy water supply.	100,000	No plans.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Boreas Ponds (1), Cedar River (10), Cheney Ponds (4), Elm Lake (11), Goodenow (3), Indian Lake (enlargement) (9), Lake Pleasant (12), Ords Falls (2), Piscoo Lake (14), Schroon Falls (5), Thirteenth Lake (7), Trout Brook (6), and Warrensburg (13), N. Y.: Dams for flood control and river regulation.	\$10,850,000	

¹Map key number shown following community name.

2. NEW JERSEY-NEW YORK COAST

Development, conservation, and control of water supplies are immediate problems of this populous area. Pollution abatement is badly needed in the harbors, bays, and coastal waters; health and recreation for millions of people are menaced and a large seafood industry is seriously affected. Work should be started immediately on the extensive works required to correct these conditions. Navigation facilities are extensive and should be further improved to serve the heavy traffic. The control of beach erosion and the protection of beach inlets are important to the highly developed resorts and recreational areas. Other needs include flood control and the drainage of marshlands to eliminate mosquitoes. The effective solution of these and related problems depends upon obtaining adequate basic data.

General Description

The area here considered extends for about 200 miles along the coast, from Bridgeport, Conn., to Cape May, N. J., including a part of Connecticut, the great metropolitan district of New York and its harbor, Long Island, and all of New Jersey east of the Delaware watershed. The drainage area is about 5,000 square miles or slightly larger than the area of Connecticut. In Connecticut and in northern New Jersey the river valleys are narrow, deep, and often rocky. In southern New Jersey and most of Long Island the topography is nearly flat or gently rolling with broad river valleys at low altitudes. Of the 17 principal streams other than the Hudson, the largest two are the Raritan and the Passaic Rivers, draining areas of 1,105 and 949 square miles, respectively.

Between the barrier islands along the Atlantic Ocean and the mainland in New Jersey there is an extensive system of inland bays and tidal estuaries for 80 miles. The inland waterway, maintained by the State, affords a passage for fishing boats and other small craft. The largest body of water in this tidal system is Barnegat Bay, about 20 miles long and 3 miles wide. Along the south shore of Long Island there are similar barrier islands and tidal estuaries, including Great South Bay, and a system of inland waterways.

The forest cover is estimated at 70 percent of the area in Connecticut, and 60 percent on the eastern half of Long Island and in southern New Jersey. The average annual temperature ranges from about 49° in Connecticut to 54° at Cape May, New Jersey. The average annual precipitation ranges from 40 to 50

inches, heaviest in the highland portion of the basin.

Cities and towns are numerous and those in the northern part form a concentrated metropolitan district. The most important city is New York with a 1930 population of 6,930,446. Next is Newark with 442,337. The population of the entire area exceeds 10,000,000, an average density of 2,000 people per square mile.

North of the Raritan River the cities are centers of industrial development. On the Connecticut shore, throughout Long Island, and along the New Jersey coast, there are summer resorts and recreation centers developed as intensively as on Long Island. The resorts in the past 30 years grew in value from \$57,000,000 to \$600,000,000. The summer-resort business in this area is perhaps as great in monetary return as any other single industry.

Many of the rivers and inlets have been improved for navigation. At New York there is the largest concentration of ocean commerce in the United States.

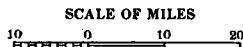
Recommended Plan

Water supplies from surface and underground sources present a variety of problems of immediate importance in most of this highly industrialized and densely populated area.

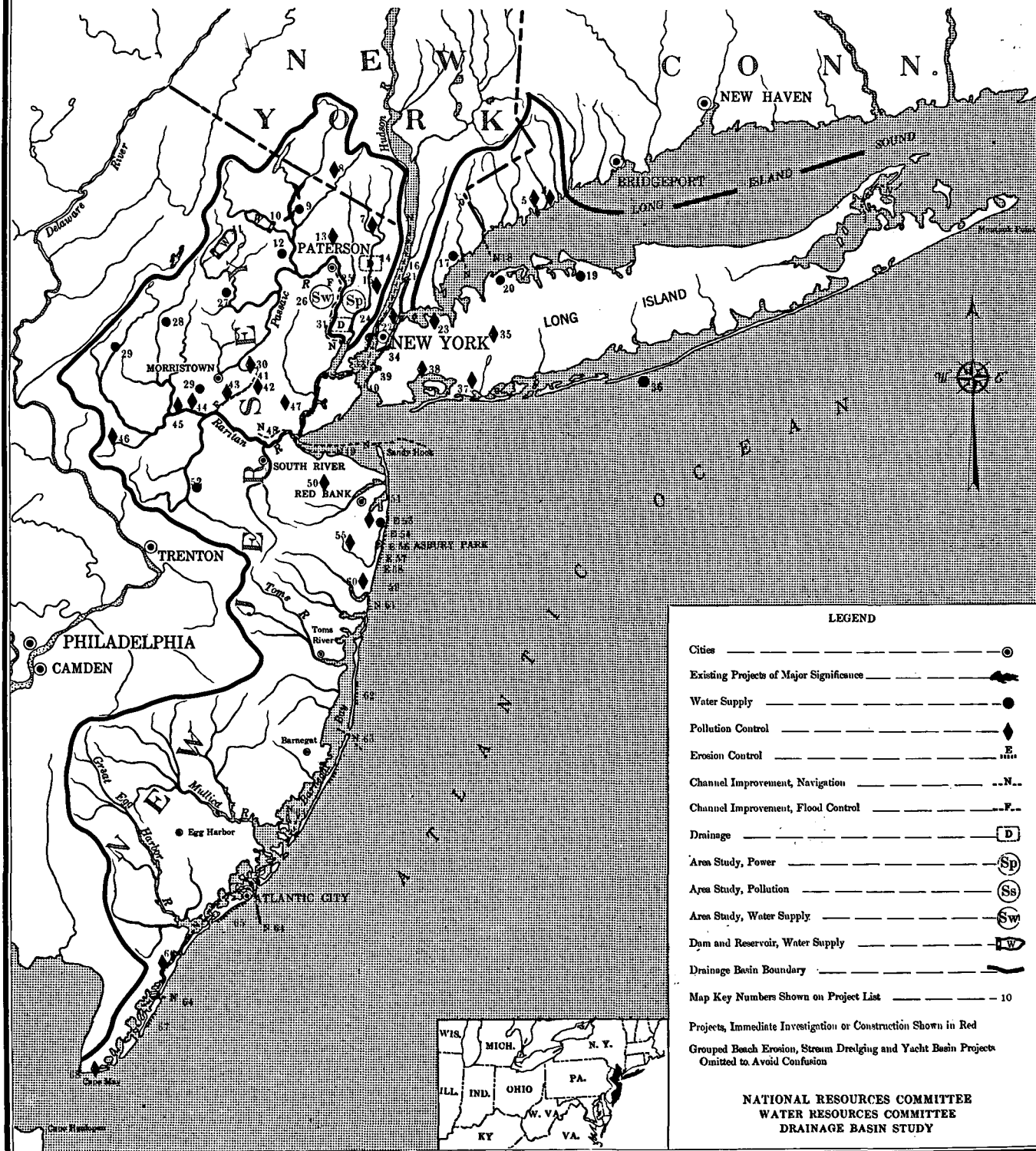
There are few areas of equivalent size in the United States where underground water resources have been developed as intensively as on Long Island. The recent construction of main highways has opened up considerable territory in which the population is growing rapidly. Future water supplies will be taken in part from underground sources. The intrusion of salt water indicates that the safe yield of the water-bearing formations has already been reached in certain parts of Long Island. It is important that investigations be made to determine the best methods for developing, conserving, and apportioning the water yield. New York City draws most of its water supply from outside sources, but in 1932 the city made application to the New York State Water Power and Control Commission to obtain 100 million gallons daily from driven wells in Nassau and Queens Counties. This application, which was opposed by municipalities on Long Island which depending upon the same underground source for their potable water supplies, was denied in large part.

Underground sources in New Jersey from Sandy Hook to Cape May are also depended upon. Ample supplies for probable future needs will be available in most of the area, if the sources are properly de-

NEW JERSEY—NEW YORK COAST



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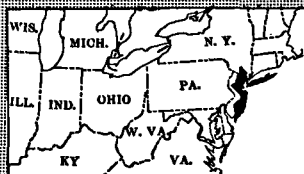


LEGEND

Cities	○
Existing Projects of Major Significance	■
Water Supply	●
Pollution Control	◆
Erosion Control	⋈
Channel Improvement, Navigation	...N...
Channel Improvement, Flood Control	...F...
Drainage	[D]
Area Study, Power	(Sp)
Area Study, Pollution	(Ss)
Area Study, Water Supply	(Sw)
Dam and Reservoir, Water Supply	[W]
Drainage Basin Boundary	—
Map Key Numbers Shown on Project List	— 10

Projects, Immediate Investigation or Construction Shown in Red
 Grouped Batch Erosion, Stream Dredging and Yacht Basin Projects
 Omitted to Avoid Confusion

**NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY**



veloped; but in some sections the safe yield has been reached or closely approached. In Atlantic City the water level in wells to the 800-foot stratum has dropped 100 feet or more in the past 40 years. The possibility of increasing the yield, and the danger of the intrusion of salt water, are now being studied by the United States Geological Survey, in cooperation with the New Jersey State Water Policy Commission. The infiltration of salt water due to overpumping, as at Atlantic City, is a constant menace. Definite plans should be made for a future water supply for the region as a whole. Investigations should include interconnections of various sources of supply serving the north Jersey metropolitan district, to meet deficiencies by diverting water from points where there is a surplus.

On Long Island and in northern New Jersey some supplies are taken from small streams and large quantities from tributaries of the Passaic River. These sources have been developed to such an extent that increased supplies will probably encounter unduly high costs or will involve an interstate problem by the construction of reservoirs in New York.

Water supply needs of the New York metropolitan district are discussed in connection with the Delaware Basin, where a large project is recommended for construction.

Pollution from sewage and industrial wastes is a serious problem in this area and corrective measures are urgently needed in the interests of health, navigation, and recreation. The pollution now existing in New York Harbor and in the bays, estuaries, and coastal waters should be abated by the construction of intercepting sewers and treatment plants, together with proper control of trade wastes. Extensive shellfish areas along the Connecticut and New Jersey coasts and the eastern end of Long Island have been condemned by the several State health authorities because of contamination. Magnificent recreational facilities, used by millions, are seriously affected. Pollution of these waters became so bad in 1926 that the New York City Department of Health prohibited bathing at all public beaches except along the south shores of Staten Island, Coney Island, and the Rockaways, which are open to the ocean.

A general program has been started for the construction of treatment works for all of the sewage which originates in New York City. Similar action should be taken at other places where conditions are

already bad. The interstate nature of the problem has been recognized in the creation of the Tri-State Treaty Commission by New York, New Jersey, and Connecticut in 1931. A study should be made leading to the construction of trunk sewers and sewage-treatment plants for the municipalities in New Jersey on the west bank of the Hudson River and for municipalities that now discharge sewage on the east side of Newark Bay and into the Kill Van Kull. Consideration should also be given to pollution from oil and trade wastes in Kill Van Kull and Arthur Kill, the tidal waters between Staten Island and the New Jersey mainland.

Navigation facilities, already highly developed, are of great importance in this area and should be extended. The bays of New York, Newark, and Raritan, with their interconnecting tidal channels and rivers, afford docking and anchoring facilities for ocean, coastal, and inland vessels carrying the greatest concentrated water commerce in the United States. Projects now under construction should be completed and others now authorized should be started. Other improvements are recommended for construction at a later time if and when the need increases.

Beach erosion and movement of inlets along the coast are serious problems for many of the communities where recreational uses are highly developed. The shifting of sands by wind, wave, and tidal currents is tending to move the inlets that form connecting channels between the ocean and the inland tidal bays and estuaries; during storms new channels may be cut across the narrow sand barrier islands that form the summer-resort beaches. These forces of wind, wave, and tide can be restrained by bulkheads and jetties, but in many cases the necessary protective works are beyond the capacity of the small municipalities to finance. Several projects of this kind are recommended for immediate construction; others are listed for later action.

Flood control is needed at several places in New Jersey. Serious property damage has occurred in the industrial area below Great Falls on the Passaic. It is estimated that a recurrence of the flood height of 1903 would now cause a loss of \$30,000,000. The Corps of Engineers is investigating flood prevention on this river.

Drainage is recommended for mosquito control in extensive marshes in Hudson and Bergen Counties, N. J.

New Jersey-New York Coast Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
26	Study of interconnections to existing water supply systems in northern New Jersey metropolitan district to provide for proper distribution of available supplies and to devise method of administrative control.	\$75,000	
24	Hudson County, N. J.: Study of intercepting sewers and sewage treatment problems.....	50,000	
23	New York, N. Y.: Sewage treatment plant at Tallmans Island.....	7,155,000	Plans completed.
38	New York, N. Y.: Sewage-treatment plant at Jamaica Bay.....	3,888,000	Plans being prepared.
44	Somerville, N. J.: Interceptor sewers and sewage-treatment plant.....	211,000	Plans prepared.
45	Raritan, N. J.: Interceptor sewers and sewage-treatment plant.....	264,000	Do.
33	New York, N. Y.: Channel deepening of New York-New Jersey channels, from point near Sandy Hook, through Gedney and Bayside Channels, lower New York Bay, Raritan Bay, and Staten Island Sound to upper New York Bay.....	10,000,000	Cost given is for next 2 years. Additional needed to complete, \$12,119,000. Authorized by Congress.
16	New York, N. Y.: Widening channel of Hudson River.....	257,000	Sum needed to complete. Authorized by Congress.
21	New York, N. Y.: Straightening channel of Harlem River.....	200,000	Cost given is for next 2 years. Additional needed to complete, \$300,000. Authorized by Congress.
39	New York, N. Y.: Dredging of Bay Ridge and Red Hook Channels.....	120,000	Sum needed to complete. Authorized by Congress.
40	New York, N. Y.: Dredging of anchorage at Red Hook Flats.....	2,431,000	Cost given is for next 2 years. Additional needed to complete, \$624,000. Authorized by Congress.
34	New York, N. Y.: Deepening of Buttermilk Channel.....	783,000	Survey completed.
6	Port Chester, N. Y.: Remove isolated rock shoals.....	12,000	Survey completed. Authorized by Congress.
18	Centre Island, N. Y.: Waterworks system.....	56,000	Preliminary plans prepared.
17	Harrison and Mamaroneck, N. Y.: Water-supply improvements.....	419,000	Do.
9	Wanaque, N. J.: New water supply.....	18,000	Plans prepared.
27	Parsippany and Troy Hills, N. J.: New water supply.....	73,000	Plans completed.
52	Rocky Hill, N. J.: Waterworks system.....	65,000	Do.
32	Jersey City, N. J.: Rehabilitation of 72-inch water main.....	651,000	Sketch plans in preparation.
58	Belmar, N. J.: Beach-erosion control by jetties and bulkheads.....	105,000	Preliminary plans prepared.
57	Avon, N. J.: Beach-erosion control by jetties and bulkheads.....	82,000	Preliminary plans completed.
53	Long Branch, N. J.: Beach-erosion control by jetties and bulkheads.....	570,000	Survey and preliminary plans completed.
35	Hempstead, N. Y.: Sewer system.....	684,000	Preliminary plans prepared.
(1)	Flemington (46), Hawthorne (13), Sea Girt (60), Sea Isle City (66), and Westwood (7), N. J.: Sewer system and/or sewage-treatment plants.....	184,000	
43	Middlesex, N. J.: Sewer system and sewage-treatment plant.....	551,000	
37	Valley Stream, N. Y.: Sewage-treatment plant.....	1,758,000	
31	Hudson County, N. J.: Drainage of 90,000 acres of marshland for mosquito extermination.....	169,000	Survey started.
41	Middlesex, Somerset, and Union Counties, N. J.: Channel improvements of Green and Stony Brooks for flood control.....	350,000	
54	Deal, N. J.: Beach-erosion control by jetties and bulkheads.....	320,000	Plans prepared.
56	Bradley Beach, N. J.: Beach-erosion control by jetties and bulkheads.....	160,000	Do.
29	Bunnvale or Chimney Rock, N. J.: Dam, aqueducts, aerators, filtration plant, and distribution systems for water supply to northeastern New Jersey communities.....	47,000,000	Preliminary studies completed.
22	New York, N. Y.: Sewage-treatment plants.....	74,310,000	Preliminary plans made. To complete 10-year program.
(1)	Bayville (20), N. Y., Chester (28) and Long Branch (53), N. J., and Northport (19), N. Y.: Water supply systems.....	189,000	Plans completed.
12	Lincoln Park, N. J.: Waterworks system.....	241,000	Plans prepared.
47	Woodbridge, N. J.: Intercepting sewers and sewage-treatment plant.....	180,000	Do.
50	Union Beach, N. J.: Sewer system and sewage-treatment (partial) plant.....	396,000	Do.
55	Ocean Township, N. J.: Sewer system and sewage-treatment (partial) plant.....	100,000	Do.
68	West Cape May, N. J.: Sewer system.....	51,000	Do.
42	South Plainfield, N. J.: Sewer system and sewage-treatment plant.....	387,000	Plans completed.
15	Fort Lee, N. J.: Replacement of combined sewer outfall to Hudson River.....	100,000	Do.
30	Watchung, N. J.: Extension of sewer system.....	111,000	Do.
(1)	Darien (6), Rowayton (4), and Westport (3), Conn.: Sewage-treatment plants.....	625,000	
63	Barneget Inlet, N. J.: Dredging navigation channel.....	533,000	Authorized by Congress.
17	Mamaroneck, N. Y.: Dredging navigation anchorage in west basin of harbor.....	53,000	Do.
25	Clifton, N. J.: Improvement of Weasel Brook channel for flood protection.....	205,000	Plans completed.
25	Paterson, N. J.: Channel improvements on Passaic River from Great Falls to Newark Bay.....	6,000,000	Includes cost of study of storage reservoir and mosquito elimination between Great Falls and Little Falls.
GROUP B—FOR DEFERRED CONSTRUCTION			
64	Atlantic, Cape May, and Ocean Counties, N. J.: Redredging of inland waterways for navigation....	\$52,000	Surveys completed.
61	Point Pleasant, N. J.: Protective bulkheads for navigation.....	100,000	Do.
51	Middlesex and Monmouth Counties, N. J.: Dredging channel of Shrewsbury River and construction of yacht basin in Raritan Bay.....	80,000	Do.
11	Rockaway Township, N. J.: Dam for third naval district, Lake Denmark.....	40,000	Sketch plans in preparation.
10	Butler, N. J.: Dam for water supply.....	246,000	Do.
36	Ocean Beach, N. Y.: Improvements to water supply.....	130,000	
8	Sloatsburg, N. Y.: Sewage-treatment plant.....	98,000	
53	Long Branch, N. J.: Intercepting sewer, pumping station, and force main.....	266,000	
48	Perth Amboy, N. J.: Dredging navigation channel in Raritan River.....	267,000	Survey completed.
14	Bergen County, N. J.: Cleaning and regrading brooks to improve drainage for mosquito elimination.....	302,000	Surveys started.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Allenhurst Township, Atlantic City, Avon-by-the-Sea, Bradley Beach, Brigantine, Cape May City, Cape May Point, Deal Highland, Madison Township, Monmouth Beach, Ocean City, Ocean Township, Seabright, and Seal Isle City, N. J.: Bulkheads, jetties, and groynes for beach erosion control.....	\$5,619,000	
62	Ocean County, N. J.: Beach-erosion control by bulkheads, jetties, and groynes.....	1,155,000	Surveys and preliminary plans completed.
65	Atlantic County, N. J.: Beach-erosion control by bulkheads, jetties, and groynes.....	204,000	Do.
59	Monmouth County, N. J.: Beach-erosion control by bulkheads, jetties, and groynes.....	1,506,000	Do.
67	Cape May County, N. J.: Beach-erosion control by bulkheads, jetties, and groynes.....	856,000	Do.
1	Greenport, N. Y.: Dredging navigation anchorage in Sterling Basin of Greenport Harbor.....	53,000	Surveys completed.
	New Jersey: In all counties inland lake improvements: Atlantic Highlands; harbor improvement and breakwater; and Brigantine cut-off in Atlantic County, Cedar Creek, Elizabeth, Harvey Cedars to Mantoloking, Manasquan River, Mantoloking, Metedeconk River, Creeks in Monmouth County, Mullica River, Newark Bay, Beach Channel to Harvey Cedars in Ocean County, creeks in Ocean County, inland waterways in Ocean County, Sheephead Bay Meadows, Toms River to Manasquan Inlet, Tuckahoe River, Wading River, and Bass River: Dredging navigation channels or anchorages.....	3,391,000	Do.
	Atlantic Highlands, Hackensack River in Bergen County, no. 1 on Passaic River in Essex County, no. 1 on Hackensack River in Hudson County, Keansburg, Ocean City, no. 2 on Passaic River in Passaic County and Perth Amboy, N. J.: Yacht basins.....	1,297,000	Surveys and plans completed.

¹ Map key number shown following community name.

3. DELAWARE

The water-use problems of the Delaware Basin, in order of importance, are the provision of additional water supplies for New York City, Philadelphia, and other communities; the abatement of excessive pollution in the lower Delaware and in the Schuylkill Rivers; the control of soil erosion; the development of hydroelectric power; and the control of floods. The basin lies in four States and the utilization of its water resources is affected with potentially conflicting interests of grave importance. The public interest requires that the future development of these resources be effectively coordinated under the guidance of an interstate agency clothed with appropriate authority. An important initial step in this direction has been taken through the organization of the interstate commission on the Delaware River.

General Description

The Delaware River rises in the western slopes of the Catskill Mountains in east-central New York and flows about 275 miles to the head of Delaware Bay. It is the boundary between Pennsylvania and New Jersey. The drainage area is 12,765 square miles, of which one-half is in Pennsylvania. The northern part of the basin is mountainous and the central basin is in the highlands, both containing considerable forest areas. The southern portion is in the Coastal Plain. The region is rich in agricultural land and also in minerals, including large deposits of anthracite coal, cement rocks, slates, and building stone.

The population of the basin is about 4,800,000. The sparse population of the headwater area has changed but little for many years, except for the summer influx of tourists and campers. The industrial sections along the lower reaches of the rivers have been growing rapidly, and the great metropolitan population of New York City has been added to the number of those who look to this basin for water supplies. The problems of such water use are accordingly increasing in size and complexity.

On the tidal river and the bay from Trenton to the sea navigation is highly developed. The port of Philadelphia ranks second in the United States in tonnage of export and import trade. Substantial tonnage is also contributed by the ports of Trenton, Camden, Gloucester, Chester, and Wilmington.

Temperature ranges in the basin between extremes of minus 50° and 110°. Average annual precipitation is about 50 inches in the headwaters region and 40 inches in the southern tributary area. The annual

and seasonal distribution of rainfall is fairly regular. At Trenton, N. J., the drainage area is about 5,800 square miles and the average discharge 12,500 cubic feet per second. The maximum recorded discharge was about 200,000 and the minimum 1,240 cubic feet per second.

Recommended Plan

Water supply can be drawn from the Delaware for New York, Philadelphia, and other cities. New York City has an immediate plan to build impounding reservoirs in the upper basin, on the Neversink River and the East Branch of the Delaware, connected by an aqueduct to a reservoir on Rondout Creek in the Hudson watershed and thence to the municipal system. The project will develop 540 million gallons daily, 440 million of which will be diverted from the Delaware Basin. This diversion was authorized, with certain provisions, in a decree by the United States Supreme Court. The cost is estimated by the city board of water supply at \$272,587,000. This project is recommended for construction.

Various plans for additional supplies have been formulated. Thus, the Corps of Engineers has considered a joint plan for New York, Philadelphia, and northern New Jersey, which is predicated on an additional supply of 800 million gallons per day to be taken after 1950 to provide for the estimated requirements of New York until 1980. This plan proposes reservoirs on the lower Neversink River and on the Delaware River.

Philadelphia uses about 330 million gallons daily, about half of which is pumped from the Delaware River at Torresdale and the rest from the Schuylkill River above Fairmount Dam. Both sources are polluted with sewage and industrial waste, and all of the water has been filtered for the past quarter century. There are complaints of tastes and odors, particularly in the water from the Schuylkill River, which has a hardness greater than that from the Delaware.

Various plans for improving the Philadelphia water supply have been discussed for many years. The latest comprehensive study, in 1924, recommended replacing the Schuylkill water with an upland supply from the Perkiomen and Tohickon watersheds, and continuing the use of the Delaware River. This plan would yield 500 million gallons per day at an estimated cost of \$91,500,000. There were criticisms of the proposal to continue use of the Delaware water, and a further

recommendation was made to replace it with water from Neshaminy Creek. The Perkiomen-Tohickon-Neshaminy plan would yield 430 million gallons per day at an estimated cost of \$116,100,000.

Another suggestion was to get water from the Blue Mountains—from Bushkill, Broadheads, Pocono, and McMichaels Creek on the Delaware; and Tobyhanna, Big Creek, Pohopoco, and Mud Run on the Lehigh. This was considered to be the best of all the upland sources, although the water would have to be filtered to remove sediment, swamp color, and tastes. The plan was rejected at the time as being beyond the power of the city to finance.

The Corps of Engineers has also considered an impounding reservoir at Tock's Island 6 miles above the Delaware Water Gap, with interconnected reservoirs on the Tohickon and Neshaminy watersheds, to furnish a gravity supply of 639 million gallons per day for Philadelphia. The project would also supply water for Chester and other neighboring towns, together with 400 million gallons per day for communities in northeastern New Jersey; and it would generate hydroelectric power.

The Pennsylvania Department of Health has noted various objections to this plan. Admitting that the water would be superior to the present supply, the department points out that it would not be as desirable as water from the Pocono Blue Mountains where great on inhabited areas could be acquired and reserved. The Tocks Island Reservoir might at times deliver water of inferior quality after a 60-foot draw-down for power purposes, or after too brief storage in great freshets. The health department objected to the inclusion of Philadelphia's future water supply in a power project, and to the relatively small quantity of water allocated to Pennsylvania as compared to the amount reserved for New York.

In view of the unsatisfactory status of this complex problem a study is recommended to establish a definite and comprehensive plan for Philadelphia's future water supply. Meanwhile various long-delayed improvements to its filter plants, pumping stations, and distribution system should be carried forward at once, costing \$3,130,000.

Water supplies for northeastern New Jersey do not now come from the Delaware. The plan of the Corps of Engineers would take 400 million gallons per day from the Tocks Island Reservoir on the Delaware as a future supply for this district. Various New Jersey authorities have studied the possibility of using the New Jersey tributaries of the Delaware and the Raritan. The problem has controversial aspects, and a cooperative study project is recommended to establish a general plan for this area in conjunction with the investigation of the Philadelphia water-supply problem.

Water-supply projects for Camden, Alpha, Gloucester, and Clementon, N. J., are not units in this comprehensive plan and are recommended for construction as soon as financial and legal difficulties can be overcome.

Gross *pollution* of the Delaware and Schuylkill Rivers at Philadelphia has been a major problem for many years. Studies begun in 1907 led to the approval of a general plan in 1915. Today, with a sewage flow of 400 million gallons per day, only one-seventh is being treated. The Schuylkill River below Fairmount Dam, with its entire flow diverted for long periods into the water supply, has become so polluted that septic action is constantly taking place. The Delaware River condition is little better. Recently the representatives of 20 shipping companies threatened to withdraw their vessels from Philadelphia unless this nuisance is eliminated. The most urgent work on the Philadelphia system will cost about \$25,000,000. There are proportionate requirements for other communities on the Delaware River, such as Camden and Chester, and for a number of towns on the Schuylkill River.

A sewage treatment plant is recommended for Port Jervis, N. Y. According to the decree of the Supreme Court, this plant must be built before New York City may divert water from the Delaware watershed. Port Jervis is now discharging industrial wastes and the raw sewage of a population of over 10,000 into the Delaware River.

Hydroelectric power has not been developed to an important extent in the Delaware Basin, except on two tributaries, the Wallenpaupack in Pennsylvania and the Mongaup in New York. The Corps of Engineers has proposed a project of eight reservoirs with an installed capacity of 326,600 kilowatts. For power alone the development is not now economically justified but it will furnish other benefits to the basin, including water supply and regulation of low-water flow. The project is listed for future consideration. The Tobyhanna Reservoir on the Lehigh is also listed for future construction as a unit for flood-control and river regulation.

Flood control.—Preliminary recommendations have been made by the Corps of Engineers for five reservoirs on the west branch of the Delaware, in view of the floods of July 1935 in southern New York and northern Pennsylvania. Recommendations for construction will await the results of investigations now under way.

The Tobyhanna Reservoir (already noted) in the Pocono Blue Mountain area has been favored as an upland source of water supply. This reservoir, costing \$3,030,500, will serve for hydroelectric power, and will also assist in flood protection and in adding to the low-water flow of the Delaware River.

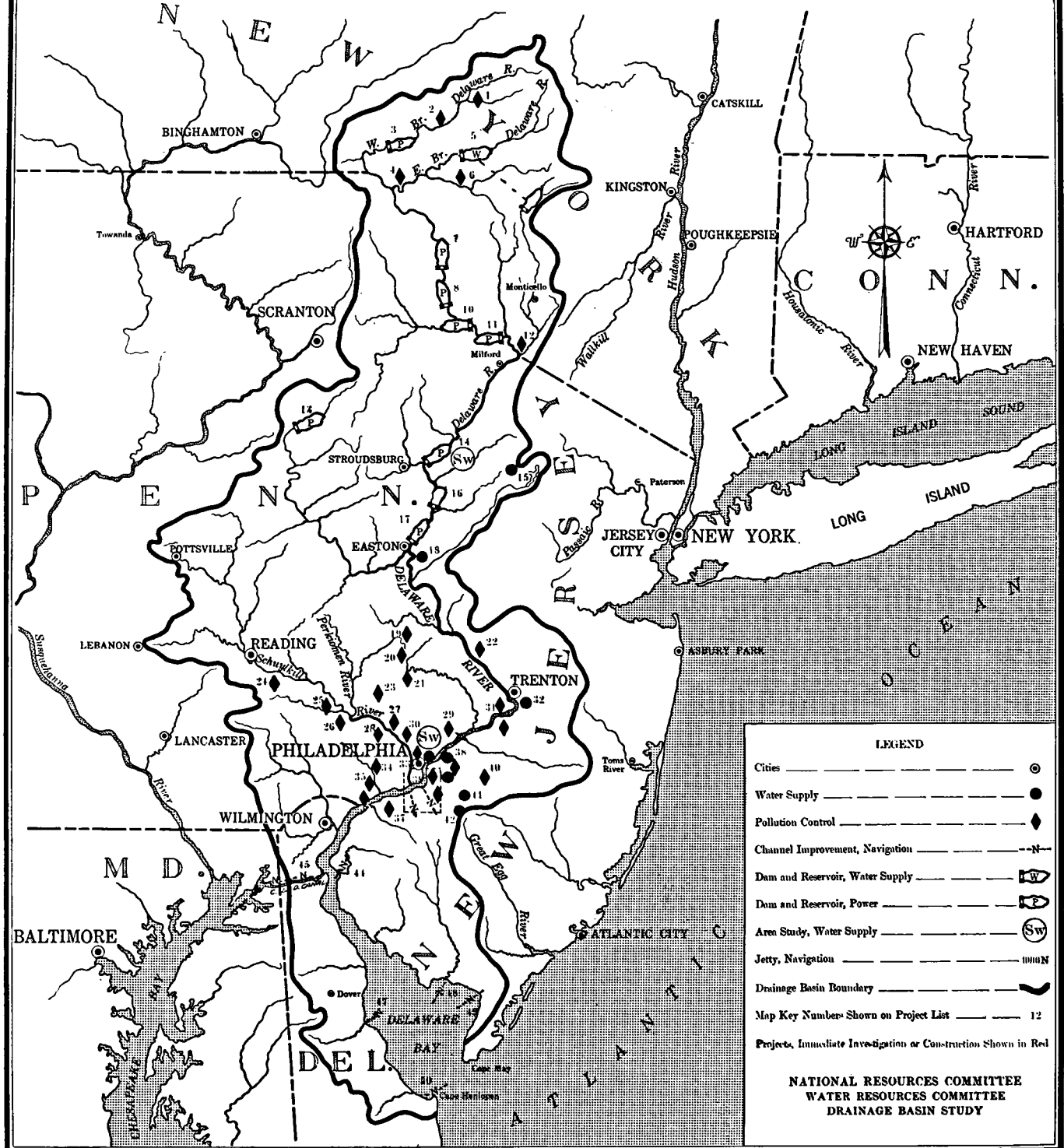
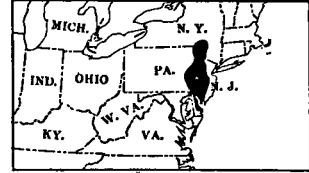
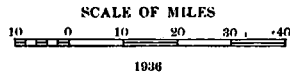
The Schuylkill River presents a serious flood hazard which can be reduced by the removal of channel encroachments and the elimination of anthracite culm wastes that collect in the river below the Pottsville district. The Corps of Engineers is now studying the situation, with the immediate objective of protection against silting in the ship channel of the lower Schuylkill, which carries about one-third of the tonnage of the port of Philadelphia. Since 1933 more than a million cubic yards of silt have been removed every year from the lower channel. Half of this material is fine coal. The amount is increasing each year, and huge deposits are piling up above the Fairmount Dam, interfering with recreation and occasionally fouling the city water supply. When the Schuylkill is cleaned up by dredging and the construction of dikes, levees, and retaining walls it will provide one of the finest recreation areas in the country for a large population.

Regulation of low-water flow would reduce the degree of pollution, particularly in the navigable parts

of the river. A larger amount of dilution will make it possible for the cities along the tidal stream to satisfy reasonable requirements of sewage treatment at a much lower cost than would otherwise be necessary.

River regulation would also assist in driving back the salt water which has shown a tendency to work upriver, even at times as far as Philadelphia, creating serious problems for many industries along the shores. As a result of a serious invasion of salt water in 1930 the Pennsylvania Department of Health, the Corps of Engineers, and a group of industrial firms each made studies of the salinity problem. The conclusion reached by the department of health was that the proposed diversion by New York City, with the release of compensation waters at low river stages as ordered by the Supreme Court, would tend to improve conditions rather than to make them worse. Other reservoir projects upstream would also help to hold back the salinity invasion by assisting river regulation.

DELAWARE



- LEGEND**
- Cities ———— ○
 - Water Supply ———— ●
 - Pollution Control ———— ◆
 - Channel Improvement, Navigation ———— -N-
 - Dam and Reservoir, Water Supply ———— [W]
 - Dam and Reservoir, Power ———— [P]
 - Area Study, Water Supply ———— (Sw)
 - Jetty, Navigation ———— [|||||]
 - Drainage Basin Boundary ———— [---]
 - Map Key Number Shown on Project List ———— 12
 - Projects, Immediate Investigation or Construction Shown in Red

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Delaware Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
5	New York, N. Y.: Additional water supply; reservoirs on Neversink River, East Branch of Delaware and Rondout Creek (Hudson Basin) with interconnecting aqueducts and appurtenant structures.	\$272,587,000	Plans complete; \$17,500,000 of the estimated cost has been appropriated by New York City, construction to extend over 8 to 10 years.
33	Philadelphia, Pa.: Water supply; improvements in existing filter plants, pumping stations, and distribution system, including installation of pumping mains.	3,130,000	Plans completed.
33	Philadelphia, Pa.: Sewer system—Interceptors and 2 first stage sewage treatment plants and extension of existing plant.	25,000,000	Preliminary plans and estimates made.
(1)	Philadelphia (30), Pa.: Study of future water supply; including consideration of Tocks Island (14) and other sources.	60,000	Preliminary study made.
14	Northeastern New Jersey municipalities: Study of future water supply including consideration of proposed Tocks Island reservoir and other sources.	40,000	Do.
38	Camden, N. J.: Two first stage sewage treatment plants.	3,000,000	Preliminary plans and estimates made.
36	Chester, Pa.: First stage sewage treatment plant.	600,000	Do.
12	Port Jarvis, N. Y.: Sewage-treatment plant for complete treatment.	300,000	Preliminary plans made.
(1)	Haverford (34) and Radnor (28) Townships, Pa.: Sewage-treatment plant for complete treatment.	328,000	Plans completed.
(1)	Delaware (34) and Montgomery (23) Counties, Pa.: District sewer system and sewage-treatment plants, to serve 27 communities.	6,000,000	Do.
29	Abington Township, Pa.: Sewer system, pumping stations, and complete sewage-treatment plant.	1,400,000	Do.
35	Rose Valley, Pa.: Sewage-treatment plant.	37,000	Do.
24	Birdsboro, Pa.: Sewer system and first stage sewage treatment plant.	300,000	Preliminary plans made.
31	Florence, N. J.: Sewer system and sewage-treatment plant.	140,000	Plans completed.
39	Brooklawn, N. J.: Reconstruction of sewage-treatment plant.	36,000	Survey being made.
21	Lansdale, Pa.: Sewer construction.	100,000	Comprehensive plan made.
19	Souderton, Pa.: Sewer system and sewage-pumping station.	150,000	Plans completed.
20	Hatfield, Pa.: Sewer system and complete sewage-treatment plant.	150,000	Preliminary plans made.
40	Haddon Township, N. J.: Sewage-treatment plant.	48,000	Sketch plans in preparation.
42	Pine Hill, N. J.: Water-supply system.	150,000	Plans prepared.
15	Andover, N. J.: Water-supply system.	45,000	Sketch plans prepared.
32	Bordentown, N. J.: Water-supply collecting system.	28,000	Plans in preparation.
39	Big Timber Creek, N. J.: Dredging navigation channel 10 feet deep and 60 feet wide.	38,000	Survey completed. Authorized by Congress.
39	Mantua Creek, N. J.: Dredging navigation channel 10 to 12 feet deep; 60 to 100 feet wide.	25,000	Sum needed to complete. Authorized by Congress.
45	Chesapeake and Delaware Canal: Dredging channel to a depth of 27 feet.	5,393,000	Sum needed to complete. Authorized by Congress.
	Retarding dams in headwaters of Susquehanna and Delaware Rivers and Finger Lakes region for flood control.	See remarks	Estimated cost of reservoirs in Delaware Basin included in Susquehanna Basin project.
22	Lambertville, N. J.: Sewage-treatment plant.	229,000	Plans completed.
38	Camden, N. J.: Wells and water mains.	810,000	Do.
18	Alpha, N. J.: Water-supply system.	60,000	Do.
39	Gloucester, N. J.: Wells and water mains.	55,000	Do.
41	Clementon, N. J.: Extensions and repairs to waterworks system.	42,000	Do.
48	Maurice River, N. J.: Dredge channel 8 feet deep and 150 feet wide.	65,000	Cost to complete. Survey completed. Authorized by Congress.
GROUP B—FOR DEFERRED CONSTRUCTION			
44	Gloucester and Salem Counties, N. J.: Dredging channels from deep water in Delaware River into creeks.	\$85,000	Survey completed.
49	Dennis Creek, N. J.: Dredging navigation channel from deep water in Delaware River to Dennis Creek.	110,000	Do.
25	Spring City, Pa.: Sewer system and sewage-treatment plant.	205,000	Investigation made.
26	Phoenixville, Pa.: Sewer system and first-stage sewage-treatment plant.	750,000	Plans being prepared.
27	Coushockton, Pa.: Sewer system and first-stage sewage-treatment plant.	804,000	Preliminary plans made.
39	Gloucester, N. J.: Sewer system and first-stage sewage-treatment plant.	300,000	Plans completed for sewer system only.
37	Paulsboro, N. J.: Sewage-treatment plant.	76,000	Plans completed.
31	Morrisville, Pa.: Sewer system and first-stage sewage-treatment plant.	375,000	No plans.
1	Delhi, N. Y.: Sewage-treatment plant.	100,000	
6	Fleischmans, N. Y.: Sewage-treatment plant.	300,000	
2	Walton, N. Y.: Sewage-treatment plant.	210,000	
4	Hancock, N. Y.: Sewage-treatment plant.	86,000	
33	Philadelphia, Pa.: Raise height of seawall and erect protective fence at Frankfort Arsenal.	100,000	Plans in progress.
50	Harbor of Refuge, Delaware Bay: Dredge channel 15 feet deep and 300 feet wide.	65,000	Survey completed. Authorized by Congress.
47	Mispillion River, Del.: Extension of north jetty at mouth of river for approximately 3,500 feet.	90,000	Survey completed.
38a	Delanco, N. J.: Excavation of a cross channel off Delanco, N. J., 200 feet wide and 8 feet deep.	32,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
13	Lehigh River, Pa.: Dam on Lehigh River below mouth of Tobyhanna Creek.	\$3,030,000	Further investigation required.
14	Delaware River: Dam at Tocks Island.	15,260,000	Do.
(1)	Delaware River: Belvidere (16), N. J.; Cannonsville (3), and Barryville (10), New York; Chestnut Hill (17), Pa.; Cochection (7), Mongaup (11), and Narrowsburg (8), New York: Hydroelectric dams and power houses.	24,837,000	Do.
	New Jersey: Bidwells, Crosswicks, Fishing, Fortesque, Pensanken, Rancocas, and Stow Creeks: Dredging channels; Camden, Cumberland, and Mercer Counties: Dredging channels from deep water in Delaware River into the creeks; Ottens Harbor: Dredging harbor; Chansey River: Dredging public yacht basin; Bidwells Creek, Cohansy River, Fishing Creek, and Fortesque Beach: Yacht basins.	845,000	Surveys completed for dredging projects; surveys and plans complete for yacht basins, piers, and boat slips.

¹ Map key number shown following community name.

4. SUSQUEHANNA RIVER

Extensive and recurring damage and loss of life by flood, and gross pollution of the waters by sewage and industrial wastes are immediate problems in the valleys drained by the Susquehanna and its tributaries. Retarding dams and levees are needed to control the floods; sewers and treatment plants to abate pollution. Industrial wastes, especially from mines, present a special problem for which investigation is recommended. Better water supply is needed now for the populous area at Harrisburg; future requirements should be anticipated for other communities. Power resources of great magnitude have been developed and can be greatly improved by regulation of the flow. Water uses in the basin are affected by important interests in three States.

General Description

The Susquehanna River and its tributaries drain a large part of south-central New York, most of central Pennsylvania, and a small section of Maryland. The area of the basin is 27,400 square miles, slightly more than the combined areas of Massachusetts, Vermont, and New Hampshire.

The Susquehanna River is formed at Northumberland in central Pennsylvania by the union of its north and west branches, and flows southward to its mouth at the head of Chesapeake Bay. Below Northumberland the stream is wide and shallow with many rocky islands to a point about 23 miles north of the Pennsylvania-Maryland boundary, where it enters a gorge having a series of lakes formed by power dams.

The population of the basin is about 3,000,000, a density of 110 per square mile; it has increased about 29 percent in the last three decades. Nearly one-quarter of the total is contained in the nine principal cities, Scranton, Wilkes-Barre, Altoona, Harrisburg, Lancaster, York, and Williamsport in Pennsylvania; Binghamton and Elmira in New York.

Forests, mainly second-growth, cover about 50 percent of the basin area. The lumbering industry has been steadily declining since about 1900 and is now relatively unimportant. The cleared lands are devoted almost entirely to agriculture and dairying; the principal agricultural products are truck, poultry, fruit, fodder, grain, and tobacco.

Almost all of the anthracite coal used in the United States is mined in northeastern Pennsylvania; the field lies mainly within the Susquehanna Basin. Bituminous coal is mined in the western part of the basin near Clearfield, Pa.

Important and varied industries scattered throughout the basin manufacture products which include steel, textiles, refractories, paper, and leather in Pennsylvania, and abrasives, clay, stone products, enamelware, castings, and furniture in New York.

The climate is temperate in general, but temperatures range from 100° F. in the summer to -30° F. in winter. The average annual precipitation is about 41 inches.

The average discharge of the Susquehanna River at Harrisburg from a drainage area of 24,100 square miles is 34,600 cubic feet per second. The minimum discharge in 1930 was 1,600 cubic feet per second. A destructive flood in the upper reaches of the Susquehanna in 1935 took 52 lives. In the next year, 1936, the lower reaches were inundated by the greatest flood of record. Due to their magnitude and destructiveness, these two floods predominate in the minds of the people of the valleys; but their magnitude was closely approached in 1865, 1889, 1894, 1901, 1902, 1913, 1914, 1933, and 1934, and in the intervening years the lowlands along the streams were often flooded.

Property damages by the two most recent floods have been estimated at \$16,773,770 for 1935, and \$72,000,000 for 1936. The 1935 estimate does not include indirect damages to trade, agriculture, and industry by loss of wages, stopping of all transactions, interruption of communication and transportation, and increased prices. These indirect losses may equal or exceed the direct property losses. The estimate of all damages due to these two floods may be placed at \$100,000,000.

Recommended Plan

The diverse economic interests of the Susquehanna Basin create many interrelated problems in the use, control, and conservation of surface and underground waters. The area contains large industrial districts, bituminous and anthracite coal fields, gas fields, hydroelectric plants, populous cities, rich agricultural and dairying areas, and extensive networks of railroads and highways—all vitally concerned with proper measures for the utilization of the water resources.

Flood control.—The most urgent problem of the Susquehanna River and its tributaries is the control of floods. For the social welfare of the present and future inhabitants of the flood plain, as well as for economic reasons, flood-control projects should go forward as rapidly as practicable.

A general system of retention reservoirs is recommended for the upper reaches in northern Pennsylvania and south-central New York. The Corps of

Engineers has made preliminary location plans and cost estimates for these reservoirs in the headwater streams and is conducting field surveys of the sites. Levees along the lower Susquehanna are needed for the protection of the cities and boroughs.

Pollution.—Next in importance to flood control is the problem of preventing stream pollution from becoming a grave menace. Health is endangered by domestic sewage and by mining and industrial wastes, through public water supplies and also through recreational water uses. Certain industrial wastes interfere with other industries that use the river water; fish life is menaced, and is entirely absent in many reaches of the streams. In many places the water is unsafe or intolerable for boating, bathing, or fishing; excellent and needed recreational facilities are thus withheld from a large population. With an increasing population and the growth of new industries an impossible burden will fall upon the streams in carrying away the waste load unless steps are taken to abate excessive pollution.

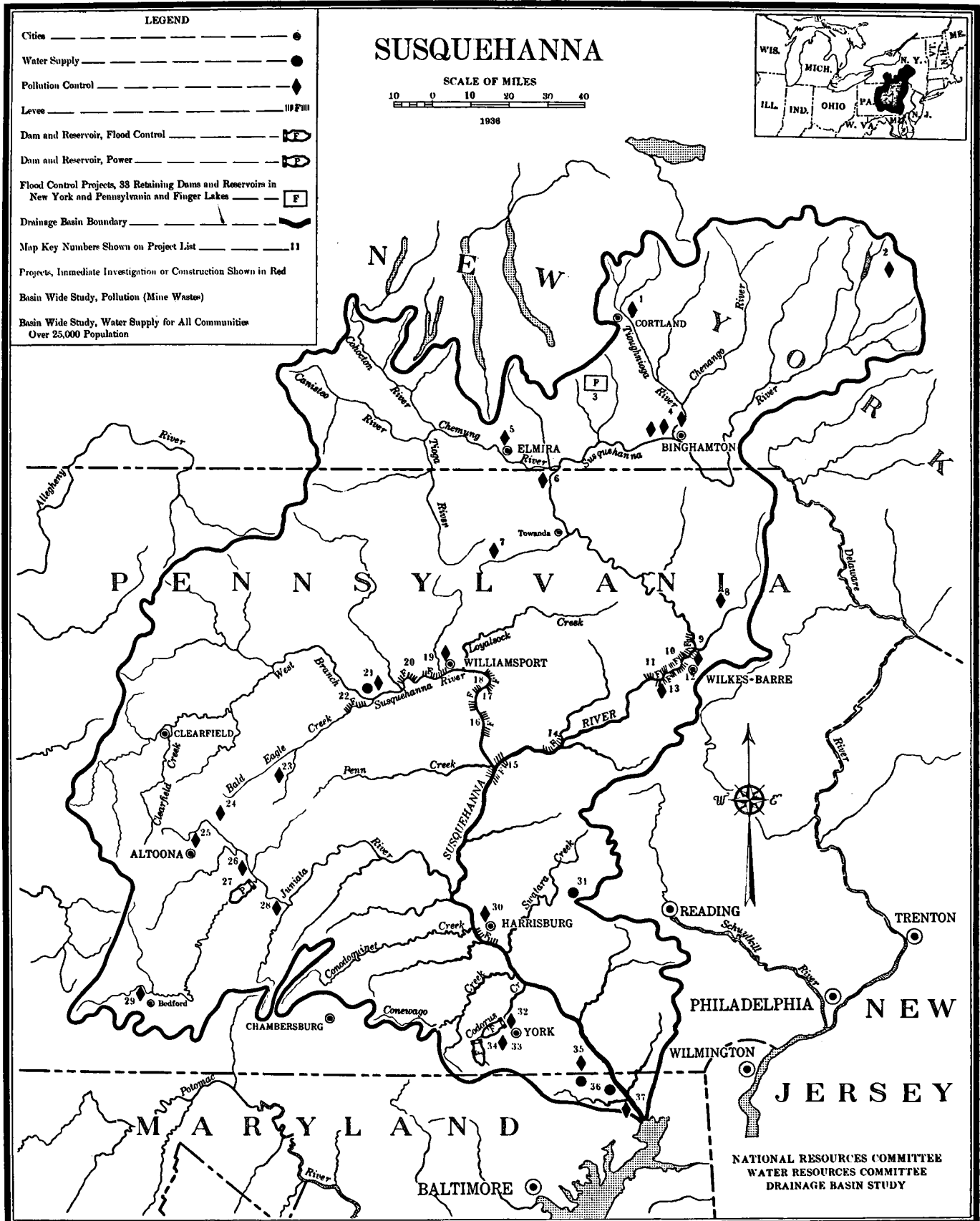
Untreated domestic sewage enters Susquehanna waters from more than 80 percent of the sewered population of 1,650,000, including 138 municipalities. Of the 11 major cities of more than 25,000 population each, only 4 have sewage treatment plants: Altoona, Lancaster, York, and Lebanon, Pa. Only 23 municipalities under 25,000 in population have treatment plants. Not all of these plants are adequate; some in Pennsylvania have been notified by the State Department of Health to prepare plans for improvement or reconstruction. The constitutional limitation on municipal debt is a serious handicap.

Most of the industrial waste comes from mining. Acid waters flow and are pumped from operating and abandoned mines and drain from gob and culm piles. In the anthracite region culm is washed into the streams, forming deposits in pools of the river at low flow. When the stream levels rise with freshets and heavy rains, these pools are purged and an acid load is imposed on the stream heavy enough to kill the fish. This condition is objectionable and the only effective means of control is at the source—preventing the

culm and drainage from washing into the streams. A special study to determine methods of control is recommended. Industrial wastes from certain large industries have been satisfactorily controlled through mutual agreements, but much remains to be done.

Water supply.—Most of the communities in the Susquehanna Basin obtain their water supply by impounding upland streams or by filtering water from creeks, rather than from the river. Some of the smaller communities and most of the rural population use springs or wells. Large use is made of underground water for coal washing and for cooling purposes. Water supplies in general appear to be adequate for present needs except at Harrisburg, Pa. Harrisburg and Steelton use water from the river and at times of low flow treatment is difficult. Major plant improvements are needed to cope with this situation. A study is recommended to determine whether this problem could best be solved by a metropolitan water supply from an upland source for Harrisburg, Steelton, and neighboring communities. Possible future supplies for all of the other cities over 25,000 in population should be investigated at the same time. Consideration should also be given to the conservation of underground water supplies, in view of their widespread use and the increased draft of additional wells for air conditioning and cooling purposes.

Power.—This basin, adjoining the great industrial and manufacturing centers of eastern Pennsylvania, southern New York, and New Jersey, is an important present and potential source of power for an extensive market. The installed capacity of existing plants of more than 100 horsepower in the basin is 630,000 kilowatts; the Safe Harbor, Holtwood, and Conowingo stations on the lower end of the river together contain 81 percent of this, or 507,000 kilowatts at present, with an ultimate total of 827,000 kilowatts. The performance of both present and future plants will be materially improved by regulation of the stream flow. Power development should be carefully planned and coordinated in an orderly manner with stream flow regulation, with market requirements, and with other great power resources within transmission distance of the markets.



Susquehanna Project List

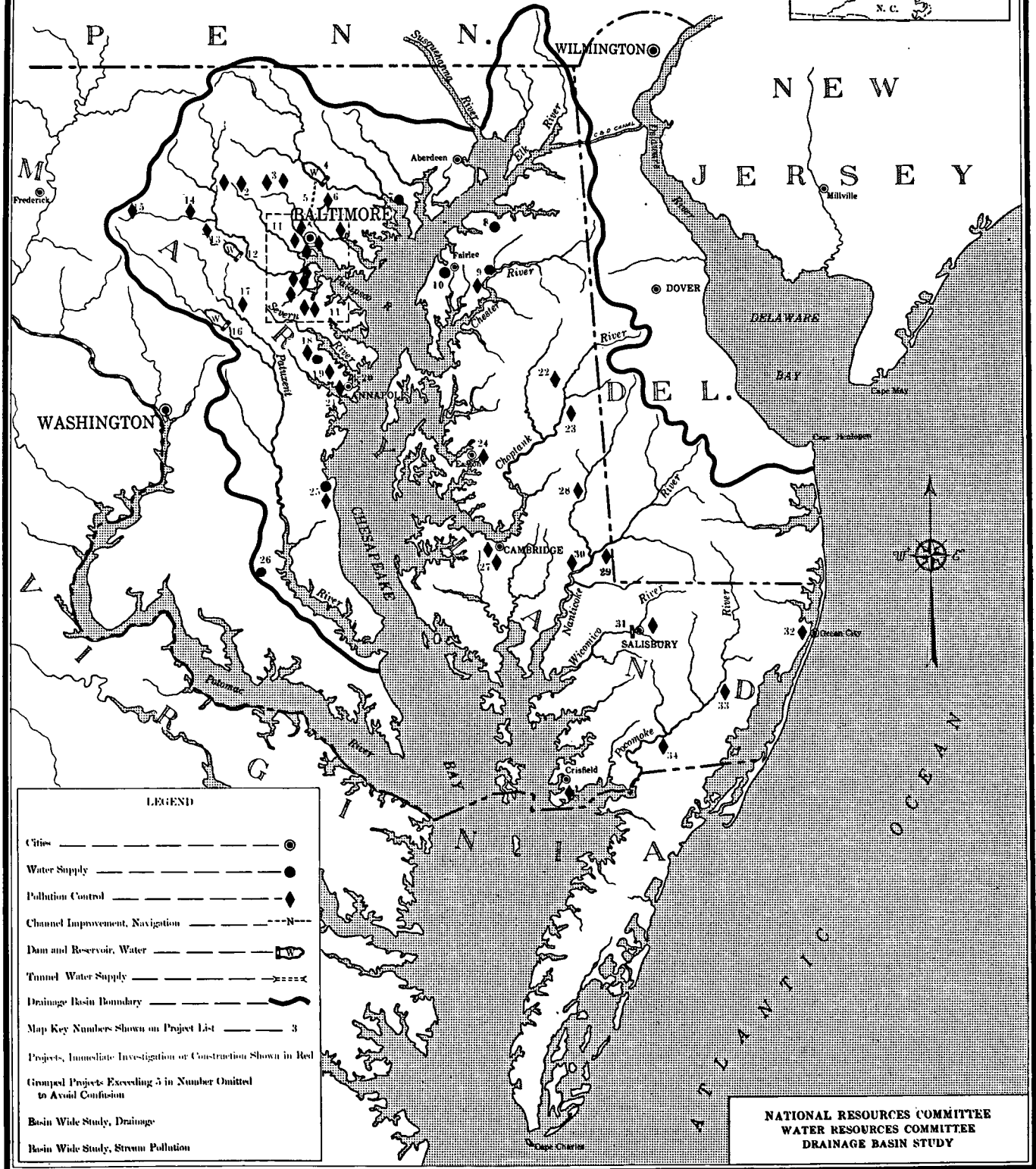
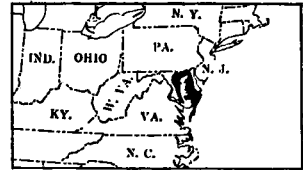
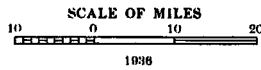
Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study to determine the future water supply needs for all municipalities over 25,000 population throughout the basin including advisability of creating a metropolitan water-supply project for Harrisburg, Pa., and vicinity.	\$75,000	
12	Study to determine methods of eliminating mine wastes from the Susquehanna and Delaware Rivers and tributaries thereby removing existing pollution.	25,000	
10	Wilkes-Barre and Hanover Township, Luzerne County, Pa.: Levees on North Branch of Susquehanna River for flood protection.	281,000	Authorized by Congress.
15	Kingston and Edwardsville, Pa.: Levees on North Branch of Susquehanna River for flood protection.	226,000	Do
23	Sunbury, Pa.: Levees on Susquehanna River for flood protection.	109,000	Plans being prepared. Authorized by Congress.
25	Borough of State College, Pa.: Sewage treatment plant.	121,000	
8	Altoona, Pa.: Sewage treatment plant.	1,250,000	Plans completed.
4	Clarks Summit, Pa.: Sewer system and sewage treatment plant.	391,000	Do.
5	Binghamton, Endicott, and Johnson City, N. Y.: Sewage treatment plants.	1,600,000	
29	Elmira, N. Y.: Intercepting sewers and sewage treatment plant.	900,000	
3	Bedford, Pa.: Sewer system and sewage treatment plant.	170,000	Do.
	Retarding dams in headwaters of Susquehanna and Delaware Rivers and Finger Lakes region for flood control.	31,516,000	Cost to complete as authorized by Congress. Plans being prepared. Includes estimated cost of land, \$5,930,000.
GROUP B—FOR DEFERRED CONSTRUCTION			
31	Lebanon, Pa.: Water-filtration plant.	\$250,000	
30	Harrisburg, Pa.: Levees on Susquehanna River for flood protection.	109,000	Plans being prepared. Authorized by Congress.
19	Williamsport, Pa.: Levees on West Branch of Susquehanna River for flood protection.	2,600,000	Do.
34	York, Pa.: Retarding dams on Codorus Creek.	2,600,000	Do.
(1)	Bloomsburg (14), Forty Fort (9), Jersey Shores (20), Lock Haven (22), Milton (16), Montgomery (17), Muncy (18), Nanticoke (13), Plymouth (11), Swoyersville (10), and West Pittston (9), Pa.: Levees for flood control.	5,891,000	Plans being prepared.
19	Williamsport, Pa.: Sewage-treatment plant.	700,000	
12	Wilkes-Barre, Pa.: Sewage-treatment plant.	1,300,000	
13	Nanticoke, Pa.: Sewage-treatment plant.	400,000	
2	Cherry Valley, N. Y.: Sewage-treatment plant.	50,000	
1	Cortland, N. Y.: Sewage-treatment plant.	314,000	
32	York, Pa.: Improvements to sewage-treatment plant.	150,000	
33	Spring Garden Township, York County, Pa.: Sewer system.	795,000	
6	Sayre, Pa.: Sewage-treatment plant.	180,000	
7	Canton, Pa.: Sewage-treatment plant.	50,000	
24	Tyrone, Pa.: Sewage-treatment plant.	180,000	
26	Huntingdon, Pa.: Sewage-treatment plant.	150,000	
28	Mount Union, Pa.: Sewage-treatment plants.	120,000	
21	Greenwood, Pa.: Reservoir and water-supply system.	136,000	
30	Harrisburg, Pa.: Sewage-treatment plant.	1,200,000	
35	Cardiff, Md.: Sewer-system and sewage treatment plant.	25,000	Preliminary plans complete.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
37	Havre de Grace, Md.: Sewage-treatment plant.	\$150,000	
27	Huntingdon County, Pa.: Hydroelectric power dam and reservoir on Raystown Branch of Juniata River.	21,528,000	
(1)	Cardiff (35), and Darlington (36), Md.: Water-supply systems.	35,000	

¹ Map key number shown following community name.

MIDDLE ATLANTIC DRAINAGE BASINS

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UPPER CHESAPEAKE



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Channel Improvement, Navigation ———— N
- Dam and Reservoir, Water ———— [Dam Symbol]
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- Basin Wide Study, Stream Pollution

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

1. UPPER CHESAPEAKE

For proper development of the water resources of the upper Chesapeake Basin the plan will include the construction or extension of water supply systems for domestic and industrial purposes, the study of underground water supplies, soil conservation and the treatment and disposal of sewage and industrial wastes. There are also included recommendations for navigation improvements, and for studies of the control and prevention of beach erosion, of drainage and mosquito control, and of flood control.

General Description

The basin lies between a line running north and south through the District of Columbia on the west and a similar line through the middle of the State of Delaware on the east, comprising about two-thirds of the State of Maryland, a small area in southeastern Pennsylvania, and the western portion of Delaware.

The area includes portions of the Coastal Plain and of the Piedmont Plateau. In the Coastal Plain, the topography is gently rolling or nearly flat; altitudes range up to 250 feet. In the Piedmont Plateau, the topography is likewise rolling but with altitudes as high as 800 feet at the west.

A striking drainage feature of the region is the large number of rivers tributary to Chesapeake Bay whose lower reaches are navigable tidal estuaries.

The most important sources of water supply are the Patuxent and Patapsco Rivers and Gunpowder Falls. The water in the upper reaches of these and other streams is of good quality for domestic and industrial uses, being fairly soft and of relatively low turbidity except immediately after storms. In the eastern part of the region most of the water supplies are from wells which furnish water of satisfactory quality.

The population of the basin in Maryland, including that of Baltimore and many smaller communities, is 1,260,000, which is three-fourths of the total population of the State. It is classed as two-thirds urban and one-third rural. The lands of the region are fertile and suitable for agriculture. The average annual precipitation is about 40 inches and is usually well distributed throughout the year. In the eastern portion, where the land is nearly flat, there are many marshy areas. The oyster and fishing industries are important along the bay.

Recommended Plan

Additional *water supplies* for domestic and industrial purposes constitute an urgent need in parts of this

basin. Most of the projects proposed are for small communities which are now without public systems, or whose present supplies are inadequate. The largest single project is that sponsored by the Washington suburban sanitary district for the utilization of the waters of Patuxent River, considered the most pressing necessity of this kind in the basin. It involves the provision of an additional supply from this basin to serve a large population, most of which resides in the Potomac River Basin.

Four other water supply projects are scheduled for deferred construction. Three of these will be required to take care of the rapidly increasing population of Baltimore and of the Washington suburban sanitary district. The city of Baltimore plans to strengthen the existing tunnel from the present source of supply to the filtration plant at an estimated cost of \$1,800,000 and, ultimately, to raise the level of the present water in the Gunpowder Reservoir at a cost of \$17,200,000.

A comprehensive study of the underground waters of the basin is needed. Considerable data are already available. These should be tabulated and correlated with additional field data.

Waste disposal is only slightly less important in the area than water supply. Sewer systems, sewage treatment plants, or both, are recommended for immediate construction in 40 communities. Certain of the sewer projects are urgently needed to reduce stream pollution and protect public health. All of the problems of industrial waste in the western part of the basin originate in the distilling industry. Adequate amelioration of stream pollution would necessitate the treatment of wastes from 8 distilleries. Abatement of pollution would improve conditions at oyster beds in Chesapeake Bay and its tributary waters.

Twenty-nine sewerage projects to be undertaken within the next 10 years have been included in the project list for deferred construction. These projects include a sewage treatment plant at Salisbury, the largest community in the eastern section of the basin, and extensions to the systems of the Baltimore County Metropolitan district and the city of Baltimore.

Navigation is another important feature of this basin. The most important improvement at present is the deepening of the Chesapeake and Delaware Canal to accommodate vessels of greater draft. This project was authorized by the Rivers and Harbors Act of August 30, 1935. Work has been started. The esti-

mated cost of \$5,393,000 appearing in the Delaware project list is for completion of the work. It may well prove desirable to supplement the project now under way by measures to safeguard wildlife habitat in the Susquehanna Flats area.

Beach erosion projects have been proposed; further study is necessary and is recommended.

Drainage and mosquito control are needed in some portions of the basin, and a project has been listed to provide for further study to determine the most effective program. The study should include also the relation of this drainage to agricultural lands.

Flood control is not a major problem in this basin. Only one project is recommended.

Upper Chesapeake Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Comprehensive study of stream pollution problems in the basin.....	\$5,000	Cooperative investigation by State and Federal agencies.
16	Washington Suburban Sanitary District, Maryland: Water-supply development from Patuxent River.....	275,000	Plans completed.
3	Baltimore County metropolitan district, Maryland: Sewer-system extension.....	750,000	Preliminary plans made.
25	Chesapeake Beach and North Beach, Md.: Water-supply system.....	100,000	No plans have been made.
	Bowie, Cecilton, Church Hill, Chesapeake City, Galena, Goldsboro, Hebron, Hillsboro, Mardella Springs, Marion, Millington, Northeast, Prince Frederick, Queen Anne, Round Bay and Severna Park, Solomons, Stillpond, Sudlersville, Sykesville, and Upper Marlboro, Md.: Water-supply systems.....	571,000	
(1)	Betterton (8), Charlotte Hall (26), Chestertown (9) and Edgewood Arsenal (7), Md.: Water-supply extensions.....	95,000	
(1)	Crowsville (18) and Ellicott City (12), Md.: Water supply extensions and filtration.....	115,000	
11	Baltimore, Md.: Boston Street and Bayliss Street sewers and sewage disposal for Camp Holabird..	241,000	Plans completed.
11	Baltimore, Md.: Lafayette Avenue Storm Drain.....	623,000	Do.
11	Baltimore, Md.: Jones Fall Interceptor sewer.....	2,024,000	Do.
27	Cambridge, Md.: Sewage-treatment plant.....	105,000	Do.
35	Crisfield, Md.: Sewer system extensions and sewage-treatment-plant additions.....	120,000	
32	Ocean City, Md.: Sewer system extensions and treatment-plant additions.....	250,000	Partial plans made.
27	Cambridge, Md.: Sewage-treatment plant for Eastern Shore State Hospital.....	30,000	
11	Brooklyn Park, Md.: Sewer system.....	125,000	Plans completed.
19	West Annapolis, Md.: Sewer system.....	57,000	Do.
11	Baltimore County, Md.: Montrose School for Girls; sewer system extensions.....	4,000	Do.
18	Crownsville, Md.: Relief outfall sewer.....	12,000	Do.
20	Annapolis Md.: Dredging channel 16 feet deep, 100 feet wide, in Severn River and Anchorage Basin in Opa Creek.....	24,000	Survey completed.
24	Easton, Md.: Sewage-treatment plant.....	125,000	Preliminary plans made.
25	Chesapeake Beach and North Beach, Md.: Sewer system and sewage-treatment plant.....	150,000	No plans have been made.
	Betterton, Chesapeake City, Church Hill, East New Market, Elkridge, Ellicott City, Hampstead, Manchester, Mardella Springs, Hillsboro, Northeast, Oxford, Princess Anne, Public Landing, Queen Anne, Queenstown, Rock Hall, Round Bay and Severna Park, St. Michaels, and Secretary, Md.: Sewer systems and sewage-treatment plants.....	821,000	
(1)	Chestertown (9), Federalsburg (28), and Springfield State Hospital (14), Md.: Sewer system extension.....	165,000	Plans completed for Federalsburg and Chestertown only.
(1)	Maryland House of Correction (17), Maryland Training School for Boys (6) and Ridgely (22), Md.: Sewage treatment plants.....	122,000	
(1)	Henryton Tuberculosis Sanitorium (13), Maryland Training School for Colored Girls (1), and Rosewood (2), Md.: Sewage-treatment-plant additions.....	50,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
31	Salisbury, Md.: Floodgates and spillway at Shoemakers Pond.....	\$20,000	Preliminary plans made.
5	Baltimore, Md.: Strengthen Loch Raven-Montebello water-supply tunnel.....	1,800,000	Do.
11	Baltimore, Md.: Vail street storm drain.....	60,000	Do.
4	Baltimore, Md.: Raise Loch Raven water-supply reservoir.....	17,200,000	Do.
16	Washington suburban sanitary district, Maryland: Additional water supply on Patuxent.....	1,000,000	Do.
10	Fairlee, Md.: Water-supply system.....	20,000	Plans have not been made.
31	Salisbury, Md.: Sewage-treatment plant.....	250,000	Do.
3	Baltimore County metropolitan district, Maryland: Sewer-system extensions and sewage-treatment plant.....	750,000	Preliminary plans made.
	Bowie, Cecilton, Fairlee, Galena, Goldsboro, Hebron, Marion, Millington, Prince Frederick, Solomons, Stillpond, Sullersville, Sykesville, Trappe, and Upper Marlboro, Md.: Sewer-systems and sewage-treatment plants.....	373,000	Plans have not been made for any of these projects except Goldsboro, which has partial plans.
(1)	Denton (23), Mount Airy (15), Pocomoke City (34), and Snow Hill (33), Md.: Sewer-system extensions and sewage-treatment plants.....	190,000	Plans completed for Mount Airy, and partial plans for Denton, Pocomoke City, and Snow Hill.
(1)	Ferndale (11), Glenburnie (11), Homewood-Germantown (21), Linthicum Heights (11), and Overlook (11), Md.: Sewer-system extensions.....	42,000	Preliminary plans made for each project.
(1)	Sharptown (29), and Vienna (30), Md.: Sewage-treatment plants.....	50,000	Partial plans made for each project.
11	Baltimore, Md.: Chesapeake outfall sewer.....	4,156,000	Preliminary plans made.

1 Map key number shown following community name.

2. POTOMAC

The principal immediate objectives of a water plan for the Potomac River Basin are abatement of pollution, control of floods, soil conservation enlargement of the supplies of water for various communities, and promotion of the recreational values of the streams and their borderlands. The opportunities for further improvement of the waterways of the basin in behalf of commercial navigation are restricted, and the possibilities of utilizing advantageously its numerous power sites are uncertain. Most of the immediate and prospective problems to be solved interlock in large measure, and therefore are not susceptible of individual treatment. They concern not only the States that lie in part within the basin, but also in a unique manner the Nation at large, since the national capital is in the basin. The satisfactory solution of these problems obviously will require cooperative action by the four States involved and the Federal Government.¹

General Description

The Potomac River is formed by the confluence of its north and south branches near Cumberland, Md., and flows in a general southeasterly direction for 158 miles to the fall line at Great Falls. From Great Falls the river drops 156 feet in 14 miles to tide level at Washington. The tidal section from Washington to Chesapeake Bay is 117 miles long. The Potomac drainage area covers 14,500 square miles lying in Maryland, Virginia, West Virginia, Pennsylvania, and the District of Columbia. The Shenandoah River, the largest tributary, drains 3,054 square miles and empties into the Potomac River at Harpers Ferry, W. Va.

The upper section of the basin, including the Shenandoah Valley, is in the Appalachian Mountains, rising to nearly 3,000 feet in Maryland and 4,500 feet in Virginia and West Virginia. The rock formations include sandstone, limestone, and shales. In the Shenandoah Valley the principal formation is limestone and there are many caves and faults. Because of this condition, sites for dams must be chosen with extreme care. Near Harpers Ferry the Potomac cuts through the northern end of Blue Ridge into the Piedmont Plateau where altitudes range up to 1,000 feet. Here the rocks include granites, metamorphosed sandstone, and schists. Below Washington, the val-

¹The National Resources Committee's Special Advisory Committee on Stream Pollution proposed the establishment of a Potomac River conservancy district not only as a means of providing the requisite cooperation but also as a demonstration and research organization in a drainage area admirably suited to the major purpose which it had in view, the abatement of stream pollution.

ley is part of the Coastal Plain, underlain by unconsolidated sands, marls, clays, and gravel.

Severe and protracted droughts in the Potomac Valley have been quickly followed by intense precipitation, exceeding on occasion 6 inches in 24 hours. Accordingly, the Potomac is a flashy stream. The discharge at Great Falls has varied from 650 to 480,000 cubic feet per second, with an average flow of 8,000 cubic feet per second. Two outstanding floods have occurred: In June 1889 and in March 1936; below Cumberland the highest crest was reached in 1936.

In general, water from the northern part of the watershed is soft and suitable for industrial and domestic use; that from the southern part is hard. Below Harpers Ferry, tributaries bring in large quantities of red mud, resulting in high turbidity of the main stream.

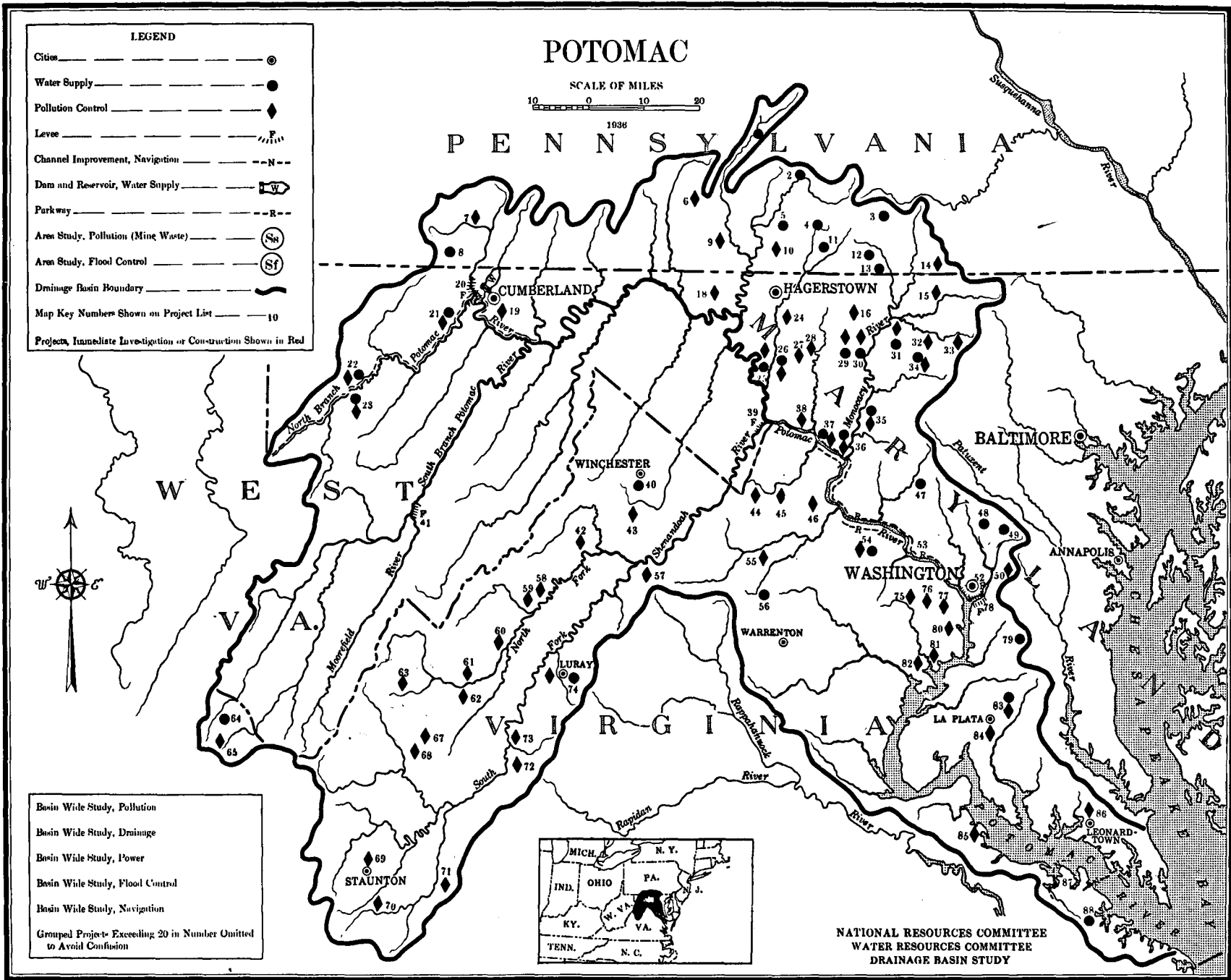
The underground waters differ from place to place in quantity, quality, and hardness. In the central part of the basin there are many caverns providing natural storage basins whose springs in some cases discharge as much as 4,000 gallons per minute. This water is clear, cool, and wholesome, but hard. In the Piedmont Plateau and Blue Ridge section the granites and other ancient rocks are relatively impervious; most of the springs are weak, but the quality of their water is good. In the Coastal Plain water from many shallow wells is of poor quality, but artesian supplies of good quality have been found.

In 1932 the entire basin contained 1,200,000 people, half of them in the city of Washington. The mountainous section around the headwaters is sparsely settled; the inhabitants, many of whom were formerly employed in lumbering and mining, now live largely by farming. In central Maryland and in the Shenandoah Valley, the lands are fertile and highly cultivated. Dairying is important.

Coal is the important mineral resource in the basin. Cumberland is the leading manufacturing center. In the tidewater counties near Chesapeake Bay, the oyster and fishing industries are important sources of income. East of Blue Ridge and south of Washington there are opportunities for additional farming operations with good markets at Baltimore and Washington.

Recommended Plan

Additional water supply is a pressing need in a number of cities and communities in the basin. In the Cumberland, Md., region a troublesome shortage of



water exists, and it is proposed to tap Evitts Creek. The situation has been aggravated by the fact that the pollution of the Potomac River has forced some of the industries to draw upon the public supply.

In the important residential section around Washington, the population is rapidly increasing and an additional water supply is needed. For the Maryland suburban area, a project is included in the plan for the Patuxent River, as noted in connection with the Upper Chesapeake Basin. At a later date a supply from Seneca Creek may also be required. The situation is also serious in the Virginia suburban area. Many other communities in the basin will doubtless need additional water soon or later.

Sewage disposal is needed in most of the communities that require additional water supplies. Important sewage treatment projects are planned for the city of Staunton, Va.; for the Washington suburban area below Bladensburg, Md.; and for Alexandria, Va.

The Savage River dam is a storage project; water from the reservoir would be available during low water periods to increase the flow of the Potomac.

Industrial wastes constitute a serious element of water pollution in the basin. Undesirable wastes are related to textile mills, pulp and paper, coke and gas, leather, certain chemical industries, and the canning of food and dairy products. Acid water from abandoned coal mines has been partially stopped by sealing the mines, but studies should be made for the control or treatment of acid water from active coal mines.

Flood control projects for immediate construction include levees and retaining walls at Cumberland, Md.; Washington, D. C.; and Moorefield and Harpers Ferry, W. Va. The reservoirs of a comprehensive plan for power development could also be operated to reduce flood stages.

Navigation.—Two meritorious navigation projects, already authorized by the Congress, have been included in the project list.

Recreation.—An increase in the low water flow of the Potomac would enhance the beauty of Great Falls and facilitate recreational boating on the river. Abatement of pollution would likewise conserve and promote its recreational values. In addition, the river and its scenic and historic surroundings should be made more readily accessible and enjoyable by completion of the George Washington Memorial Parkway along both banks of the river from Mount Vernon to Great Falls and through use of the abandoned Chesapeake and Ohio Canal as a recreation waterway, at least as far as Point of Rocks. Extensions of this parkway system could be made to the Skyline Drive at Harpers Ferry and up Monocacy Creek toward Gettysburg Battlefield.

Power development.—The potential water power of the Potomac River and its tributaries is of great magnitude and has been studied by the Corps of Engineers in conjunction with its investigations of flood control and navigation possibilities. The plan and program of development which would afford maximum benefits cannot be determined without further and continuing studies. Such studies should include the correlation of proposed flood-control measures included in the Flood Control Act of 1936 with proposed storage reservoirs, the abatement of pollution, the promotion of recreation, the effects of joint operation of reservoirs for flood control and power use, the costs of power, and the power market in a coordinated transmission system covering the metropolitan areas of the middle Atlantic States.

Potomac Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Comprehensive study of drainage problems in the basin.....	\$8,000	Cooperative investigation by State and Federal agencies.
	Preparation of basin-wide program of pollution control in conjunction with flood control, navigation and power development.....	300,000	Recommended in Report of Advisory Committee on Water Pollution, and endorsed by State Departments of Health.
	Georges Creek Valley, Md.: Development of metropolitan district for water supply and sewerage.....	10,000	Preliminary plans made.
19	Cumberland, Md.: Evitts Creek development additional water supply.....	1,000,000	Do.
48	Washington Suburban Sanitary District, Maryland: Paint Branch water-supply development.....	160,000	Do.
40	Winchester, Va.: Development of water supply from Cedar Creek.....	532,000	Plans completed.
64	Crabbottom, Va.: Development of springs and construction of mains.....	9,000	Do.
54	Herndon, Va.: Water-supply system.....	68,000	Preliminary plans made.
21	Cresaptown, Md.: Water-supply system.....	100,000	Do.
49	Beltsville, Md.: National Agricultural Research Center—additions to waterworks system.....	90,000	Plans partially completed.
49	Beltsville, Md.: U. S. Bureau of Plant Industry—improvement and extension of waterworks and irrigation systems.....	46,000	
19	Cumberland and upper Potomac River, Md.: Savage River Dam for regulating flow of Potomac River.....	1,600,000	Plans in preparation.
50	Washington Suburban Sanitary District, Md.: Anacostia River and Little Falls Branch sewer system.....	925,000	Preliminary plans made.
19	Cumberland, Md.: Sewage-treatment plant.....	300,000	No detailed plans made.
69	Staunton, Va.: Sewage-treatment plant.....	244,000	Plans completed.
76	Falls Church, Va.: Sewer system and sewage-treatment plant.....	170,000	Do.
20	Cumberland, Md.: Levees and diversion for flood protection.....	887,000	Authorized by Congress.
52	Washington, District of Columbia: Levees and grade raising for flood protection.....	587,000	Do.

Potomac Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
39	Harpers Ferry, W. Va.: Levees and walls.....	\$189,000	Authorized by Congress.
41	Moorefield, W. Va.: Levees and walls.....	47,000	Do.
87	Westmoreland, Va.: Nomini Creek—dredging channel.....	10,000	Do.
78	Washington, District of Columbia: Potomac River water front improvements.....	1,650,000	Authorized by Congress; survey completed.
78	Washington, D. C.: Deepening harbor channels to 24 feet.....	173,000	Authorized by Congress.
(1)	Adamstown (36), Cheltenham (79), Libertytown (34), Keedysville (26), Sharpsburg (25), Waldorf (83), Walkersville (30), and Vindex (22), Md.: Water-supply systems.	185,000	No plans made.
(1)	Buckeystown (35), Kitzmillersville (23), Lewistown (29), Point of Rocks (37), and Woodsboro (31), Md.: Water supply systems.	125,000	Do.
47	Washington Suburban Sanitary District: Great Seneca Creek water-supply development.....	650,000	Preliminary plans made.
74	Luray, Va.: Construction of mains and development of new water supply.....	60,000	Do.
56	Marshall, Va.: Development of new water supply.....	39,000	Do.
88	Kinsale, Va.: Water-supply system.....	30,000	No plans made.
(1)	Fairfield (12), Fannettsburg (1), Iron Springs (13), Marion (5), McKnightstown (3), Mount Alto (4), Quincy (11), Scotland (2), and Wellersburg (8), Pa.: Water-supply systems.	222,000	Do.
71	Waynesboro, Va.: Construction of sewers and complete sewage-treatment plant.....	100,000	Preliminary report made.
46	Leesburg, Va.: Construction of sewers and complete treatment plant.....	140,000	Do.
80	Alexandria, Va.: Construction of sewers and partial treatment plant.....	250,000	Do.
53	Chesapeake and Ohio Canal (Washington to Point of Rocks) and George Washington Memorial Parkway (Mount Vernon to Great Falls).	9,100,000	Availability and restoration for recreational use, authorized by Congress; establishment of park along river, authorized by Congress.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Arlington Experiment Farm (77), Broadway (62), Front Royal (57), Herndon (54), Lorton (82), Middleburg (55), and Shenandoah (73), Va.: Sewer systems and sewage-treatment plants.	\$230,000	Complete plans for Broadway, Front Royal, Herndon, Lorton, and Shenandoah; plans not complete for Middleburg; no detailed plans for Arlington Experiment Farm.
(1)	Adamstown (36), Boonsboro (27), Brunswick (38), Clear Spring (18), Cresaptown (21), Funkstown (24), Keedysville (26), Leonardtown (86), Libertytown (34), Myersville (28), New Windsor (33), Taneytown (15), Thurmont (16), Union Bridge (32), Walkersville (30), and La Plata (84), Md.: Sewer systems and sewage-disposal plants.	605,000	
(1)	Greencastle (10), Hyndman (7), Littlestown (14), McConnellsburg (6), and Mercersburg (9), Pa.: Sewer systems and primary treatment plants.	425,000	No plans made.
(1)	Colonial Beach (85), Dayton (68), Elkton (72), Harrisonburg (67), Luray (74), Monterey (65), Stanley (63), Stephens City (43), and Stuarts Draft (70), Va.: Sewer systems and provision for partial treatment of sewage.	315,000	Preliminary report made.
(1)	Buckeystown (35), Kitzmillersville (23), Lewistown (29), Point of Rocks (37), Sharpsburg (26), Vindex (22), Waldorf (83), and Woodsboro (31), Md.: Sewer systems and sewage-treatment plants.	190,000	No plans made.
(1)	Edinburg (59), Fort Belvoir (81), Mount Jackson (60), Purcellville (45), Round Hill (44), Strasburg (42), Timberville (61), Vienna (75), and Woodstock (58), Va.: Sewer systems and provision for treatment of sewage.	255,000	Preliminary report made.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Ashburn, Bluemont, Boyce, Churchville, Clifton, Dumfries, Greenville, Grottoes, Hamilton, Haymarket, Keezletown, Lincoln, Lovettsville, McCaheysville, Middletown, Mount Crawford, Occoquan, Stephens City, The Plains, Toms Brook, Upperville, Vienna, and Waterford, Va.: Water supply systems.	\$637,000	
	Ashburn, Bluemont, Boyce, Bridgewater, Churchville, Clifton, Greenville, Grottoes, Hamilton, Haymarket, Keezletown, Kinsale, Lincoln, Lovettsville, McCaheysville, Middletown, Mount Crawford, Occoquan, The Plains, Toms Brook, Upperville, and Waterford, Va.: Sewer systems.	638,000	

¹ Map key number shown following community name.

3. LOWER CHESAPEAKE

Among the water projects noteworthy in the lower Chesapeake Bay area are drainage for mosquito control, the installation of sewers and sewage treatment plants, and navigation improvement.

General Description

The area covers the drainage basins of the Rappahannock and York Rivers, and the Eastern Shore of Virginia between Chesapeake Bay and the Atlantic Ocean. It lies entirely in Virginia and comprises about one-seventh of the land area of that State. A small portion only is cultivated; woodlands and waste lands occupy about three-fourths of the total area.

The headwaters of the Rappahannock and its principal tributary, the Rapidan, lie in the eastern slope of Blue Ridge, running down within 20 miles to the rolling hill country of the Piedmont Plateau. On the plateau, which is there about 60 miles wide, are the headwaters of the Anna and North Anna Rivers, which flow by way of the Pamunkey to the York. Below the fall line at the eastern edge of the Piedmont Plateau is 60 miles of rather level farming country, the "tidewater Virginia" of the early settlements, where the tidal portions of the Rappahannock and York extend back into the country as far as the falls. On the Eastern Shore all the streams are estuaries. The Rappahannock River is a tidewater stream as far as Fredericksburg; the York and its tributaries are tidal up to the "fall line" at the edge of the Piedmont Plateau.

Surface and underground water supplies are ample. In the Blue Ridge there are many springs, and in the Piedmont Plateau water is obtained at moderate depths. On the Eastern Shore artesian water is obtainable on low lands near the rivers. The average annual rainfall varies from 37 to 45 inches. Except for summer storms, the rainfall is rather evenly distributed throughout the year. The growing season averages about 250 days.

The population in 1930 was 265,000, of which 16,000 was urban. Records indicate that the population as a whole has been decreasing, except in the northern

counties, where it has been influenced by nearness to the District of Columbia. Williamsburg and Fredericksburg are the principal communities in the basin.

There is great variety of farming. Truck and potatoes are principal crops on the Eastern Shore, while livestock and dairying are important in the northwestern region. Industries are few and scattered.

Recommended Plan

A state-wide survey of Virginia to collect basic data necessary for the development of water use is recommended. It will include studies of stream pollution, surface run-off, and underground water supplies in the lower Chesapeake and other areas.

Pollution of streams by industrial wastes and sewage is not at present serious, but a number of the towns are without suitable sewer and sewage treatment facilities. With a view to preventing further pollution, projects to supply these needs should be considered and construction started when plans are completed.

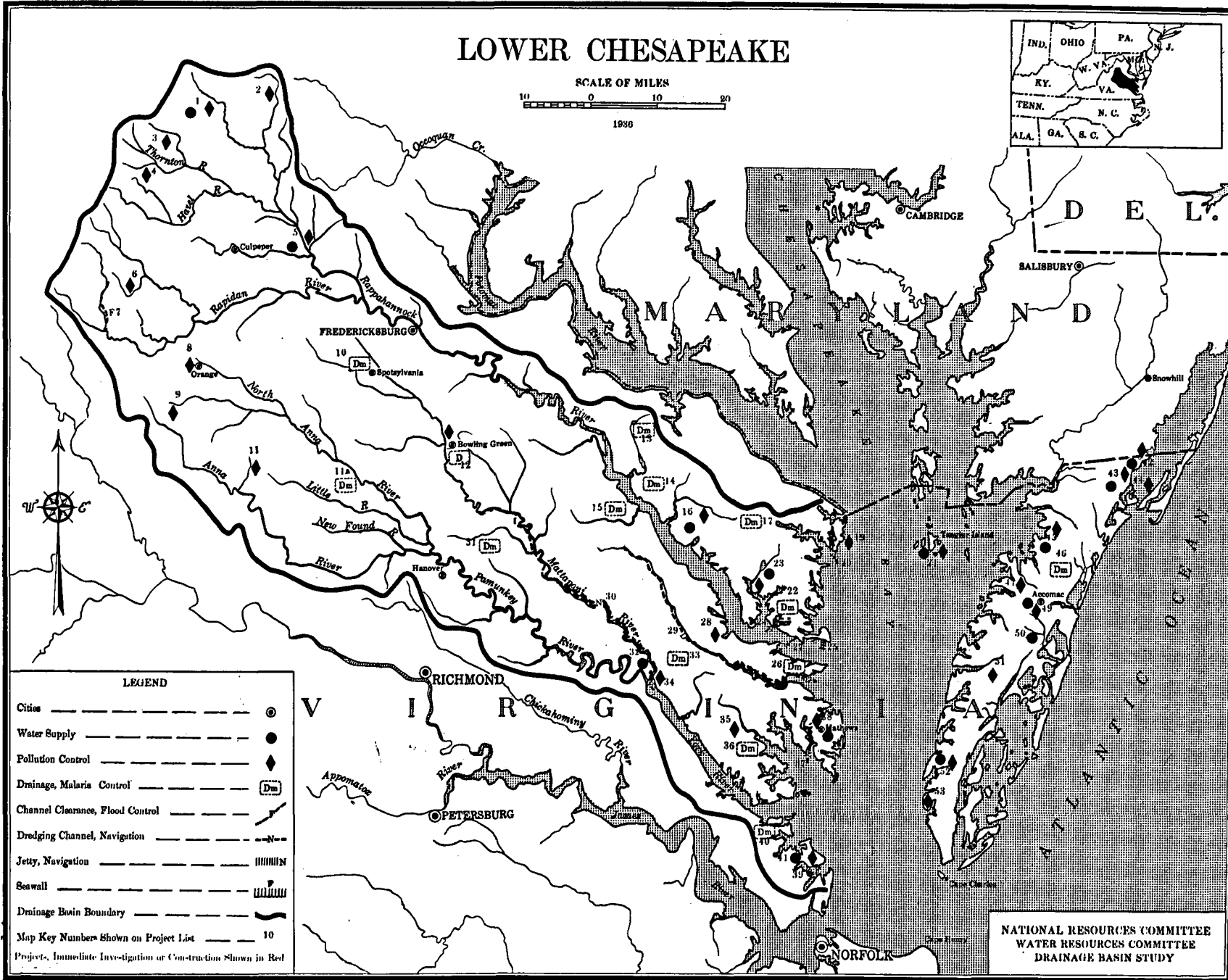
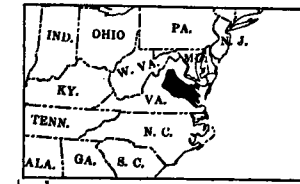
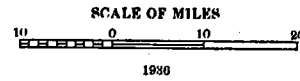
Drainage problems in this basin are of two general classes. One involves the control of malaria by rechanneling of fresh-water and salt-water drainage areas. The other concerns the cleaning of certain stream beds which have been clogged with windfalls or sunken logs, left from the time when the streams were used for lumbering operations. Drainage projects are listed for 12 counties of Virginia. In this connection, care should be taken to protect certain important wildlife habitats.

Water supply is inadequate in some of the smaller communities. This deficiency should receive attention. One project could be started now; others should be undertaken later.

Navigation can be improved advantageously at some places. Several surveys for channel improvement have been authorized by the Congress and are now under way.

Water-power studies in conjunction with power plans for the adjoining basins of the Potomac and James Rivers may find some power projects to be feasible in this area.

LOWER CHESAPEAKE



LEGEND

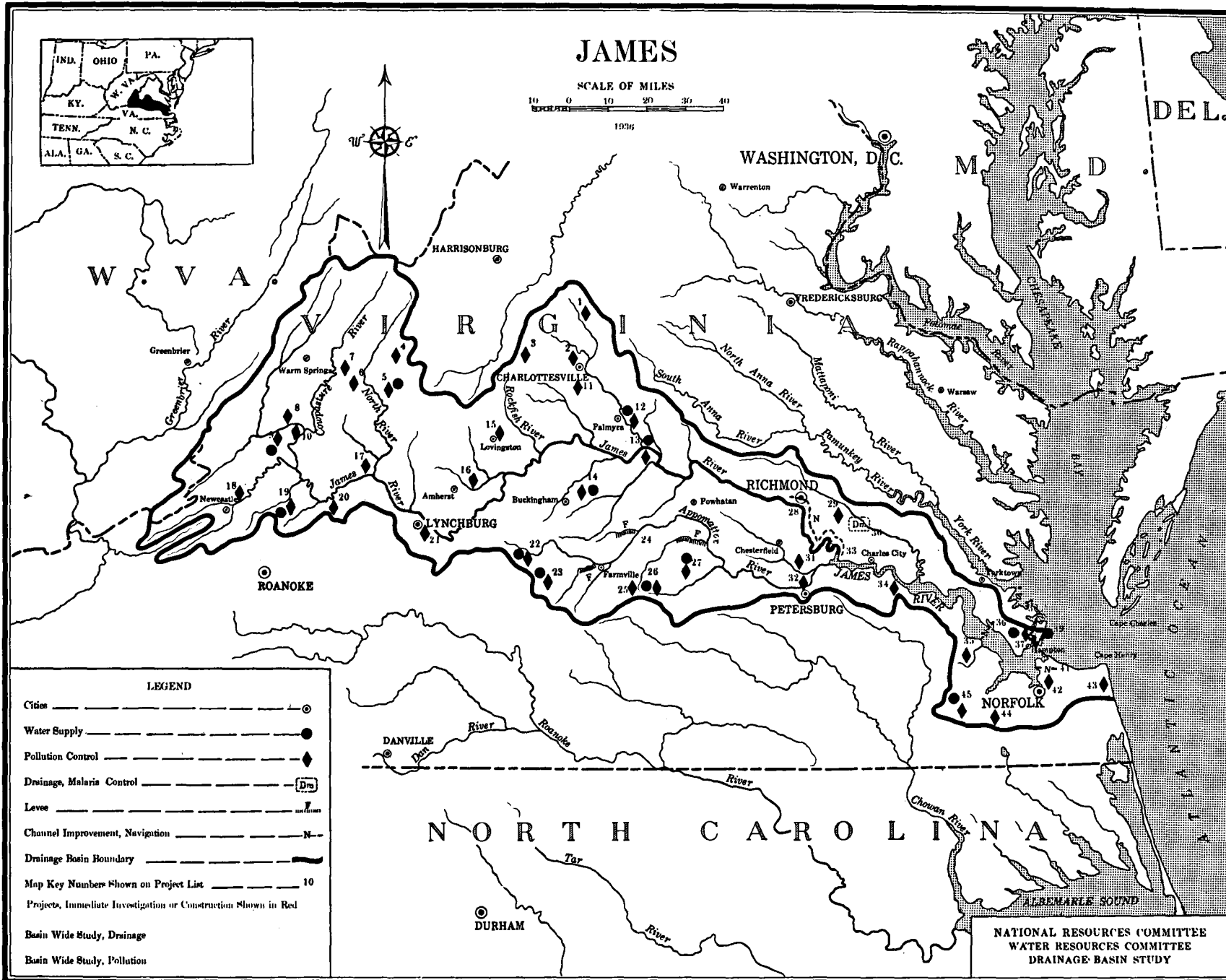
- Cities ———— ○
- Water Supply ———— ●
- Pollution Control ———— ◆
- Drainage, Malaria Control ———— [Dm]
- Channel Clearance, Flood Control ———— /
- Dredging Channel, Navigation ———— -N-
- Jetty, Navigation ———— |||||N
- Seawall ———— |||||
- Drainage Basin Boundary ———— ~~~~~
- Map Key Number Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Lower Chesapeake Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
29	Essex, Gloucester, Middlesex, and King and Queen Counties, Va. Cleaning of Dragon Run to improve flow and for mosquito control.	\$81,000	Preliminary surveys completed.
7	Madison County, Va.: Clearing river channels for flood control.	7,000	Surveys completed.
(1)	King and Queen, King William, Lancaster, Middlesex, and Northumberland Counties, Va.: Dredging navigation channels in Mattaponi River (30), Carters Creek (24), Mill Creek (27), and Cockrels Creek (20).	98,000	Do.
45	Parksley, Va.: Waterworks system.	39,000	Preliminary plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Lancaster and Mathews Counties, Va.: Complete channel in creek at Mathews (37), and build two jetties at Windmill Creek (25).	\$14,000	Surveys completed.
39	Langley Field, Va.: Seawall to protect laboratory.	100,000	Preliminary plans completed.
(1)	Caroline County (12), Essex County (15), Gloucester County (36), Hanover County (31), King William County (33), Lancaster County (22), Middlesex County (26), Northumberland County (17), Richmond County (14), Spotsylvania County (10), Westmoreland County (13), York County (31) (40), Va.: Drainage work for mosquito control.	30,000	Preliminary surveys completed.
(1)	Bowling Green (12), Cape Charles (53), Chincoteague (44), Gloucester (35), Gordonville (9), Madison (6), Marshall (2), Mineral (11), Onancock (47), Parksley (45), Reedville (19), Sperryville (4), and Washington (3), Va.: Sanitary sewers and sewage treatment plants.	390,000	Preliminary report made.
(1)	Urbanna (28) and West Point (34), Va.: Sewage-treatment plants.	40,000	Do.
8	Orange, Va.: Sewage-treatment plant for complete treatment.	20,000	Do.
(1)	Accomac (49) and Eastville (52), Va.: Water supply, wells, distributing systems.	55,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Belle Haven (51), Flint Hill (1), Greenbackville (42), Horntown (43), Lancaster (23), Mathews (38), Messick (41), Port Richmond (32), Remington (5), Tangier (21), Wachapreague (50), and Warsaw (16), Va.: Waterworks systems.	\$639,000	No plans prepared.
(1)	Flint Hill (1), Lancaster (23), Remington (5), and Warsaw (16), Va.: Sanitary sewers and sewage-treatment plants.	100,000	Do.
(1)	Accomac (49), Belle Haven (51), Eastville (52), Greenbackville (42), Horntown (43), Messick (41), and Tangier (21), Va.: Sanitary sewers and sewage-disposal plants.	436,000	
46	Accomac County, Va.: General drainage throughout county.	225,000	Preliminary survey completed.
38	Mathews, Va.: Sewer system.	150,000	No plans made.

¹ Map key number shown following community name.



4. JAMES, ROANOKE, AND CHOWAN RIVERS

Immediate water needs in the basins of the James, Roanoke, and Chowan Rivers are principally those of modern waste-disposal systems and municipal water supplies. Certain minor navigation works are recommended to extend the generally adequate facilities now available. Drainage for mosquito control involves other projects deserving of early construction. Additional sewer systems, treatment plants, and water supplies are listed for future action; these include an important group project for communities in the Norfolk area to abate pollution that is now damaging valuable oyster beds. State legislation is suggested to implement the control of pollution from both sewage and industrial wastes. There is a considerable amount of potential water power in the streams whose possibilities should be studied in connection with the resources and requirements of this and adjoining areas. Investigations are also recommended to collect information needed for future guidance on stream pollution, on drainage for land use and mosquito control, and on surface and underground water supplies.

General Description

The James and Roanoke River systems rise in the great valley of Virginia and flow in a general southeasterly direction through Blue Ridge and the Piedmont Plateau to the Coastal Plain, the James emptying into the lower end of Chesapeake Bay at Newport News, Va., and the Roanoke into Albemarle Sound in North Carolina. The Chowan River drains an area mainly in the Coastal plain between the James and Roanoke. The total watershed area, three-quarters as large as Virginia, is about 31,000 square miles; 20,000 in Virginia, a few hundred in West Virginia at the headwaters of the James, and the remainder in North Carolina. Important tributaries of the James are the Cow Pasture and Jackson Rivers, joining to form the James in the Allegheny Mountains near Clifton Forge, Va.; the Rivanna River and North River, above Richmond; the Chickahominy and Appomattox Rivers, below Richmond. Included with the Roanoke and Chowan Basins in this report are the drainage areas of the Meherrin, Nottaway, and Blackwater Rivers in Virginia, and a considerable coastal area north and south of Albemarle Sound.

In the James River Basin about 70 percent of the area is woodland of some sort and the remainder is cultivated or pasture land. In the Roanoke Basin the ratio is roughly reversed. The average annual temperature of the region is about 56°; minimum tem-

peratures in the mountains range as low as 15° below zero. The average annual rainfall ranges from 40 to 50 inches.

The population of the area is 1,493,000 of which 45 percent is urban. The average density of population is 48 per square mile. There are eight cities over 20,000 in population, of which the largest three are Richmond, Norfolk, and Roanoke. The chief agricultural crops are tobacco, cotton, peanuts, potatoes, corn, grains, and fruits. Fishing is of commercial importance in the coastal section. Manufactures include textiles, pulp, paper, rayon, cast-iron pipe, and building materials.

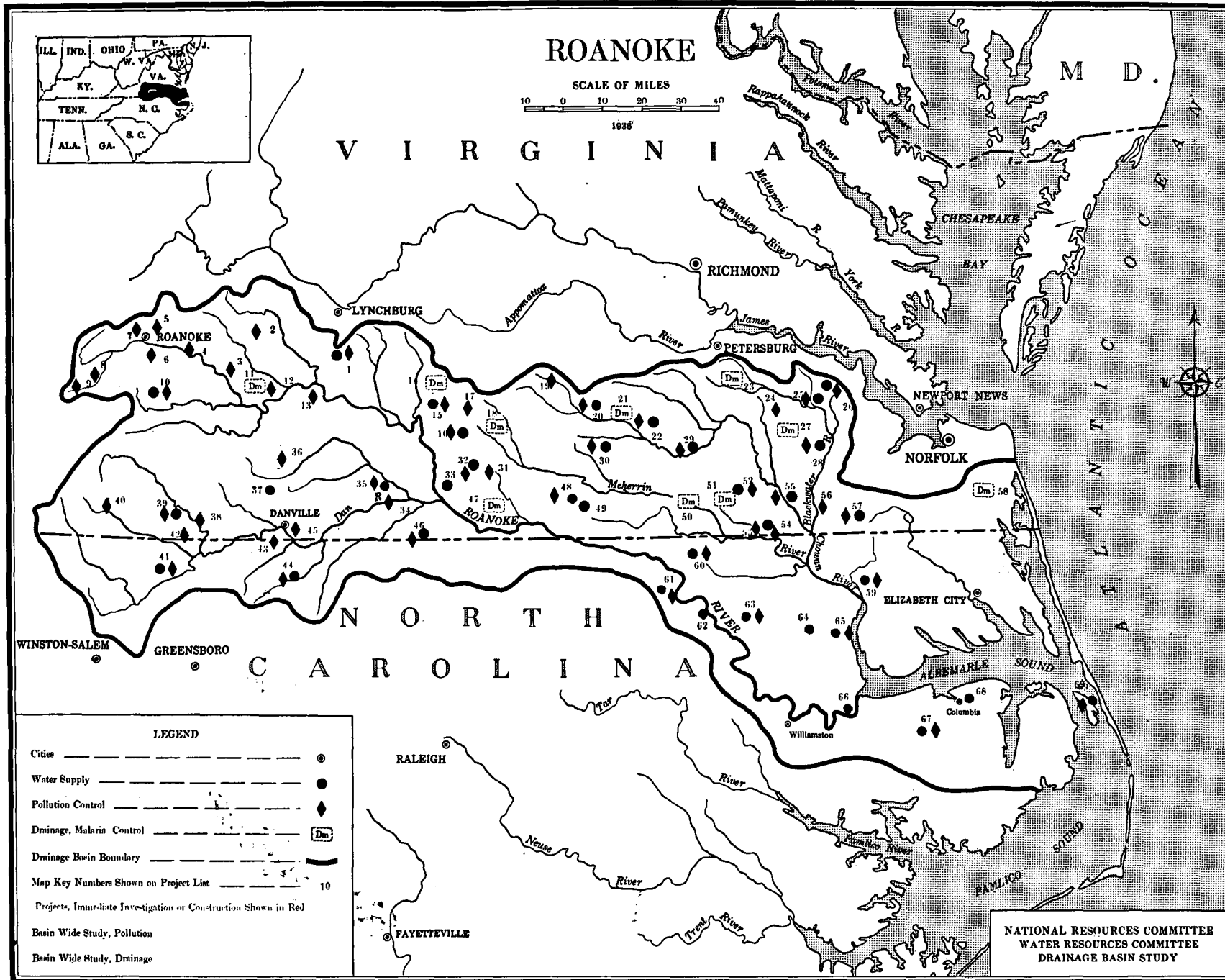
The intracoastal waterway follows the shore line of the region along its entire ocean front. The improvement of the James River below Richmond for navigation has been in progress intermittently for a century, and the present project is nearing completion. Various other streams, including the Roanoke, have been improved adequately for present commerce.

Recommended Plan

Pollution.—The principal cities of the area have sanitary sewer systems but there are no treatment plants and many important towns are completely without sewerage facilities. Studies should be made of measures to correct existing conditions, and also of legislation to compel such correction and provide for control in the future. Many of the industries not only require more water of satisfactory quality, but produce wastes that adversely affect the use of the water in the rivers below. For a special problem of pollution in the tidal waters of the Norfolk area, neglected for years until an embargo was placed on the shipment of oysters from certain beds, preliminary studies have been made but a comprehensive plan of sewers and treatment plants has not been worked out and a method of financing has not been adopted; construction should proceed as soon as practicable.

Water supplies have ordinarily been ample to serve the cities and larger towns. Many smaller communities, however, are either without any public supply or require additional facilities. A study should be made of the quality of surface supplies and of means of purification to make them suitable for domestic and industrial use.

In the Appalachian province there are many large springs whose waters are potable but chemically unsatisfactory. In the Piedmont province there are both



shallow and deep wells, but in most cases their yield is not large. Except in the Coastal Plain, reliable information as to satisfactory underground water supplies is meager and a detailed survey is needed, particularly for the benefit of the smaller communities that are without public systems and cannot afford treatment plants for surface supplies. Information on surface supplies is also inadequate.

Drainage.—Several minor projects are recommended for mosquito control. A research project is recommended as a basis for a comprehensive drainage plan, especially for the lower Coastal Plain. This would take account of the prevalence and distribution of malaria. Consideration also should be given to the problem of malaria resulting from improper design and operation of various water projects.

Flood control.—Damages due to floods are far less than the estimated cost of any conceivable storage projects on the main rivers. The channel cut-offs for navigation improvement in the James River below Richmond, however, will act to reduce the annual damage to terminal facilities in that vicinity.

Power.—Seventy-five percent of the total 326,000 kilowatts of installed capacity is in steam-electric plants. The cost of coal is low. Additional supplies of energy will soon be necessary, beyond the extensions to existing plants which are now under way. There are important water-power possibilities in the various streams and especially in the Roanoke. The more favorable sites have been investigated by the Corps of Engineers. The economic aspects of future power development in this region in relation to similar possibilities in other southeastern States should be studied.

James Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Comprehensive study of drainage problems in the basin.....	\$5,000	Cooperative investigation by State and Federal agencies.
	Comprehensive study of stream-pollution problems in the basin.....	10,000	
39	Fort Monroe, Va.: Sewage-treatment plant.....	52,000	Survey completed.
37	Keocoughtan, Va.: Sewage-treatment plant.....	12,000	Survey in progress.
37	Keocoughtan, Va.: Sewage-treatment plant.....	25,000	Do.
38	Hampton Creek and Phoebus Channels, Va.: Dredging to improve navigation.....	88,000	Survey made. Authorized by Congress.
28	Richmond, Va.—James River: Dredging channel above city wharf for navigation.....	29,000	Plans completed.
45	Windsor, Va.: Water-supply system.....	24,000	Plans completed.
11	Albemarle County, Va.: Sewer system and sewage-treatment plant for Fry Springs Sanitary District.....	84,000	Preliminary plans made.
39	Fort Monroe, Va.: Improvement of Big Bethel water supply.....	145,000	Preliminary sketches made.
21	Campbell County, Va.: Partial sewage-treatment plant for Brookville Sanitary District.....	95,000	Preliminary plans made.
30	Charles City, Chesterfield, Dinwiddie (Petersburg) Goochland, Henrico (Highland Springs), Hanover (Ashland), James City (Williamsburg), Norfolk, Princess Anne, Prince Edward (Farmville), Powhatan Counties, Va.: Drainage projects for mosquito control.....	126,000	Do.
33	James River, Va.: Dredging 25-foot channel from Hopewell to Richmond.....	1,186,000	Cost given is for next 2 years. Additional needed to complete \$61,000.
42	Hampton, Newport News, Norfolk, Portsmouth, Phoebus, South Norfolk, Va.: Combined project for trunk-sewer and sewage treatment.....	8,000,000	Preliminary survey made.
43	Virginia Beach, Va.: Sewage-treatment plant.....	150,000	Preliminary plans made.
GROUP B—FOR DEFERRED CONSTRUCTION			
24	Amelia, Cumberland, and Prince Edward Counties, Va.: Flood-protection project on creeks at the following locations: Farmville, Little Guinea, Sandy, and Flat Creeks.....	\$6,000	Plans completed.
41	Lafayette River, Va.: Dredging yacht basin.....	16,000	Survey made.
36	Menchville, Va.: Dredging Deep Creek for navigation.....	34,000	Survey completed.
(1)	Amelia (27) and Appomattox (22), Va.: Water-supply systems.....	58,000	No plans made.
(1)	Amelia (27), Amherst (16), Appomattox (22), Burkeville (25), Buchanan (20), Chester (31), Charlottesville (2), Claremont (34), Clifton Forge (8), Colonial Heights (32), Crozet (3), Craigsville (4), Fincastle (19), Glasgow (17), Goshen (6), Highland Springs (29), Iron Gate (10), Lovingson (15), Millboro (7), New Castle (18), Smithfield (35), Stanardsville (1), and Windsor (45), Va.: Sewer systems and sewage-treatment plants.....	750,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Brownsburg (5), Columbia (13), Dillwyn (14), Fincastle (19), Iron Gate (10), Jetersville (26), Palmyra (12), Pamplin (23), and Selma (8), Va.: Water-supply systems.....	\$261,000	No plans.
(1)	Brownsburg (5), Columbia (13), Dillwyn (14), Jetersville (26), Palmyra (12), Pamplin (23), Selma (8), and Suffolk (44), Va.: Sewer systems and sewage-treatment plants.....	195,000	Do.

¹ Map key number shown following community name.

Roanoke Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OF CONSTRUCTION			
	Comprehensive study of stream pollution by municipal and industrial wastes in the basin.....	\$15,000	Cooperative investigation by State and Federal agencies.
	Comprehensive study of drainage problems in the basin.....	14,000	Do.
65	Colerain, N. C.: Water-supply system, sewers, and sewage treatment plant.....	31,000	Plans completed.
67	Creswell, N. C.: Water-supply and sewer systems.....	47,000	Do.
69	Manteo, N. C.: Water and sewer systems.....	73,000	Do.
44	Yanceyville, N. C.: Water-supply system, sewers, and sewage-treatment plant.....	64,000	Preliminary plans made.
63	Rich Square, N. C.: Water-supply system, sewers, and sewage-treatment plant.....	104,000	Do.
60	Seaboard, N. C.: Water-supply system, sewers, and sewage-treatment plant.....	67,000	Do.
41	Stoneville, N. C.: Water-supply system, sewers, and sewage-treatment plant.....	75,000	Do.
61	Halifax, N. C.: Water-supply system, sewers, and sewage-treatment plant.....	60,000	Do.
66	Plymouth, N. C.: Water-supply system.....	65,000	Do.
59	Gatesville, N. C.: Water-supply system, sewers, and sewage-treatment plant.....	25,000	Do.
68	Columbia, N. C.: Extensions to water-supply system.....	41,000	Do.
62	Winton, N. C.: Water-supply system.....	87,000	Do.
64	Powellsville, N. C.: Water-supply system.....	11,000	Do.
(1)	Bedford (11), Charlotte (14), Dinwiddie (21), Greensville (50), Lunenburg (18), Mecklenburg (47), Prince George (23), Princess Anne (58), Southampton (51), and Sussex (27) Counties, Va.: County-wide drainage projects.	137,000	Do.
5	Roanoke County, Va.: Sewer system for Williamson Road sanitary district.....	271,000	Plans completed.
49	Lacrosse, Va.: Water-supply system.....	38,000	Do.
35	Halifax, Va.: Water-supply system.....	52,000	Do.
15	Charlotte Courthouse, Va.: Sewer system and sewage-treatment plant.....	24,000	Do.
3	Bedford County, Va.: 6 septic tanks and 9 wells for county schools.....	17,000	Do.
24	Waverly, Va.: Sewer system and sewage-treatment plant.....	96,000	Preliminary report ready.
37	Pittsylvania County, Va.: Water supply, 8 wells at county schools.....	6,000	Plans not started.
35	Halifax Courthouse, Va.: Sewer system and sewage-treatment plant.....	19,000	Preliminary report ready.
43	Schoolfield, Va.: Sewer system.....	25,000	Plans not started.
20	Blackstone, Va.: Water supply, sewer system, and sewage-treatment plant.....	125,000	Plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
39	Bassett, Va.: New wells for water supply.....	\$40,000	Preliminary study made.
6	Roanoke, Va.: Sewage-treatment plant.....	250,000	Preliminary investigation made.
(1)	Altavista (13), Bassett (39), Bedford (2), Boykins (53), Boones Mill (10), Cambria (9), Chase City (31), Chatham (36), Crewe (19), Danville (45), Dendron (25), Franklin (56), Iver (28), Keysville (17), Lacrosse (48), Martinsville (38), Salem (7), Shawsville (8), South Boston (34), Stony Creek (29), Stuart (40), Surry (26), Vinton (4), Va.: Sewer systems and sewage-disposal plants.	760,000	Preliminary investigations made.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Alberta (30), Boones Mill (10), Branchville (54), Broadnax (49), Capron (52), Clover (32), Courtland (55), Dendron (25), Drakes Branch (16), Holland (57), Iver (28), McKinney (22), Rustburg (1), Scottsburg (33), Stony Creek (29), Surry (26), Virgilina (46), Va.: Water-supply systems.....	\$520,000	No plans made.
(1)	Alberta (30), Branchville (54), Capron (52), Clover (32), Courtland (55), Drakes Branch (16), Holland (57), Huddleston (12), McKenney (22), Ridgeway (42), Rustburg (1), Virgilina (46), Va.: Sewer system and sewage-treatment plants.	395,000	Do.

¹ Map key numbers shown following community names.

5. CAROLINA COAST

Water supply and sewer systems, treatment of municipal and industrial wastes, abatement of soil erosion, and malaria control are all pressing needs in this region. Long-range plans should include provisions for navigation, flood control, power production, recreation, and conservation of wildlife. Effective planning in all these fields will call for topographic mapping and the collection of basic data, now far from complete.

General Description

The area covers the greater part of North Carolina and South Carolina draining into the Atlantic Ocean east of the Appalachian Divide, from the Roanoke-Albemarle Sound Basin on the north to the Savannah River Basin on the south. The total land area of about 61,000 square miles is roughly equal to 68 percent of the two Carolinas. The population, 4,023,000, is about four-fifths of that of the two Carolinas, with an average density of 66 persons per square mile.

Three distinct sections characterize the topography: The Appalachian Mountain slopes, the Piedmont Plateau, and the Atlantic Coastal Plain.

The Coastal Plain, roughly 100 miles in width and parallel to the sea, is low and almost flat, with nearly three-quarters of its area in forest. Cotton and tobacco are major crops; vegetables are also extensively grown, maturing between the close of Florida production and the beginning of the northern season. The gently rolling Piedmont Plateau, 500 to 1,200 feet above sea level and from 100 to 130 miles wide, is economically the most important section through its rapid industrial and commercial development. It is a center of the southern textile and tobacco manufacturing industries. Other manufactures include furniture, fertilizer, foodstuffs, and clay products. An important electrolytic aluminum plant is situated on the Yadkin. Agricultural products include cotton, tobacco, corn, hay, and forage. There is a considerable dairy industry. The mountain section, less than one-thirtieth of the total area of the region, is a country of narrow valleys and crests that reach altitudes of 3,500 and 4,000 feet. Its use as a summer recreational district is increasing. The forests are still important. There are rich farm lands in the valleys.

The boundaries of these three distinct areas are cut squarely across by the main stream courses, with a well-defined fall line where they reach the Coastal Plain. The principal rivers, and their drainage areas in square miles, are the Tar (4,580), Neuse (5,640),

Cape Fear (8,570), Yadkin-Peedee (16,320), Santee (15,700), and Edisto-Combahee (6,150). The Yadkin-Peedee and the Santee, with headwaters in the mountains, are in part interstate streams and deserve particular consideration in long-range planning for coordinated use of their water resources.

Piedmont streams are characterized by occasional rapids with long intervening pools and favorable sites for storage dams. Underground waters are not abundant, springs are relatively weak, and dry-season flow of the smaller tributaries is relatively low. Most of the concentrations of population are in small tributary basins, where the water problems are largely those arising from deficient stream flow. Much of the land shows the effects of serious erosion under the plow, although the slopes are moderate.

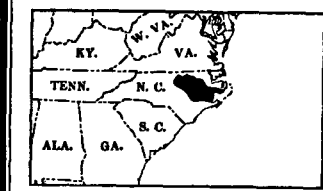
Streams in the Coastal Plain are sluggish, and are generally bordered with extensive well-timbered swampy areas which serve as natural reservoirs to retain the frequent floods. Along the upper coast few and generally shallow inlets cut the narrow sand strip that separates the sea from the shallow inland sounds; to the south there are many small tidal inlets and salt marshes. The sounds support an important fishing and shell-fish industry, and recreational hunting of wildfowl is an economic asset.

There are two principal seaports, Charleston and Wilmington, but river navigation is relatively limited. Parallel to the coast the intracoastal waterway runs the full length of the region, providing a channel for small craft.

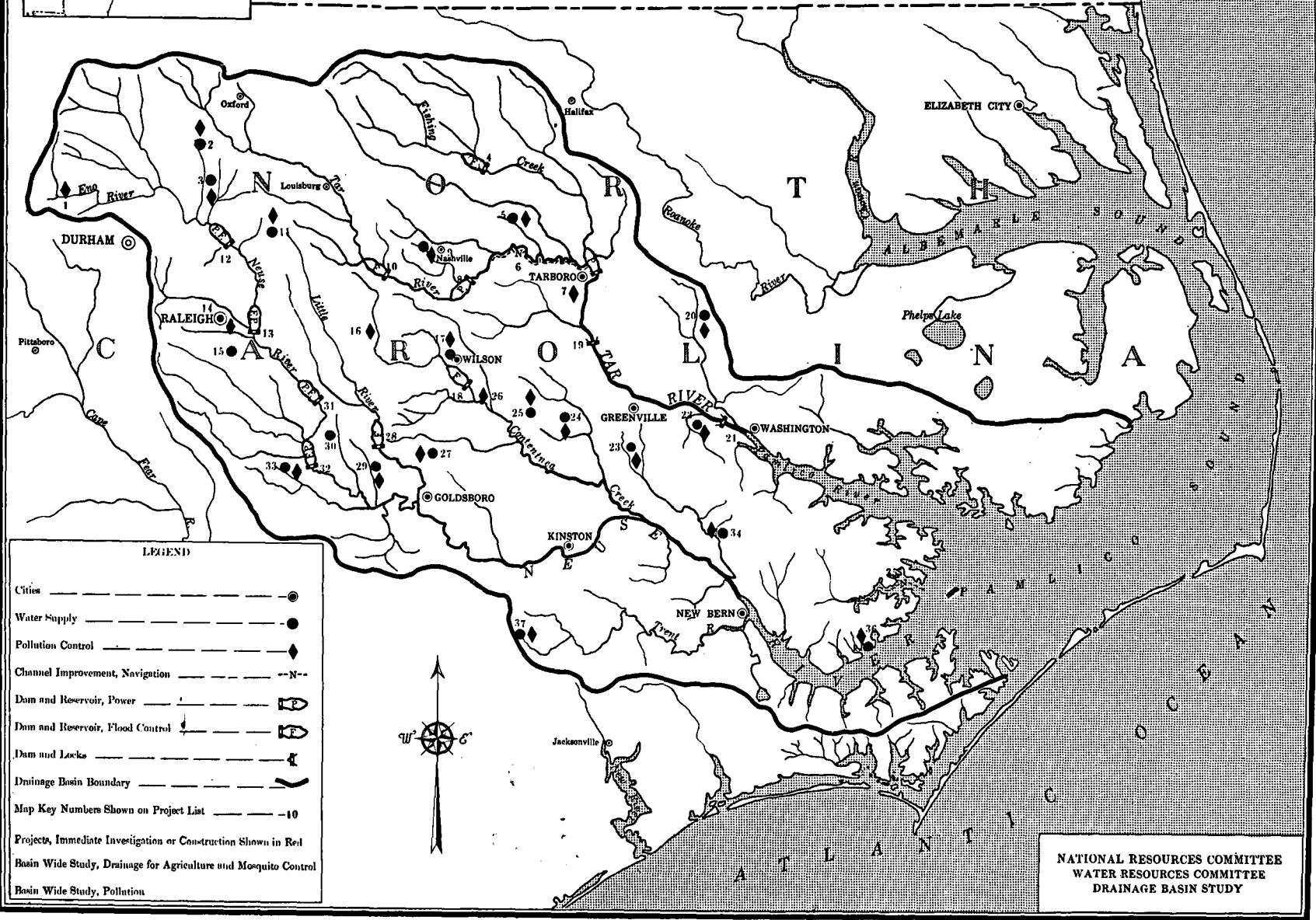
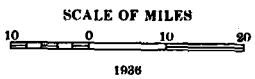
Over the entire area rainfall is ample and well distributed for agricultural purposes. Average annual precipitation is about 47 inches, with the heaviest fall in the mountains. Normally about one-third of the rainfall runs off as stream flow, but the figure is subject to wide variation under unusual conditions. Temperatures are favorable to agriculture, with a moderate range and an average annual record of about 61°.

Recommended Plan

Water-supply and stream-pollution problems are particularly acute in the Piedmont, where the rapid growth of industry and of urban population has overloaded the capacity of many of the present sewage treatment plants and has created pollution problems along many of the streams. 86 plants of this kind are listed for immediate construction and many others should be undertaken in the near future.



TAR-NEUSE



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Channel Improvement, Navigation ———— -N-
- Dam and Reservoir, Power ———— [Dam Symbol]
- Dam and Reservoir, Flood Control ———— [Dam Symbol]
- Dam and Locks ———— [Dam Symbol]
- Drainage Basin Boundary ———— [Thick Line]
- Map Key Numbers Shown on Project List ———— -10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Drainage for Agriculture and Mosquito Control
- Basin Wide Study, Pollution



NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

In the coastal section the water supply is obtained chiefly from underground sources; surface pollution is therefore a less serious problem, except in the contamination of shellfish beds in the vicinity of settlements where sewage treatment is inadequate. Near Beaufort, S. C., the State board of health has found it necessary to forbid the taking of shellfish from certain areas.

The discharge of raw sewage from Orangeburg, S. C., into the Edisto, 50 miles above the intake of the Charleston aqueduct, now under construction, is a special problem. Though the condition does not apparently constitute an immediate or serious hazard to the new water supply, it should be studied to determine what corrective measures may be necessary.

Malaria control through drainage is a problem particularly of the lower Coastal Plain and in certain farming areas of the Piedmont where the water courses have been choked by soil erosion. The incidence of the disease is high and is the cause of a large economic loss.

The South Carolina Board of Health is cooperating with the WPA in a program of malaria-control drainage. The first year's program, covering 30 county-wide projects, is recommended for immediate action. Plans made for other drainage projects, including a number in North Carolina, have been listed for later consideration because they have not yet been studied sufficiently. There are a number of old drainage systems which have lost their usefulness through lack of proper maintenance; some of these should perhaps be restored, others abandoned. What is needed at present is a thorough study of the malaria-control problem and the preparation of a comprehensive plan in accordance with the best modern practice. Consideration also should be given to the problem of preventing malaria resulting from improper design and operation of water projects.

Soil erosion is of serious importance in this region. The Santee, the Yadkin-Peedee, and the Cape Fear Basins are three of the seven along the Atlantic coast listed by the Soil Conservation Service of the Department of Agriculture as presenting the most urgent erosion problems. The trouble is most acute in the rolling, easily eroded lands of the Piedmont, and is found to a lesser extent in the mountains. In the Santee Basin it is estimated that 85 percent of the area has lost from 4 to 24 inches of topsoil, and that 11,000 square miles are in need of immediate remedial work.

The Soil Conservation Service has established a number of demonstration farms, as a means of illustrating to the farmers of the region the benefits of proper control methods. The economic health of the area can be preserved only by a widespread conservation program, involving a general reorganization of

land use. This must be brought about by education of the landowners. The work of the Soil Conservation Service should therefore be extended as rapidly as possible.

Navigation facilities are, for the most part, ample for present needs. In addition to the seaports at Wilmington and Charleston, deepwater facilities have recently been provided at Morehead City, N. C. The Santee-Cooper navigation project involves power development and is discussed below under hydroelectric power. Among navigation projects listed are a minor channel dredging operation on Smith Creek, and another on the Ashley River near Charleston.

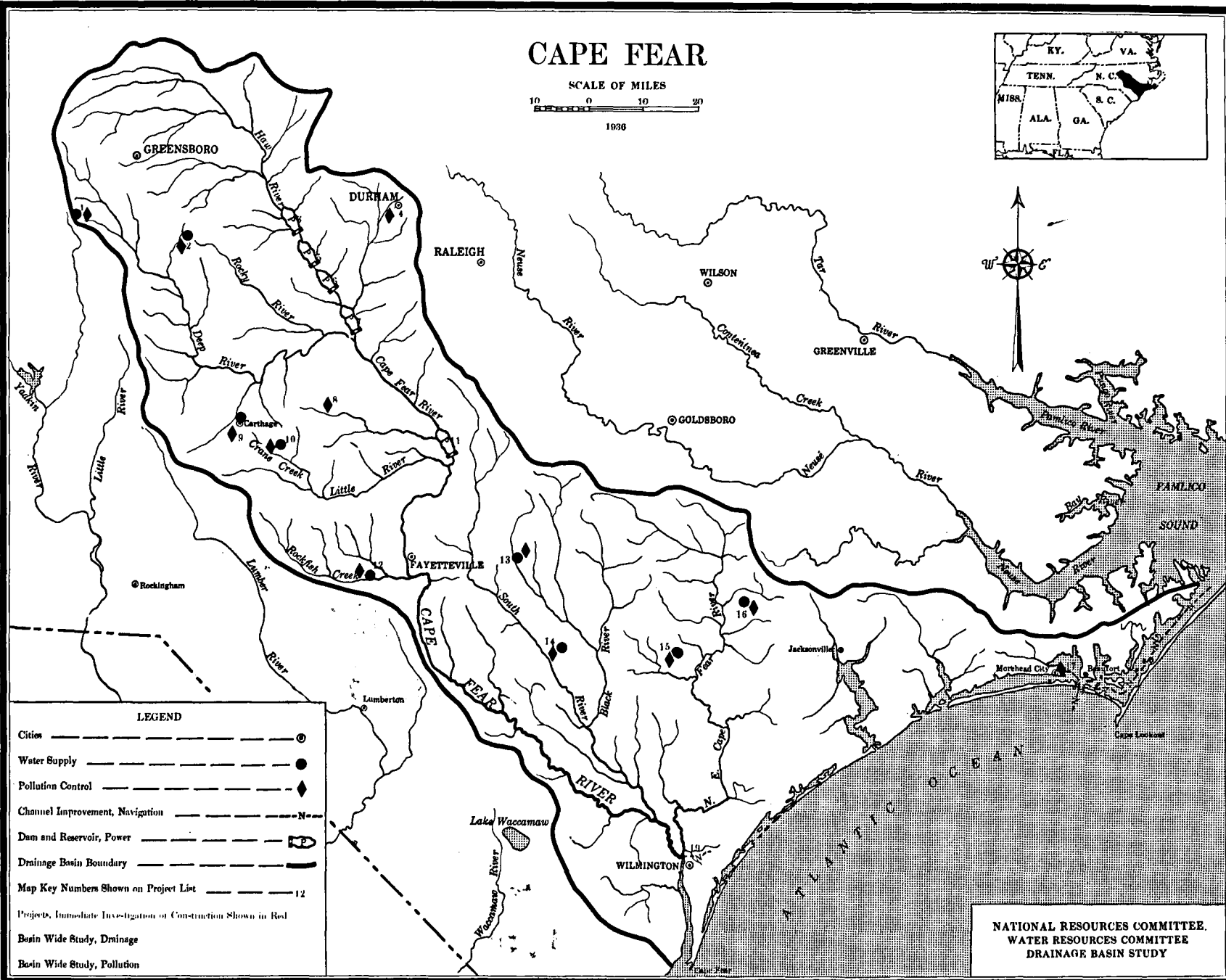
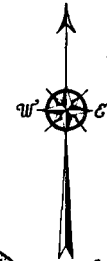
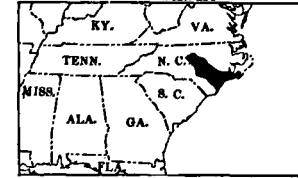
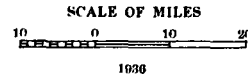
Flood control is not a pressing question in this region for the paradoxical reason that floods are so frequent, especially in the timbered bottom lands of the coastal section, as to discourage land development in the affected areas. One meritorious project to protect public and private property in the Neuse Valley is recommended for later construction. Local protective works may become necessary in the future, particularly in the industrial Piedmont Belt, but none appear economically justified for immediate construction.

Hydroelectric power development is already advanced, chiefly along the Santee and the Yadkin-Peedee. The Santee has 47 plants with 875,000 kilowatts of installed capacity—80 percent of the water-produced power in the two basins. The Yadkin-Peedee has 11 plants with 226,100 kilowatts installed capacity. A network of transmission lines covers the region, interconnecting with neighboring systems in Virginia, Tennessee, and Georgia.

Studies have been made of nine additional developments possible on the Santee, with a total capacity of 300,760 kilowatts, and of eight others on the Yadkin-Peedee, aggregating 237,345 kilowatts. There are other potential developments on these and other streams. Construction of most of them must await the increased demand for power that would accompany further general development of the area.

The largest project previously approved for construction is the Santee-Cooper development, involving 185,000 kilowatts of power, combined with flood-control and navigation improvement. The plan includes the diversion of water from the Santee to the Cooper River, providing a navigable waterway that would reduce the water route between Charleston and Columbia from 238 miles to 145 miles. An initial allotment of \$6,000,000 has been made by the Public Works Administration for this project, the total estimated cost of which is \$37,500,000, but the work is held up at present by litigation. No recommendation is made on this project since it has already been approved by the President.

CAPE FEAR



LEGEND

- Cities ———— ○ ————
- Water Supply ———— ● ————
- Pollution Control ———— ◆ ————
- Channel Improvement, Navigation ———— N ————
- Dam and Reservoir, Power ———— [Dam Symbol] ————
- Drainage Basin Boundary ———— [Thick Line] ————
- Map Key Numbers Shown on Project List ———— 12 ————
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Drainage
- Basin Wide Study, Pollution

NATIONAL RESOURCES COMMITTEE.
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Greenwood County, S. C., has obtained an allotment from the Public Works Administration for the development of 8,600 kilowatts on the Saluda River, a tributary of the Santee. This project is also tied up by litigation.

Recreation and wildlife conservation are important in this region, but are reasonably well provided for, and no new work is proposed for immediate action. The Resettlement Administration has several areas now under development. The State of South Carolina has been offered an 8,000-acre tract in Beaufort County for use as a wildlife sanctuary; the development of this tract at an estimated cost of \$200,000 is listed for the indeterminate future.

Basic data are seriously lacking, a fact which handicaps the preparation of any comprehensive plan for

dealing with stream pollution and with the other problems above discussed. There are adequate flow records for but few of the streams. Knowledge of underground water supplies is scanty. Steps should be taken at once to gather such data by establishing stream-gaging stations and facilities for the study of quantity and quality of under-ground water reserves.

There is needed also a comprehensive survey of the sources, character, and degree of pollution of the various streams, including as an important factor the effect of eroded soil upon the quality of the water. This need is particularly urgent in the industrial Piedmont. In addition to the special studies already noted, the topographic mapping of both North Carolina and South Carolina, now far from complete, should be carried to completion as rapidly as possible.

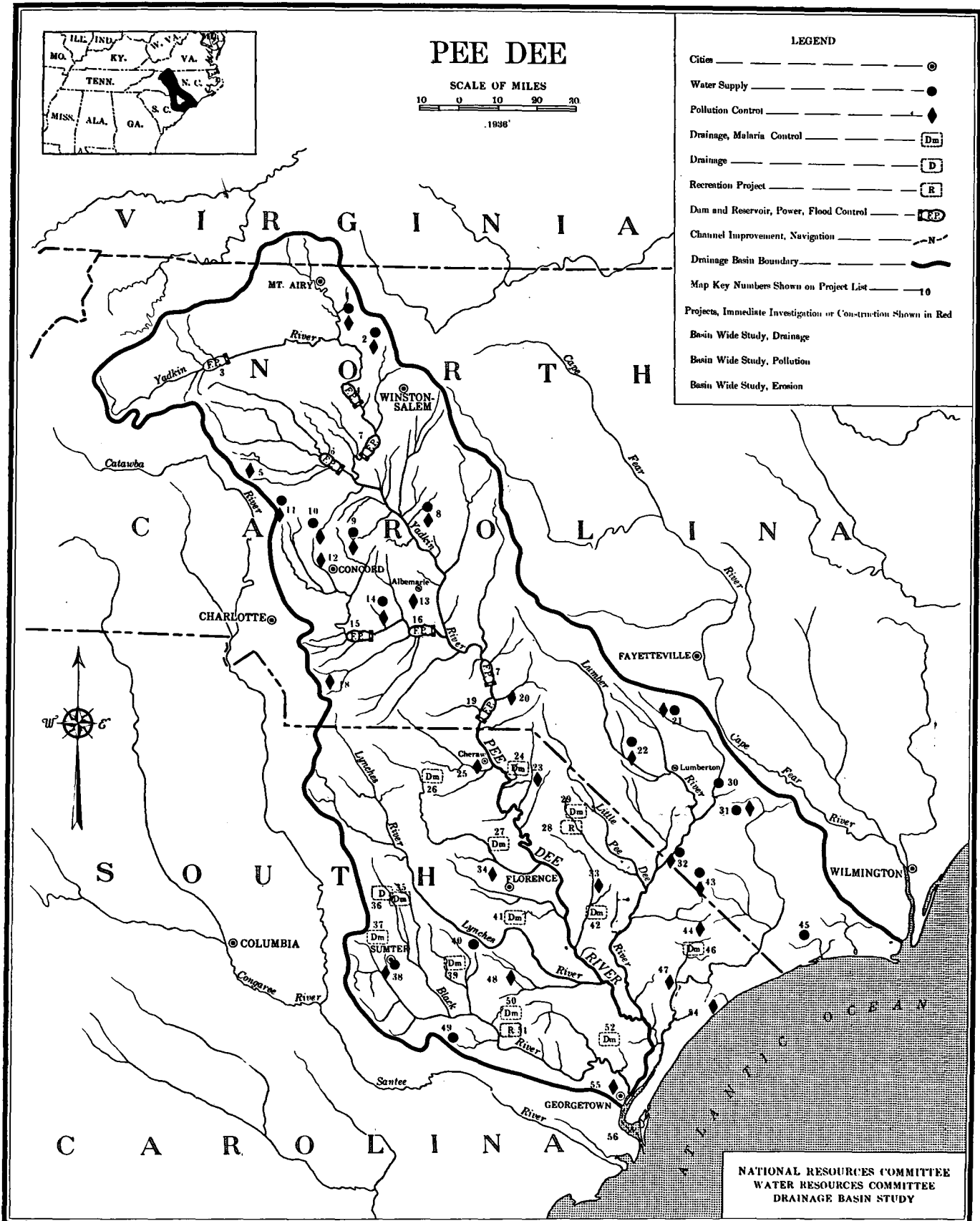
Tar-Neuse Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Comprehensive study of drainage problems, both for land use and mosquito control.....	\$5,000	Cooperative investigation by State and Federal agencies.
(1)	Comprehensive study of stream pollution by municipal and industrial wastes.....	8,000	Do.
	Battleboro (5), Creedmoor (3), Everett (20), Farmville (24), Four Oaks (33), Grimesland (22), Nashville (9), Oriental (36), Pikeville (27), Pick Hill (37), Princeton (29), Stem (2), Vanceboro (34), Walstonburg (25), Winterville (23) and Youngsville (11), N. C.: Water-supply and sewer systems.	966,000	
7	Tarboro, N. C.: Sewage treatment.....	245,000	Preliminary plans prepared.
1	Hillsboro, N. C.: Sewage treatment.....	96,000	
14	Raleigh, N. C.: Sewage treatment.....	790,000	Do.
17	Wilson, N. C.: Water-supply and sewer system.....	998,000	Do.
16	Middlesex, N. C.: Sewer system.....	31,000	
30	Selma, N. C.: Water-supply system.....	74,000	Do.
15	Garner, N. C.: Water-supply system.....	35,000	
26	Stantonsburg, N. C.: Sewer system.....	40,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
6	Tarboro to Rocky Mount, N. C.: Cleaning and dredging of Tar River Channel for 39 miles.....	\$83,000	Plans and surveys made.
35	Bayboro, N. C.: Cleaning and improving Bay River Channel for navigation.....	9,000	Surveys completed.
31	Wilson Mills, N. C.: Flood control on Neuse River.....	1,460,000	Preliminary surveys and estimates prepared.
12	Falls, N. C.: Flood control on Neuse River.....	1,332,000	Do.
28	Baker's Mill, N. C.: Flood control on Little River.....	873,000	Do.
18	Wiggin's Mill, N. C.: Flood control on Contentnea Creek.....	625,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
4	Fishing Creek near Meltons Bridge, N. C.: Storage dam and reservoir for flood control.....	\$2,025,000	Preliminary surveys and estimates prepared.
10	Webbs Bridge, near Spring Hope, N. C.: Storage dam and reservoir on Tar River for flood control.....	3,234,000	Do.
8	Sapony Creek, N. C.: Power dam and reservoir on Tar River for hydroelectric power.....	3,052,000	Do.
7	Tarboro, N. C.: Power dam and reservoir on Tar River for hydroelectric power.....	1,928,000	Do.
19	Pillsboro Landing, N. C.: Lock and dam for navigation on Tar River.....	449,000	Do.
21	Yankee Fall Landing, N. C.: Lock and dam for navigation on Tar River.....	666,000	Do.
31	Wilson Mills, N. C.: Combined power and flood-control reservoir and plant on Neuse River.....	1,542,000	Additional cost required for power installation at flood control project listed in Group B.
32	Smithfield, N. C.: Combined power and flood-control reservoir and plant on Neuse River.....	2,775,000	Preliminary surveys and estimates prepared.
12	Falls, N. C.: Combined power and flood-control reservoir and plant on Neuse River.....	1,227,000	Additional cost required for power installation at flood control project listed in Group B.
13	Milburnie, N. C.: Combined power and flood-control reservoir and plant on Neuse River.....	2,247,000	Do.

Cape Fear Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Comprehensive study of drainage problem.....	\$4,000	All interested State agencies should cooperate.
10	Comprehensive study of stream pollution caused by municipal and industrial wastes.....	5,000	Do.
16	Cameron, N. C.: Water supply and sewer system.....	27,000	
1	Beulsville, N. C.: Water supply and sewer system.....	33,000	
1	Archdale and Trinity, N. C.: Water supply systems and sewage-treatment plant.....	173,000	
9	Carthage, N. C.: Water supply system and sewage-treatment plant.....	58,000	Preliminary plans and estimates prepared.
13	Salemberg, N. C.: Water supply system and sewage-treatment plant.....	40,000	
2	Liberty, N. C.: Waterworks extensions and sewage-treatment plant.....	18,000	
17	Morehead City, N. C.: Sewage-treatment plant.....	231,000	Do.

1 Map key number shown following community name.



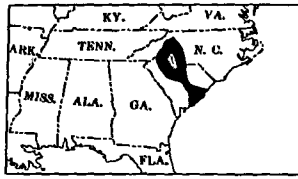
Cape Fear Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
8	Jonesboro, N. C.: Sewage-treatment plant.....	\$51,000	Preliminary plans and estimates prepared. Survey completed. Report and estimates in preparation.
12	Hope Mills, N. C.: Water supply system and sewage-treatment plant.....	80,000	
14	Garland, N. C.: Water supply system and sewage-treatment plant.....	33,000	
15	Rose Hill, N. C.: Water supply system and sewage-treatment plant.....	67,000	
19	Smith's Creek, N. C.: Dredging channel.....	11,000	
4	Durham, N. C.: Sewage treatment works extension.....	350,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
18	Pamlico Sound, N. C., to Beaufort, N. C.: Dredging channel to Atlantic, North Carolina.....	\$13,000	Surveys completed.
17	Morehead City, N. C.: Harbor, inlet jetties.....	1,000,000	Surveys completed; construction delayed pending further observations of inlet scour.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
3	Hendale, N. C.: Hydroelectric power on Haw River.....	\$5,782,000	Preliminary surveys and estimates made.
5	Bysum, N. C.: Hydroelectric power on Haw River.....	4,984,000	Do.
6	Moore's Hill, N. C.: Hydroelectric power on Haw River.....	2,957,000	Do.
7	New Hope, N. C.: Hydroelectric power on Haw River.....	7,563,000	Do.
11	Smiley Falls, N. C.: Hydroelectric power on Cape Fear River.....	2,558,000	Do.

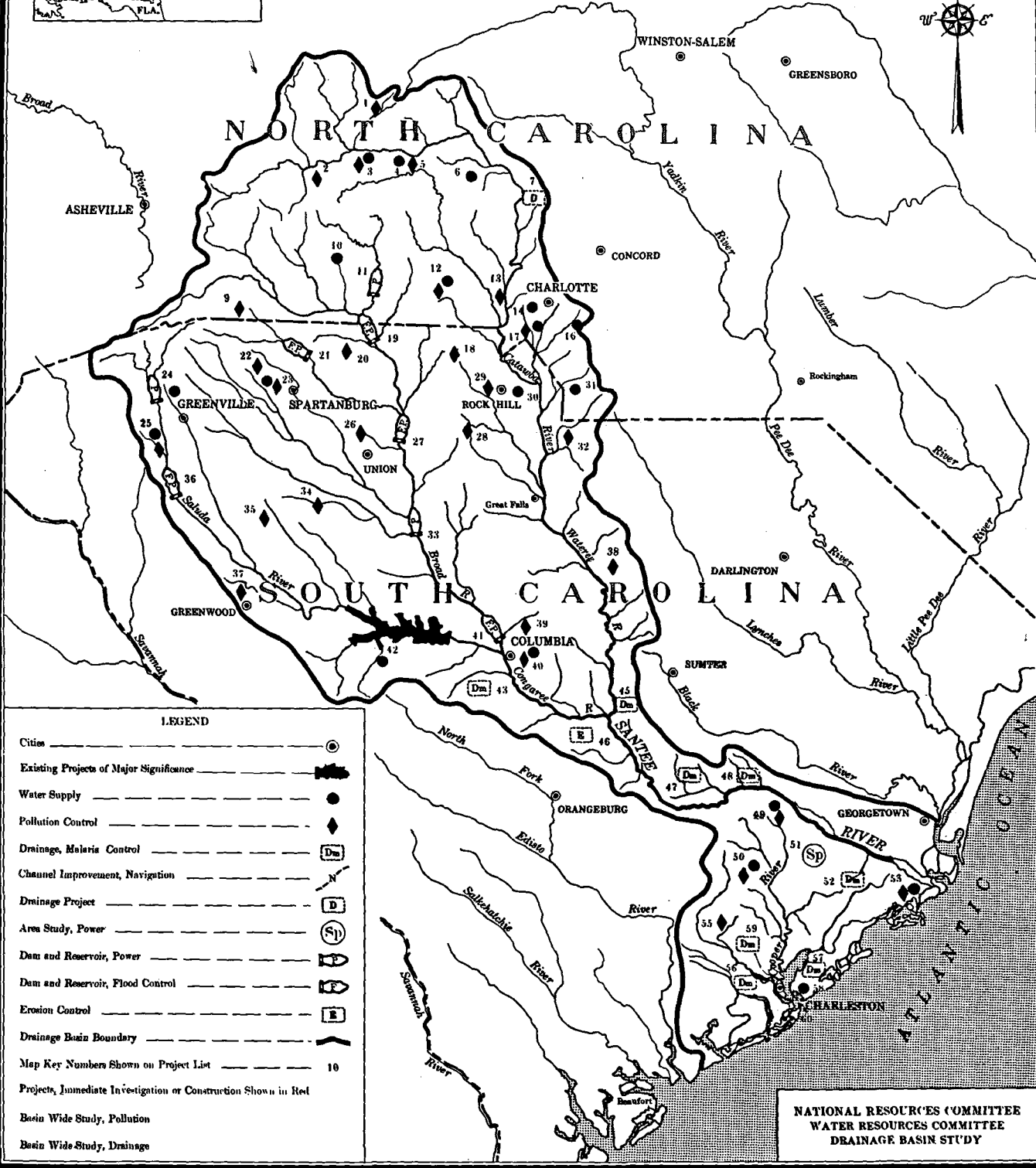
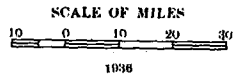
Peedee Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
.....	Comprehensive study of drainage problems in the basin.....	\$12,000	Cooperative investigation by State and Federal Agencies.
.....	Comprehensive study of stream pollution by municipal and industrial wastes and soil erosion in the basin.....	18,000	Do.
38	Sumter, S. C.: Sewage-treatment plant and extensions to water-supply and sewer systems.....	96,000	Preliminary plans completed.
20	Rockingham, N. C.: Sewage-treatment plant.....	31,000	Preliminary plans made.
12	Concord, N. C.: Sewage-treatment plant.....	195,000	Preliminary plans completed.
5	Statesville, N. C.: Sewage-treatment plant and extensions to sewer system.....	293,000	
11	Moore'sville, N. C.: Extensions to water-supply and sewer systems; sewage-treatment plant enlargement.....	127,000	
44	Loris, S. C.: Sewer system and sewage-treatment plant.....	58,000	Do.
34	Darlington, S. C.: Sewage-treatment plant.....	75,000	Do.
18	Benton Heights, N. C.: Sewer system and sewage-treatment plant.....	36,000	Preliminary plans ready.
13	Albermarle, N. C.: Sewage-treatment plant and incinerator.....	280,000	
30	Bladenboro, N. C.: Water-supply system.....	38,000	Preliminary plans completed.
43	Tabor City, N. C.: Sewer system with treatment plant; water-supply extension.....	104,000	
31	Clarkton, N. C.: Water-supply and sewer systems; sewage-treatment plant.....	40,000	Preliminary plans made.
22	Pembroke, N. C.: Water-supply and sewer systems; sewage-treatment plant.....	57,000	
1	Pilot Mountain, N. C.: Water-supply and sewer system; Imhoff tank.....	127,000	Do.
9	Rockwell, N. C.: Water-supply and sewer systems; sewage-treatment plant.....	80,000	Do.
2	Rural Hall, N. C.: Water-supply and sewer systems; sewage-treatment plant.....	73,000	Do.
21	Parkton, N. C.: Water-supply and sewer system; treatment plant.....	49,000	Do.
10	Landis, N. C.: Water-supply and sewer systems; sewage-treatment plant.....	176,000	Do.
14	Oakboro, N. C.: Water-supply and sewer systems; septic tanks.....	60,000	
8	Denton, N. C.: Water-supply and sewer systems; sewage-treatment plant.....	86,000	Do.
45	Shalotte, N. C.: Water-supply system.....	37,000	Do.
32	Fair Bluff, N. C.: Water-supply and sewer system.....	76,000	Preliminary plans completed.
(1)	Chesterfield (26), Clarendon (39), Darlington (27), Dillon (29), Florence (41), Georgetown (52), Horry (46), Lee (35), Marion (42), Marlboro (24), Sumter (37), and Williamsburg (50) Counties, S. C.: Drainage for malarial control.	280,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
54	Myrtle Beach, S. C.: Sewer system and sewage-treatment plant.....	\$200,000	Preliminary plans completed.
48	Lake City, S. C.: Sewage-treatment plant.....	40,000	Do.
40	Olanta, S. C.: Water-supply system.....	29,000	Do.
49	Greeleyville, S. C.: Water-supply system.....	31,000	Do.
36	Lee County—Ashwood rural community, S. C.: Drainage.....	29,000	Do.
56	Georgetown County, S. C.: Dredging navigable channel of Winyah Bay.....	136,000	Plans completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
25	Cheraw, S. C.: Sewage-treatment plant; extensions to sewer system.....	\$75,000	No plans. Recommend further study.
33	Marion, S. C.: Sewage-treatment plant; extensions to sewer system.....	75,000	Do.
55	Georgetown, S. C.: Sewage-treatment plant; extensions to sewer system.....	100,000	Do.
47	Conroy, S. C.: Sludge-treatment plant; extensions to sewer system.....	50,000	Do.
23	Bennettsville, S. C.: Sewage-treatment plant; extensions to sewer system.....	40,000	Do.
23	Dillon County Park, 2 miles west of Dillon, S. C.: Recreational park facilities.....	14,000	Preliminary plans completed.
28	Dillon County Park, 2 miles west of Dillon, S. C.: Recreational park facilities.....	75,000	Preliminary plans complete. Further study needed.
51	Williamsburg County Recreation Park, Kingstree, S. C.: Recreational park facilities.....	75,000	Preliminary plans ready.
16	Stanly County, N. C.: Water-power development, Crumps Ford site on Rocky River to extend rural electrification.....	3,600,000	
(1)	Water-power and flood-control projects as follows: North Wilkesboro (3), Styers (4), Junction (7), Coolemees (6), Loves Ford (15), Greater Blewett Fall (17), Morven (19), N. C.	35,161,000	

¹ Map key number shown following community name.



SANTEE



LEGEND

- Cities
- Existing Projects of Major Significance
- Water Supply
- Pollution Control
- Drainage, Malaria Control
- Channel Improvement, Navigation
- Drainage Project
- Area Study, Power
- Dam and Reservoir, Power
- Dam and Reservoir, Flood Control
- Erosion Control
- Drainage Basin Boundary
- Map Key Numbers Shown on Project List
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution
- Basin Wide Study, Drainage

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

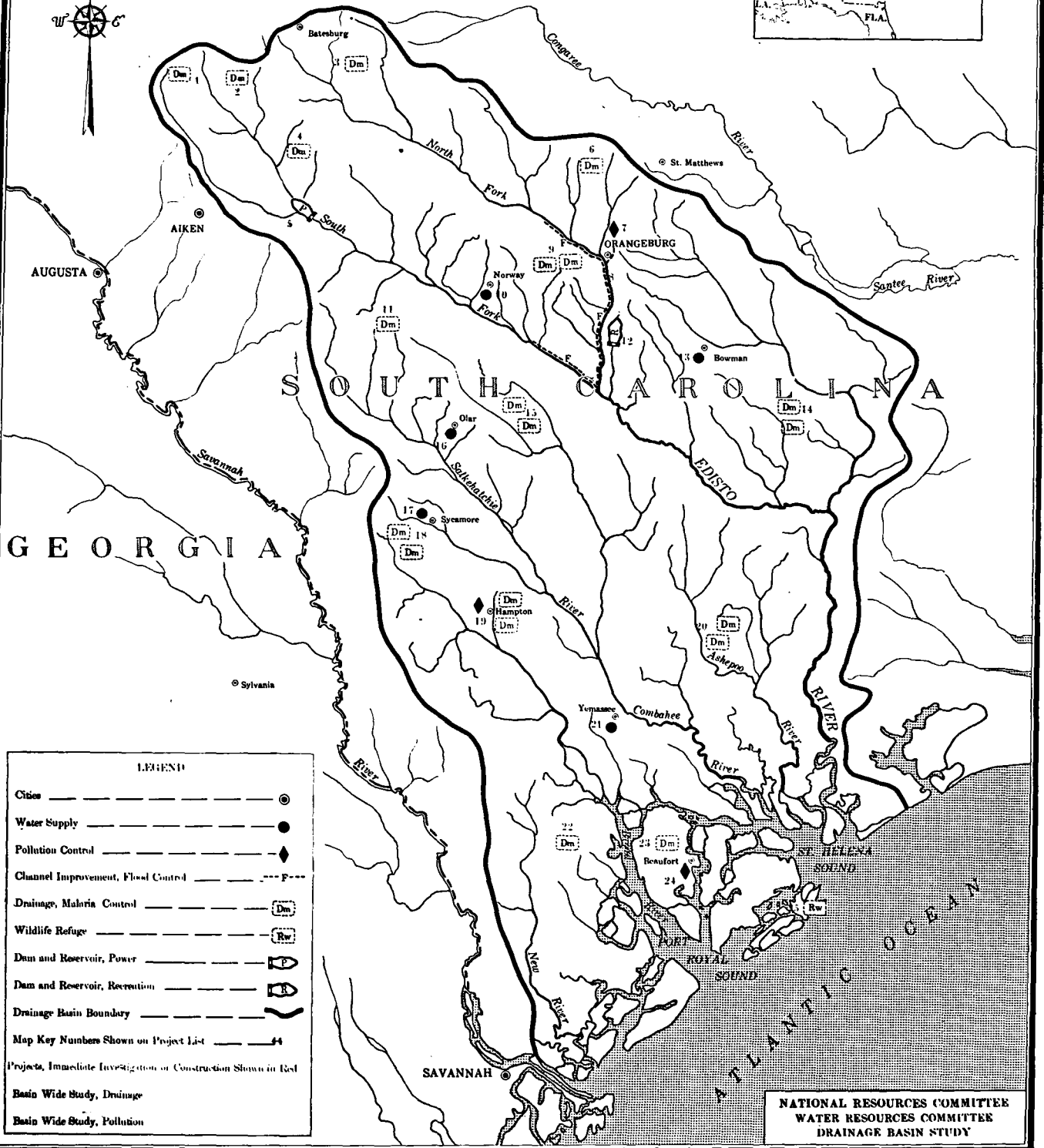
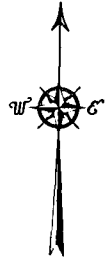
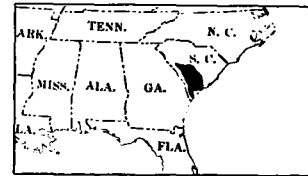
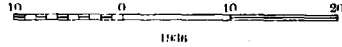
Santee Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	A comprehensive study of stream pollution by municipal and industrial wastes in the basin.....	\$32,000	Cooperative investigation by State and Federal Agencies.
	A comprehensive study of drainage problems in the basin.....	16,000	Do.
3	Valdese, N. C.: Water-supply and sewer systems.....	108,000	Preliminary plans made.
2	Morganton, N. C.: Sewage-treatment plant.....	120,000	Preliminary plans completed.
42	Leesville, S. C.: Water-supply system.....	51,000	
1	Lenoir, N. C.: Sewage-treatment plant.....	251,000	
9	Tryon, N. C.: Sewage-treatment plant.....	100,000	Preliminary plans ready.
55	Summerville, S. C.: Sewer system and sewage-treatment plant.....	113,000	Preliminary plans completed.
5	Hickory, N. C.: Sewage-treatment plant.....	216,000	
23	Tucahau, S. C.: Water-supply and sewer systems.....	82,000	Do.
17	Pineville, N. C.: Water-supply and sewer systems.....	62,000	Do.
49	St. Stephen, S. C.: Water-supply and sewer system, and sewage-treatment plant.....	53,000	Do.
50	Moncks Corner, S. C.: Water-supply and sewer system, and sewage-treatment plant.....	69,000	Do.
12	Kings Mountain, N. C.: Extensions to water-supply and sewer system; new sewage-treatment plant.....	96,000	
58	Sullivan Island, S. C.: Water-supply system.....	133,000	Do.
16	Matthews, N. C.: Water-supply system.....	36,000	
6	Claremont, N. C.: Water-supply system.....	38,000	
10	Ellenboro, N. C.: Water-supply system.....	36,000	
4	Longview, N. C.: Water-supply system.....	80,000	Preliminary plans ready.
24	Greenville, S. C.: Water-supply system (Westville water and sewer subdistrict).....	21,000	Preliminary plans completed.
31	Warhaw, N. C.: Water-supply system.....	38,000	Preliminary plans prepared.
13	Belmont, N. C.: Sewage-treatment plant.....	30,000	Plans and estimates prepared.
30	Ebenezer, S. C.: Water-supply system.....	17,000	Preliminary plans completed.
40	Camp Jackson, near Columbia, S. C.: Water-supply and sewer systems.....	140,000	Do.
46	Calhoun County, S. C.: Soil erosion.....	225,000	Do.
7	Davidson Creek drainage district, Iredell and Mecklenburg Counties, N. C.: Drainage project.....	18,000	
(1)	Berkeley (52), Calhoun (46), Charleston (57), Clarendon (47), Dorchester (86), Lexington (43), Richland (39) Sumter (45), and Williamsburg (48) Counties, S. C.: Drainage for malarial control.	160,000	Do.
59	Charleston Ordnance Depot, S. C.: Drainage project and filling swamp area for mosquito control.	7,000	
14	Charlotte, N. C.: Extension of filtration plant and raw-water supply, ground storage, and elevated storage for clear water.	1,000,000	No plans prepared.
GROUP B—FOR DEFERRED CONSTRUCTION			
60	Charleston, S. C.: Dredging channel of Ashley River, 7¼ miles long from mouth of river to standard wharf, for navigation.	\$340,000	Surveys completed.
25	Felzer, S. C.: Water-supply and sewer extensions.....	204,000	Preliminary plans made.
32	Lancaster, S. C.: Sewage-treatment plant.....	170,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
11	Shelby, N. C.: Water-power plants.....	\$294,000	Preliminary plans made.
53	McClellanville, S. C.: Water-supply and sewer systems and sewage-disposal plant.....	35,000	
39	Columbia, S. C.: Sewage-treatment plant (partial treatment).....	2,500,000	No plans made.
20	Gaffney, S. C.: Sewage-treatment plant.....	100,000	Survey made and estimate prepared.
28	Chester, S. C.: Sewage-treatment plant.....	50,000	No plans made.
29	Rock Hill, S. C.: Sewage-treatment plant.....	300,000	Large amount of industrial waste including dye-works wastes to be treated. No plans made.
38	Camden, S. C.: Sewage-treatment plant and completion of sewer system (partial treatment).....	70,000	Only 50 percent of city sewered. No plant.
26	Union, S. C.: Two sewage-treatment plants.....	100,000	No plans made.
35	Laurens, S. C.: Sewage-treatment plant.....	75,000	Do.
22	Lyman, S. C.: Sewage-treatment plant and completion of sewerage system.....	100,000	Considerable industrial waste present. No plans made.
18	York, S. C.: Sewage-treatment plant.....	80,000	No plans made.
37	Greenwood, S. C.: Sewage-treatment plant.....	100,000	Do.
34	Clinton, S. C.: Sewage-treatment plant and completion of sewer system.....	75,000	Do.
24	Greenville, S. C.: Hydroelectric-power development on Saluda River at Forks Dam site.....	3,000,000	Preliminary plans and estimate.
33	Lylesford, S. C.: Tri-county hydroelectric power development on Broad, Enoree, and Tiger Rivers.	13,214,000	Preliminary plans and estimate made.
21	Spartanburg, S. C.: Hydroelectric power development and flood control on Facolet River about 8 miles east of Spartanburg.	1,200,000	Do.
27	Lockhart, S. C.: Greater Lockhart hydroelectric-power development and flood control on Broad River near Lockhart.	19,900,000	Do.
8	Clinchfield, N. C.: Water-power development and flood control on Broad River.....	4,610,000	Preliminary plans and estimate prepared.
36	Upper Ware Shoals, S. C.: Hydroelectric-power development and flood control on Saluda River near Princeton.	1,260,000	Preliminary plans and estimate made.
41	Near Columbia, S. C.: Hydroelectric-power development and flood control on Broad River.....	14,900,000	Do.
19	Greater Gaston Shoals, S. C.: Hydroelectric-power development and flood control on Broad River near Gaffney.	9,350,000	Do.
50	Near Moncks Corner, S. C.: Santee-Cooper hydroelectric-power development, flood control, and navigation.	34,350,000	Do.

1 Map key number shown following community name.

EDISTO

SCALE OF MILES



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Channel Improvement, Flood Control ———— F---
- Drainage, Malaria Control ———— Dm
- Wildlife Refuge ———— Rw
- Dam and Reservoir, Power ———— D
- Dam and Reservoir, Recreation ———— R
- Drainage Basin Boundary ———— ()
- Map Key Numbers Shown on Project List ———— #
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Drainage
- Basin Wide Study, Pollution

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

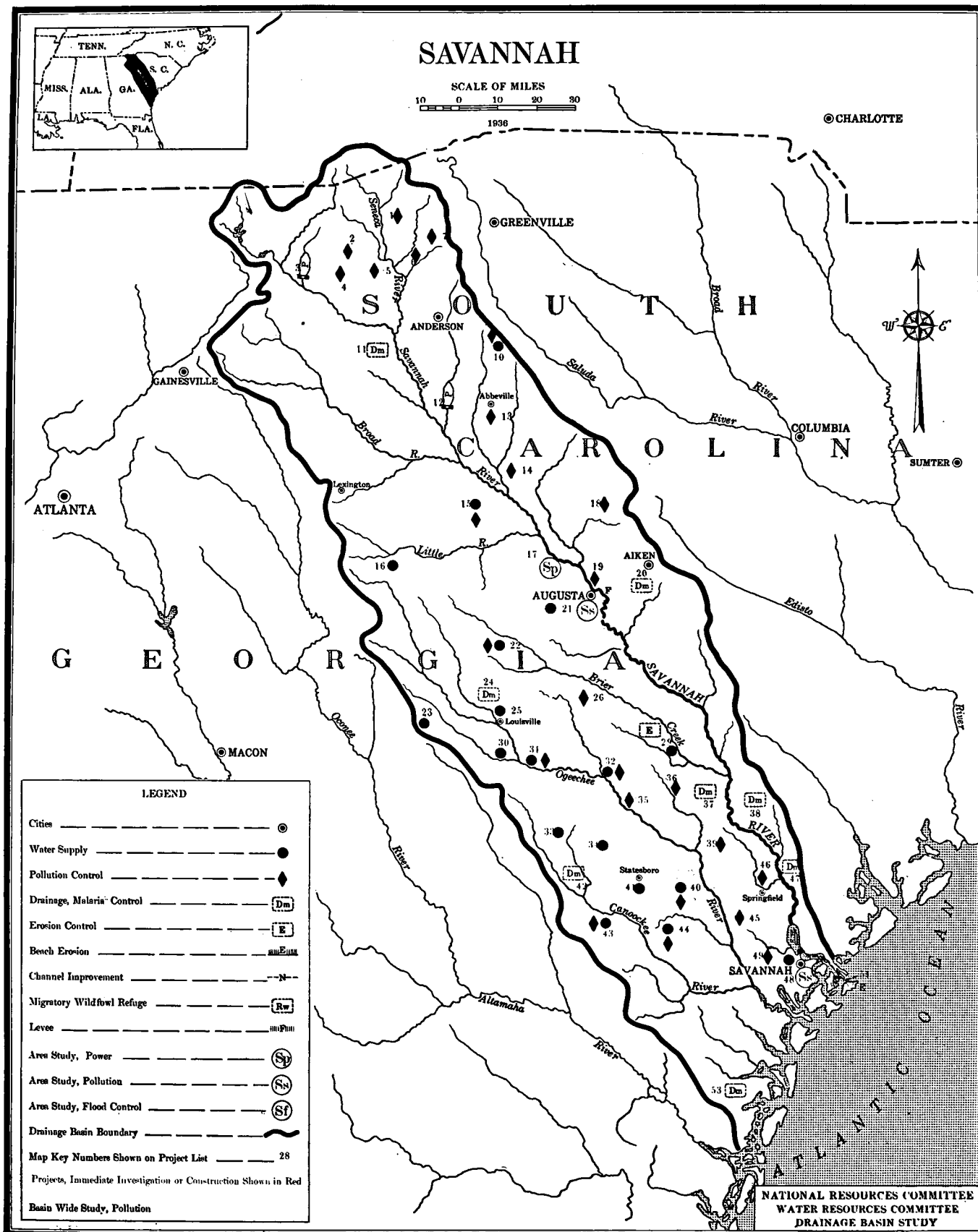
Edisto Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Basin-wide study of potential drainage both agricultural and malarial control.....	\$5,000	Cooperative investigation by State and Federal Agencies.
	Basin-wide study of stream pollution.....	5,000	Do.
16	Olar, S. C.: Water-supply system.....	27,000	Preliminary plans completed.
10	Norway, S. C.: Water-supply system.....	27,000	Do.
21	Yemassee, S. C.: Water-supply system.....	33,000	Do.
13	Bowman, S. C.: Water-supply system.....	27,000	Do.
17	Sycamore, S. C.: Water-supply system.....	11,000	Do.
19	Hampton, S. C.: Sewer system and sewage-treatment plant.....	49,000	Do.
(1)	Aiken (4), Allendale (18), Bamberg (15), Barnwell (11), Beaufort (23), Calhoun (6), Colleton (20), Dorchester (14), Edgefield (1), Hampton (19), Jasper (22), Lexington (3), Orangeburg (9), and Saluda (2) Counties, S. C.: Drainage work throughout Edisto Basin for malaria control.	250,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
24	Beaufort, S. C.: Sewage-treatment plant.....	\$50,000	Recommend further study.
8	Orangeburg County, S. C.: Clearing 10 miles of South Fork Edisto River channel and 23 miles of North Fork Edisto River channel.	35,000	Plans completed.
7	Orangeburg and suburbs, S. C., storm drainage, deepening and widening ditches.....	26,000	Preliminary plans completed.
7	Orangeburg, S. C.: Sewage-treatment plant.....	125,000	No plans made.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
5	Aiken County, S. C.: Hydroelectric-power development on South Fork Edisto River below mouth of Shaw Creek.	\$1,700,000	Preliminary plans complete.
12	Rowesville, S. C.: Clearing 15 miles of Sandy Lake and raising 1½ miles of present dam 2 feet with a width of 8 feet at top.	18,000	Do.
(1)	Allendale (18), Colleton (20), Dorchester (14), Bamberg (15), Hampton (19), Lexington (3), and Orangeburg (9) Counties, S. C.: Drainage.	308,000	Further investigations are recommended.
25	Beaufort County, Hunting Island: Develop for recreation and wildlife refuge.....	200,000	Property offered by owner for State development.

¹ Map key number shown following county name

SOUTHEAST DRAINAGE BASINS

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1. SAVANNAH-ALTAMAHA

Problems of primary importance to these river basins are those of malaria control, stream pollution, public water supply, soil erosion, and the orderly utilization of water power. Of less immediate import, but definitely a part of any comprehensive long-range plan, are problems relating to flood control and navigation. Studies of the quantity and quality of both underground and surface waters are needed to provide data upon which to base a program of improvement.

General Description

The basins of the Altamaha, Savannah, Ogeechee, and Newport Rivers together occupy most of northern and eastern Georgia and a strip of South Carolina. The total area is 31,166 square miles, about equal to all South Carolina. Most of the area is in the Piedmont Plateau at altitudes of 400 to 1,800 feet, and in the low-lying Coastal Plain. About 1,600 square miles at the headwaters of the Savannah are in the mountains with altitudes as high as 5,000 feet.

The lower half of the region is covered largely with pine and hardwood forests, interspersed with many farms. Much of the coastal country is marshy and some of the inland watercourses are bordered by extensive swamps.

The population is more than 1,538,000, about one-third of which is urban. Savannah, with 85,000, is the largest city; a part of Atlanta lies within the Altamaha drainage area, but for the purposes of this report it is included with the neighboring Chatahoochee Basin where most of the city belongs.

The farms of the region yield a large variety of products including cotton, corn, tobacco, hay, sugarcane, peanuts, vegetables, fruit, livestock, and poultry. Natural resources include timber, granite, sand, gravel, clay, kaolin, talc, manganese, asbestos, and bauxite. Although the region is primarily agricultural, there is a considerable industrial development in the Piedmont area, producing textiles, lumber, furniture, naval stores, brick, tile, pottery, cottonseed oil, fertilizer, paper, and canned foods.

Ocean-going vessels touch at Savannah, and there is shallow-draft navigation from that city to Augusta during most of the year. The intracoastal waterway traverses the region along the coast.

In the mountains and along the coast the climate is more moderate than in the Piedmont belts, where extreme temperatures as high as 105° occur. The average growing season is 240 days. The average

annual rainfall is 48 inches over the entire region, but this is not uniformly distributed; it ranges from more than 80 inches in the mountains to 46 inches in the Piedmont, increasing again to 48 and 49 inches toward the coast.

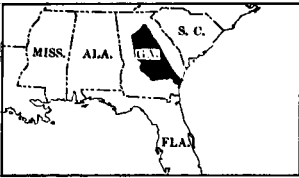
Only one stream in the basin, the Savannah River, extends back as far as the Appalachian Mountains. The heavier rainfall here accounts for the fact that the Savannah carries about as much water as the Altamaha and is subject to even greater floods, although it is shorter and drains a smaller area. At Augusta the Savannah discharges about 2,000 cubic feet per second at low water and 350,000 at maximum; the corresponding records for the Altamaha at Doctortown are 2,000 and 250,000 cubic feet per second.

Recommended Plan

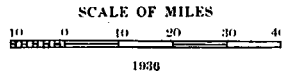
Remedial works relating to malaria control, water supply, pollution control, and soil conservation are of essential importance to the health and well-being of the inhabitants of this region. Heretofore such projects have been left largely to local initiative; they should be developed in the future with the cooperation of such agencies as the Georgia and South Carolina State Boards of Health and the East Georgia Planning Council, as well as the Federal agencies concerned.

Malaria control is badly needed, particularly in the rural sections of the Coastal Plain, where this disease constitutes a serious drain upon the health, vigor, and material well-being of the people. Projects for malaria control are now under way by the Works Progress Administration in 56 counties; these should be completed and extended, and steps taken to insure their proper maintenance. In addition to this basin-wide effort, it is recommended that plans of the Georgia State Board of Health for the drainage of swampy streams near Hartwell, Ga., be carried out.

Water supply from underground sources is becoming inadequate in some localities. At Savannah, for example, there are indications that the artesian supply is being depleted—that the city will probably be forced to resort to surface sources. Knowledge of the quantities and qualities of both underground and surface waters is fragmentary and inadequate for an intelligent general plan. Immediate steps should be taken to increase the number of rainfall and stream flow stations, and to determine the present status and future trends of ground-water storage, water-table elevations, and artesian heads.



ALTAMAHA



LEGEND

- Cities ———— ○
- Existing Projects of Major Significance ————
- Water Supply ———— ●
- Pollution Control ———— ◆
- Drainage, Malaria Control ————
- Levee ————
- Drainage Basin Boundary ————
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution

**NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY**

The extent of *stream pollution* in this region is indicated by the fact that the largest three cities—Savannah, Augusta, and Macon—all discharge raw sewage into the streams. A few of the smaller towns have some form of treatment, but the usual method of disposal is by direct discharge. Many municipalities are located on small streams where dilution is insufficient. Nuisance-producing industries also present a problem that will require expensive abatement programs in the future unless their wastes are more carefully controlled. Water supply or sewerage improvements, or both, are recommended in a number of communities in this region. A regional study of pollution problems should be made to formulate a policy and plan for the protection of municipal water supplies, the shellfish industry, and the recreational uses of water.

Soil erosion is a serious long-range problem in this region, particularly in the soft, easily-washed soils of the Piedmont Plateau. It is estimated that well over half of the entire area has already lost a major part of its productive topsoil; large sections have been abandoned as worthless. Corrective measures have scarcely been started. A careful study of the entire problem is badly needed and the resulting plan should be actively prosecuted on a large scale.

Waterpower development includes 300,000 kilowatts of capacity in the 10 larger plants on the Savannah and 28,780 kilowatts in 7 plants on the Altamaha River and its tributaries. In addition there is an uncompleted development of 45,000 kilowatts on the Altamaha system. The Corps of Engineers has investigated 18 other sites in the Savannah Basin and 16 on tributaries of the Altamaha; the largest of these is the

Clark Hill project on the Savannah 20 miles above Augusta. A program for the orderly utilization of these power resources should be included in the objectives of the recommended regional study of power development and power markets in the southeastern States.

Flood-control works are needed at several points. The levee protecting Augusta proved inadequate in the flood of 1929. A project to raise the levee and construct a supplementary concrete retaining wall is now under way and should be completed. On the Ogeechee River the discharge of flood waters is obstructed by the Coastal Highway and by certain railway fills, affecting the drainage from 140,000 acres. Further study of this situation is recommended. On the Altamaha River the Townsend area, about 20 miles above the mouth, and Butler and Champney Islands in the delta present a dual problem in that corrective measures might benefit one and injure the other. A combined project is being studied by the Corps of Engineers.

Navigation conditions will be improved with the completion of pending projects to establish a controlling depth of 30 feet in Savannah Harbor. Between Savannah and Augusta the nominal channel depth is 6 feet, but under present conditions of storage and regulation this depth cannot be maintained at all times. Construction of a lock and dam 13 miles below Augusta has been proposed to remedy this deficiency, but it is believed that should the Clark Hill project be constructed the resulting regulation would be sufficient to maintain navigation.

Savannah Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Clark Hill, Ga.: Project for flood control, navigation, and power development; investigation of engineering and economic aspects.	-----	To be included in general study of the power situation and of the proposed power projects in the southeastern states.
	Study to determine feasible methods of flood protection of area of 140,000 acres along Ogeechee River, below the Conochee River, Ga.	\$20,000	Hearings scheduled. Preliminary studies made.
	Georgia and South Carolina: Study to determine extent to which pollution endangers public health throughout the Savannah Basin.	50,000	Cooperative investigation by State and Federal agencies.
21	Augusta, Ga.: Study of extent of sewage pollution and health hazards.....	10,000	Cooperative investigation by State and local agencies.
(1)	Aiken County (20), S. C.; Candler County (42), Ga.; Hampton (38), Jasper Counties (47), S. C.; Jefferson (24) and McIntosh (53) Counties, Ga.: Malaria control and drainage.	399,000	Under varying degrees of completion.
48	Savannah, Ga.: Study of extent of sewage pollution and health hazards.....	10,000	Cooperative investigation by State and local agencies.
18	Crawfordville, Ga.: Water supply and distribution system.....	33,000	Preliminary plans completed.
10	Honea Path, S. C.: Improvements to waterworks system and sewage treatment plant.....	40,000	Plans completed. Project authorized by Congress. Approximately 50 percent completed by W. P. A.
21	Augusta, Ga.: Earth levee and concrete retaining wall for flood protection.....	685,000	Surveys completed.
21	Augusta, Ga.: Completion of lock and dam and bank protection for navigation on Savannah River below Augusta.	862,000	Plans completed.
48	Savannah, Ga.: 30-foot navigation channel from Ocean to city.	467,000	Plans and specifications completed.
21	Augusta, Ga.: Channel improvements in Rocky Creek to improve drainage and sanitary conditions.	151,000	Study completed.
51	Fort Screven, Ga.: Seawall to prevent beach erosion.....	92,000	Study completed.
48	Savannah, Ga.: Water impounding structures to provide migratory bird refuge.....	25,000	Preliminary plans completed.

1 Map key number shown following county name.

Savannah Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
37	Savannah River Basin, Georgia, South Carolina: Malaria control, drainage and maintenance to continue present program.	\$775,000	No plans.
12	Abbeville, S. C.: Dam, generating plant, transmission lines; dam located 15 miles west of city, on Rocky River.	435,000	Awaiting compliance of town to acquire improved property.
21	Augusta, Ga.: Additions to water distribution system and modernization of treatment plant.	201,000	Study necessary before plans can be completed.
22	Wrens, Ga.: Improvements to waterworks system and sanitary sewers.	75,000	Further studies necessary before plans can be completed.
(1)	Abbeville (13), S. C.; Brooklet (40), Ga.; Central (6), S. C.; Claxton (43), Ga.; Edgefield (18), S. C.; Guyton (45), Ga.; Liberty (7), McCormick (14), S. C.; Midville (31), Millen (32), Newington (39), Ga.; North Augusta (19), S. C.; Pembroke (44), Ga.; Pickens (1), S. C.; Pooler (49), Rocky Ford (35), Ga.; Seneca (5) Springfield (46), S. C.; Sylvania (38), Ga.; Walhalla (2), S. C.; Waynesboro (26), Ga.; and Westminster (4), S. C.: Sewage collection and treatment works.	600,000	Reported by State board of health as needed to promote public health.
11	Hartwell, Ga.: Deepen channels, ditch swampy ground, and eliminate mosquito breeding places.	32,000	Plans and specifications ready.
3	Westminster, S. C.: hydroelectric plant, 4½ miles west of city, dam and reservoir.	118,000	Further study necessary to determine feasibility of project.
(1)	Brooklet (40), Claxton (43), Louisville (25), Midville (31), Millen (32), Pembroke (44), Sandersville (23), Savannah (48), Statesboro (41), Wadley (30), Ga.: Waterworks additions and extensions. Hilltonia (20), Portal (34) and Twin City (33), Ga.: Water supplies.	390,000	
2	Walhalla, S. C.: Extension of fish cultural facilities at hatchery, 24 miles from Walhalla.	25,000	U. S. Bureau of Fisheries has completed plans.
	Georgia and South Carolina: Soil and water conservation by reforestation, terracing, and other methods of controlling erosion throughout the basin.	2,000,000	First program of operation subject to results of preliminary survey.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
15	Lincolnton, Ga.: Extensions to water system and new sewer system.	\$99,000	Further studies necessary before plans can be completed.
37	Savannah River Basin, Georgia and South Carolina: Malaria-control drainage. Continuation of program to control malaria.	500,000	Dependent upon status of preceding projects.

¹ Map key number shown following community name.

Altamaha Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study to determine extent of pollution and to formulate a policy regarding sewage treatment in the Altamaha Basin, Ga.	\$30,000	
5	Appling, Ben Hill, Bibb, Bleckley, Butts, Candler, Clarke, Clayton, Coffee, DeKalb, Dodge, Dooly, Glynn, Greene, Gwinnett, Jackson, Jasper, Jefferson, Johnson, Laurens, McIntosh, Oconee, Peach, Pulaski, Telfair, Treutlen, Twiggs, and Wayne Counties, Ga.: Drainage and malaria control.	485,000	These projects are at different stages of completion.
1	Macon, Ga.: Sewer system and sewage-treatment plant.	178,000	Preliminary plans made.
1	Macon, Ga.: Trunk line storm sewer to eliminate open drains.	270,000	Preliminary plans in progress.
GROUP B—FOR DEFERRED CONSTRUCTION			
18	Lower Altamaha Basin, Ga.: Malaria control.	\$610,000	
(1)	Adrian (11), Alamo (9), Baxley (20), Cochrane (6), Collins (12), Glennville (17), Hawkinsville (7), Hazlehurst (19), Helena (8), Jesup (22), Lumber City (15), Lyons (13), Reidsville (16), Soperton (10), Swainsboro (4), Tennille (2), Vidalia (14), Wrightsville (3), Ga.: Waterworks additions and extensions. Ludowici (21), Ga.: Water supply.	570,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
23	Georgia: Flood control in McIntosh, Glynn, Long, and Wayne Counties by construction of Townsend Levee, along Altamaha River.	\$456,000	Preliminary plans made.
18	Lower Altamaha Basin, Ga.: Malaria-control drainage. Continuation of program to control malaria.	543,000	

¹ Map key number shown following community name.

2. ST. MARYS-SUWANNEE

Protection of underground water supplies, provision for municipal waterworks and sanitation facilities, and drainage are recommended for construction or study in this area. The desirability of utilizing the great Okefenokee Swamp as a semitropical national park and wildlife sanctuary should be investigated.

General Description

The area here considered covers the drainage basins of three rivers rising in southern Georgia: the Suwannee, flowing generally southward through Florida and discharging into the Gulf of Mexico; the St. Marys, flowing tortuously eastward to the Atlantic Ocean and forming a part of the boundary between the two States; and the Satilla, just north of the St. Mary, flowing also to the Atlantic. About 15,000 square miles are included.

Between the Suwannee and the headwaters of the St. Marys River lies the Okefenokee Swamp of 1,000 square miles, drained largely by the Suwannee. The entire area is within the Coastal Plain and is generally almost flat, sandy, and interspersed with swamps.

The total population is 518,000, an average density of 34 per square mile. More than half of the population is rural. The Suwannee Basin contains about three-quarters of the total. The principal communities and 1930 population are Waycross (15,510) and Brunswick (14,022) in Georgia, and Lake City (4,416) in Florida.

All of the St. Marys basin, nearly all of the Satilla Basin, and nearly half of the Suwannee Basin are classified generally as unsuitable for cropping but adaptable to forestry and grazing. Agriculture is confined to small farm production of cotton, tobacco, sugar cane, corn, and vegetables. There is some lumbering and production of naval stores.

The climate is hot and moist, with average annual precipitation of 48 to 50 inches in Georgia and 60 to 65 inches in the Florida portion. Much of the rainfall occurs in the long, warm, growing season, which encourages timber growth.

Recommended Plan

Dedication of the Okefenokee Swamp as a semitropical national park has been suggested. The Bureau of Biological Survey has options on large tracts of land in this area. An investigation of the project is recommended to determine its feasibility for recreation and for wildlife preservation. The possible relationship between this project and the proposed reservoir works to replenish the artesian underground water supply should be examined.

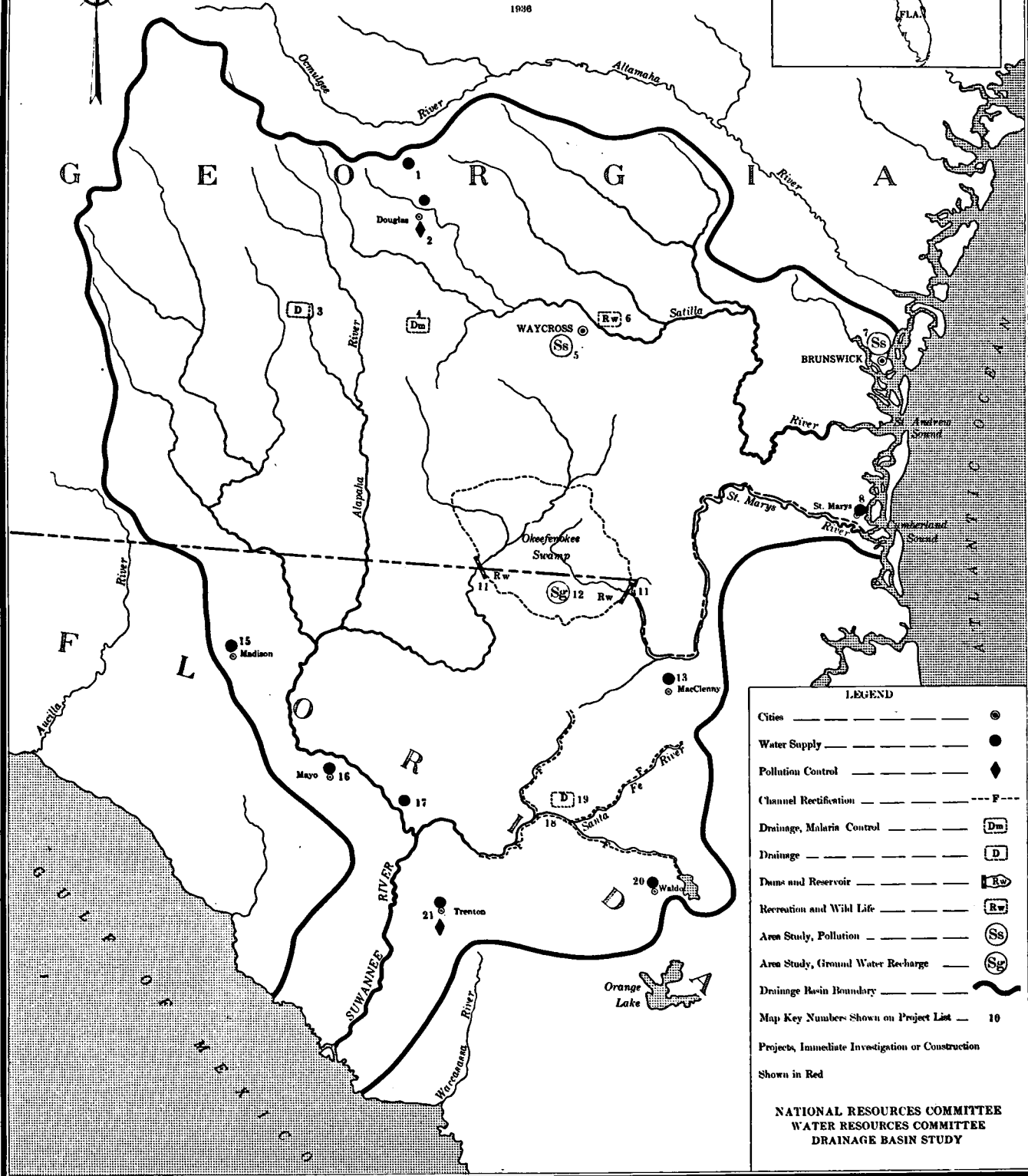
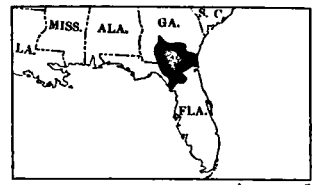
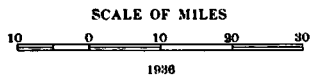
Water supplies for most of the area are obtained from deep wells, many of which are artesian. The mineral content is high and the water should be treated. The artesian pressure has been gradually decreasing for years. The surface source or intake area for this artesian water is probably the Okefenokee Swamp, since the underlying strata dip to the south from the swamp; a system of reservoirs might retain enough water in the swamp to recharge the underground storage. An investigation of this important possibility is recommended. A general study of the underground water resources of the area is also recommended, to guide their future utilization. Waterworks construction, extension, or improvement in some of the communities is needed at present; in others it can be deferred.

Sewage facilities are inadequate or wholly lacking throughout the area; but the communities are small and pollution is not generally acute. Investigations for sewage treatment are recommended at Waycross and Brunswick, Ga.

Flood control is unnecessary in the upper reaches of the rivers, but should be provided lower down in the flood plain by widening and straightening the channels in several places.

Drainage for reclamation and especially for malaria control should be investigated in the near future. Ditches and canals to drain mosquito breeding places will be needed in most of the area.

ST. MARYS - SUWANNEE



LEGEND

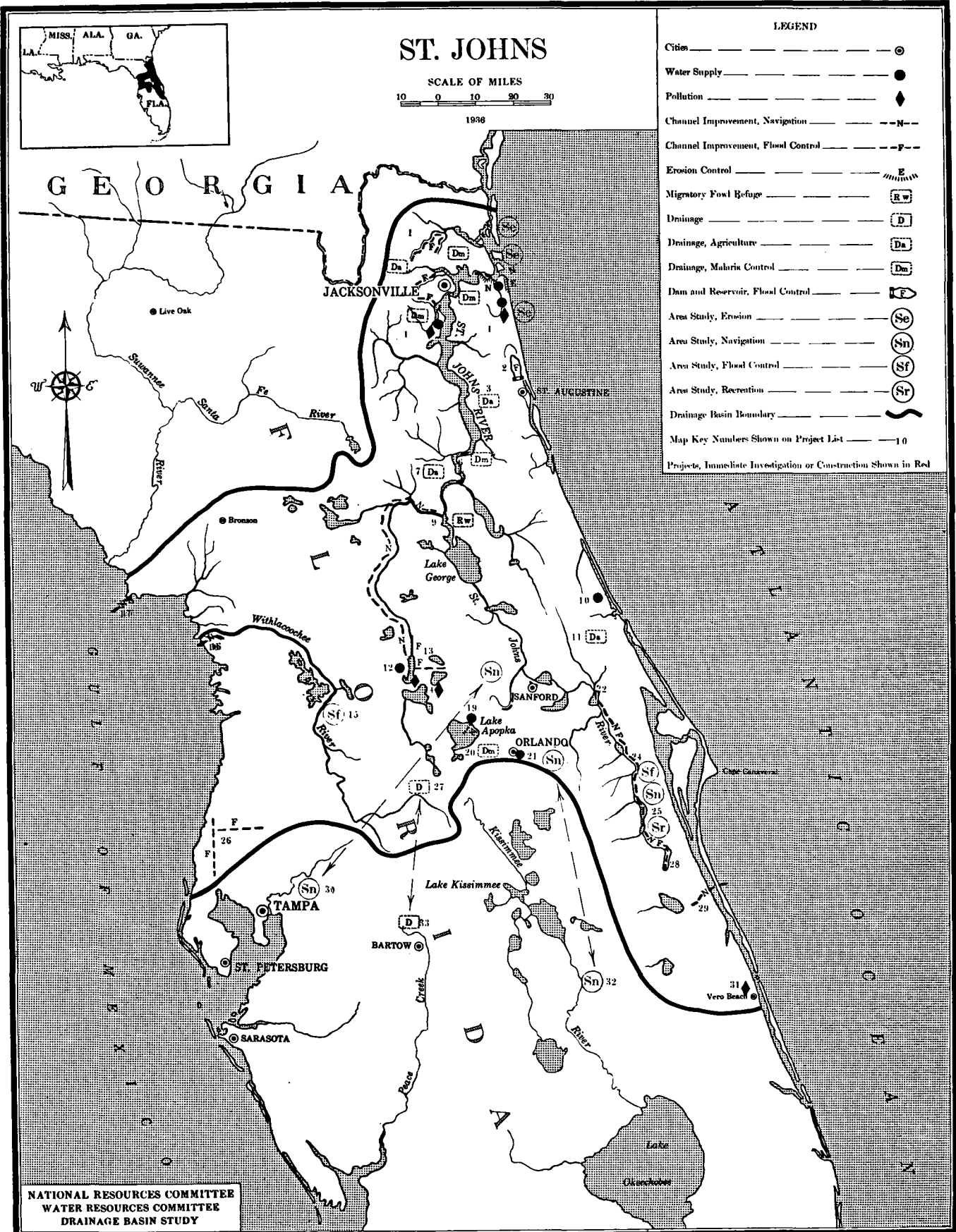
- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Channel Rectification ———— F———
- Drainage, Malaria Control ———— Dm
- Drainage ———— D
- Dams and Reservoir ———— Rv
- Recreation and Wild Life ———— Rw
- Area Study, Pollution ———— Ss
- Area Study, Ground Water Recharge ———— Sg
- Drainage Basin Boundary ———— ~~~~~
- Map Key Numbers Shown on Project List — 10
- Projects, Immediate Investigation or Construction Shown in Red

**NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY**

St. Mary's-Suwannee Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
12	Study to determine the desirability of establishing swamp reservoirs in Okefenokee Swamp to serve as the source of recharging the underground water supply in Georgia and Florida.	\$30,000	
(1)	Madison (15) and Mayo (16), Fla.; St. Marys (8), Ga., and Waldo (20), Fla.: Waterworks and distribution systems.	121,000	Plans complete for St. Marys, Ga. and Madison, Fla. Preliminary plans only for Waldo and Mayo, Fla.
21	Trenton, Fla.: Waterworks and sewer system.....	30,000	Plans completed. Awaiting decision of Supreme Court on Senate bill 515.
(1)	Alachua County (19), Fla.; Berrien County (3), Ga.; and Bradford County (19), Fla.: construction of ditches and canals to drain agricultural lands.	25,000	Preliminary plans completed.
5	Waycross, Ga.: Study to determine type and cost of sewage treatment plant and sewer system.....	5,000	No plans.
6	Brantley and Ware Counties, Ga.: Stream improvements, recreational lakes, game refuge, and forestry near Waycross, Ga.	203,000	Resettlement Administration likely to complete this project before fiscal year 1938.
7	Brunswick, Ga.: Study to determine proper plans for sewage treatment plant.....	5,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
18	Alachua, Bradford and Union Counties, Fla.: Widening and straightening existing channels for flood control.	\$48,000	Preliminary plans completed.
13	MacClenny, Fla.: Waterworks and Diesel engine power plant.....	65,000	Do.
2	Douglas, Ga.: Sewer system and sewage treatment plant.....	28,000	Plans and specifications completed.
17	Brantford, Fla.: Waterworks system including deep well and tank.....	29,000	Do.
11	Okefenokee migratory waterfowl refuge, Georgia and Florida: Construction of dam and improvements.	103,000	
	Appling, Atkinson, Bacon, Ben Hill, Berrien, Brantley, Brooks, Camden, Clinch, Colquitt, and Coffee Counties, Ga.; Hamilton County, Fla.; Lanier and Lowndes Counties, Ga.; Madison, Suwannee, and Taylor Counties, Fla.; Tift, Turner, Wayne and Worth Counties, Ga.; Ditches and canals to drain swampy areas for malaria control.	828,000	Preliminary plans only prepared. Actual plans not to be made until work progresses.
(1)	Broxton (1) and Douglas (2), Ga.: Waterworks improvements	60,000	

1 Map key number shown following community name.



3. ST. JOHNS

The chief water problems of the St. Johns Basin are those of sewage disposal, municipal water supplies, mosquito control, and improved navigation facilities for large and small boats. Flood control, drainage, beach protection, and encouragement of wildlife propagation are needed in various parts of the basin. An investigation is underway with respect to the proposed ship canal passing through this area from the Atlantic to the Gulf.

General Description

The St. Johns Basin in north central Florida consists of the St. Johns River watershed on the east, the Withlacoochee watershed on the west, and the coastal slopes draining by numerous smaller rivers into the Atlantic Ocean and the Gulf of Mexico. Most of the country is nearly flat. The Atlantic coastal slope is within 25 feet of sea level, with marshes, sand dunes, scrub flatwoods, mangrove swamp, shell mounds, and some good agricultural land. The value of the famous beaches along this coast justifies a large expenditure for protection against erosion. The west coast is more generally marshy; the coast line near the Waccasassa River for 30 miles is probably unique in having no sandy or rocky shore. The marshes slope so gradually into the Gulf that the force of shore-building wave action is completely dissipated.

The interior basins are almost as flat, with a maximum altitude of about 150 feet. The territory is occupied by citrus and farm lands, woodland pasture, timber and turpentine forests, phosphate lands, swamps, and lakes. There are many flowing springs, including Silver Springs, which is one of the larger.

The population of the area is increasing at an accelerating rate, calling for a considerable volume of new construction in water supplies and sewer systems. Water supplies come from deep wells or artesian flow and are generally adequate. In a few places such as Jacksonville, the rapid increase in population and industrialization will soon bring an acute need for additional water supplies.

Recommended Plan

Most of the larger towns and cities in the basin now have equipment for at least partial *sewage treatment*. Because of the flat nature of the country and the steady increase of population, all the growing communities should be equipped with adequate treatment plants. Such projects are immediately needed at Jack-

sonville Beach, Vero Beach, Leesburg, Tavares, and Camp Foster.

Water supplies come mainly from deep wells, but with the growing demand the water of lakes and streams will have to be more widely used. When a well is pumped too heavily and the salt water is brought in, the well may need a long rest while the fresh water slowly settles in from above and drives the salt out of reach. In such situations advance planning and prompt action are important. An extensive study of this subject has been made by the Corps of Engineers and should be published and distributed for the information of the public. Several needed projects for improvements and additions to existing water systems are recommended for immediate construction.

The St. Johns River is subject to *floods* during the rainy season. This river is a tidal estuary for 110 miles of its length at all times and for 170 miles in dry weather when its level falls below high tide. The river channel has enough capacity to protect Jacksonville from rainy weather floods originating in the upper reaches, but between Lakes Poinsett and Helen Blazes the floodwaters from the St. Johns-Kissimmee watershed are retarded and menace the whole country between Sanford, Daytona Beach, Orlando, and Titusville. Similar floods, though less severe, occur along the swampy Withlacoochee River and in other localities near smaller streams.

The large swampy areas produce mosquitoes which make the farming of some highly fertile lands difficult because of the hazard to health. The malaria death rate is high. *Mosquito-control* projects are planned for Duval, Putman, and other counties. Economic benefits will justify a large expense for draining and for building dykes and channels to prevent flooding and the formation of pools.

Recreational values are of major importance in this area, with four of the best-known bathing beaches of Florida on its east coast. On the west coast are fine estates and areas devoted to hunting, fishing, and boating. Waterways in the interior as well as near the coasts can be developed for recreational as well as for commercial traffic. Fish hatcheries will be valuable and likewise sanctuaries for the bird life wintering in the area. The economic value of recreation is an important factor in connection not only with its own facilities, but also with other improvements such as water supplies, sewage disposal, flood protection, and mosquito control.

Beach protection is an economic need. Severe storms in recent years have damaged two of the most popular beaches, at Jacksonville and Daytona. The Corps of Engineers is making a limited study of erosion in collaboration with the city of Daytona and the engineering experiment station of the University of Florida. A more extended investigation is recom-

mended to develop an adequate program for protecting these major assets of the region.

Harbors and channels have been extensively improved, and need at present only minor improvements to care for the growing commerce and population. Several studies are recommended of possible future developments.

St. Johns Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of Atlantic-Gulf Ship Canal, Florida: Navigation project to provide intercoastal ship canal; dredging jetties and accessory works.	-----	Now under investigation.
15	Study to determine method for flood control on the Withlacoochee River.....	\$2,000	
25	Study of surveys to determine cost and location of additional channels connecting the St. Johns River Basin and the Intra-coastal Waterway (East Coast Waterway) for navigation, flood control and recreation by dredging and flood gates.	50,000	
(1)	Study to determine plans for the improvement of navigation on the St. Johns River at or near Sanford (18), Fla., to Tampa, Fla., via Kissimmee and Alafia Rivers and Tampa Bay (30). Also—St. Johns River (23) to Kissimmee River (32), Fla., and thence to Okeechobee Cross-Florida Canal Channel: Navigation improvement; dredging.	5,000	
1	Study to prepare plans and estimates for control of beach erosion, North Atlantic Coastal Slope at Amelia Island (Fernandina Beach), Fort George Island, Jacksonville Beach, and vicinities.	50,000	
31	Vero Beach, Fla.: Sewage treatment plant.....	149,000	Preliminary plans completed.
14	Leesburg, Fla.: Sewage treatment plant.....	90,000	Do.
14	Tavares, Fla.: Sewer system.....	82,000	Do.
1	Jacksonville Beach, Fla.: Extension of water and sewer systems.....	47,000	Do.
1	Camp Foster, near Yukon, Fla.: Extension of sewer and waterworks systems.....	69,000	Plans completed.
21	Orlando, Fla.: Waterworks extensions.....	617,000	Preliminary plans completed.
(2)	Atlantic Beach, (1) Port Orange (10) and Winter Garden (19), Fla.: Waterworks systems.....	177,000	Do.
12	Fruitland Park, Fla.: Extension of waterworks system.....	14,000	Do.
(3)	Camp Foster (near Yukon) (1), East Palatka (6), Jacksonville (1); Duval (1) and Polk (20), Counties, Fla.: Dredging and drainage of lands for malarial mosquito elimination.	203,000	Plans for Camp Foster project completed. Preliminary plans completed.
1	Neptune Beach, Fla.: Erosion control by construction of concrete seawall.....	111,000	Preliminary plans completed.
(4)	Duval (1), Putnam (Bostwick) (7), St. Johns (Hastings) (3), and Volusia (New Smyrna) (11) Counties, Fla.: Drainage of land for agricultural purposes.	175,000	Do.
1	Jacksonville, Fla.: Dredging channel of St. Johns River to ocean for improvement of navigation.....	330,000	Estimated cost given is amount needed for completion.
9	Leesburg, Fla.: Dredging channel of Ocklawaha River from St. Johns River to Leesburg for improvement of navigation.	36,000	Do.
16	Port Inglis, Fla.: Dredging channel of Withlacoochee River from Port Inglis to mouth for improvement of navigation.	100,000	Do.
(2)	Jacksonville, Fla.: Dredging channel, Jacksonville (1) to Palatka (8), for improvement of navigation.	14,000	Do.
17	Cedar Key, Fla.: Dredging harbor for improvement of navigation.....	4,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
(5)	Duval (1), Lake (13), Orange (19), and Pasco (26) Counties, Fla.: Flood control by improvement of creek channels and canals.	\$120,000	Preliminary plans completed.
2	St. Augustine, Fla.: Flood control by construction of dam and spillway.....	15,000	Do.
1	St. Johns River, Fla.: Protection of shore line by rock revetment.....	88,000	Under consideration by War Department.
29	Melbourne, Fla.: Navigation improvement. Dredging new channel and turning basin of Melbourne Harbor and inlet and Crane Creek for improvement of navigation.	12,000	Plans completed.
19	Winter Garden, Fla.: Dredging canal from Winter Garden to Lake Apopka in connection with park improvements and recreation.	21,000	Preliminary plans prepared.
9	Welaka, Fla.: Conservation project—Fish hatchery and game farm; construction of 50 acres of rearing ponds and accessory plant.	235,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(4)	Withlacoochee (27)—Hillsborough—Peace Rivers (33) drainage areas; flood control and drainage.....	\$5,000,000	Project extends into Peace-Hillsborough Rivers Basin. Total cost of entire project estimated at \$5,000,000.
(5)	Brevard, Seminole, and Volusia Counties, Fla.: Flood control and navigation improvement by dredging channel from Lake Harney (22) to Lake Washington (28).	1,000,000	

1 Map key number shown following location name.
 2 Map key number shown following community name.
 3 Map key number shown following county name.
 4 Map key number shown following river name.
 5 Map key number shown following lake name.

4. SOUTHERN FLORIDA

(Kissimmee, Tampa, and Everglades)

The water problems of southern Florida, with its great recreational interests, are mainly those of finding adequate quantities of fresh water for domestic use and of disposing of surplus waters in a relatively flat country. In certain places of the coastal region, the dense and rapidly growing population will soon require the use of surface water to supplement the underground water supplies. Stream pollution by raw or ineffectively treated sewage has become serious, and studies should be made for an adequate plan of sewage treatment.

The opportunities for water recreation are major factors in the economy of the region.

Other water projects include drainage of swamp areas near the coast, and additional storm sewers in urban communities. Channels for pleasure craft should be improved along the eastern coast. On the Kissimmee River, the need for flood control and improved navigation should be investigated. Studies of beach erosion are needed and work should be done in the improvement of State parks for recreation and wildlife conservation. Data and plans are incomplete for many of the water projects and further studies are necessary before adequate planning can be done. There is an urgent demand for topographic maps.

A general water-use plan for the area will be required in the future if the pressure of population develops beyond the available underground water supplies. In the meantime, most of the water problems are local in character.

General Description

The southern Florida area extends from the Keys northward to Clearwater Harbor on the Gulf, to Fort Pierce on the Atlantic coast, and nearly to Orlando in the interior. The area is made up of the Everglades, Hillsborough-Peace, and Kissimmee basins, with a number of smaller streams. These basins together contain about half the population of Florida.

Aside from the famous beaches, the economic activities include the important citrus-fruit industry, phosphate mining, cigar making, cement and building materials, food packing, and canning. Rainfall varies from 52 to 60 inches, concentrated principally in a few months of the year, with an occasional downpour of as much as 14 inches in 24 hours. Most of the area is so nearly flat and the streams so sluggish that with heavy rainfall or high winds the country is easily

flooded. In the Lake Wales district of the interior toward the north, however, the land rises to about 300 feet.

The Everglades lie south of Lake Okeechobee. Most of the area is in swamps and unsuitable for cultivation, grazing, or forest, only one-eighth of it being farm land. The establishment of not less than 2,000 square miles in this swamp and water area as the Everglades National Park has been approved by Congress, contingent on presentation of the land to the Government. A portion of the Everglades can be reclaimed by controlled drainage. The soil, however, contains so much organic matter that when dry and exposed it blows away or burns easily. Any drainage system should be so arranged that water can be applied whenever these soils become dangerously dry.

The population of the Everglades area, as here considered, includes about 250,000 permanent residents, mainly concentrated along the Atlantic coast.

At Miami is the southern terminus of the Intra-coastal Waterway, extensively used by pleasure craft as well as by commercial boats. Practically all the natural streams of this basin are tidal; there are also a number of drainage canals which have been cut from Lake Okeechobee to the Atlantic coast. Deep Lake, in the central part of the basin, is notable for the fact that although it is about 90 feet deep the water is fresh.

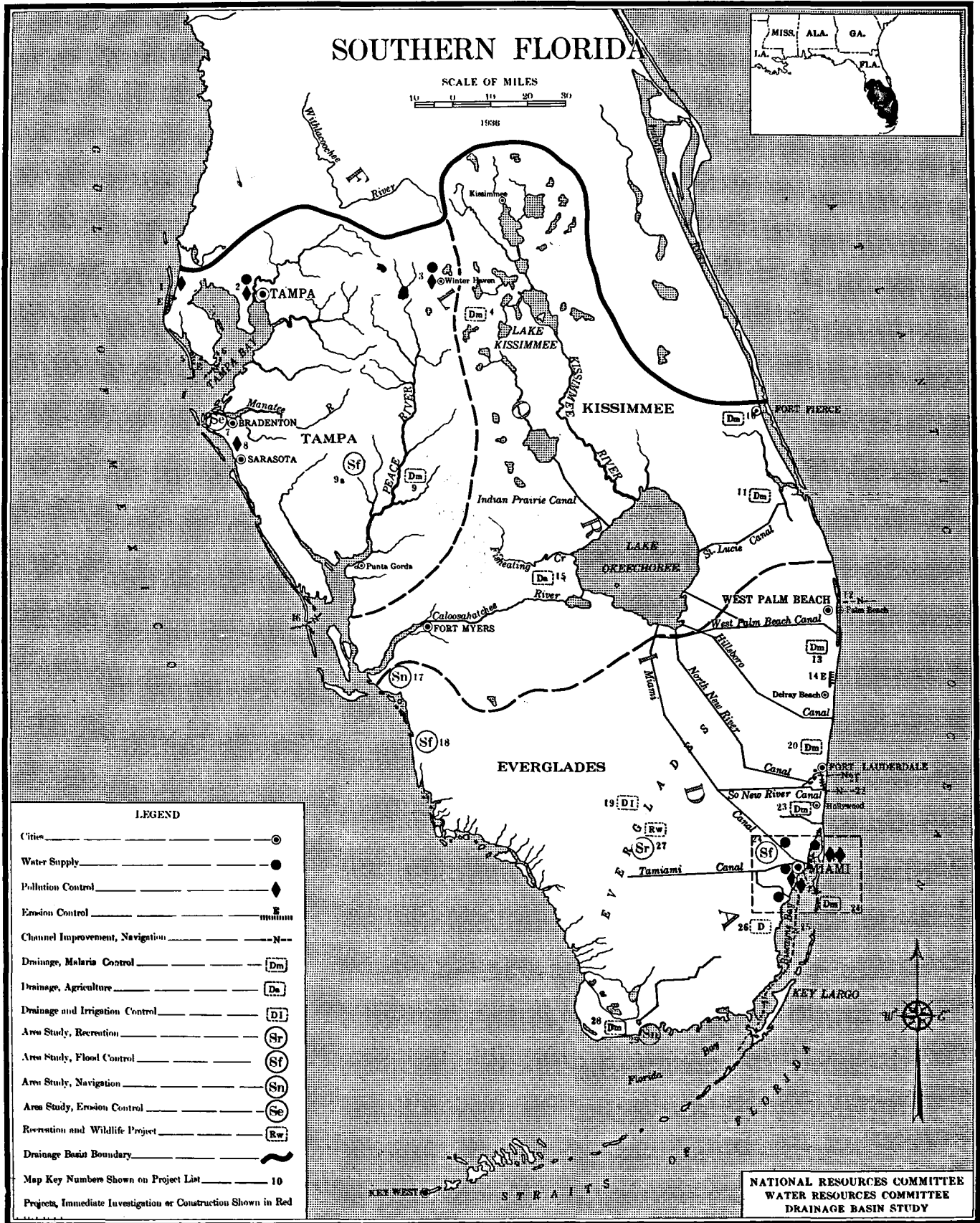
The Kissimmee Basin, including Lake Okeechobee, occupies the northeastern part of the area. The land is generally adapted to forestry or to a combination of forestry and grazing, only about one-fifth being suitable for farming. The population is about equally rural and urban.

The Tampa Basin to the northwest is predominantly urban, with 13 cities of over 2,500 population and Tampa over 100,000. Seventy percent of the land area is grazing or timber land, the rest being generally adaptable to farming. The country has many springs, some of which are highly mineralized.

Recommended Plan

Recreation and wildlife preservation would be furthered by the early establishment of the Everglades National Park. The problems of management and development of this area and its possible extension call for further investigation to preserve these resources.

Water supply for domestic and industrial purposes is a pressing problem, especially in the crowded area



along the Atlantic. Present supplies are chiefly from shallow wells, which in some places are beginning to be overdrawn, with lowering of the ground water level and a tendency to salting. Studies should be made with a view to supplementing the supplies with surface water suitably protected against floods and pollution. Projects for immediate construction include extensions to the water system in the Miami area.

Pollution is beginning to be serious both in fresh water streams and in salt water areas. Many cities discharge raw sewage directly into streams or in the sea close to shore; others have inadequate treatment systems. Miami has plans for an up-to-date installation, and Miami Beach is considering a plan to pump its sewage offshore into the Gulf Stream. Studies of pollution in the area are needed as a basis for adequate plans. Meanwhile several sewage treatment projects are ready for immediate construction.

Flood control in this area will involve provision of canals and improvement of stream channels. Canals from Lake Okeechobee to both coasts are now under construction. With the completion of the flood control works for areas adjacent to the lake, the most im-

portant remaining project is the improvement of the Kissimmee River. Plans for channel improvements should take account of the prospect that Lake Okeechobee may be a future source of water supply for a considerable area. Studies are needed for the planning of storm water sewers to protect Miami against floods, and for prevention of flooding between Estero and Bonita Springs.

Controlled drainage is needed in parts of the area. The land is nearly flat, and drainage channels can be made so that water may be pumped in or out as conditions require. Studies are proposed for a general plan of drainage and irrigation, combined with mosquito and sandfly control in the eastern part of the area. Immediate work can be started in three southern counties.

Navigation improvements, so far as may be judged from data now in hand, should in general be restricted to waters in the immediate vicinity of the coast. Appropriate studies are now in progress.

Beach erosion is occurring at some places. Studies should be made for the construction of works to protect the valuable beaches.

Kissimmee Project List

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
15 (1)	Glades County, Fla.: Drainage of agricultural lands in "Highlands" section..... Martin (11), Folk (4), and St. Lucie (10), Counties, Fla.: Drainage projects for mosquito control....	\$247,000 134,000	Further plans and study required. Plans insufficient. All interested agencies should be consulted.

¹ Map key numbers shown following community name.

Tampa Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A.—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
9a	Basin-wide flood control studies.....	\$25,000	
2	Tampa, Fla.: Improvement to existing sewer system and installation of sewage treatment plant....	1,450,000	
1	Clearwater, Fla.: Extensions and improvements to sewer system.....	316,000	
3	Winter Haven, Fla.: Improvement to water supply system and sewage treatment plant.....	160,000	
8	Sarasota, Fla.: Extensions to sewer system.....	115,000	
2	Tampa, Fla.: Improvements and extensions to water supply system.....	1,760,000	
2	Peace River Basin: Malaria and pest mosquito control by drainage in 6 counties.....	164,000	
1	Clearwater, Fla.: Construction of groins to protect and build up beaches.....	160,000	Study completed.
7	Bradenton, Fla.: Studies and plans for beach erosion control.....	5,000	

GROUP B.—FOR DEFERRED CONSTRUCTION

6	St. Petersburg Harbor, Fla.: Dredging channel 20 feet by 200 feet wide in Tampa Bay.....	\$123,000	
16	Charlotte Harbor, Fla.: Deepening and widening existing channel to 30 feet by 300 feet, from Gulf of Mexico to Boca Grande.....	59,000	Surveys completed.
9	Peace River Basin: Malaria and pest mosquito control by drainage in 6 counties.....	345,000	Plans insufficient. Further study necessary.
5	Boca Ciega, Fla.: Construction of groins to protect beaches, and improvements.....	216,000	Study almost completed by Beach Erosion Board.
(1)	Clearwater (1) and Sarasota (8), Fla.: Improvement and enlargement of ditches and canals for storm water drainage.....	36,000	Plans insufficient.

¹ Map key numbers shown following community name.

Everglades Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A.—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
27	Everglades National Park and adjoining areas: Study of problems of management and development.....	\$100,000	Joint study by interested agencies.
27	Everglades, Fla.: Establishment of national park.....	1,000,000	
24	Dade County, Fla.: Flood control studies in vicinity of Miami River.....	5,000	
18	Bonita Springs, Lee County, Fla.: Flood control studies.....	5,000	
19	Everglades drainage basin: Soil conservation, controlled drainage and irrigation studies.....	25,000	
24	Florida Bay (17) to Caloosahatchee River (29): Navigation channel investigation.....	10,000	Would materially assist in development of Everglades National Park.
24	Miami, Fla.: Sewage treatment plant.....	5,000,000	
24	Miami Beach, Fla.: Storm sewer for relief of flood conditions.....	391,000	
24	South Miami, Fla.: Water supply system for Greater Miami area.....	221,000	
24	Miami, Fla.: Extensions to water supply system, for increasing distribution.....	500,000	
24	Miami, Fla.: 2 additional reservoirs for water supply.....	110,000	
24	Miami Beach, Fla.: Extensions to water supply system, for additional supply.....	407,000	
24	Miami Harbor-Biscayne Bay, Fla.: Deepening harbor channels.....	800,000	Authorized in 1935 River and Harbor Act. \$2,200,000 has already been spent on project; \$800,000 required to complete.
22	Port Everglades-Hollywood Harbor, Fla.: Dredging 35-foot channel.....	940,000	Surveys completed. Project approved by Congress
25	Miami to Florida Bay, Fla.: Intracoastal waterway, 7-foot channel.....	130,000	Do.
26	Dade County, Highland section, Fla.: Drainage and water control.....	74,000	
14	Delray Beach, Fla.: Retaining wall along intracoastal waterway, to prevent bank-erosion.....	23,000	

GROUP B.—FOR DEFERRED CONSTRUCTION

24	Miami Harbor, Fla.: Extending present turning basin.....	\$300,000	Not yet approved by Congress. Surveys completed.
21	Fort Lauderdale, Fla.: New River Channel to Fort Lauderdale, Fla.: Intracoastal waterway for navigation and flood control.....	40,000	Surveys and plans completed.
12	Palm Beach, Fla.: Deepening port to 27 feet.....	448,000	
24	Miami Beach, Fla.: Extension to sewer system.....	245,000	Plans completed.
(1)	Ojus (23), Virginia Key and Tahiti Beach (24), Fla.: Mosquito control.....	78,000	Investigation required.
20	Fort Lauderdale, Fla., in vicinity of Fort Lauderdale within Broward County anti-mosquito control district: Drainage.....	39,000	Further investigation required.
13	Palm Beach County, Fla.: Drainage for mosquito control.....	39,000	Do.
28	Monroe County, Fla.: Drainage for mosquito control.....	25,000	Do.

GROUP C—TIME OF CONSTRUCTION INDETERMINATE

24	Miami area, Fla.: Additional outlets for floodwater.....	\$2,000,000	
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¹ Map key number shown following community name.

5. APALACHICOLA-CHATTAHOOCHEE

Water problems of primary importance in the Apalachicola Basin are those of municipal water supplies, sewer systems and sewage-treatment plants, and drainage for the control of malaria mosquitos. Soil conservation is also needed, especially in the central and upper parts of the basin. Navigation improvement and water-power development are less pressing problems. Additional recreation facilities should be provided.

General Description

The combined drainage basins of the Apalachicola, Chattahoochee, and Flint Rivers comprise about 19,500 square miles, including most of the western half of Georgia, a strip of Alabama, and a section through Florida. The region is roughly 400 miles long.

The Chattahoochee River, the longest stream, rises in the mountains; the Flint River rises south of Atlanta and unites with the Chattahoochee at the extreme southwest corner of Georgia to form the Apalachicola River, which flows south across Florida and empties into Apalachicola Bay.

Altitudes are as high as 2,000 feet at the source of the Chattahoochee, 1,500 to 2,000 feet in the Piedmont Plateau, and 500 feet or less in the Coastal Plain.

The total population for the Apalachicola River drainage area in 1930 was 1,083,576, about one-fifth of which was in Atlanta.

Slightly more than half of the entire area is classified as fair, good, or high-grade farm land; the remainder is unsuited to cropping, but adapted to forestry and grazing. Much of the grazing land has been subject to severe erosion for years. Principal farm products are corn, cotton, hay, small grain, potatoes, sugarcane, peanuts, melons, garden truck, peaches, apples, poultry, and livestock.

Natural resources of the basin include gold, pyrites, granite, clays, building and concrete sand, timber, and naval stores. Among the principal industries are textile and cottonseed oil mills, fruit and vegetable canneries, fertilizer factories, tanneries, and brick and terra-cotta kilns. Industrial development is concentrated chiefly in the Piedmont area. The Apalachicola and some smaller streams are navigable for shallow-draft boats. The tonnage carried is small, and reports of the Corps of Engineers indicate that these channels are adequate for the commerce.

Average annual temperatures range from 59° in the northern part of the basin to 68° at the Florida end. The average annual rainfall is 58 inches in the

northern end, about 50 inches in the middle part, and 55 inches in the south. The average discharge of the Apalachicola River is 20,000 cubic feet per second; the flood flow of March 1929 reached 293,000 cubic feet per second, and a low flow of 224 cubic feet per second occurred at West Point, Ga., on September 12, 1925.

Recommended Plan

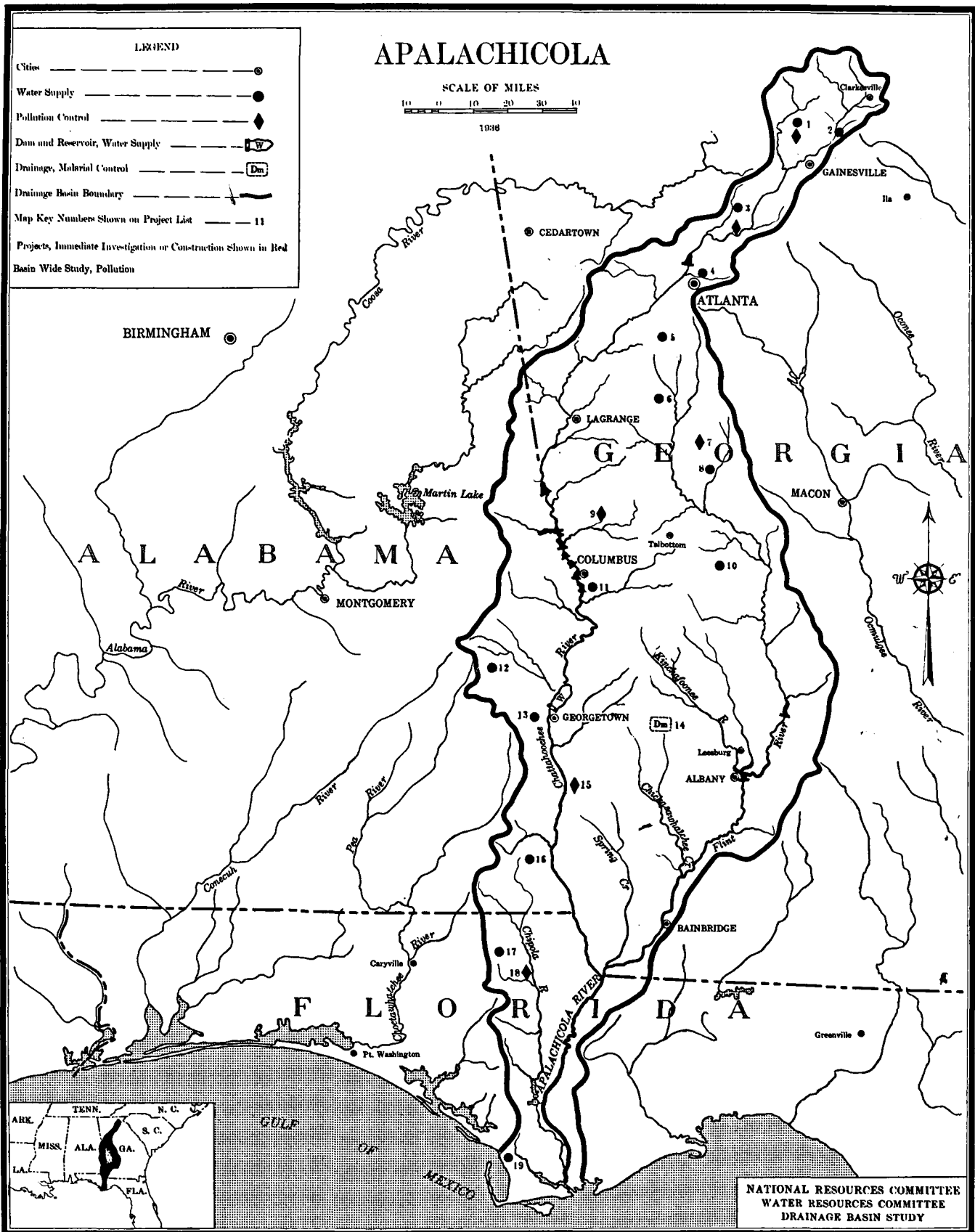
Public water supplies in this part of Georgia are generally not adequate. Many supplies from wells barely serve ordinary needs. In the Piedmont region most of the wells are adequate only for small towns and rural uses. In the Coastal Plain the wells are somewhat more reliable, but the water is hard and the larger cities and towns are beginning to seek surface supplies. When there is any large increase in population at and above Atlanta, new supplies will be necessary.

Information on the quantity and quality of underground and surface waters in the basin is scattered and inadequate. Investigations are needed to determine the location and extent of underground water storage and to forecast probable future changes. Chemical characteristics of both underground and surface waters should also be investigated.

Sewers and sewage treatment plants are widely needed in the area. About one-half of the 41 cities and towns in the Georgia part discharge raw sewage into the streams. Most of the other communities, however, have treatment plants; a few having plain sedimentation only. Lack of funds has restricted the installation of sewers, delayed contemplated additions, and interfered with proper maintenance and operation. To remedy this deficiency in Atlanta, the city has now under construction sewer projects totaling in cost more than \$7,000,000. A basin-wide study of sewage and pollution problems is recommended, including the effect of stream pollution on municipal water supplies, on public health, and on the recreational uses of the streams.

Drainage to eliminate malaria mosquitoes has been undertaken extensively in the region and has yielded definitely beneficial results. This work should be continued and enlarged and should form an important part of the general improvement program.

Soil erosion has reached a serious stage in the central and northern parts of the basin. Much of the land surface has already suffered great injury. Serious surface erosion with some gullying exists in all parts



of the Piedmont Upland areas. Still more severe gullyng occurs in the upper Coastal Plain region along the Chattahoochee River below Columbus. This erosion also increases the silting of storage reservoirs. A comprehensive study should be made of the entire problem and an effective remedial program should be adopted.

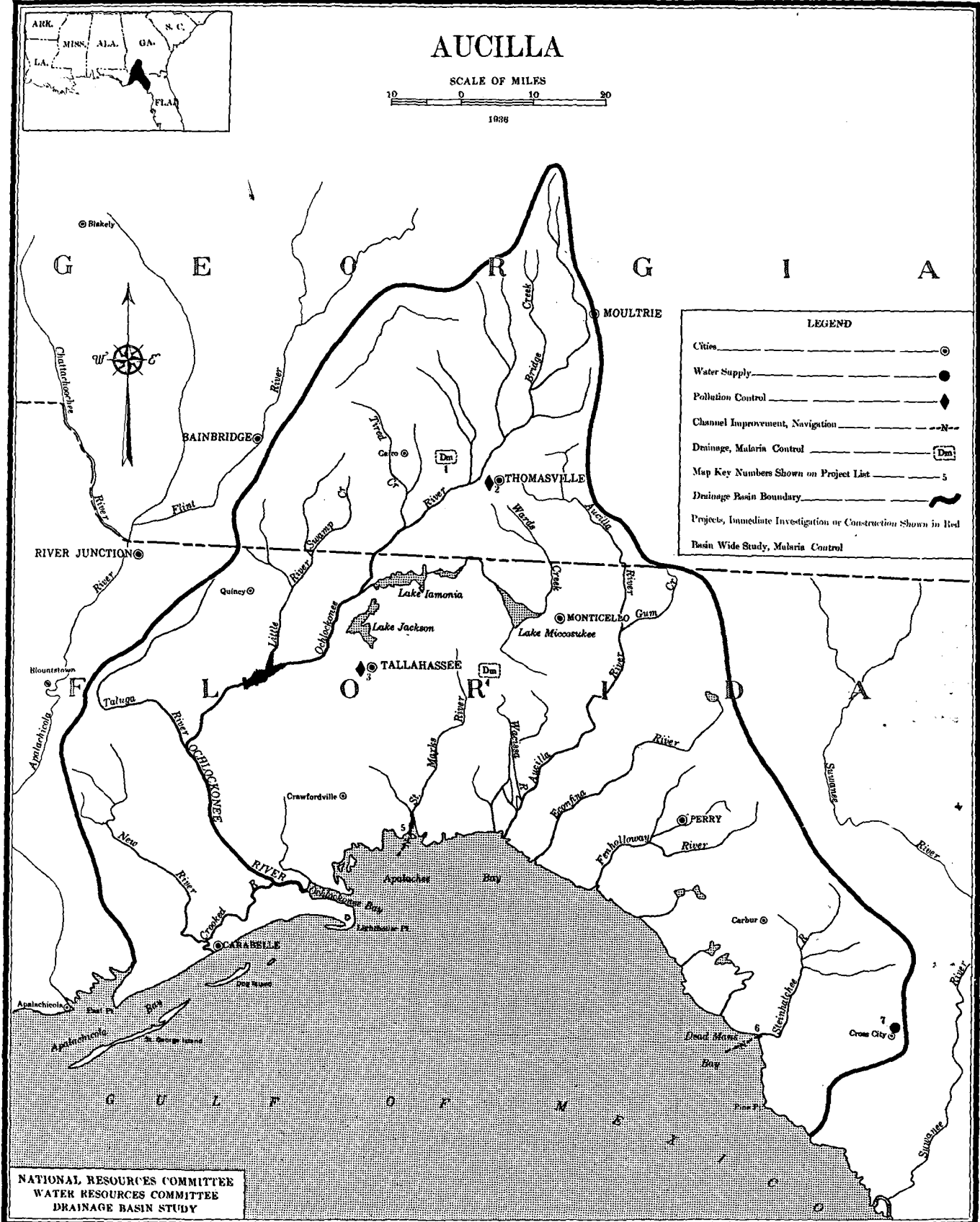
Navigation on the Apalachicola, Chattahoochee, and Flint Rivers has been carried on for a long time, but in recent years the amount of traffic has decreased in both tonnage and value. In the belief that deeper channels for larger boats would increase the traffic and justify the expense of such improvements, projects have been proposed by local interests for deepening the channels. A review of the economic justification

for these projects is being made by the Corps of Engineers.

Hydroelectric power possibilities are large both on the Chattahoochee River and the Flint River. The potential sites could provide a total installed capacity of 917,700 kilowatts at an estimated cost of \$127,948,000, according to the Corps of Engineers, which has not yet reported on the economic desirability of such construction. A comparative study of these possibilities is recommended in connection with a comprehensive investigation of power development in the Southeastern States. Among other factors, consideration should be given to the contingency that municipal and industrial water supplies may prove to have first claim on the upper reaches of the Chattahoochee.

Apalachicola Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study and survey of stream pollution throughout the basin to formulate policy regarding sewage treatment and to determine extent of pollution.	\$30,000	
13	Eufaula, Ala.: Dam and storage reservoir, water treatment plant and mains.	105,000	Plans completed. Land acquired.
11	Fort Benning, Ga.: Improvement to water works.	105,000	Preliminary study made. Land acquired.
11	Fort Benning, Ga.: New storage reservoir.	75,000	Preliminary sketches made. Land acquired.
18	Marianna, Fla.: Sewage collecting system and treatment plant.	65,000	Plans completed.
3	Cumming, Ga.: Water supply and sewer systems.	44,000	Do.
1	Cleveland, Ga.: Waterworks, sewer system, and sewage treatment plant.	39,000	Do.
6	Senoia, Ga.: Well, elevated tank, and distribution system for water supply.	36,000	Preliminary plans completed.
17	Cottondale, Fla.: Water supply system.	36,000	Do.
19	Port St. Joe, Fla.: Water supply system.	36,000	Plans completed.
2	Demorest, Ga.: Water supply system.	32,000	Preliminary plans completed.
12	Midway, Ala.: Water supply system.	31,000	Plans completed.
16	Ashford, Ala.: Water-supply system.	28,000	Do.
5	Union City, Ga.: Water-supply system.	25,000	Preliminary plans completed.
8	Meansville, Ga.: Water-supply system.	24,000	Plans completed.
10	Butler, Ga.: Water-supply system.	22,000	Preliminary plans completed.
15	Fort Gaines, Ga.: Sewer system.	34,000	Plans completed.
9	Chipley, Ga.: Sewer system.	18,000	Do.
7	Zebulon, Ga.: Sewer system and treatment plant.	16,000	Do.
14	Chattahoochee, Clay, Clayton, Coweta, Crawford, Crisp, Decatur, DeKalb, Dooly, Early, Fayette, Hall, Harris, Macon, Meriwether, Mitchell, Muscogee, Seminole, Talbot, Troup, Terrell, Taylor, Turner, and Worth Counties, Ga.: Drainage projects for malaria control.	491,000	Plans for most of the projects completed.
4	Atlanta, Ga.: Filtration plant.	695,000	Preliminary plans completed.



6. EASTERN GULF

The major water problems within the several small basins of this group relate to sewage disposal, municipal water supply, navigation, and the control of malaria. Less important or less pressing needs have to do with wildlife and recreational facilities, flood control, power production, and soil conservation. Topographic surveys and studies of underground water resources are urgently needed.

General Description

Because of the great similarity of conditions and problems within the basins of the short rivers emptying into the Gulf of Mexico on either side of, but not including, the Apalachicola Basin, their needs are grouped together in this report.

To the west of the Apalachicola are the Perdido, Escambia-Conecuh, Blackwater, Yellow, and Choctawatchee Rivers and other small streams running into Choctawatchee and St. Andrews Bays. On the east are the New, Ochlockonee, Sopchoppy, St. Marks, Wacissa, Aucilla, Enconfina, Fenholloway, and Steinhatchee Rivers. The drainage basins of these streams have a combined area of 21,440 square miles, chiefly in Florida and Alabama. No one of these streams is much over 100 miles in length and most of them are considerably shorter.

The population of this area is 601,000; an average of 28 per square mile. Only one-fourth of these people live in towns and cities, of which the largest is Pensacola, well known as a naval base, with a population of 30,826. Other major communities are Tallahassee, the capital of Florida, and Thomasville, a winter resort in Georgia, with 11,700 each, and Panama City with 8,701.

Although primarily agricultural, the region also produces lumber and naval stores. Along the coast there is considerable industry based upon fishing, including sponge fishing, and the transportation of freight in barges. The manufactures of the Alabama section include textiles, glass and clay products, and lumber. The tourist trade is small, but the region has great possibilities as a winter resort for hunting and fishing.

About three-fifths of the total land area is classified as fair to high-grade farm land. The remaining two-fifths, although not adapted to cropping, can be used for forestry and grazing. The average temperature is about 71°, with relatively small variations above or below the average. The growing season is from 250 to 300 days.

At the headwaters of the streams the land at its highest point is about 500 feet above sea level. The country slopes rapidly downward to lowlands which are only a few feet above the Gulf. Average annual rainfall is 54 inches, but in the wettest year on record there was nearly 85 inches of precipitation. Floods do considerable damage in the low country where the streams are sluggish.

Recommended Plan

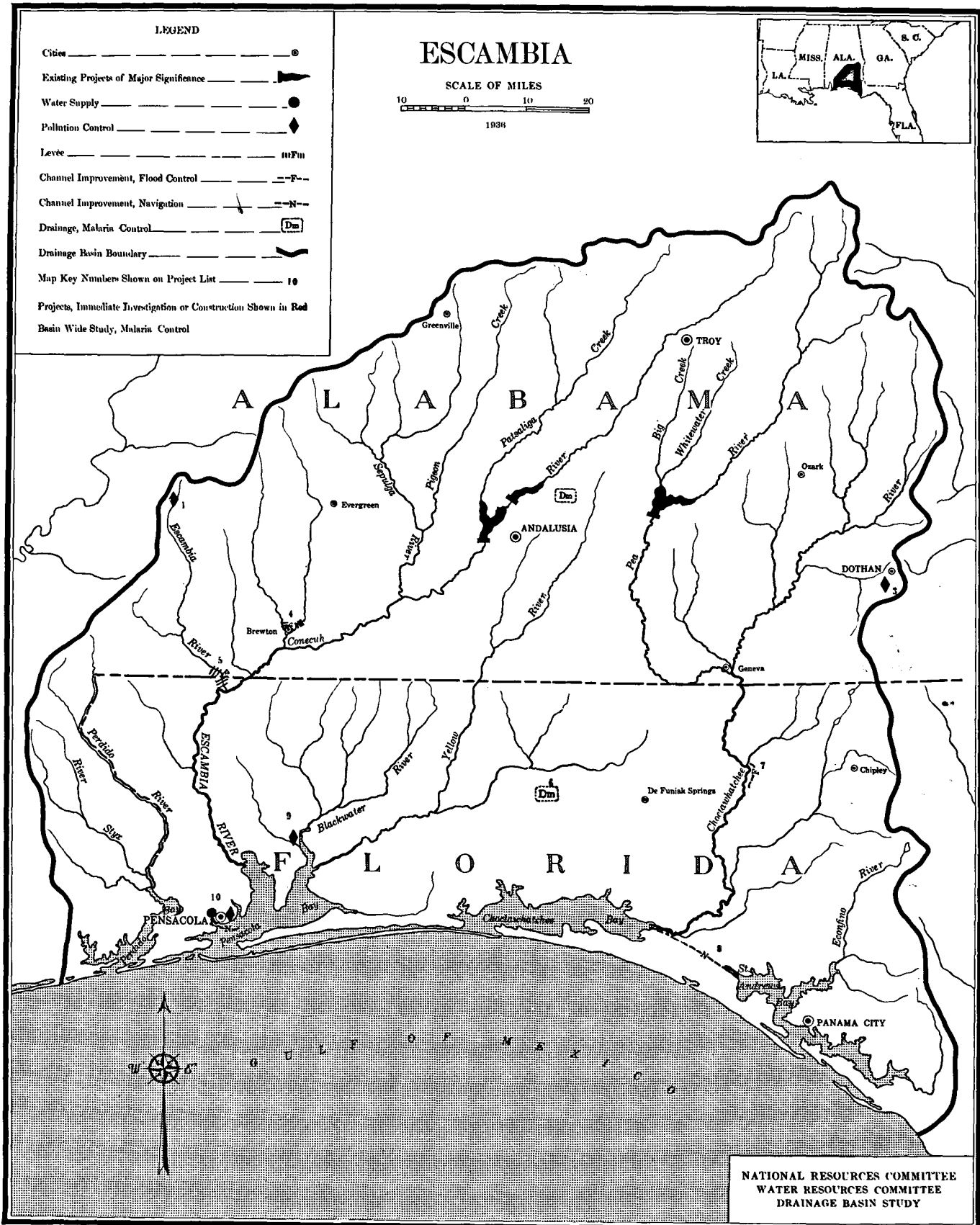
This region has few water problems that require immediate solution, but there are a number of potential troubles which can be anticipated by farsighted planning.

Sewage treatment has been provided to some extent by 46 communities, but only in Tallahassee is the treatment adequate and even there an extension of the collecting system is needed. Pensacola presents the most acute problem, since the discharge of its raw sewage into Pensacola Bay has polluted the water to such an extent that the shellfish beds have been condemned. Santa Rosa Sound, Choctawatchee Bay, and St. Andrews Bay are all important sport and commercial fishing grounds which should be protected against further pollution by raw sewage.

Immediate construction of treatment plants is recommended at Thomasville, Ga.; Pensacola and Milton, Fla.; and Dothan, Ala. A complete sewer system and sewage-treatment plant are necessary at Frisco City, Ala. Stream pollution is not now critical in other places but any material increase in population would present additional problems.

Municipal and domestic *water supplies* come almost entirely from deep wells, the waters of which are now highly mineralized and show increasing salinity. In the future it probably will be necessary to use surface waters to a greater extent than at the present. Some communities which depend entirely upon private wells should have municipal systems. A study of available resources of both surface water and underground water is recommended. Two projects are recommended for immediate construction; one for an additional supply for Pensacola, the other for a new municipal supply at Cross City.

Navigation.—Pensacola Harbor and St. Andrews Bay (Panama City Harbor) have been improved to accommodate large vessels. Future industrial development at Port St. Joe may create a need for better port and navigation facilities there.



The St. Marks River has been improved to some extent for navigation and the desirability of its further improvement is now being studied. A much needed harbor of refuge for off-shore fishing boats could be provided at the mouth of the Steinhatchee River.

The route of the intracoastal waterway parallels the entire coast, but it has not been located definitely at several points. Congress has authorized the dredging of a 26-mile stretch between Choctawatchee Bay and West Bay. Crooked River is now being surveyed.

Death rates from malaria in this region range from 36 to 155 per 100,000 of population, indicating a great need for control measures. The problem is complicated by legal difficulties and by the fact that the inhabitants cannot finance a widespread program. Several projects for eliminating mosquito-breeding grounds have been initiated but much work remains to be done. A comprehensive study of the problem is needed, including the collection of basic data not now available and the preparation of a logical plan of attack which will deal first with the areas in which the disease is serious.

Consideration also should be given to maintenance of any control works that may be provided.

Recreation and wildlife possibilities are plentiful in this region, but have not been developed to any great extent because of lack of capital. There are three national forests in the area and an ideal site for a migratory waterfowl refuge on the St. Marks River, for the improvement of which plans have been completed by the Bureau of Biological Survey. Bathing beaches near Pensacola, Fort Walton, and Panama City are menaced by sewage pollution, but this threat would be removed by the treatment plants recommended.

Flood control studies are being made by the Corps of Engineers in the Escambia and Choctawatchee Basins. Projects now underway at Geneva and Elba should be completed. Levees have been authorized at Brewton and Flomaton, Ala. Protection works are needed also at Caryville, Fla.

Water power is not important in this area. A few small plants are in operation and the few potential sites may be utilized when the power market develops.

Aucilla Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
2	Thomasville, Ga.: Sewage-treatment plant and improvements to sewer system.....	\$94,000	Plans completed.
3	Tallahassee, Fla.: Extension to sewer system.....	265,000	Do.
7	Cross City, Fla.: Water-supply system.....	36,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
5	Wakulla County, Fla.: Dredging channel 10 feet deep to St. Marks River.....	\$75,000	Plans not completed. Further study necessary.
6	Dixie County, Fla.: Dredging channel 6 feet deep to Steinhatchee River.....	68,000	Do.
4	Florida portion of basin: Drainage for malaria control.....	226,000	Do.
1	Georgia portion of basin: Drainage for malaria control.....	117,000	Do.
6	Increase depth of entrance channel to Steinhatchee River from 6 feet as now recommended to 9 feet....	250,000	Do.

Escambia Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of drainage for malaria control in specific areas with high malaria incidence.....	\$10,000	Pertains to construction project.
10	Pensacola, Fla.: Improvements to sewer system.....	84,000	Plans completed.
3	Dothan, Ala.: Improvements to sewer system including treatment plant.....	48,000	
9	Milton, Fla.: Sewage-treatment plant for primary treatment.....	44,000	Do.
1	Frisco City, Ala.: Sewer system with septic tank.....	30,000	
10	Pensacola, Fla.: Additional water supply with installation of new wells.....	26,000	Do.
8	Intracoastal waterway extension from Choctawatchee Bay to West Bay by dredging 26-mile channel 100 feet wide, 9 feet deep.....	770,000	Plans under way. Project authorized by Congress.
4	Brewton, Ala.: Levees or improvement of flood channels.....	242,000	Authorized by Congress.
5	Flomaton, Ala.: Levees or improvement of flood channels.....	154,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
10	Pensacola Harbor, Fla.: Dredging channel and basin to provide refuge and repair basin for medium sized vessels.....	\$40,000	Surveys completed. Not yet authorized by Congress.
6	Florida portion of basin: Drainage for malarial mosquito control.....	146,000	Plans incomplete. Further study necessary. Should await completion of study project in Group A.
2	Alabama portion of basin: Drainage for malarial mosquito control.....	328,000	Plans incomplete. Further study necessary. Await completion of study project in group A.
7	Caryville, Fla.: Flood control improvements.....	139,000	Tentative plans ready.

7. MOBILE

(Mobile, Alabama, Black Warrior, and Tombigbee)

Plans for the best use of water resources in the Mobile Bay drainage area include as most immediate the installation and improvement of water supply systems and of works for the abatement of pollution. Other needed projects pertain to navigation and drainage for mosquito control.

General Description

The Mobile Bay drainage area includes the basins of the Mobile, Alabama, Tombigbee, Black Warrior, Cahaba, Coosa, and Tallapoosa Rivers, and their tributaries discharging into Mobile Bay on the Gulf of Mexico. The region is about 370 miles long from northeast to southwest and 330 miles wide, covering most of Alabama, parts of northeast Mississippi, and northwest Georgia, and a small section of Tennessee. Its area is about 44,000 square miles, more than equivalent to New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island.

The eastern and southern parts of the region are in the Great Coastal Plain; the land is relatively low and flat, and the soils in most places are fertile and suited to large-scale agriculture. Erosion is not as widespread as in some other sections but has caused much land to be abandoned. In the central-north and northeastern portions the land is hilly or mountainous with great mineral wealth in its deposits of coal, iron ore, and cement materials. There is some farming on good land on the higher plateaus. Serious soil erosion has affected some of the country drained by the Coosa River. The central-eastern portion of the region is a plateau 500 to 2,000 feet above sea level; it contains good farm lands which are highly cultivated but some of its soils are badly eroded. There are six large hydroelectric plants in this area on the Coosa and Tallapoosa Rivers, including Martin Dam with one of the larger water-storage reservoirs in the country.

The total population of the region is about 2,500,000. The larger cities include Birmingham, Mobile, Montgomery, Gadsden, Bessemer, Tuscaloosa, and Selma in Alabama; Rome in Georgia, and Columbus in Mississippi. The urban population is about one-fourth of the total, and there is a tendency toward rapid growth in the industrial cities. Agriculture is the principal occupation of the people, but parts of the region are highly industrialized. River transportation facilities, already excellent, are worthy of certain needed improvements.

Recommended Plan

With the rapid growth of urban population, some cities have been unable to provide needed water supplies, waterworks extensions, sewer systems and especially sewage-treatment plants. Under P. W. A. and W. P. A. auspices much of the resulting deficiency has been corrected; the additional projects listed in this report, if carried out, would further improve the situation.

Water supply needs exist in many communities and projects are recommended to fill them. Some of the surface and underground waters are hard, but in general potable water is available in all sections. Because of the abundant rainfall and the nature of the underlying formations, good water can generally be found in drilled or dug wells for domestic, municipal, and industrial supply, though most waters from the limestone formations need treatment.

Stream pollution by sewage and by wastes from mines and industrial plants is becoming serious. Without adequate control, some of the rivers will become unsuited for any except crude industrial use. Action should be taken to prevent extreme pollution of the Warrior River and the waters of Mobile Bay. Many sanitation projects are ready for immediate execution.

Navigation facilities can be improved by providing a 9-foot channel from Mobile into the coal fields at the headwaters of the Warrior River. It is proposed to dredge cut-offs, straighten the channel, improve the present locks and dams, and build new ones. Other navigation projects are listed for future consideration.

Water power projects could be combined with proposed improvements for navigation on the Tombigbee and Warrior Rivers, but they have not been recommended as feasible. Power might be developed in connection with navigation on the Coosa River if the river flow is regulated by reservoirs on the Etowah River.

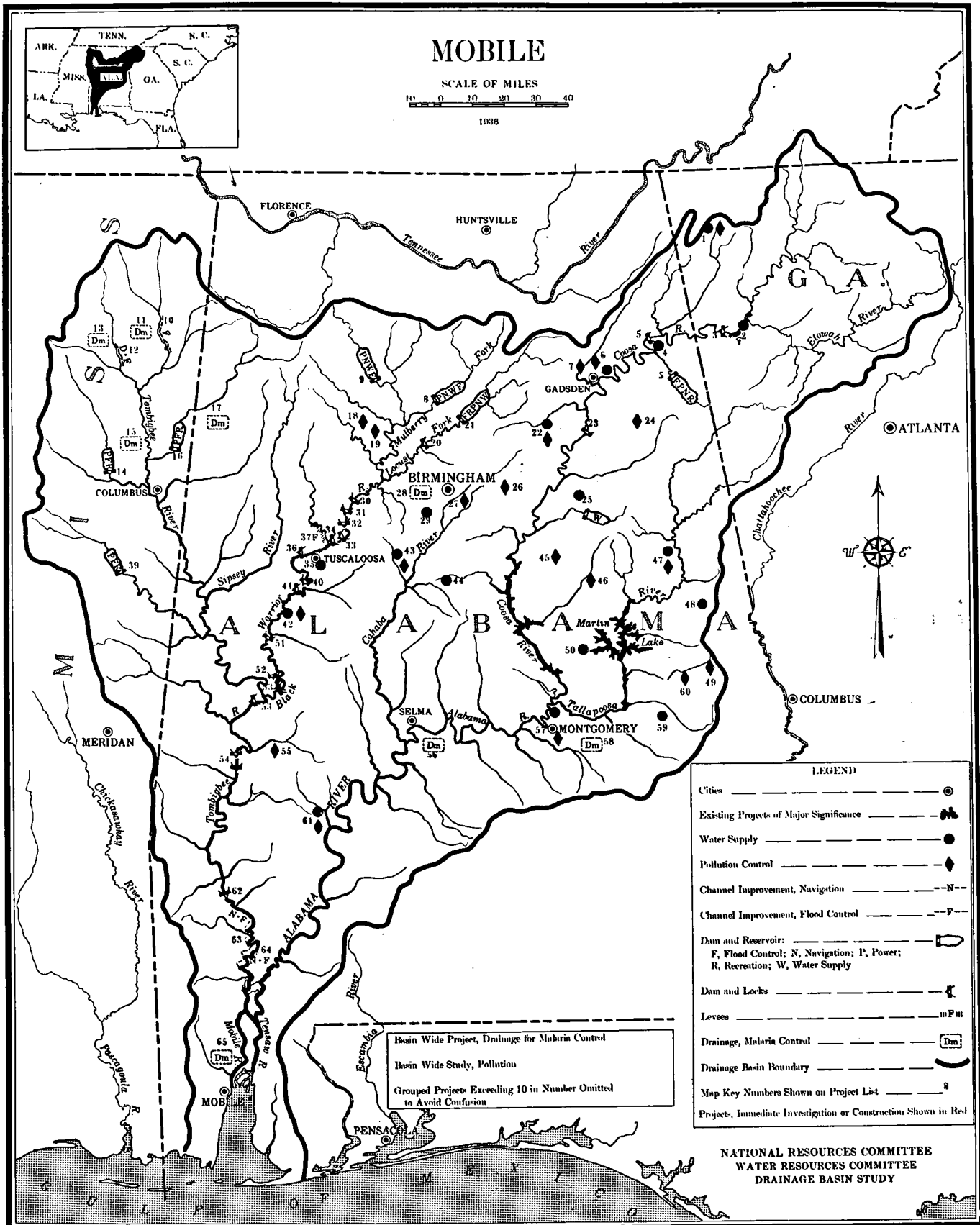
Investigation and planning of these and other large power possibilities are included in the comprehensive study recommended for the general problem of power development in the Southeastern States.

Drainage is needed in some sections for mosquito control and for land reclamation. Much has already been accomplished with Federal aid and the projects listed would further improve the basin.

Mobile Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study to determine means for pollution control of streams by gathering data on domestic and industrial waste throughout the basin.	\$50,000	
2	Rome, Ga.: Improvements and extensions to water works system.....	240,000	Plans completed.
57	Montgomery, Ala.: Sewage treatment plant for complete treatment.....	220,000	Do.
57	Montgomery, Ala.: Improvements and extensions to water works system including 6 wells, pumps, and storage tank.....	340,000	Do.
35	Tuscaloosa, Ala.: Extensions to waterworks system.....	47,000	Do.
(1)	Blotson (43), Center (4), Eclectic (50), Lafayette (48), and Wilton (44), Ala.: Water supply systems.....	190,000	Do.
(1)	Attalla (7), Blocton (43), Cordova (19), Goodwater (46), Jacksonville (24), Jasper (18), Leeds (26), Linden (55), Opelika (49), and Sylacauga (45), Ala.: Sewer systems or extensions.....	455,000	Do.
(*)	Itawamba (11) County, Miss.; Jefferson (28) County, Ala.; Lee (13) and Monroe (15) Counties, Miss.: Drainage canal projects for mosquito control, land reclamation, and channel improvements.....	188,000	Do.
36	Tuscaloosa County, Ala.: Construction of new dam and lock no. 10 on Warrior River at Mile 361 near Tuscaloosa, Ala., to replace dams nos. 10, 11, and 12.....	2,550,000	Plans completed. Authorized by Congress. Amount of cost needed to complete project. Cost includes \$25,000 for land and damages.
63	Clark and Washington Counties, Ala.: Dredging channel for 9-foot depth on the Tombigbee River from mouth to dam and lock no. 1 at Mile 111, for navigation and flood control.....	30,000	Plans completed. Authorized by Congress. Under construction.
64	Clark and Washington Counties, Ala.: Dredging cut-off canal at Sunflower Bend on the Tombigbee River from Mile 78 to Mile 90 for navigation and flood control.....	335,000	Plans completed. Cost includes \$37,000 for land and damages.
40	Tombigbee-Warrior Rivers, Ala.: Installing temporary 1-foot flashboard on dams no. 1 to no. 9, inclusive, to increase channel depth from mouth to lock no. 10.....	36,000	Plans completed. Authorized by Congress.
(1)	Akron (42), Ashville (22), Ala.; La Fayette (1), Ga.; Pine Hill (61) and Wadley (47), Ala.: Waterworks and sewer systems.....	258,000	Plans completed.
6	Gadsden, Ala.: Sewage treatment plant.....	390,000	Preliminary plans completed.
(1)	Boston, Brent, Cuba, Ala.; East Tupelo, Miss.; Gordo, Haleyville, Helena, Jackson, Kennedy, Ala.; Maben, Miss.; Marion, Montgomery, Oakman, Pleasant Grove, Ragland, Ala.; Salltillo, Miss.; Talladega and Wilsonville, Ala.: Waterworks and water-supply systems or extensions.....	611,000	Plans completed.
(1)	Auburn (60) and Jasper (18), Ala.: Sewage treatment plants.....	97,000	Preliminary plans completed.
	Alexander City, Ala.: Baldwin, Miss.; Berry, Boaz, Camden, Fort Payne, Gadsden (Club Heights), Grove Hill, Hamilton, Livingston, Oakman, Talladega, Ala.: Sewer systems and extensions.....	448,000	Plans completed.
	Study to determine drainage and reclamation projects necessary for malaria and mosquito control throughout the basin.....	50,000	
	Drainage for malaria control throughout the basin.....	1,968,000	Preliminary plans completed. This is dependent upon study project.
59	Tuskegee, Ala.: Water supply and waterworks improvements.....	113,000	Plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Northport (37), Tuscaloosa, County Ala.: Levees.....	100,000	Preliminary plans completed.
27	Homewood, Ala.: Sewer system extension.....	\$96,000	Plans completed.
29	Bessemer, Ala.: New waterworks system and supply.....	1,018,000	Do.
6	Gadsden, Ala.: Improvements to waterworks system.....	96,000	Do.
25	Talladega, Ala.: Dam and reservoir for water supply.....	74,000	Plans being prepared.
6	Gadsden, Ala.: Sewer system extensions.....	200,000	Plans completed.
(*)	Dallas (56) and Lamar (17) Counties, Ala.: Drainage canals for malaria control and land reclamation.....	85,000	Do.
65	Mobile County, Ala.: Drainage for malaria control, land reclamation and channel improvement of Three Mile Creek near Mobile.....	300,000	Do.
58	Montgomery County, Ala.: Drainage for malaria control throughout the county.....	124,000	Plans being prepared.
56	Dallas County, Ala.: Drainage for malaria control throughout the county.....	113,000	Do.
2	Rome, Ga.: Levees for flood control.....	330,000	Plans being prepared. Cost includes pumping equipment and changes in bridges, street levels, railroads, etc. Authorized by Congress.
10	Itawamba County, Miss.: Straightening river channel in East Fork of Tombigbee River near Fulton for flood control.....	109,600	Preliminary survey completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
12	Tupelo, Miss.: Drainage canal and dredging channel of West Fork for flood control.....	\$184,000	Plans completed.
41	Green and Hale Counties, Ala.: New dam and lock on Warrior River at Mile 296 to replace present dams and locks nos. 8 and 9.....	2,723,000	Do.
51	Green and Hale Counties, Ala.: New dam and lock on Warrior River at Mile 275 to replace present dam and lock no. 7.....	2,796,000	Do.
52	Green and Hale Counties, Ala.: New dam and lock on Warrior River at Mile 252 to replace present dam and lock no. 6.....	2,972,000	Do.
53	Marengo and Sumter Counties, Ala.: New dam and lock on Tombigbee River at Mile 227 to replace present dams and locks nos. 4 and 5.....	2,582,000	Do.
54	Choctaw and Marengo Counties, Ala.: New dam and lock on Tombigbee River at Mile 184 to replace present dams and locks nos. 2 and 3.....	2,867,000	Do.
62	Clark and Washington Counties, Ala.: Raising dam no. 1 three feet and constructing new lock on Tombigbee River at Mile 111.....	1,725,000	Do.
34	Tuscaloosa County, Ala.: Construct new lock 95 feet by 460 feet at lock no. 13 on Warrior River at Mile 370.....	1,651,000	Do.
33	Tuscaloosa County, Ala.: Construct new lock, 95 feet by 460 feet at lock no. 14 on Warrior River at Mile 374.....	1,585,000	Do.
32	Tuscaloosa County, Ala.: Construct new lock, 95 feet by 460 feet at lock no. 15 on Warrior River at Mile 380.....	1,651,000	Do.
31	Tuscaloosa County, Ala.: Construct new lock, 95 feet by 460 feet at lock no. 16 on Warrior River at Mile 386.....	1,518,000	Do.
30	Tuscaloosa County, Ala.: Construct new lock, 95 feet by 460 feet at lock no. 17 on Warrior River at Mile 388.....	6,100,000	Do.
23	Calhoun and Saint Claire Counties, Ala.: Patly Dam and locks on Coosa River near Ohatchee at Mile 592 for navigation, generation of power, flood control and recreation.....	2,892,000	Preliminary survey completed.
5	Cherokee County, Ala.: Cut-off canal, dam and locks on Coosa River near Leesburg at Mile 579 for navigation, generation of power, flood control and recreation.....	3,993,000	Do.
3	Floyd County, Ga.: Mayo's Bar Dam raised 2 feet and locks rebuilt on Coosa River at Mile 662 for navigation.....	762,000	Do.

¹ Map key number shown following community name.
² Map key number shown following county name.



Mobile Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP C—TIME OF CONSTRUCTION INDETERMINATE—Continued			
20	Jefferson County, Ala.: Dam and lock B on Locust Fork of Warrior River at Mile 444 for navigation, generation of power, flood control, and recreation.	6,468,000	Preliminary survey completed.
9	Winston County, Ala.: Impounding dam no. 1 on Sipsey Fork of Warrior River at Mile 471 for generation of power, navigation, water supply, flood control, and recreation.	6,647,000	Do.
8	Cullman County, Ala.: Impounding dam no. 2 on Mulberry Fork of Warrior River at Mile 466 for generation of power, navigation, water supply, flood control.	4,672,000	Do.
21	Blount County, Ala.: Impounding dam no. 3 on Locust Fork of Warrior River at Mile 479 for generation of power, navigation, water supply, flood control, and recreation.	7,746,000	Do.
36	Tuscaloosa County, Ala.: Power plant at new dam no. 10 on Warrior River near Tuscaloosa, Ala., at Mile 361.	2,293,000	Do.
31	Tuscaloosa County, Ala.: Power plant at dam no. 16 on Warrior River at Mile 386.....	1,485,000	Do.
32	Tuscaloosa County, Ala.: Power plant at dam no. 15 on Warrior River at Mile 380.....	1,549,000	Do.
33	Tuscaloosa County, Ala.: Power plant at dam no. 14 at Warrior River at Mile 374.....	1,530,000	Do.
34	Tuscaloosa County, Ala.: Power plant at dam no. 13 on Warrior River at Mile 370.....	1,505,000	Do.
39	Noxubee County, Miss.: Impounding dam no. 4 on Noxubee Creek at Mile 351 for generation of power, flood control, and recreation.	3,443,000	Do.
14	Clay and Oktibbeha, Miss.: Impounding dam no. 5 on Tibbee River at Mile 410, for generation of power, flood control, and recreation.	6,702,000	Do.
16	Monroe and Lowndes Counties, Miss.: Impounding dam no. 6 on Buttahatchee River at Mile 407 for generation of power, flood control, and recreation.	3,121,000	Do.

TENNESSEE VALLEY

1. Tennessee Valley

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1. TENNESSEE VALLEY

In the Tennessee River Basin the annual rainfall and the run-off are relatively high. Their distribution is so irregular that even on the Tennessee River itself the flow during maximum floods is 50 to 100 times as great as the lowest flow. The principal water problem is regulation of the streams for navigation, flood control, and incidental power-development purposes. Other important benefits to be realized through water control in the basin are: more reliable water supply for industrial, municipal, and domestic uses; improvement of sanitary and stream-pollution conditions; fisheries and wildlife conservation; and the provision of facilities for recreation.

In order to accomplish these ends, dams with navigation locks are now needed in the main stream, and perhaps will be needed later on some of the tributaries. Storage dams are required on tributary streams. Municipal water supply, sewage treatment and disposal, and drainage improvements are needed to benefit sanitary and health conditions.

General Description

The Tennessee River is formed by the Holston and French Broad Rivers which join just above Knoxville, Tenn. It is 650 miles long and flows first in a south-westerly direction through Tennessee. It then crosses Alabama, forms a small portion of the northeastern boundary of Mississippi, and flows northward through western Tennessee and western Kentucky to empty into the Ohio River at Paducah, Ky.

The basin, which includes portions of seven States, is an irregular area having a length of about 500 miles, an average width of about 80 miles, and a total area about equal to that of the State of Ohio. It is almost separated by a contraction near Chattanooga, Tenn., into two nearly equal parts.

From the mile-high peaks of the Appalachian highland, the floor of the watershed slopes through limestone valleys of the interior plains to the more recently formed clays and sands of the lower valley. The altitude is only 300 feet at Paducah, where the Tennessee River cuts into the Mississippi alluvial area and joins the Ohio River.

Some 13,500,000 acres, approximately half the area of the watershed, is in woodland, mainly on the mountain slopes. Spruce, balsam, and northern hardwoods are found high up in the Appalachians, oak and hickory types in the central hardwood forest, and southern pine and river-bottom types in the western part of the valley.

The population of the basin is approximately 2,250,000, 60 percent of which is rural. Population distribution is remarkably even, despite the rugged topography of the mountain areas. The population has increased slowly but steadily for a century. The development of the basin now under way by the Tennessee Valley Authority should cause an increased rate of growth in cities and on farms.

Of the open land in the Tennessee Valley, about half is used for pasture, hay, and small grains, and more than one-fourth for intertilled crops, chief of which are corn, tobacco, cotton, sweetpotatoes, and potatoes. On about 90 percent of the open farm area erosion ranges from moderate sheet washing on the gentle slopes to excessive sheet washing and gullying on the steep slopes. Appreciable erosion also occurs in cut-over and poorly developed forest areas.

The textile industry is the most important manufacture of the basin. The knit goods branch of this industry is particularly important here, with many hosiery mills operating in small communities. Chattanooga and Knoxville are centers for the finishing of textiles and the manufacture of underwear, respectively. Asheville manufactures rayon and cellulose, both of which help to support important industries in the Kingsport-Johnson City area and in Chattanooga.

Woodworking industries, including production of flooring, furniture, veneer, barrel staves, wood distillation, and tanning extract, are founded on the hardwood resources of the region and serve national markets. Other manufacturing industries, significant where they appear, include aluminum, cement, marble, foundries, woolen textiles, paper, sulphuric acid, and alkalies.

Transportation facilities in the basin include about 130 miles of waterways of 9-foot depth or greater, about 330 miles of 3- to 9-foot depth, and about 525 miles of less than 3-foot depth; some 6,900 miles of Federal and State highways; 3,670 miles of railroads; and some 25 airports built or under construction.

The average annual rainfall is approximately 52 inches, varying from about 40 inches in dry years to about 60 inches in wet years. Over limited areas, the average annual rainfall may be as high as 80 inches, or as low as 40 inches. The average annual run-off is about 24 inches, varying from about 13 inches in a dry year to about 34 inches in a wet year. Some small isolated areas have an average annual run-off as low as

14 inches, others as high as 44 inches. Most of the run-off occurs from December to May, inclusive. During the remainder of the year stream flow is small.

Recommended Plan

The Tennessee River system requires a unified plan of construction and water control because of many and varied uses of the water; chief among which are navigation, flood control, and power development. Without such integrated control, the developments in the system would lose much of their usefulness and value. There is an existing navigation project, adopted by Congress in 1930, providing for a 9-foot navigable depth throughout the entire length of the main Tennessee River from Knoxville, Tenn., to its mouth. The Tennessee Valley Authority Act, as amended in 1935, contains provisions covering the development of the Tennessee River system. Construction is in progress by the Tennessee Valley Authority. The act provides that the Authority:

Shall have power to construct such dams and reservoirs in the Tennessee River and its tributaries, as in conjunction with Wilson Dam, and Norris, Wheeler, and Pickwick Landing Dams, now under construction, will provide a 9-foot channel in the said river and maintain a water supply for the same, from Knoxville to its mouth, and will best serve to promote navigation on the Tennessee River and its tributaries and control destructive flood waters in the Tennessee and Mississippi River drainage basins; and shall have power to acquire or construct power houses, power structures, transmission lines, navigation projects, and incidental works in the Tennessee River and its tributaries, and to unite the various power installations into one or more systems by transmission lines (Sec. 4 (j)).

The act also gives the Authority supervisory control over works constructed by other agencies. It provides in addition for the generation and disposal of electric energy in the following terms:

The board is hereby directed in the operation of any dam or reservoir in its possession and control to regulate the stream flow primarily for the purposes of promoting navigation and controlling floods. So far as may be consistent with such purposes, the board is authorized to provide and operate facilities for the generation of electric energy at any such dam for the use of the corporation and for the use of the United States or any agency thereof; and the board is further authorized, whenever an opportunity is afforded, to provide and operate facilities for the generation of electric energy in order to avoid the waste of water power, to transmit and market such power as in this act provided, and thereby, so far as may be practicable, to assist in liquidating the cost or aid in the maintenance of the projects of the Authority (Sec. 9a).

When this act was passed, the high head Wilson Dam, locks, and power and nitrate plants were in existence on the Tennessee River, having been built by the Federal Government as a World War measure. Also, certain hydroelectric plants had already been

built by private interests on the Tennessee River and some of its tributaries. The most important of these is the Hales Bar Dam on the main river below Chattanooga, in which a navigation lock was installed. These two main stream projects provided 9-foot navigable depth over disconnected river reaches totaling less than one-tenth of the total river mileage. The principal privately owned power dams on the tributaries are the Calderwood, Cheoah, and Santeetlah Dams on the Little Tennessee and Cheoah Rivers; the Waterville Dam on the Big Pigeon River; and the Ocoee no. 2, Ocoee no. 1, and the Blue Ridge Dams on the Ocoee and Toccoa Rivers, tributary streams of the Hiwassee River. All of the tributary stream water power projects are located on headwater tributaries of the Tennessee River in the eastern section of the basin. These and numerous existing smaller plants must be taken into consideration in planning the development of the river system.

When work was begun to carry out the authorizations of Congress, embodying, among other things, a 9-foot navigable depth for the entire Tennessee River and maintaining a water supply therefor, the control of destructive flood waters in the Tennessee and Mississippi River drainage basins, and the generation of electric energy, the Authority found the main stream improved for dependable 9-foot navigation at only two points. These navigable sections of river were formed by the slack-water pool from the Wilson Dam, located about 260 miles above the mouth of the river, which provides 9-foot navigation over the Muscle Shoals reach about 15 miles long, and by the pool from the Hales Bar Dam, about 431 miles above the mouth, which provides 9-foot navigation upstream to the vicinity of Chattanooga, a distance of about 33 miles. In order to complete the navigation project, there remained about 600 miles of main stream to be improved. To complete this work the Authority has so far constructed or has under construction four additional locks and dams and two high storage dams on headwater tributary streams. The main-stream dams are: Pickwick Landing Dam, about 207 miles above the mouth, to provide navigation for about 53 miles up to Wilson Dam; Wheeler Dam, 275 miles above the mouth and at the head of the Wilson Dam pool, to provide navigation for about 74 miles up to the site of the Guntersville Dam; Guntersville Dam, 349 miles above the mouth and at the head of the Wheeler Dam pool, to provide navigation for about 82 miles to the existing Hales Bar Dam; and Chickamauga Dam, 471 miles above the mouth and about 7 miles above Chattanooga, to provide navigation for about 59 miles up to the site for the proposed Watts Bar Dam. Upon completion of these four main-stream dams and certain proposed increases in height of the Hales Bar

and Wilson Dams, 9-foot navigable depth will be available over a continuous river reach of about 325 miles, half the length of the river. Navigation conditions on the main stream were the worst in this 325-mile section.

There will remain about 184 miles of lower river and 120 miles of upper river to be improved. The Authority has recommended three additional dams, one in the lower river near the mouth and two in the upper river, to meet this need. These dams are: Gilbertsville, near the mouth of the river above Paducah in the pool formed by dam no. 52 in the Ohio River, to provide navigation up to Pickwick Landing Dam; Watts Bar Dam, 530 miles above the mouth and at the head of the Chickamauga Dam pool, to provide navigation for about 74 miles up to the proposed Coulter Shoals Dam; and Coulter Shoals Dam, 604 miles above the mouth and at the head of the proposed Watts Bar Dam pool, to provide navigation for about 46 miles up to Knoxville, Tenn., near the head of the main river. The construction of these three dams would complete the 9-foot navigation improvement of the Tennessee River.

While the construction of all these main-stream dams, together with the two existing dams, would completely canalize the Tennessee River, would afford a measure of flood control on the Tennessee and Mississippi Rivers, and would develop some power, they would lack in full effectiveness without upstream storage for the regulation of stream flow. Such regulation is most needed during flood and drought seasons, as both destructive floods and extremely low flows occur.

The two tributary storage dams, Norris Dam on the Clinch River and Hiwassee Dam on the Hiwassee River, are being constructed to provide needed regulation. Another tributary storage dam, Fontana Dam on the Little Tennessee River, has been recommended for the same purpose. Both flood-control and navigation benefits have already been provided by the Norris Dam (which was placed in operation in March 1936). During subsequent heavy spring rainfalls, with resulting floods downstream, floods which were especially severe at Chattanooga on the main stream, water was stored in this reservoir. It is estimated that as a result the flood peak at Chattanooga was reduced by about 4 feet. This operation probably reduced the flood damage in that city alone by several hundreds of thousands of dollars. Later in the year, throughout the low-water season during the summer and fall, the stored water was released to aid navigation. In addition to maintaining a regulated flow necessary for normal traffic, several special releases were made to provide adequate depths for craft which otherwise would not have been able to navigate. With the com-

pletion of the two additional tributary storage dams much greater flood control and navigation regulation will be possible. Moreover, the operation of these storage projects and all of the main-stream dams as a unit will result in obtaining maximum navigation, flood-control, and power-development benefits throughout the system. The benefits of this unified operation will extend downstream to the lower Mississippi, where a measurable decrease in flood waters and an increase in navigable depths during periods of low flows will be assured.

When the Wilson Dam and power house were completed more than 10 years ago, 8 hydroelectric power generating units were installed with a total capacity of 184,000 kw, and space was provided in the power house for 10 additional units having a capacity of about 250,000 kw. During the summer low-water season the minimum, natural river flow is about enough to run two of the units already installed, enough to produce 50,000 kw of continuous electric power.

At the Norris Dam on the Clinch River, two hydroelectric power units have been installed with an aggregate capacity of 100,000 kw. These units will not be operated during the winter season while the reservoir is being filled, but may be operated when needed during the summer season, while the reservoir is being emptied to increase the low-water flow in the Tennessee River. The water discharged at Norris Dam will more than double the low-water flow at Wilson Dam, and will increase correspondingly the amount of continuous prime power that can be produced at Wilson Dam.

At Wheeler Dam two hydroelectric units are being installed with an aggregate capacity of 64,000 kw, two identical units are being ordered, and intake openings are being provided through the dam for four additional units, so that these may be added if desired.

At the other dams it is expected that the initial power installations will be as follows: Pickwick Landing, two 36,000 kw units; Gunter'sville, two 25,000 kw units; Chickamauga, two 25,000 kw units; Hiwassee, none. Space is being provided for four additional units at Pickwick Landing, and for two at Gunter'sville, and Chickamauga. Space also is being provided for two units at Hiwassee.

At all the other main stream and tributary dams it is probable that intake openings will be built so that it will be possible to install power units if desired. It has not yet been decided how many such openings will be provided and it is impossible to predict when, if ever, they may be used.

It is of the greatest importance to the development of the Tennessee River Basin that a comprehensive plan for water development be made. One of the main functions of the Tennessee Valley Authority is the preparation of such a plan. In order to develop the

plan it is essential that much work of an investigational nature be done. To meet this need the Authority is engaged in a program of completely mapping the basin, making borings and engineering studies of dam sites and reservoir areas, preparing specifications and estimates for construction projects, and similar work, all in connection with the development of the basin which is now under way. This is essential to a proper coordination of the work. The plan provides for a continuation of this program.

With the completion of all the projects on the main river and the three tributary storage projects, including those authorized and under construction and those recommended by the Authority, there will remain much improvement work on tributary streams of the Tennessee. Before this can be undertaken it will be necessary that extensive surveys, investigations, and studies be made to determine the best method and to prepare preliminary plans and estimates of cost of desirable projects. This investigational work should be prosecuted during the course of the present construction program on the major tributaries in the basin, including the French Broad, Holston, Clinch, Little Tennessee, Hiwassee, Sequatchie, Elk, and Duck Rivers. This has been included in the plan.

Water supply at many places in this area is unsatisfactory either in quality or quantity, and surface waters to replace underground supplies should be utilized more than at present. While springs in certain localities afford adequate quantities of water of suitable quality, the numerous surface streams of the basin must furnish most of the water for municipal and industrial purposes as the density of population increases. Already improvements and enlargements of existing water systems and new systems are needed at a number of localities. The plan contemplates the in-

stallation of necessary facilities at certain points in the basin.

Land drainage is needed particularly in the lower reaches of the valley in Alabama and Tennessee. In that region and to some extent elsewhere in the basin, pooled water provides breeding places for mosquitoes which transmit malaria. Protection of the public health requires proper drainage and other protective work. The departments of public health of the several States in the valley are aware of the situation and are actively engaged in providing remedial measures. The Tennessee Valley Authority is undertaking to control the breeding of malaria-bearing mosquitoes in its reservoir areas. In addition to the activities of the agencies now engaged in malaria-control work the plan provides for several such projects in the basin.

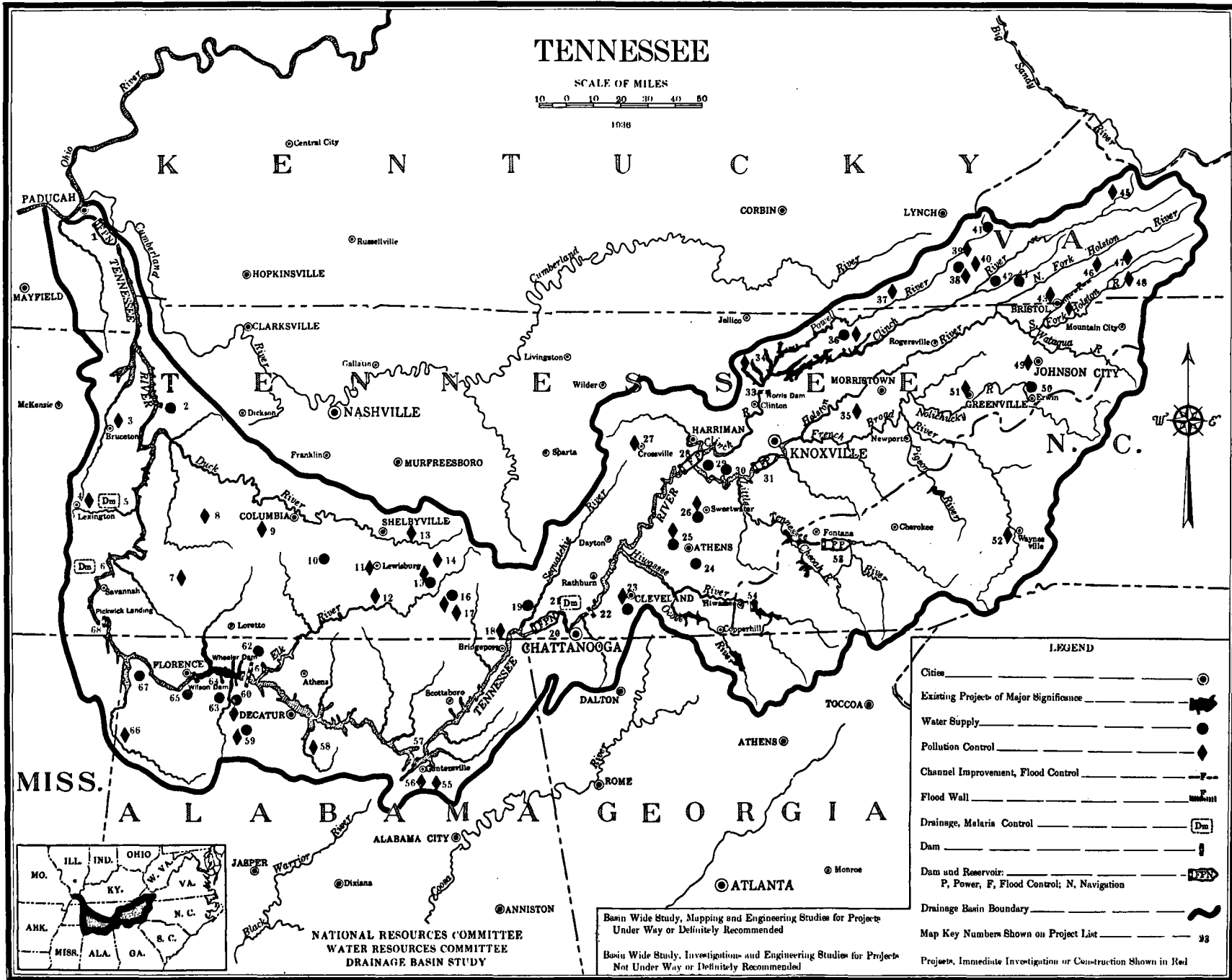
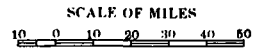
Sewage treatment and disposal heretofore have received relatively little attention since most of the streams have a flow large enough to receive raw sewage without undue pollution. This is particularly true along the main Tennessee River and the major tributary streams where most of the cities and larger towns are situated. However, there are now an increasing number of cities and towns which, in the interest of proper sanitation and public health, need to improve their sewage treatment and disposal plants or to provide new facilities. The plan provides for improvement of sewage collection, treatment, and disposal at many points in the basin.

Wildlife conservation is receiving attention in the valley by the Tennessee Valley Authority and other Federal and State, as well as private, agencies. The large reservoir areas of the Authority furnish advantageous sites for wildlife refuges.

Tennessee Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Program of mapping, engineering studies, borings, and investigations needed for design in connection with construction projects now under way.	\$2,100,000	
	Program of mapping, engineering studies, borings, and foundation studies, and preparation of preliminary plans in connection with construction projects already definitely recommended.	1,400,000	
	Program of surveys, investigations, engineering studies, borings, and preparation of preliminary plans and estimates for additional projects on major tributary streams of the Tennessee River, including the French Broad, Holston, Clinch, Little Tennessee, Hiwassee, Sequatchie, Elk, and Duck Rivers.	500,000	Preferably to be done concurrently with projects now under way. Essential for extending comprehensive plan of development to tributary streams.
33	Norris Dam on Clinch River: Construction for navigation, flood control, and incidental power development.	90,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances, including two 50,000 kilowatt generating units.
61	Wheeler Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	3,856,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances, including four 32,000-kilowatt generating units.
68	Pickwick Landing Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	8,950,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances, including two 36,000-kilowatt generating units.
57	Guntersville Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	23,697,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances, including two 25,000-kilowatt generating units.
22	Chickamauga Dam on Tennessee River: Construction for navigation, flood control, and incidental power development.	24,008,000	Work in progress. Cost given is for next 2 years. Additional needed to complete dam and initial appurtenances, including two 25,000 kilowatt generating units, \$7,375,000.

TENNESSEE



LEGEND

- Cities _____ ●
- Existing Projects of Major Significance _____ ■
- Water Supply _____ ●
- Pollution Control _____ ◆
- Channel Improvement, Flood Control _____ -F-
- Flood Wall _____ -F-
- Drainage, Malaria Control _____ [Dm]
- Dam _____ [D]
- Dam and Reservoir _____ [DPR]
- P, Power, F, Flood Control, N, Navigation
- Drainage Basin Boundary _____ ~~~~~
- Map Key Numbers Shown on Project List _____ 33
- Projects, Immediate Investigation or Construction Shown in Red



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Basin Wide Study, Mapping and Engineering Studies for Projects Under Way or Definitely Recommended

Basin Wide Study, Investigations and Engineering Studies for Projects Not Under Way or Definitely Recommended

Tennessee Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
54	Hiwassee Dam on Hiwassee River: Construction for navigation, flood control, and incidental power development.	\$7,900,000	Work in progress. Cost given is for next 2 years. Additional needed to complete dam and initial appurtenances, \$4,785,000. No generating units will be installed initially.
56	Albertville, Marshall County, Ala.: Sewer system	95,000	Preliminary plans prepared.
55	Boaz, Marshall County, Ala.: Sewer-system extension	49,000	Do.
58	Hartselle, Morgan County, Ala.: Sewer system	56,000	Do.
59	Moulton, Lawrence County, Ala.: Sewer system and sewage-treatment plant	40,000	Do.
66	Red Bay, Franklin County, Ala.: Sewer system and sewage-treatment plant	38,000	Do.
60	Courtland, Lawrence County, Ala.: Waterworks	29,000	Plans prepared.
59	Moulton, Lawrence County, Ala.: Waterworks improvements	31,000	Do.
65	Sheffield and Tusculumbia, Colbert County, Ala.: Waterworks	297,000	Preliminary plans prepared.
43	Bristol, Sullivan County, Tenn.: Sewage collection and treatment	750,000	Do.
27	Crossville, Cumberland County, Tenn.: Water supply; new source, treatment and extensions	78,000	Do.
51	Greeneville, Greene County, Tenn.: Sewage treatment and new outlet	250,000	Do.
11	Lewisburg, Marshall County, Tenn.: Sewage treatment plant additions	26,000	Do.
43	Bristol, Washington County, Va.: Flood control, stream clearance, and retaining wall	20,000	Plans completed.
(1)	Cherokee (67) and Leighton (63), Colbert County; Rogersville (62), Lauderdale County; and Town Creek (60), Lawrence County, Ala.: Waterworks and waterworks improvements	115,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
5	Beach River, Decatur and Henderson Counties, Tenn., and Knoxville, Knox County, Tenn.: Drainage and ditch lining for malaria control	\$175,000	
25	Athens, McMinn County, Tenn.: Water system improvements	100,000	
25	Athens, McMinn County, Tenn.: Sewer system including sewage treatment plant	150,000	
43	Bristol, Washington County, Va.: Sewers and sewage treatment plant	300,000	
49	Johnson City, Washington County, Tenn.: Sewage treatment plant and new outfall sewer	350,000	
30	Lenoir City, Loudon County, Tenn.: Water treatment plant	50,000	
26	Sweetwater, Monroe County, Tenn.: Water supply, improvements and treatment	35,000	
26	Sweetwater, Monroe County, Tenn.: Sewer system improvements and sewage treatment plant	50,000	
52	Hazelwood and Waynesville, Haywood County, N. C.: Sewage treatment plant	221,000	Preliminary plans prepared.
3	Bruceston, Carroll County, Tenn.: Sewage treatment plant	47,000	Do.
23	Cleveland, Bradley County, Tenn.: Water supply, new source and treatment	200,000	
23	Cleveland, Bradley County, Tenn.: Sewer-system improvements	200,000	
17	Cowan, Franklin County, Tenn.: Sewer-system improvements and sewage-treatment plant	75,000	
(1)	Abingdon, Washington County (42), and Clintwood, Dickenson County (41), Va.: Englewood, McMinn County (24); Erwin, Unicoi County (59); Jasper, Marion County (19); Tullahoma, Coffee County (15); and Waverly, Humphreys County (2), Tenn.: Water-supply systems, improvements, and extensions	290,000	
(1)	Fayetteville, Lincoln County (12); Jefferson City, Jefferson County (35); Manchester, Coffee County (14); Mount Pleasant, Maury County (9); Shelbyville, Bedford County (13); South Pittsburg, Marion County (18); Tullahoma, Coffee County (15); Tenn.: Sewer extensions, sewage-treatment and collecting plants; new installations and improvements	518,000	
42	Washington County sanitary district, Virginia: Water supply system	478,000	Plans prepared and project ready to advertise, except for some legal or other difficulties. Plans completed. Work begun in 1934, but discontinued due to lack of funds
6	White Oak, Hardin County, Tenn.: Drainage for malaria control	25,000	Plans completed.
21	Chatanooga, Hamilton County, Tenn.: Lining of ditches for malaria control	100,000	Plans completed.
53	Fontana Dam on Little Tennessee River: Construction for navigation, flood control, and incidental power development	8,225,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances, (preliminary estimate only) \$20,775,000.
1	Gilbertsville Dam on Tennessee River: Construction for navigation, flood control, and incidental power development	10,000,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances, (preliminary estimate only) \$68,756,000.
28	Watts Bar Dam on Tennessee River: Construction for navigation, flood control, and incidental power development	7,280,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances, (preliminary estimate only) \$23,720,000.
31	Coulter Shoals Dam on Tennessee River: Construction for navigation, flood control, and incidental power development	475,000	Cost given is for first 2 years. Additional needed to complete dam and initial appurtenances, (preliminary estimate only) \$19,525,000.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
20	Hales Bar Dam on Tennessee River: Raising dam, and/or dredging, or construction of low-lift lock and dam, for navigation, flood control and incidental power development	\$4,000,000	To be built upon authorization by Congress and completion of surveys, investigations, and plans. Preliminary estimate only, covering dam and initial appurtenances.
64	Wilson Dam on Tennessee River: Raising Wilson Dam and lock and dam no. 1 for navigation, flood control, and incidental power development	500,000	Do.
(1)	Decherd (16), New Tazewell (36), and Waynesboro (7), Tenn.: Water supplies and sewerage systems, improvements and new facilities	322,000	
(1)	Chilhowee (48), Va.: Lynnville (10), and Rockwood (29), Tenn.: Water supply, extensions and new sources	106,000	
(1)	Appalachia (39) and Big Stone Gap (38), Va.: Hohenwald (8), La Follette (34), and Lexington (4), Tenn.; Marion (47), Norton (40), Pennington Gap (37), Richlands (45), and Saltville (46), Va.: Sewerage systems, extensions, treatment and disposal plants	485,000	

1 Map key number shown following community name.

OHIO DRAINAGE BASINS

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OHIO

The Ohio River Basin as considered in this report covers the entire area drained by the Ohio River and its tributaries, except the Tennessee Valley. Included are about one-eighteenth of the land surface of the United States and one-seventh of its population. Problems of water use throughout the basin are complex and interrelated, presenting grave dangers and great opportunities. Some of these problems involve the entire river system, others are less broad in significance.

The following discussion takes up, first, those matters which affect the basin as a whole; next, those which pertain mainly to regions or sections of the area, divided for convenience into three great groups of secondary drainage systems—the upper river and its tributaries, including the Monongahela, the Allegheny, the Beaver, and the Kanawha; the northern tributaries, principally the Muskingum, Scioto, Miami, and Wabash; and the southern tributaries, of which the Big Sandy, the Kentucky, the Green, and the Cumberland are most important.

Problems which must be considered from the viewpoint of the basin as a whole are those involving the manifold use and reuse of water by communities and industries along the streams, the interrelationship of requirements for the control of floods on the one hand and of low-water flow on the other, and the utilization of the main stream itself. Problems more localized to the several subdivisions—but still in many cases related to the interests of the whole—are those of underground water supply, soil erosion, local navigation, recreation, and the development of power. Local situations are in some cases the most important or the most acute. They should therefore not be disregarded or slighted because of their position in this report.

Problems of the Basin as a Whole

The Ohio River is a highway, a sewer, and a water supply. The main stream and its tributaries supply the water essential to the health and welfare of the communities and industries that line their banks, furnish the only means of disposal for nearly all the waste products of human and industrial activity, and carry the heaviest river traffic in the country.

Continually increasing use of the principal rivers for waste disposal has already destroyed the value of many of them for recreation and now urgently threatens many of the water supplies indispensable to the existence of various communities. Some cities are practically drinking their own and their neighbors'

sewage. Recent record-breaking floods have focused attention on the danger of uncontrolled high waters. Works proposed for flood control, if properly designed and operated on the basis of sound comprehensive data, may also prevent the extremely low flows which aggravate the menace of waste disposal. These problems, largely interstate, involve great areas and demand for their solution a comprehensive attack. Data are insufficient at present for the immediate prosecution of such an attack. This report outlines the requirements, recapitulates briefly the results of the excellent work so far accomplished, and lists the projects and studies next in line to supply the more pressing needs and to furnish a sound basis for more effective later efforts. Elimination of pollution by sewage and industrial waste calls for a comprehensive program assuring each town and industry that its own efforts at purification will not be canceled by continued pollution from other parts of the basin.

Flood control and low-water control involve a widespread system of reservoirs which must be competently integrated in design and operation, in order to regulate flood heights and minimum flows along the main stream. River navigation involves not only improvements in navigation structures, but regulation of stream flow and correlation with pollution control. Recreational possibilities depend directly on the other factors of river management to be considered in the general plan.

General Description

The Ohio River Basin, an empire somewhat larger than Germany, extends from western Pennsylvania and New York to the Mississippi River and from northern Tennessee and South Carolina nearly to the Great Lakes. In topography it ranges from the Appalachian Mountains to the nearly level plains country of Ohio and Indiana. In certain parts of the basin preglacial valleys, now filled with glacial gravel, provide large underground storage basins. Seasonal variations of temperature are strongly marked: summer temperatures reach 110° F. and winter records have been as low as minus 35° F. Rainfall is ample and usually well distributed throughout the year, but with occasional droughts and occasional flood-producing storms. Precipitation is greatest in the mountains to the southeast.

Industrially and agriculturally, the area is one of the richer in the Nation. Agricultural lands comprise about one-third of the basin. The chief products

are corn, hay, oats, livestock, wheat, and tobacco. The value of the agricultural products is about one-eighth of the Nation's total, and is about equal to the value of the manufactured products of the basin. A large share of the national production of steel, coal, oil, natural gas, building limestone, fire clay, asphalt, and fluorspar is credited to the Ohio Basin. Other industries and products of national importance are automobiles, rubber, electrical machinery, meat packing, and tobacco processing.

Recommended Plan

Pollution of the Ohio by untreated domestic sewage, complicated by the presence of industrial wastes and acid-mine waters, is a continual and imminent threat to public health. The situation is serious because of the general use of river water for municipal supplies. Examinations at water intakes have shown bacteria of the coli-aerogenes group in numbers as high as 100,000 per 100 cc, 20 times the average limit indicated by the observations of the U. S. Public Health Service as a safe bacteriological loading of treatment plants. Even if using every means of water purification, some of the cities have suffered widespread epidemics of an intestinal nature attributed to the water supply. Magnificent facilities for swimming, boating, and fishing, in a thickly populated area with few lakes, are rendered useless by this contamination.

The population of the Ohio Basin is about 16,000,000 and the sewage from 6,500,000 of these people drains to the Ohio River either directly or through tributaries. Less than 30 percent of the sewage receives any treatment. The population sewered directly to the river is 3,800,000.

When the Monongahela and the Allegheny join at Pittsburgh to form the Ohio, sewage from some 2 million people has already been discharged into a stream which has an extreme low water flow of only 1,000 cubic feet per second. The intolerable nuisance which might be expected is prevented only by the presence of great quantities of sulphuric acid in the stream, largely derived from mine waters. While this acid prevents the putrefaction of sewage at Pittsburgh, it likewise retards the processes of natural purification.

On days of minimum flow, about 1 quart of every gallon flowing in the river at some places has passed through a sewer system. This liquid after filtration is used as drinking water by 2,500,000 people.

Canalization of the Ohio has an important bearing on the pollution problem. Navigation pools are formed by a series of dams retarding flow during low water. As sewage enters these pools the solids settle to the bottom and accumulate during long periods. When the river rises, the accumulated sludge is washed down, mixed with fresh sewage, to waterworks be-

low. At such times extreme care in the management of water-supply plants is required to prevent invasion of bacteria into city supplies.

Thus the Ohio conveys the raw sewage of one city to the water supply intake of the next, sometimes losing a little of its pollution on the way and then picking up a fresh load. Pollution loads at the intakes of some of the city waterworks are among the worst in the United States.

The effect of pollution at Charleston, W. Va., in 1930 showed that water purification plants cannot be depended upon in cases of extreme overload. The Elk River, which furnished the water supply, became so low that water was drawn up from the Kanawha River past the Charleston sewer outfall and garbage dump. The water was treated so that it met the Federal Treasury Department bacteriological standards for drinking water, but it had a nauseating taste. More than 4,000 people were stricken with an intestinal disturbance—not fatal, but disagreeable. Later, when the polluted water was washed downstream, the same disease followed down from town to town, even though the water plants took every precaution and met every bacterial test. This experience indicates the ever-present danger that some accident may precipitate a serious epidemic among the millions who drink these heavily polluted waters.

A determined attack on the Ohio River pollution problem has been recommended by the Ohio Board of Engineers, consisting of the chief engineers of the health departments of the States in the Ohio Basin. It recommends that, beginning with larger cities, every community along the river should undertake to collect and treat its sewage according to plans approved by its State health department, and should proceed with the construction of treatment works as fast as finances permit.

The United States Public Health Service, in a special report in July 1936, makes a similar recommendation and adds that the minimum treatment should be removal of solids by settling basins and disinfection of the liquid sewage by the use of chlorine, supplemented later by more complete treatment at certain points where natural purification in the river is inadequate. Adoption of a program to eliminate harmful industrial wastes, in cooperation with industry, is also recommended. The report adds that because of the time required for planning, financing, and construction, a start should be made at once.

The total cost of the necessary pollution-control projects is roughly estimated as between \$55,000,000 and \$75,000,000. Accurate estimates will require the drawing of plans and specifications. The necessary engineering plans for these projects should be pushed vigorously.

Acid drainage from mines is a costly form of contamination. The acid retards purification and aggravates the domestic pollution problem; it corrodes concrete bridge abutments, steel barges, exposed pipe lines, and the distribution systems of cities; it kills fish. Large sums must be expended by industries and municipalities to neutralize these acids before they can use the water.

A large part of the acid contamination can be prevented by sealing the openings of abandoned mines to keep air out. A mine-sealing program is now being carried on by the Works Progress Administration under direction of the United States Public Health Service. It is estimated that \$5,000,000 to \$7,000,000 should be spent on a 4-year extension of this program, with appropriate provision for maintenance. The natural alkalinity of the surface waters will neutralize a moderate amount of acid; if a practical plan for reducing the contamination from active mines, culm piles, and steel mills can be added to the mine-sealing program, the prospects are excellent for bringing acidity under control.

Industrial wastes have constantly increased in quantity and in variety. The new continuous pickling process in the steel mills has increased the discharge of acid water. Tannery wastes and the washings from pulp and paper mills contribute their share. The breweries and distilleries are among the worst sources of pollution.

Much has been accomplished by inducing various industries to cooperate in finding ways to salvage or dispose of their wastes without polluting the streams. As time goes on it may become necessary for the various State health departments to assume somewhat greater jurisdiction over the control of industrial waste products. Such a program must be of wide scope, to avoid unfair competitive conditions within the industries affected.

Flood control has been brought to public attention by the suddenness and unprecedented height of the Pittsburgh flood of 1936. The Ohio River is not only capable of destroying property on a large scale, but has contributed more than any other stream to the flood waters of the Mississippi.

A system of flood-control reservoirs on the tributaries has been found by the Corps of Engineers, after extensive study, to be the most practical method of control for the main Ohio River. The comprehensive plan of the Corps of Engineers includes some 89 reservoirs for flood control and power production. Many of the possible flood benefits could be obtained by building 39 of these reservoirs, about half of which are judged to be economically justified at the present time. Several such reservoirs are now under construction and 14 more have been authorized by Con-

gress in the Flood Control Act of 1936. The investigation underlying this authorization involved a careful research into the behavior of floods in the Ohio River and its tributaries. The resulting project is generally termed the "14-reservoir plan." The cost is estimated at \$85,350,000. One reservoir, the Bluestone, may be used for power as well as for flood control. Other proposed improvements, such as numerous small reservoirs, or reforestation, although they may be valuable for other purposes, do not approach the proposed reservoirs either in low cost or effectiveness as instruments of flood control.

The dams will be provided with outlet gates, and discharge will be controlled according to a schedule designed to give the lowest possible flood heights at the cities down river. The operating schedule will be complex and extremely important, as the beneficial results cannot be obtained if releases from different dams are allowed to meet downstream at such times as to create higher stages. These reservoirs will not eliminate floods, but they will reduce the height of the crests. In other words, a flood of a given height will occur less often. If the reservoir system had been in operation in 1936 the crest of the record-breaking flood would have been reduced and the damage would have been correspondingly diminished, although even with this reduction the 1936 flood would have been greater than most floods on record.

The annual benefits from the project, mainly in the form of reduced flood damages, have been estimated at \$4,100,000, a return of 4.3 percent on the cost (4.8 percent when power from the Bluestone Power Plant is marketed). Unfortunately, there is no generally accepted method of estimating such benefits. At present, the answer reached depends largely on the particular method used and the judgment of the engineer.

Flood damages are caused by placing valuable property on flood plains and then leaving it there to be damaged. If land use were controlled in such a way as to keep valuable property out of the danger zone, or if flood prediction permitted shifting movable property to a place of safety, the damage would be smaller, and the benefits of flood control would be correspondingly less. It is conceivable that it might be cheaper over a period of time to prevent the construction of new buildings in flood zones, and gradually to eliminate those now threatened as they become obsolete, rather than to allow the construction of new buildings and then attempt to protect them. These matters deserve further study.

After reservoirs are built, a popular feeling that flood hazards no longer exist may lead to additional construction on the flood plains. If this is carried too far, even less frequent floods will result in more damage

than at present. A study of means to prevent this is recommended.

Questions remain as to the best sites for some of the reservoirs; surveys and foundation borings are needed, and a revision of the cost estimates in the light of such knowledge is required. This work should be included in the studies.

Despite the conflict between need of storage space for floods and storage of water for other purposes, multiple use of large flood reservoirs for purposes of stream regulation, power, and recreation is possible. A study of such possibilities is included in investigations now under way.

In planning and designing all reservoirs careful consideration should be given to the possibilities of utilizing them for multiple purposes and provision should be made, to the maximum extent feasible, for such utilization. The different purposes that the reservoirs are designed to serve may impose requirements that appear to conflict. Frequently, however, by modification in the design of the dams or in the operation of the reservoirs, these conflicts can be resolved. For example, economical generation of hydroelectric power may be made possible by increasing the height of a dam intended primarily for flood control. Proper control of pools may enhance their value for recreation. Regulation of the discharge from a power or flood-control dam may greatly improve the utilization of the available water for industrial or domestic supply or for augmenting the low flow of the stream to improve navigation or sanitary conditions. Several reservoirs on a single river or river system can possibly be coordinated in operation for combined power production and flood control. Such increased benefits to the public through the multiple use of reservoirs should be exhaustively studied and if found practicable should be included in the plan.

A navigation channel of 9-foot depth has been provided throughout the entire length of the main river by series of locks and dams. The major tonnage is sand and gravel, coal, petroleum, iron, and steel products, most of it moved by private carriers. The Monongahela leads all rivers of the country in volume of traffic.

Further work on this 9-foot system will consist of replacement of obsolete dams and of improvements to facilitate operation and reduce maintenance costs. A number of dams have been raised already to reduce

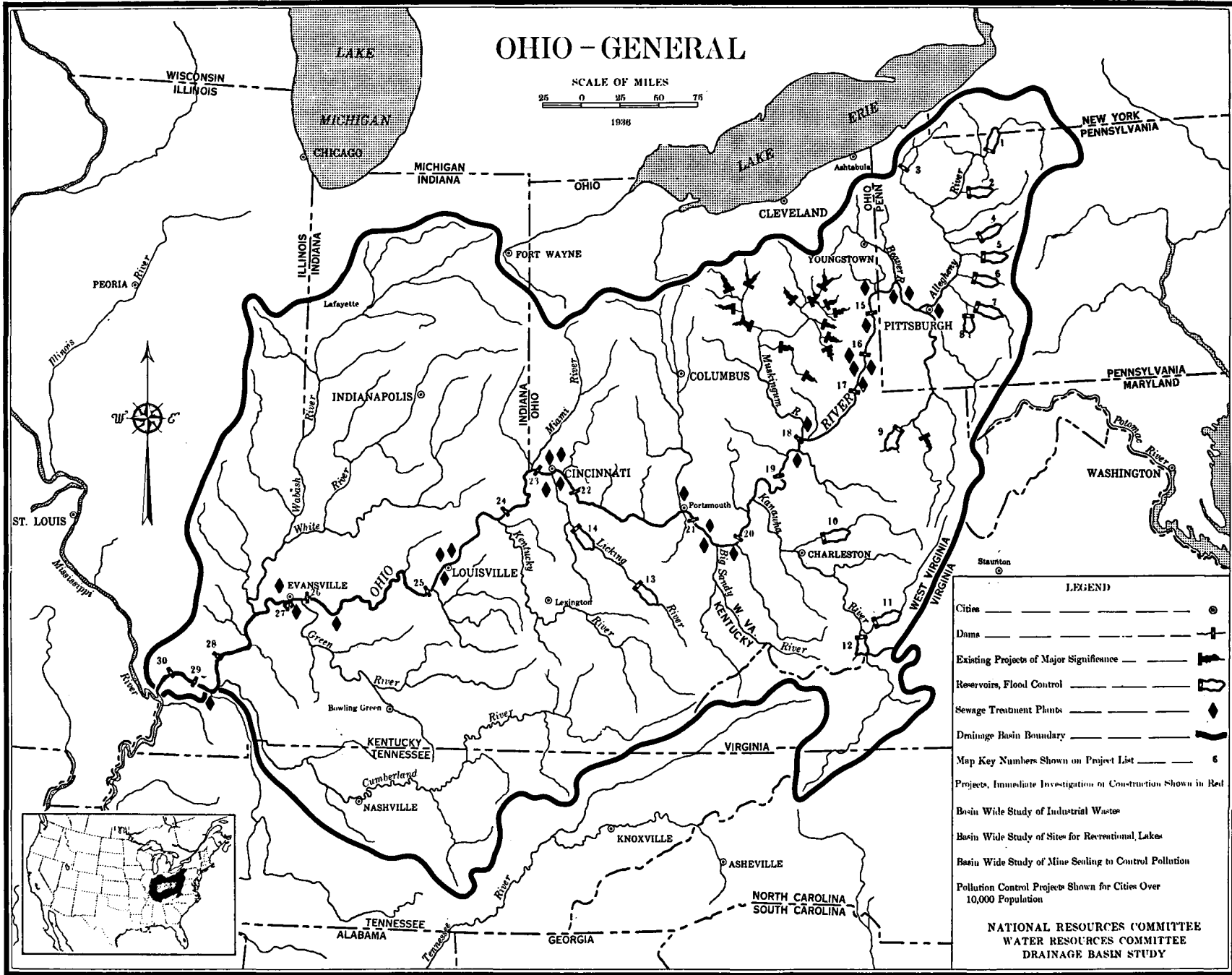
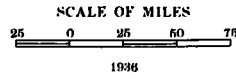
expenditures for dredging, and projects to raise dams 18, 47, 51, 52, and 53 should be considered. Bank-revetment and stream-contraction works, to flush out deposits of silt and thus reduce dredging, would also be of value at certain points. A plan to dredge a 500-foot channel has been authorized by the Congress and is under construction by the Corps of Engineers.

More dams of the bear-trap type, which can be raised rapidly, are needed to maintain pool levels after summer floods and to avoid delays to navigation; additional bear-trap capacity should be considered for dams 43, 39, 30, 27, and 21. A number of the dams are becoming inadequate for navigation, and new dams will be needed when the growth of traffic warrants the expenditure; these dams are to be built at Scotts Landing, Black Island, Brilliant, present dam 37, and at a point 2 miles above dam 36. The Corps of Engineers is now completing a study of the value of replacing locks 7 to 9.

Water recreational facilities are meager throughout the basin, although there are a number of State parks close to the larger cities. The cleaning up of the Ohio River, coupled with low-flow regulation by auxiliary use of the flood-control reservoirs, would be of great value in providing such facilities and would benefit millions of people. Many potentialities exist for camping, hunting, and fishing along the Ohio and its tributaries. With modern roads and motor transportation, people who seek such recreation are no longer limited to one locality. A general study should, therefore, be made to select and develop such areas at locations convenient to the larger communities and where they will produce the greatest good for the least expenditure. Migratory birds have largely abandoned this area because of the destruction or pollution of their resting areas. Restoration of suitable water areas for bird life should be considered in planning reservoirs for other purposes.

The only water-power plant on the Ohio River itself is situated at Louisville, Ky., at dam no. 41. The present capacity is 80,000 kilowatts with provision for increase to 100,000-kilowatt capacity. High water renders the plant inoperative about 40 days of the year. The flood-control reservoirs will be of benefit to this plant, both in reducing the tail-water level during floods and in increasing the low flow of the river.

OHIO - GENERAL



LEGEND

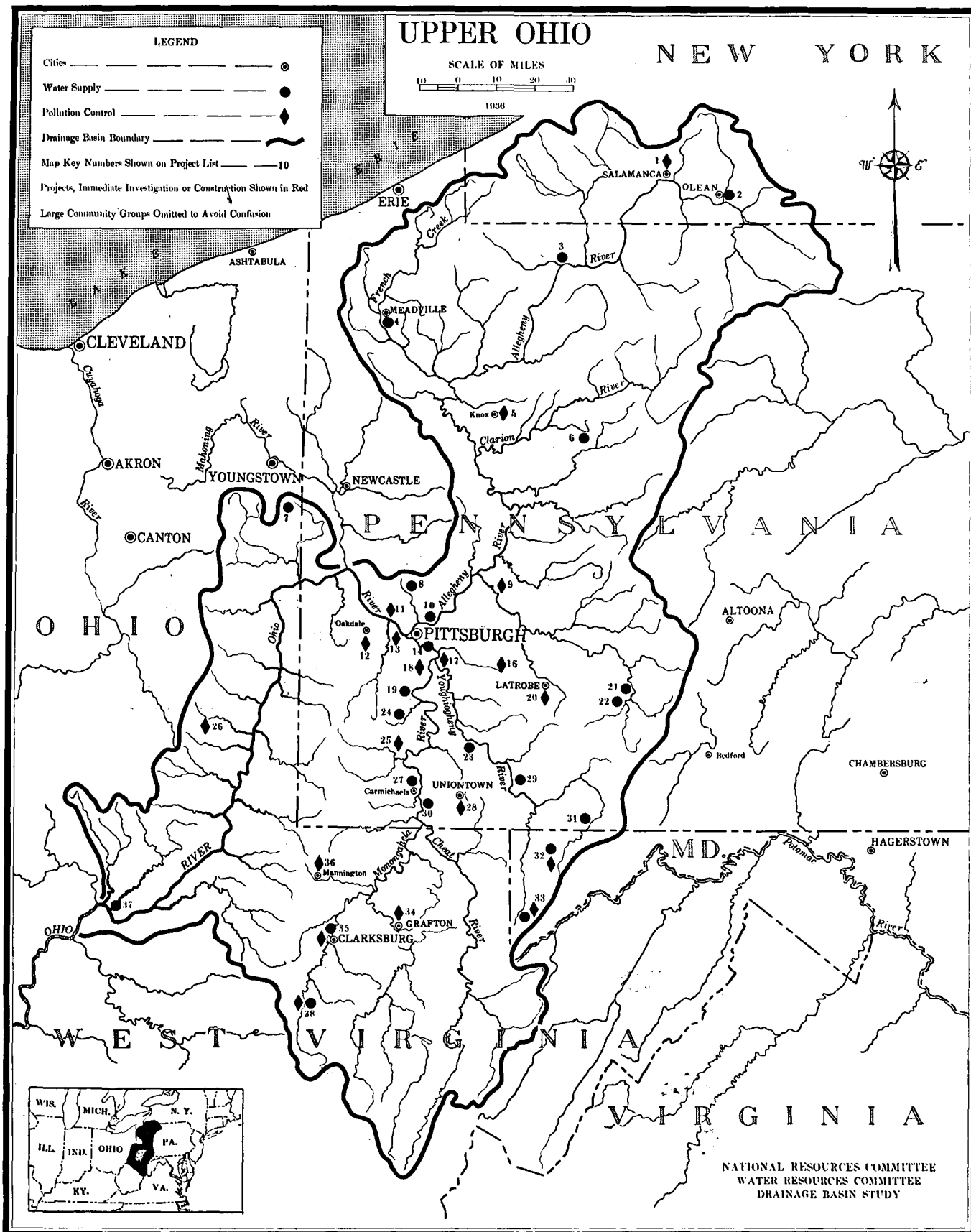
- Cities ———— ○
- Dams ———— ⊕
- Existing Projects of Major Significance ———— [Symbol]
- Reservoirs, Flood Control ———— [Symbol]
- Sewage Treatment Plants ———— ◆
- Drainage Basin Boundary ———— [Thick Line]
- Map Key Numbers Shown on Project List ———— 6
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study of Industrial Wastes
- Basin Wide Study of Sites for Recreational Lakes
- Basin Wide Study of Mine Sealing to Control Pollution
- Pollution Control Projects Shown for Cities Over 10,000 Population

**NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY**

Ohio Basin General Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	District-wide investigation to prepare a plan for an integrated system of reservoirs having multiple use.	\$500,000	A continuation and expansion of previous and current surveys by the Corps of Engineers. Program now under way.
	Sealing of abandoned mines, to protect public water supplies, to reduce acid in streams which injures concrete and metal structures, boats, and piping and aggravates pollution.	7,000,000	
	Study of industrial wastes in Ohio Valley to determine points of most pollution, to devise means of handling industrial wastes and to adopt a common policy in cooperation with industry in regard to corrective measures required.	150,000	
	Study to determine suitable sites for recreational lakes in relation to cost and accessibility to population.	50,000	Many proposed projects in need of classification.
	Dredging Ohio River to provide 500-foot width channel.....	2,000,000	Work under way. will continue as need arises. Cost given is for next two years. Additional needed to complete \$2,700,000.
	Alliquippa and Ambridge, Pa.; Ashland, Ky.; Baden and Beaver, Pa.; Bellaire, Ohio; Bellevue, Ky.; Benwood, W. Va.; Bridgeport, Ohio; Catlettsburg, Ky.; Chester, W. Va.; Cincinnati, Ohio, and vicinity; Covington and vicinity and Dayton, Ky.; East Liverpool, Ohio; Evansville, Ind.; Follansbee, W. Va.; Freedom, Pa.; Gallipolis, Ohio; Henderson, Ky.; Hollidays Cove, W. Va.; Hopewell Township, Pa.; Huntington, W. Va.; Ironton, Ohio; Jeffersonville, Ind.; Louisville and Ludlow, Ky.; Madison, Ind.; Marietta and Martins Ferry, Ohio; Maysville, Ky.; McMechen, W. Va.; Metropolis, Ill.; Middleport, Ohio; Midland, Pa.; Mingo Junction, Ohio; Monaca, Pa.; Mount Vernon, Ind.; Moundsville, W. Va.; New Albany, Ind.; New Boston, Ohio; New Martinsville, W. Va.; Newport, Ky., and vicinity; Norwood, Ohio, and vicinity; Owensboro and Paducah, Ky.; Parkersburg, W. Va.; Pittsburgh, Pa.; Pomeroy and Portsmouth, Ohio; Sistersville, W. Va.; Steubenville, Ohio; Tall City, Ind.; Toronto, Ohio; Wellsburg, W. Va.; Wellsville, Ohio; Wheeling and Weirton, W. Va.: Collecting sewers and one or more primary sewage treatment plants to clean up the Ohio River, safeguard water supplies, and water recreation.	75,000,000	Will probably require concerted action by all States and communities. Estimate is highly approximate. Includes cost of surveys, which should be undertaken prior to construction.
GROUP B—FOR DEFERRED CONSTRUCTION			
(7)	At Ohio dams nos. 43 (25), 39 (24), 30 (21), 27 (20), and 21 (19): Construction of additional bear trap capacity to facilitate operation of dams and maintain pool levels for navigation.	\$1,300,000	Plans prepared.
(2)	At Ohio dams nos. 18 (18), 47 (26), 51 (28), 52 (29), and 53 (30): Raise each dam 2 feet to reduce dredging costs.	900,000	Preliminary plans ready.
(2)	Ohio River flood control project, including construction of 14 reservoirs as follows Allegheny (1), Tionesta (2), Crooked Creek (6), French Creek (3), Conemaugh R. (7), Loyalhanna (8), Mahoning Creek (5), Red Bank Creek (4), West Fork River (9), Clendenin (10), Big Bend (11), Bluestone (12), Falmouth (14), and Cave Run (13) Reservoirs.	85,350,000	The preliminary estimates given will be revised as a result of study project.
27	Reconstruct dam no. 48 to raise pool 2 feet and facilitate operation.....	3,000,000	Preliminary plans ready.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Black Island (15), Brilliant (16), Scotts Landing (17), dam 37 (23) and 2 miles above dam 36 (22): Construct new dams to replace obsolete structures.	\$22,000,000	Work to be done as present dams become obsolete; will reduce dredging and replace existing dams 7 to 13 and 35 to 37, inclusive.

1 For first year.
 2 Map key numbers show following dam numbers.
 3 Map key numbers shown following reservoir name.
 4 Map key numbers shown following project name.



1. OHIO EASTERN TRIBUTARIES (Upper Ohio, Kanawha, and Beaver)

In the following paragraphs are discussed the special problems in the drainage areas of the Ohio River above Parkersburg, W. Va. Included are the Monongahela and the Allegheny, forming the Ohio by their confluence at Pittsburgh, and their tributaries. Included also are the Beaver drainage system, with its principal lesser streams, the Mahoning and the Shenango, discharging into the Ohio 25 miles below Pittsburgh, and the Kanawha, reaching the Ohio at Point Pleasant, W. Va., 266 miles below Pittsburgh, fed by the Gauley, New, and the Greenbrier Rivers, all important from various aspects of water use. The Kanawha area includes most of West Virginia.

The condition of the Mahoning River at Youngstown, Ohio, is such that it is not only a nuisance, but is also insufficient and unsatisfactory for industrial use. Solution of the problem is to be sought through the construction of reservoirs and sewage-treatment plants. Sewage plants are also needed at other points throughout the area. Research is recommended for the Nation as a whole to discover adequate means of treating the complex chemical wastes from such industries as those on the Kanawha and New Rivers at and near Charleston, W. Va.

The flood hazard is serious at Pittsburgh and Charleston, but will be greatly reduced by the 14-reservoir project of the Corps of Engineers, described in connection with the general problems of the basin as a whole. The 14-reservoir plan includes 3 projects on the Kanawaha, to improve flood conditions on that river as well as on the Ohio.

General Description

The area drained by the upper tributaries of the Ohio River lies along the western slopes of the Appalachian highlands, from western North Carolina to western New York. The northern part, drained by the Beaver and Allegheny Rivers, has been glaciated and is characterized by broad valleys and rolling hills. Elsewhere most of the valleys are narrow and the slopes steep. The sources of the Monongahela and Kanawha Rivers, at the southern end of the area, lie in mountainous country. The Allegheny River (drainage area, 11,700 square miles) and the Monongahela (7,340 square miles) join at Pittsburgh to form the Ohio River. The Beaver (3,040 square miles) enters from the north and the Little Kanawha (2,240 square miles) and Kanawha Rivers (11,900 square miles) from the south.

The population of the area has increased rapidly in the last 3 decades to approximately 5,500,000, of which 1,500,000 are concentrated in the Pittsburgh metropolitan district. Growth of the urban population, already more than half the total, accounts for this increase. Pittsburgh, favored in early development by its location at the head of Ohio River navigation and in the midst of extensive coal deposits, has become an outstanding center of the steel industry. Youngstown, Ohio, with a population of 170,000, is the center of the Youngstown steel district. Abundant mineral resources combined with cheap fuel and power have fostered the development of a large chemical manufacturing industry at and near Charleston, W. Va. (population 60,000) which produces synthetic and natural hydrocarbons, glass, and alloys. During the war the Government built a plant at Nitro, 20 miles below Charleston, for the manufacture of war materials.

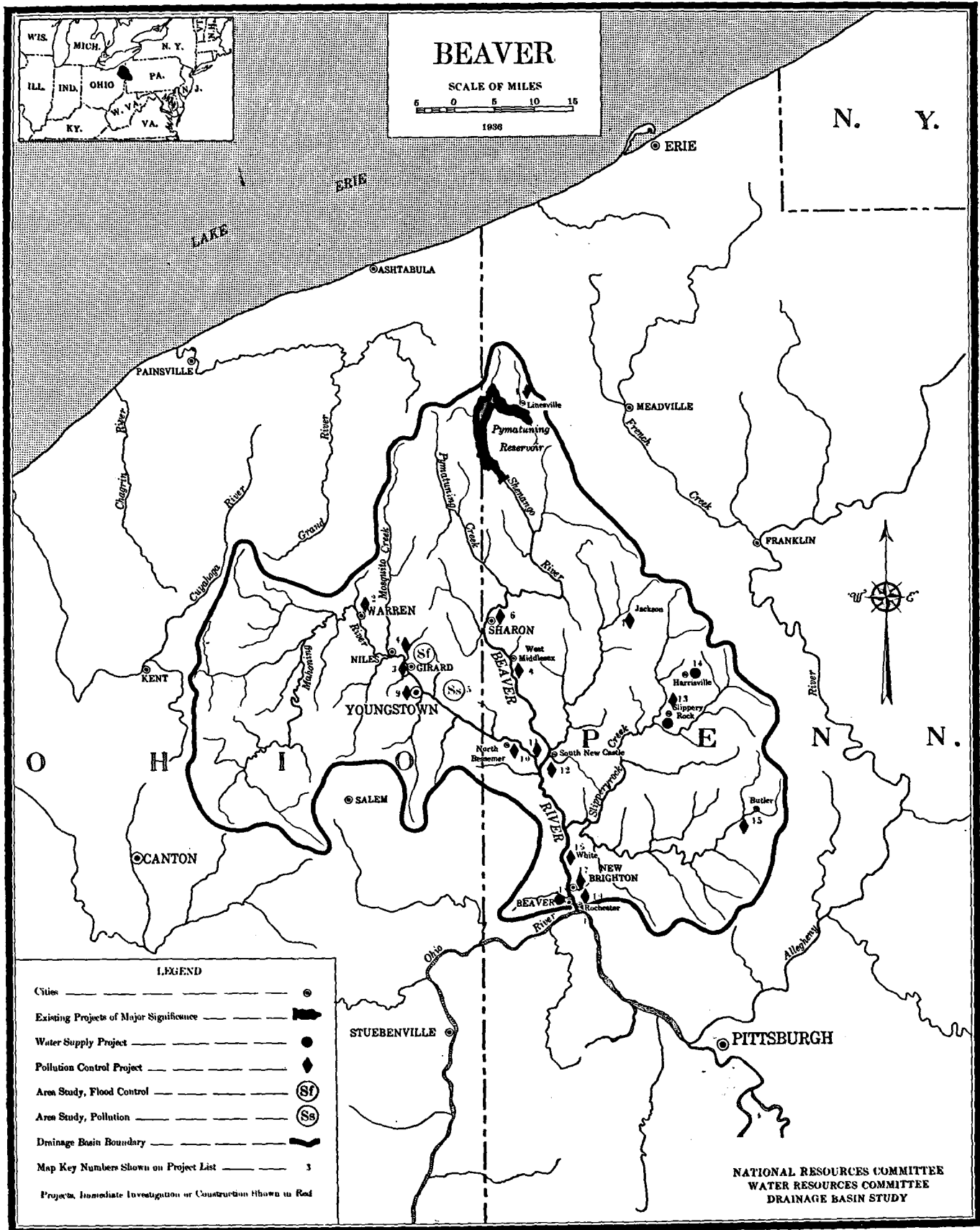
Agriculture has declined in relative importance in the last 30 years and utilizes less than half of the area. In the more rugged sections, injudicious tillage on steep slopes facilitates the washing away of the topsoil, thus rendering the land unsuited to further agricultural use. Much of the area is forest covered, but the virgin timber has long since been cut, and, in general, lumbering is much less important than formerly.

Transportation facilities are generally adequate. The Allegheny, Kanawha, and Monongahela are canalized.

The climate is temperate, the seasons strongly marked, and temperature extremes from 35° below zero to over 100° have been recorded. The rainfall is generally ample and well distributed, ranging from an annual average of 35 inches around the sources of the Beaver and Allegheny to 50 inches at the headwaters of the Kanawha. Maximum stream flows of 400 or 500 times the minimum are not uncommon.

Recommended Plan

Pollution of the Mahoning River and the shortage of industrial water at Youngstown, Ohio, and throughout the Youngstown steel district are the most acute water problems in this area. The Mahoning River here presents an extraordinary picture of the concentrated use and reuse of its highly polluted water by industries, mainly for cooling, until it becomes too hot (over 100° at times) to be satisfactory for condensing purposes. In recent years new plants have tended to seek



upstream sites in an effort to get cooler and cleaner water.

Sanitary conditions on the stream are deplorable. The Milton reservoir, near Youngstown, Ohio, increases the dry weather flow from about 20,000,000 to 50,000,000 gallons daily, but this amount is inadequate in the face of an industrial usage estimated at 16 times as much. The acidity of the water causes serious corrosion and damage to industrial equipment.

The problems of increased industrial supply, disposal of domestic and industrial wastes, and flood control are closely interrelated in the Youngstown district. None of these problems can be solved properly by itself. The technical staff of the Ohio State Planning Board has proposed measures to provide increased industrial water supply and to diminish pollution. The proposals include construction of two reservoirs to provide minimum daily stream flows of 300,000,000 gallons in normal years, together with the construction of sewage-treatment plants for Warren, Niles, Girard, and Youngstown, to correct the unsanitary condition of the river. The 1913 flood caused damages estimated at over \$2,000,000. A study by the Corps of Engineers indicated that flood control for this valley was on the borderline of economic feasibility.

Further engineering investigations are needed and are recommended. These should include surveys and borings at various reservoir sites, should provide plans for collecting and treating the sewage, and should also consider the economies of locating and designing the reservoirs to provide for flood control as well as low-water regulation.

Sewage-treatment plants for Warren, Niles, Girard, and Youngstown are recommended for construction, the degree of treatment to be determined by the results of the study above described.

Pymatuning Reservoir, on the Shenango River, another tributary of the Beaver, produces benefits similar to those which may be obtained on the Mahoning. This reservoir was built primarily to regulate the flow of the Shenango and Beaver Rivers for increasing both public and industrial water supplies, for sanitation, and for flood protection, and secondarily for recreation and the preservation of wildlife.

Pollution of the Allegheny River is very similar to that described in the section on the general problems of the entire basin. The State of Pennsylvania has ordered communities on the Allegheny River above Ford City to take steps adequately to dispose of their sewage. The depression delayed the final execution of this plan, but with the return of more prosperous conditions it is strongly recommended that this stream be cleaned up. Construction projects are accordingly recommended for these communities and for Sala-

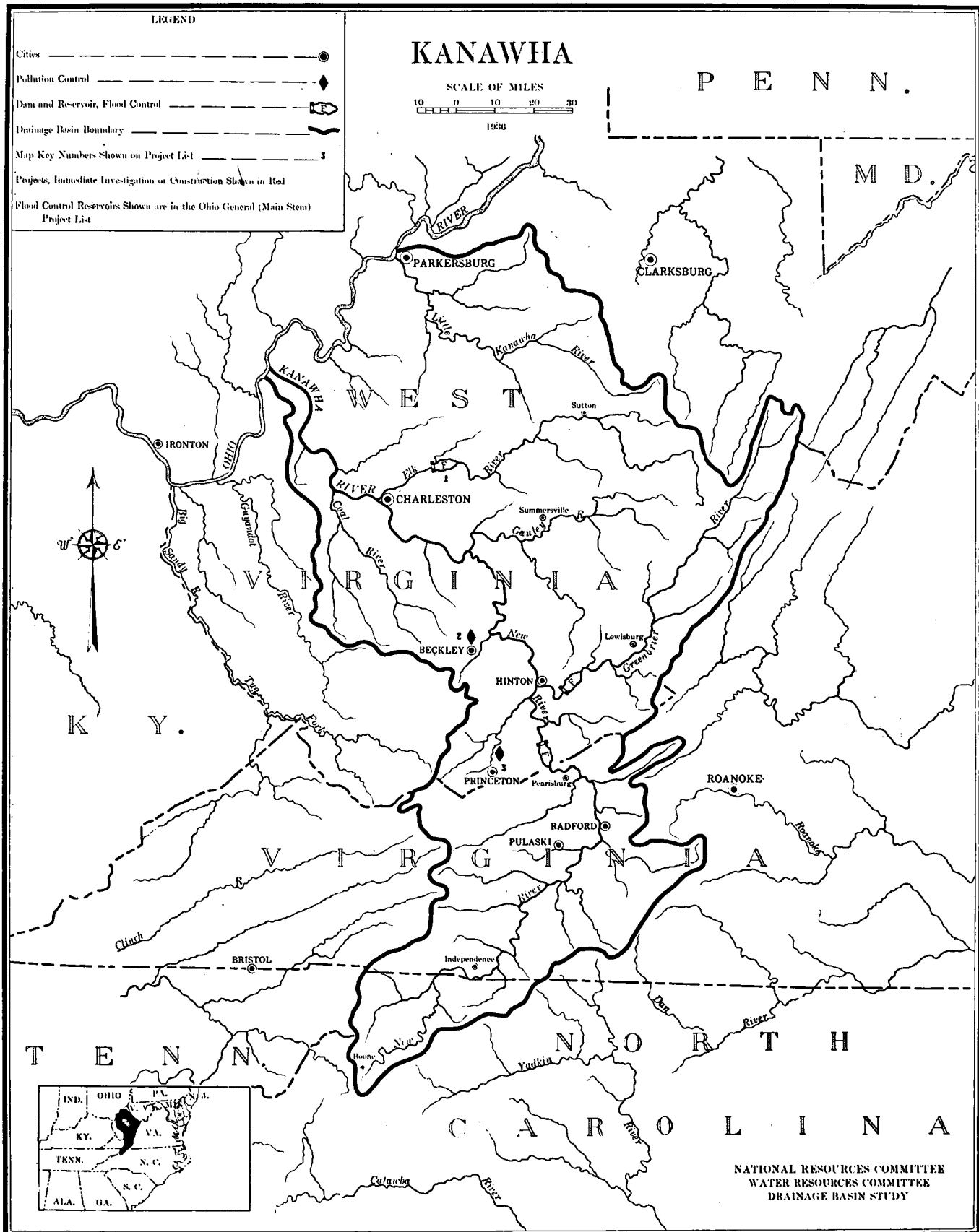
manca, N. Y. Princeton and Beckley, situated on small streams tributary to the Kanawha, experience local nuisances; sewage treatment plants are recommended for construction at these places. Pollution by domestic sewage is of less importance on the Monongahela and Kanawha Rivers, but acidity due to mine drainage, as described in connection with the general problems of the entire basin, is high, and requires correction. A plant for complete sewage treatment, costing \$440,000, is being constructed at Bluefield on New River.

The Kanawha River, below the industrial area from Belle to South Charleston, also shows evidence of serious industrial pollution. The complex chemical wastes of the industries there are not generally susceptible to treatment by ordinary methods and in some cases new methods must be devised. Public water supplies at Nitro, St. Albans, and Winfield are detrimentally affected at times in taste and odor caused by this pollution. A study of this situation is recommended. On the Gauley River serious pollution is caused by the wastes from a large paper mill. Progress has been made on the Greenbrier River, where satisfactory waste-treatment plants for two tanneries have been put into operation through cooperative effort by the industry and the State.

Flood protection is now attracting wide attention. The all-time-record flood of March 1936 at Pittsburgh, 5 feet above any previous stage, left a thick sheet of mud and a damage bill running into millions. Nine of the projects in the Corps of Engineer's 14-reservoir plan, already described, are above Pittsburgh; but additional work may be necessary there and elsewhere if complete protection is to be obtained. The flood reservoirs are to be operated so as to increase the low flows of the Kanawha, Allegheny, and Monongahela Rivers, a procedure which will be valuable for downstream power plants, water supply, waste dilution, and navigation.

Three more of the 14 reservoirs are planned for the Kanawha, above Charleston. There have been no recent great floods of the Kanawha, and there is little local appreciation of the importance of flood control; but a serious hazard exists. The flood of 1861 reached 46.9 feet and with present encroachments in the floodway might have been higher. Should this stage recur before the reservoirs are built, it would cause a disaster at Charleston and Nitro similar to that resulting from the recent flood at Pittsburgh. Most of the business district and many of the large industrial plants would be under 5 to 15 feet of water—15 feet at the Daniel Boone Hotel. Because of the character of the valley, loss of life might be severe.

In few places in the world has inland *navigation* been so highly developed as on the Monongahela and



the upper Ohio. Modern dams, with large locks, are replacing the wicket dams on the Ohio in connection with providing 9-foot channel depths. The Monongahela is canalized for its full length of 128 miles, and the Allegheny for a distance of 61 miles. Present development on the Allegheny is not extensive and has resulted in little traffic; improvement as far as Oil City has been studied by the Corps of Engineers, but has not been recommended.

The Kanawha River has been improved for navigation for about 90 miles from its mouth by a system of locks and dams, and is now being further improved.

The Beaver and Mahoning Rivers are not now used as commercial highways. A plan has been proposed for a canal through the Beaver, Mahoning, and Grand Rivers to connect Lake Erie with the Ohio River, at an estimated cost of some \$165,000,000. This project has been the subject of 19 hearings, from September 1920 to March 1936, and is now being restudied by the Corps of Engineers. Because this study is not yet complete, the project has not been considered for inclusion in the present plan.

Water supply problems, except those of industrial water in the Youngstown district, are not pressing; a majority of the communities are equipped with plants affording reasonably satisfactory supplies. Those communities depending on streams are generally assured of adequate quantities, but during recent drought years some have experienced difficulties which can be cor-

rected either by local storage reservoirs or, in some instances, by releases from proposed flood protection reservoirs. At Weston and Clarksburg, W. Va., an investigation should be made to determine the feasibility of building an impounding reservoir on West Fork River above Weston to augment the water supply of both Weston and Clarksburg, and at the same time joint action should be taken to promote sewage treatment plants at these cities. At several small communities water works improvements are recommended.

There are now in operation in the area hydroelectric plants of more than 200,000 kilowatts capacity, most of which are on the Kanawha, Cheat, and Clarion Rivers. Completion of plants now under construction or for which license applications have been made would more than double this figure. Well over 2,000,000 kilowatts of additional capacity have been investigated by various agencies. A rapidly growing power market, together with multiple uses of flood-control reservoirs and other hydraulic works, may lead to the early development of favorable sites even though the region is one of cheap fuels.

There is a distinct need of facilities for water recreation around Pittsburgh and its environs, which may be partly met through pollution control and through low-flow regulation by the flood-control reservoirs. In the upper reaches of the Kanawha River recreational facilities are exceptional and are enjoyed by thousands of people.

Upper Ohio Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Knox, Pa. (5), and Mifflin Township (18), Pa.: Sewage treatment plant for reduction of nuisance; and sewer system for Mifflin Township, Pa.	\$280,000	Plans completed.
2	Olean, N. Y.: Waterworks extensions and additional well supply to eliminate use of polluted surface water.	144,000	Preliminary plans made.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Carmichaels (27) and Salisbury (31), Pa.: Complete new water-supply system.....	\$150,000	Plans ready.
(1)	Bentleyville (24), Bradfordwoods (8), Brookville (6), and Daisytown (19), Pa., and Marietta (37), Ohio: Water filtration plant to produce better water supply.	415,000	Contract awarded at Daisytown. Plan completed for Brookville. Study complete for Bentleyville. No plans available for Bradfordwoods, and Marietta.
	Bradford, Coudersport, East Brady, Edinboro, Emlenton, Ford City, Franklin, Homer City, Johnsonburg, Kane, Kittaning, Mount Jewett, Oil City, Port Allegany, Polk State School, Ridgway, St. Marys, Sheffield Township, Smethport, Tidioute, Tionesta, Warren, and Youngsville, Pa.: Primary sewage treatment plant and intercepting sewer to clean up the Allegheny River.	3,000,000	Preliminary plans for Coudersport, Sheffield Township, Emlenton, and East Brady. Plans partly complete for Smethport, Bradford, Warren, Franklin, and Kittaning. Complete plans for Edinboro, Tidioute, Oil City, and Polk State School. Others, no plans available.
1	Salamanca, N. Y.: Collecting sewers and sewage-treatment plant to clean up the Allegheny River.	310,000	Preliminary plans made.
(1)	Irwin (16), Marianna (25), and Oakdale (12), Pa.: Sewage-treatment plants.....	100,000	No plans available.
	Arnold, Canonsburg, Connellsville, and Donora, Pa.; Friendsville, Md.; Greensburg, Euston, Johnstown, Mount Pleasant, Nanty Glo, New Kensington, and Waynesburg, Pa.; and Woodsfield, Ohio: Intercepting sewer and sewage treatment plants.	3,000,000	Plans partly completed for Greensburg and Connellsville (which includes pumping stations). Others, no plans available.
(1)	Accident (32), Md.; Glenfield (11), Pa.; Mountain Lake Park (33), Md.; North Apollo (9), Pa.; St. Clairsville (26) and Stowe Township (13), Ohio: Sewer systems for public health and convenience.	500,000	Preliminary plans for North Apollo, survey for Glenfield. Others, no plans available.
(1)	East McKeesport (17) and Latrobe (20), Pa.: Interceptor sewers.....	270,000	No plans available.
(1)	Clarksburg (35), 4-H camp and Weston (38), W. Va.: Sewage treatment plants.....	860,000	
(1)	Clarksburg (35), 4-H camp and Weston (38), W. Va.: Reservoir for joint water supply.....	800,000	Do.

¹ Map key numbers shown following community name.

Upper Ohio Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Bradnock (14), Pa.; Columbiana (7), Ohio; and O'Hara Township (10), Pa.: Water-purification plants.	\$550,000	Preliminary plans.
(1)	Accident (32), Md.; Benson (22), Conewango Township (3), Davidsville (21), Greensboro (30) Pa.; Mountain Lake Park (33), Md.; Obiopolis (26), and Vanderbilt (23), Pa.: Complete new water systems.	550,000	Plans prepared for Conewango. No plans available for other communities.
4	Meadville, Pa., water-softening plant, to produce better water and economies.....	80,000	No plans available.
(1)	Grafton (34), Mannington (36), W. Va., and Uniontown (28), Pa.: Interception and sewage-treatment plants.	350,000	Plans completed for Uniontown. No plans available for other communities.

Beaver Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
5	Study in the Youngstown district, on the Mahoning River of low flow augmentation, sewage treatment, and industrial wastes with consideration of flood control.	\$50,000	Preliminary investigation has been made.
(1)	Linesville (1) and Slippery Rock (13), Pa.: New sewage-treatment plant to protect Pymatuning reservoir at the former place—at latter place, additional units to existing sewage-treatment plants.	40,000	Plans completed.
(1)	Girard (3), Niles (4), Warren (2), and Youngstown (8) (including Campbell), Ohio: Primary sewage-treatment plants and collecting sewers to lessen unsanitary conditions and pollution in Mahoning and Beaver Rivers and to improve quality of industrial water taken from them.	8,000,000	Plans required, to be in conformity with the study recommended above.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Beaver (18), Harrisville (14), and Slippery Rock (13), Pennsylvania: Water-softening plants at Beaver and Slippery Rock, water system at Harrisville.	\$150,000	Harrisville plans complete. Others, preliminary plans.
(1)	Butler Township (15), Jackson Township (7), New Brighton (17), North Bessemer (10), Rochester Township (19), Sharon (6), South New Castle (12), Union Township (11), West Middlesex (8) and White Township (16), Pennsylvania: Community-wide sewer systems.	800,000	Plans are complete for White Township, Union Township, South New Castle, and Jackson Township, partly complete for West Middlesex and North Bessemer. Others have no plans.

Kanawha Project List

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
3	Princeton, W. Va. Sewage treatment plant.....	\$125,000	Plans needed.
2	Beckley, W. Va. Sewage treatment plant.....	200,000	Do.

1 Map key numbers shown following community name.

2. OHIO NORTHERN TRIBUTARIES

(Muskingum, Scioto, Miami, and Wabash)

The more serious problems of this area relate to stream pollution and to the damage caused by occasional great floods. Pollution may be abated by the construction of sewage treatment works, supplemented in some cases by increased low stream flows, and by control of industrial wastes. Much work remains to be done in this field. A study is being made of reservoirs for flood control and other purposes on the Scioto River, similar to control measures already adopted for the Miami and Muskingum Rivers. Of less immediate importance is the need for additional water supplies, some of which must come from surface sources at points where all the underground water available is now being used. A study of the apparent conflict between land drainage and water retention is recommended for the Wabash Valley.

Topographic maps are available for only about one-tenth of the area of Illinois. Without such maps, intelligent planning for utilization of water resources here and elsewhere is difficult. The mapping of these areas should be completed and stream gaging and rainfall stations established.

General Description

The area drained by the northern tributaries of the Ohio River covers most of Ohio and Indiana and part of Illinois. The northern portion of this area has been smoothed by glacial action, and is gently rolling. In the southern portion, along the Ohio River, the country is generally unglaciated and rather rough.

The principal rivers with their square miles of watershed are, from east to west, the Muskingum (8,000), the Hocking (1,200), the Scioto (6,510), the Little Miami (1,755), the Miami (5,385), and the Wabash (33,600), which flow southward into the Ohio; the White (11,200), and the Embarras (2,550), which flow, respectively, southwest and southeast into the Wabash.

About 6,000,000 people now occupy this area. The population is divided almost equally between rural and urban, but there has been a marked increase in the urban population, especially in and near the large centers. The principal cities and industrial centers with their populations are: Cincinnati, Ohio, 450,000; Indianapolis, Ind., 360,000; Columbus, Ohio, 290,000; Dayton, Ohio, 200,000; Evansville, Ind., 105,000; Canton, Ohio, 105,000. The number and size of these com-

munities suggest the importance of pollution and flood control projects in this region.

Farming occupies about one-half of the area, much of which is in the fertile Corn Belt. The glaciated section contains the best soil. In many parts of the unglaciated section severe erosion follows cultivation and the valley bottoms, despite floods, are generally the most suitable farm lands.

Leading industries and products are steel and other metal manufactures, paper, food, textiles, and leather, clay, glass, machinery, and transportation equipment. Coal is mined by shaft and strip methods in the western part of the area. A large portion of the Nation's building limestone is produced around Bedford and Bloomington, Ind.

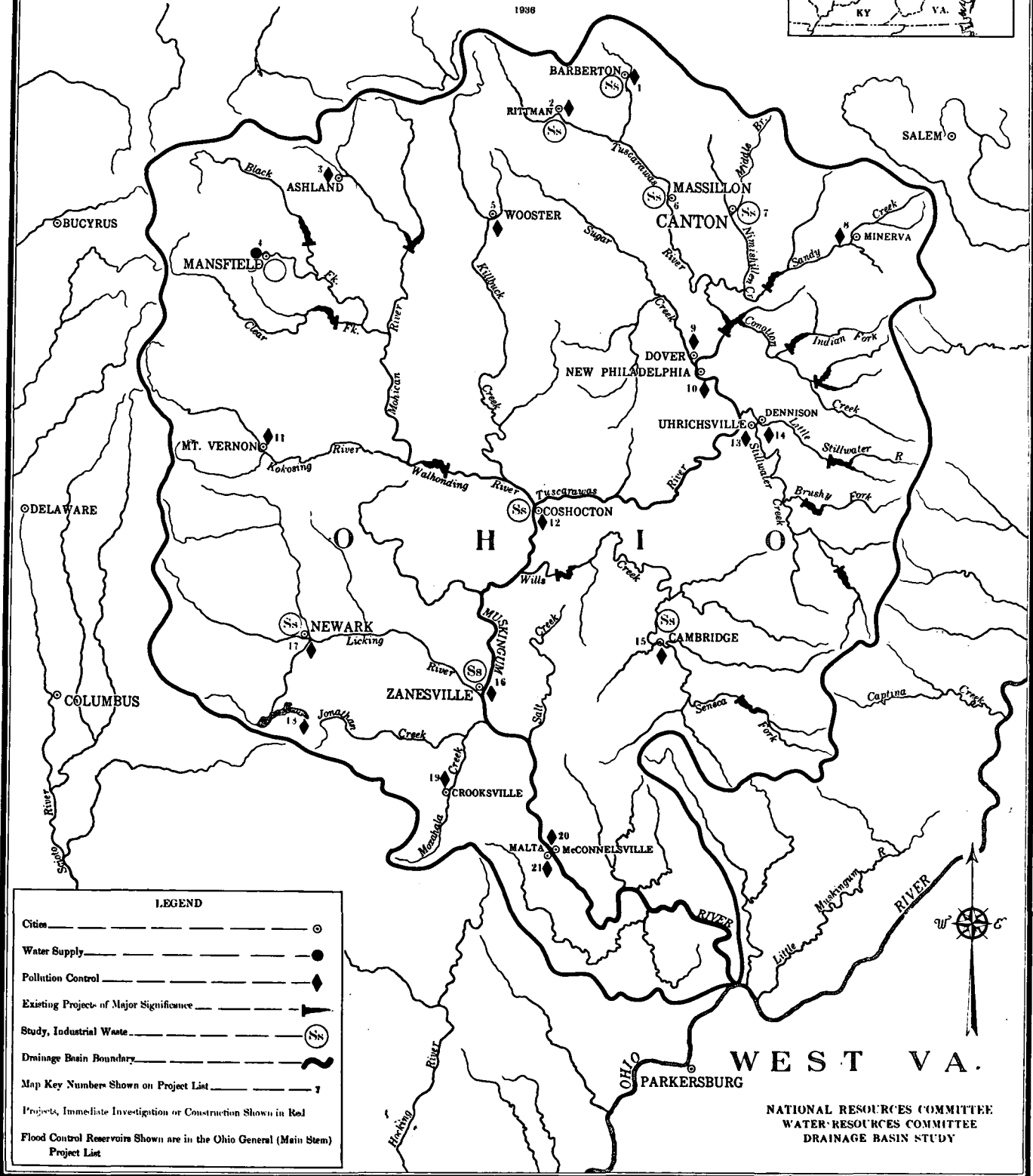
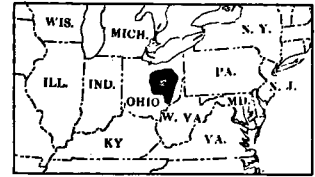
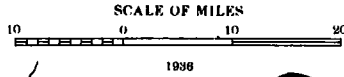
Except on the Ohio River itself, navigation is confined to a small traffic in local coal on the lower Muskingum River where 11 locks and dams make it navigable for some 90 miles above the mouth.

The climate is temperate, colder and drier than that of the southern tributary area, but well suited to agriculture. Rainfall is generally ample and well distributed throughout the year, ranging from an annual average of 42 inches along the Ohio to 36 inches in the northern section. Maximum stream flows of about 1,000 times the minima are recorded. The drought of 1930 exceeded any previous drought of record, but it in turn was surpassed in 1934.

Recommended Plan

Pollution conditions of the northern tributaries are serious and differ from those of the main Ohio River already described. The problem is generally one of correcting local nuisances, and often it requires relatively complete sewage treatment. At various points on the Miami River on days of minimum stream flow something like 30 percent of the flow in the river has passed through sewer systems. Below Dayton, the condition is so bad that swimming is out of the question, fishing and boating are not attractive, and odors are sometimes offensive. In the Wabash Valley pollution is not generally so great, but the hazard to health is more serious because the streams are used for water supply. Indianapolis takes 85 percent of its water from the White River below Noblesville, Anderson, Muncie, and other communities, all of which discharge raw sewage into the stream. The health of many cities will remain in jeopardy unless corrective mea-

MUSKINGUM



LEGEND

- Cities ———— ○
- Water Supply ———— ●
- Pollution Control ———— ◆
- Existing Projects of Major Significance ———— ▲
- Study, Industrial Waste ———— (S)
- Drainage Basin Boundary ———— ~
- Map Key Numbers Shown on Project List ———— 7
- Projects, Immediate Investigation or Construction Shown in Red
- Flood Control Reservoirs Shown are in the Ohio General (Main Stem) Project List

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

asures are taken or expensive additions to some of the water purification plants are built.

Some of the worst conditions in the area are being improved by the construction of sewage plants for both primary and secondary treatment at Columbus, Dayton, London, and Chillicothe. New plants are recommended for Zanesville, Lancaster, Hamilton, Middletown, Terre Haute, and numerous smaller communities. In some cases, both sewer systems and treatment plants are needed.

The streams cannot be cleaned up properly by municipal sewage plants alone. Throughout the area the problem of industrial waste is causing difficulty. Acid wastes from metallurgical operations, paper mill wastes, and distillery and canning plant wastes require corrective measures. This situation is particularly acute at Canton and elsewhere in the Muskingum Valley, as well as at Hamilton and Middletown on the Miami River. In the Wabash Basin, coal-mine drainage creates a problem which should be attacked by the mine-sealing program described in connection with the problems of the Ohio basin as a whole.

Severe *flood damage* is caused by the northern tributaries in their own valleys and through their effect on Ohio River floods. The damage caused by the 1913 flood of the Scioto River is variously estimated between \$18,000,000 and \$25,000,000 with the loss of 145 lives. Following that flood of 135,000 cubic feet per second, channel improvements costing \$3,500,000 were made at Columbus to provide for flows up to 75,000 or 100,000 cubic feet per second without damage, but the capacity of the channel has since been reduced by deposits to such an extent that it now may not carry safely more than half the discharge of the 1913 flood. The Corps of Engineers has included 7 flood protection reservoirs on the Scioto in its 39-reservoir plan, but these are not among the 14 authorized by the Flood Control Act of 1936. The Scioto Conservancy District has been organized and some preliminary work done on a system of flood control and low-flow regulation reservoirs. Additional water for Columbus, which must sometime increase its supply, should be taken into account in making flood-control studies. The present Columbus reservoirs are being filled with silt and the possibility of temporarily substituting one of the proposed new reservoirs for these reservoirs to allow them to be cleaned out should be considered. The economic feasibility of cleaning the present reservoirs at Columbus is open to question. Provision of increased low flow by such a system would increase dilution of sewage and industrial wastes and provide better industrial water supply. A study of all the possibilities of such a system is under way.

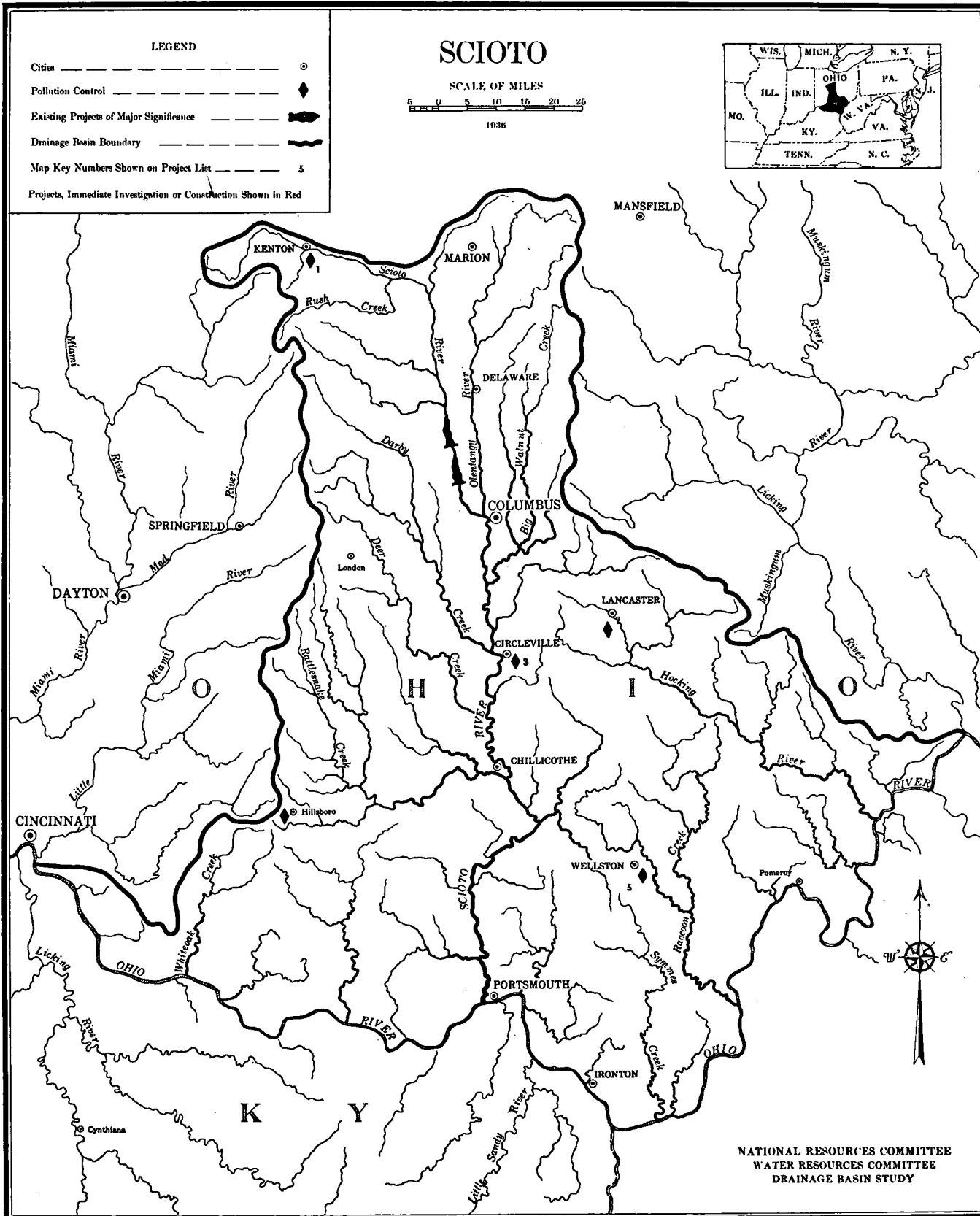
There is a widespread flood hazard in the Wabash Basin, affecting both urban and rural communities, but

flood-control reservoirs do not appear feasible because of the lack of favorable sites. Extensive investigation was made in 1932 by the Corps of Engineers. Flood protection works at certain points have been authorized for construction by the Flood Control Act of 1936. A study project is recommended to determine what measures are advisable in this area.

Two other important flood-control projects are situated in the area; the Miami reservoirs already completed, and the Muskingum reservoirs now under construction. As a result of the losses sustained at Dayton and elsewhere in the Miami Valley in 1913, a system of five flood-retarding basins with local levee and channel improvements was built. This is a large and highly successful system, but small compared to the Ohio River project described in a preceding section on the general problems of the basin. A flood-control project is now under construction in the Muskingum Basin at a cost of about 40 million dollars. When these works are completed the flood control problem will be largely solved for this river. The reservoirs will supply a small increase in the low flow of the river and will afford recreational facilities.

Underground water supplies have been extensively used by the smaller communities and by many industries. In recent years some of the supplies have shown signs of exhaustion, probably due to a succession of dry years combined with excessive withdrawals. How much of the recession of the water table is attributable to each cause, and what recovery may occur in later years, is not known. It is reported that at Indianapolis the water table is falling at a rate of approximately 2 feet per year. Threatened overdraft of the ground water is perhaps most acute in the Miami Valley. Continuation of the high degree of industrial development, especially in paper manufacturing, requires the proper utilization and conservation of the underground supply. Careful check should be kept on water levels, rates of draft, and the like, to avoid overdevelopment of water-consuming industries with consequent dangerous depletion of the supply available. The importance of this matter is emphasized by experiences in Mill Creek Valley, where industry is now appropriating all of the ground water available on a sustained yield basis, and where at times there are serious shortages. No adequate remedy has been found for this situation. In many critical localities it would seem that additional supplies must come from surface sources. Most of the underground waters would be much improved for domestic and industrial use by softening.

Many upland farmers, using shallow wells, have had a shortage of water during the recent drought years. One remedy proposed is to construct small reservoirs. For such reservoirs on small streams, many of which



are intermittent, care should be taken to insure proper sites and soundness of construction. Past experience with such dams in this area has not always been satisfactory. It has been found that some dams on intermittent streams merely stop the water long enough for it to present a larger surface for evaporation, and many reservoirs have been dry when water was needed. Other small dams either have been washed out by occasional heavy rains or impound but little water, because of faulty construction or sites which are not watertight.

Surface water supplies have generally been adequate in the past. Their quality is now threatened at many points by domestic and industrial wastes as already described, and their further use will depend in many cases on abatement of this pollution. Two special water problems will be mentioned. (1) Springfield, Ohio, obtains its supply from underground collecting galleries; the quantity is limited and a surface supply will probably have to be developed in the near future. (2) In the Wabash Basin much land has been drained in the past for malaria control and for agricultural use. Extensive land drainage seems to be in conflict with the present need for retarding stream flows and conserving underground water. Before carrying on further drainage work, there should be an investigation to determine whether a conflict in fact exists, and to fix upon the policy to be adopted. Consideration should be given to flooding swamps and to raising the levels of Indiana's numerous recreation lakes.

Additional water *recreational* areas are needed in various parts of the region. Wherever practicable they should be provided, either independently or as a phase of multiple purpose projects. Columbus, Ohio, for example, has two city parks bordering on wa-

ter supply reservoirs where boating and fishing privileges are enjoyed by a surprisingly large number of people. Such facilities are being provided in connection with the Muskingum flood-control reservoirs, and at the Miami reservoirs near Dayton.

Erosion is a serious problem in this area, notably in the lower Muskingum Valley, and two research projects are underway. On a 5,000-acre watershed in Coshocton County a study is being undertaken of erosion, rainfall, and run-off relationships as influenced by an improved land-use and erosion-control program on part of the area as compared with the other part where the prevailing land use will be maintained. The other project is a 250-acre soil and water conservation experiment station where erosion-control practices applicable to the region are being developed, tested, and improved. Experiments at this station include studies on the relationships of land cover, forests, and crops to erosion control and water conservation. It is intended to inaugurate soil erosion-control measures above several of the flood reservoirs where silting might otherwise be serious, and land has been acquired for this purpose.

On the Scioto, the older of the Columbus water supply reservoirs has lost one-quarter of its capacity from silting in the past 30 years. While this alone may not justify extensive erosion-control measures in the watershed, it should influence the selection of soil-conservation projects for this area.

There is relatively little *water power*, developed or potential, in any of the four basins of the region. Throughout most of the area the supply of water is sufficiently restricted to limit not only the development of water power, but also the location and size of steam-electric plants.

Muskingum Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Study to determine economic justification for and to devise means of removing industrial community waste pollution from plants at Canton (7), Mansfield (4), Barberton (1), Massillon (6), Zanesville (18), Newark (17), Coshocton (12), Rittman (2), and Cambridge (15), Ohio.	\$15,000	
(1)	Ashland (3), Barberton (1), Buckeye Lake (18), and Cambridge (15), Ohio: Sewer systems and complete treatment plants.	2,200,000	General plans ready for Cambridge, detailed plans for other communities.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Malta (21), McConnelsville (20), Mount Vernon (11), Rittman (2), and Zanesville (16), Ohio: Sewage-treatment plants.	\$825,000	Existing Rittman plant subject to overflows by floods.
4	Mansfield, Ohio: Increased water supply	700,000	Inadequate industrial supply.
(1)	Coshocton (12), Crooksville (19), Dennison (14), Newark (17), and Uhrichsville (13), Ohio: Sewer systems and sewage-treatment plants.	1,400,000	General plans for Coshocton; all other places no plans available. Probably combined plant for Dennison and Uhrichsville.
(1)	Dover (9), Minerva (8), New Philadelphia (10), and Wooster (5), Ohio: Sewage-treatment plants or secondary treatment plant to supplement existing plants.	600,000	Plans needed.

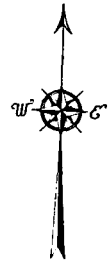
¹ Map key numbers shown following community names.

MIAMI

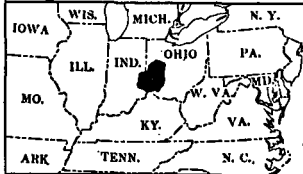
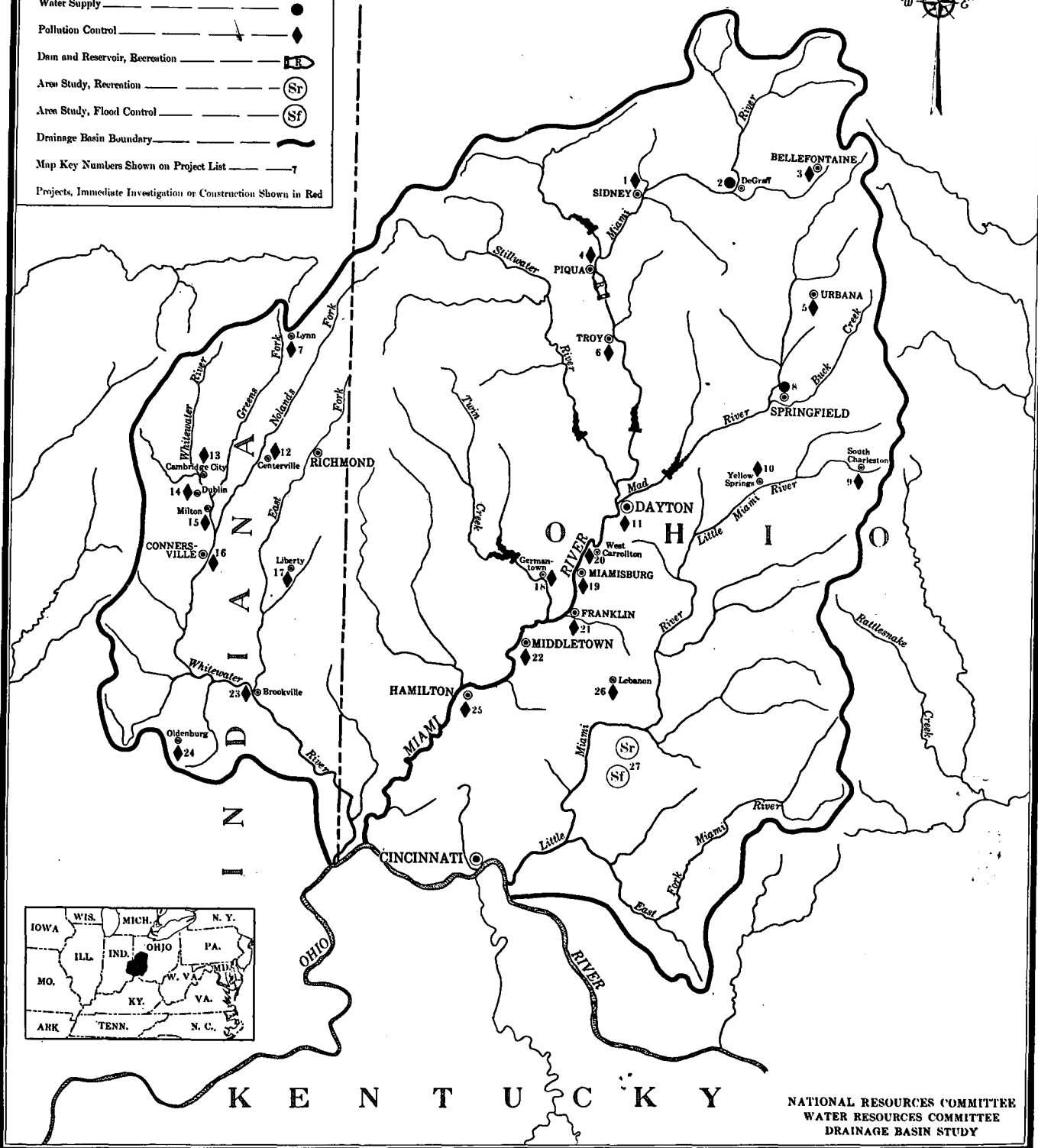
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1938



LEGEND	
Cities	○
Existing Projects of Major Significance	—▲—
Water Supply	●
Pollution Control	◆
Dam and Reservoir, Recreation	Ⓡ
Area Study, Recreation	Ⓢr
Area Study, Flood Control	Ⓢf
Drainage Basin Boundary	—
Map Key Numbers Shown on Project List	7
Projects, Immediate Investigation or Construction Shown in Red	



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Scioto Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
2	Lancaster, Ohio: Sewage-treatment plant.....	\$400,000	Investigation and preliminary plans made. Do.
1	Kenton, Ohio: Improvements to existing sewage plant which discharges into stream above Columbus water reservoirs.	40,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Circleville (3), Hillsboro (4), and Wellston (5), Ohio: Sewage-treatment plants.....	\$360,000	Investigation and plans are lacking.

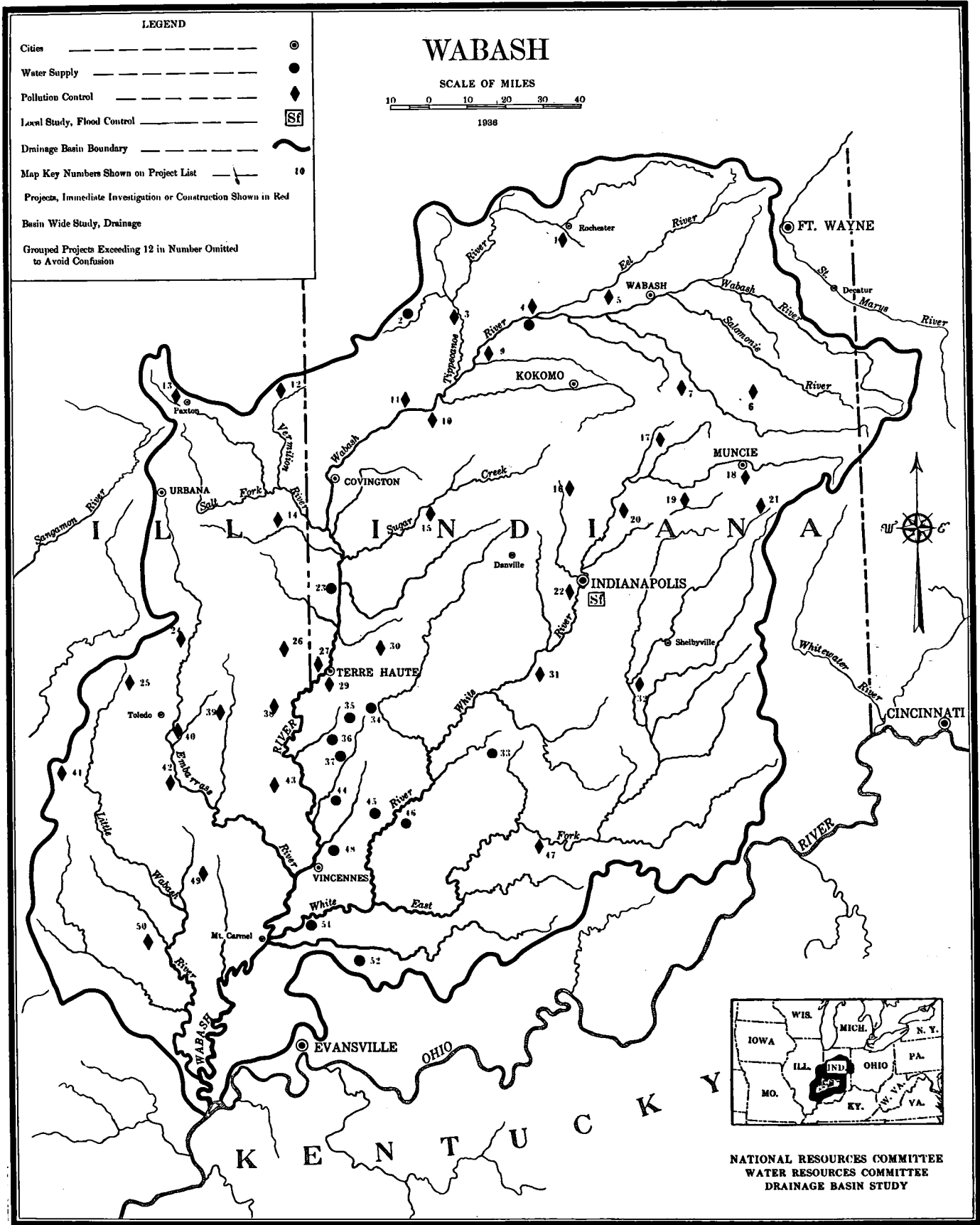
Miami Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
27	Study of proposed reservoir for recreational use and possible flood control on Little Miami River...	\$5,000	Plans made in connection with present improvements. Final plans needed.
11	Dayton, Ohio: Construction of 10 additional sprinkling filters for sewage plant.....	150,000	
25	Hamilton, Ohio: Intercepting sewers and treatment plant construction. Plans to include control of industrial pollution.	1,000,000	Final plans now being made.
4	Piqua, Ohio: Dam to provide cooling water for power plant, and recreation lake for city.....	55,000	
9	South Charleston, Ohio: Complete sewage-treatment plant.....	40,000	General plans ready. Do.
10	Yellow Springs, Ohio: Complete sewage-treatment plant.....	50,000	
8	Springfield, Ohio: Increased water supply.....	800,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
22	Middletown, Ohio: Sewage-treatment plant and relief sewers.....	\$1,000,000	Plans and surveys needed for both domestic and industrial sewage treatment works. Preliminary plans.
2	Degraff, Ohio: Municipal waterworks, wells, pumps, distribution system.....	70,000	
4	Piqua, Ohio: Primary sewage-treatment plant.....	300,000	Plans needed. Do. Preliminary plans made.
5	Urbana, Ohio: Reconstruction and extension of sewage-treatment plant.....	35,000	
18	Germantown, Ohio: New sewage-treatment plant.....	130,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Bellefontaine (3), and West Carrollton (20), Ohio: Reconstruct present sewage-treatment plants, which are inadequate.	\$200,000	No plans available.
(1)	Franklin (21), Lebanon (26), Miamisburg (19), Sidney (1), Troy (6): Sewage-treatment plants.....	700,000	Do.
(1)	Brookville (23), Cambridge City (13), Centerville (12), Connersville (16), Dublin (14), Liberty (17), Lynn (7), Milton (15), and Oldenburg (24), Ind.: Construction or remodeling of sewage-treatment plants.	800,000	Do.

Wabash Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
22	Study of flood protection for Indianapolis and elsewhere to determine what levees should be included, and cost and benefit balance.	15,000	To include project authorized by Congress.
6	Hartford City, Ind.: Correction of excessive pollution from domestic sewage and large paper mills...	\$180,000	Plans ready, need imperative. A controversial question requiring thorough investigation.
	Study of drainage policy for Wabash basin to determine whether additional land drainage is desirable and whether some existing work should be abandoned.	25,000	
(1)	Anderson (19), Muncie (18), Newcastle (21), and Noblesville (20), Ind.: Sewage-treatment plants...	3,000,000	Plans ready, need imperative. Plans ready.
(1)	Crawfordsville (15), Edinburg (32), Elwood (17), and Martinsville (31), Ind.: Sewage-treatment plants.	650,000	
(1)	Mitchell (47) and Peru (5), Ind.: Sewer systems and sewage-treatment plants.....	675,000	Do.
(1)	Bloomington (33), Carlisle (44), and Elnora (46), Ind.: Water supply systems.....	200,000	Do.

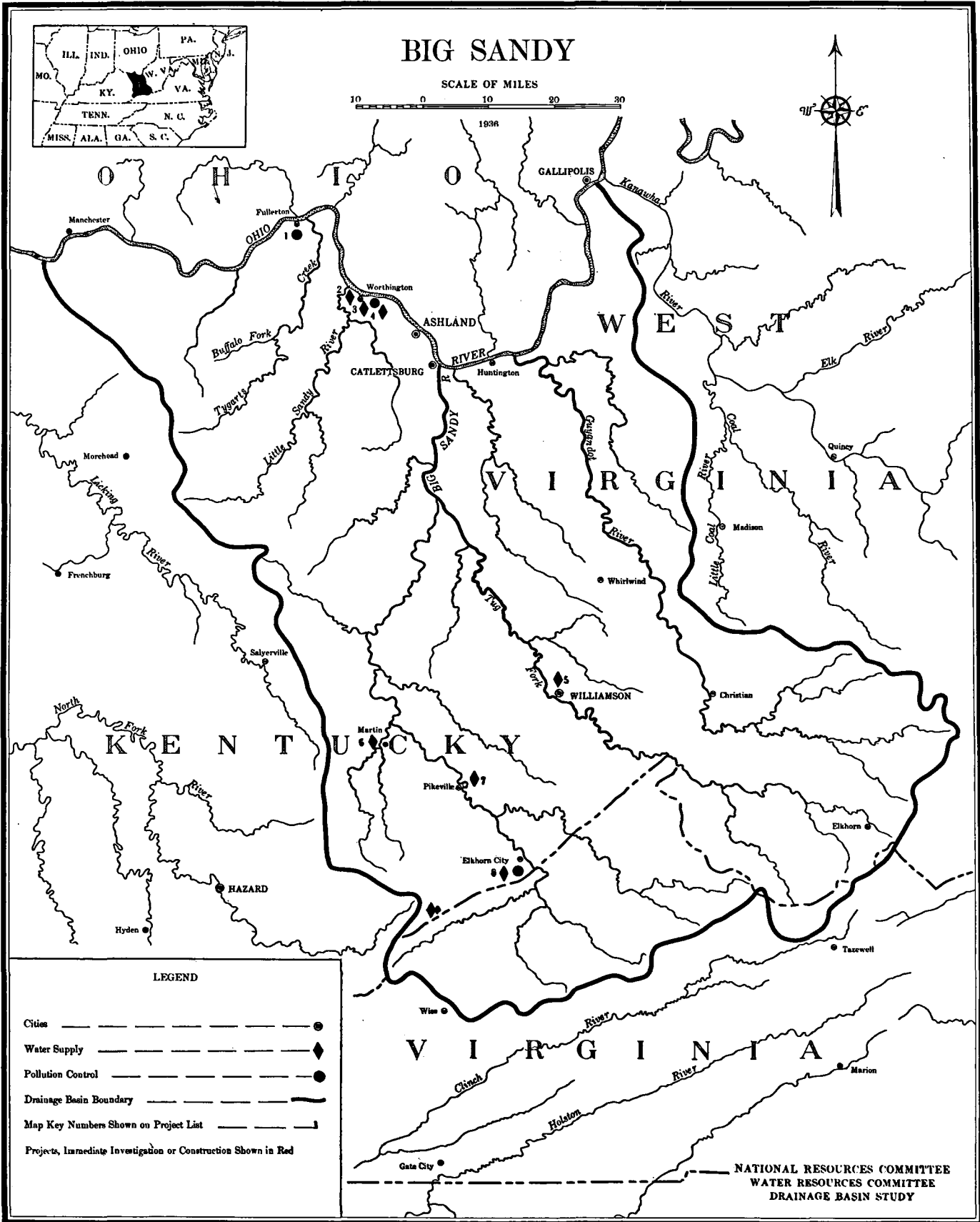
¹ Map key number shown following community name.



Wabash Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
29	Terre Haute, Ind.: Sewage-treatment plant, including some sewers to correct excessive river pollution and remove menace to water supplies of cities downstream, including Vincennes.	\$2,300,000	Plans not ready.
(1)	Casey (39), Charleston (24), Fairfield (50), Georgetown (14), Greenup (40), Hoopeson (12), Marshall (35), Mattoon (25), Palestine (43), Paris (26), and Olney (49), Ill.: Complete sewage treatment plants and collecting sewers in some cases to remove nuisance conditions, prevent suits and improve water for agricultural purposes.	1,800,000	Plans needed.
(1)	Altamont (41), Newton (42), and Paxton (13), Ill.: Sewer systems and complete sewage-treatment plants.	500,000	Do.
30	Brazil, Ind.: Secondary sewage treatment.	100,000	Plans not yet ready.
(1)	Delphi (9), Logansport (4), Marion (7), and West Terre Haute (27), Ind.: Sewer systems and sewage-treatment plants.	1,300,000	Plans not ready.
(1)	Hazleton (51) and Oakland City (52), Ind.: Water-purification plants.	75,000	Do.
34	Jasonville, Ind.: Water supply.	350,000	Do.
4	Logansport, Ind.: Water-purification plant improvements.	30,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Albany, Alexandria, Bedford, Clinton, Columbia City, Columbus, Eaton, Fortville, Lapel, Linton, Montpelier, Pendleton, Portland, Redkey, Seymour, Spencer, Warsaw, Washington, and Veedersburg, Ind.: Sewer systems and sewage-treatment plants.	\$2,200,000	Plans not ready.
(1)	Bruceville (48), Fairview Park (23), Hymera (35), Sandborn (45), Shelburn (36), Swayzee (8), Ind.: New waterworks and distribution systems.	500,000	Plans not ready. Present water supply facilities unsafe.
(1)	La Fayette (10) and West La Fayette (11), Ind.: Primary sewage-treatment plants.	400,000	Plans not ready.
1	Rochester, Ind.: secondary sewage-treatment plant.	40,000	Do.
(1)	Monticello (3), Sheridan (16), and Speedway City (22), Ind.: Sewage-treatment plants.	400,000	Do.
2	Wolcott, Ind., new water-purification plant and accessories.	30,000	Do.
37	Sullivan, Ind., additions to water supply system to protect public health.	100,000	Do.

1 Map key numbers shown following community name.



3. OHIO SOUTHERN TRIBUTARIES

(Big Sandy, Kentucky, Green, and Cumberland)

Projects for water use and control in this area are chiefly concerned with public health. Malaria is a problem and methods of control are recommended. Inadequacy of hydrologic data, especially concerning underground water, is a handicap to finding suitable farm and other water supplies and to intelligent general planning. Many of the smaller towns are without municipal water supplies and sewers; construction is recommended to remedy this condition as far as practicable. In a few cases, problems of urban water supply and pollution need attention. Destruction of fish life by discharge of distillery wastes is serious on some streams and other means of disposal for the wastes should be sought.

General Description

The southern tributaries of the Ohio drain nearly all of Kentucky and parts of West Virginia and Tennessee. The southeast section, which borders upon the Kanawha Valley, is rugged; the streams flow in narrow valleys and deep gorges. West of this section lie rolling lands of fertile soil, and to the northwest the "blue grass country", famous for its livestock. Along the Ohio, especially toward its mouth at the Mississippi, the country is more nearly level and contains many swamps.

The rivers of the region and their square miles of watershed are, from east to west, the Big Sandy, 4,283; Licking, 3,672; Kentucky, 6,935; Salt, 2,890; Green, 9,430; and Cumberland, 18,000.

The population of the area is about 3,500,000, of which about one-third is urban. Urban population, mostly concentrated along the Ohio River, is increasing rapidly, while rural population is declining at some places. The chief cities and their population are: Louisville, Ky., 307,000; Nashville, Tenn., 154,000; Huntington, W. Va., 75,000; and Covington, Ky., 65,000.

Industry, less highly developed here than elsewhere in the Ohio Basin, is diversified in character. Mineral products are coal, oil, gas, phosphate rock, fluorite, and rock asphalt.

Recommended Plan

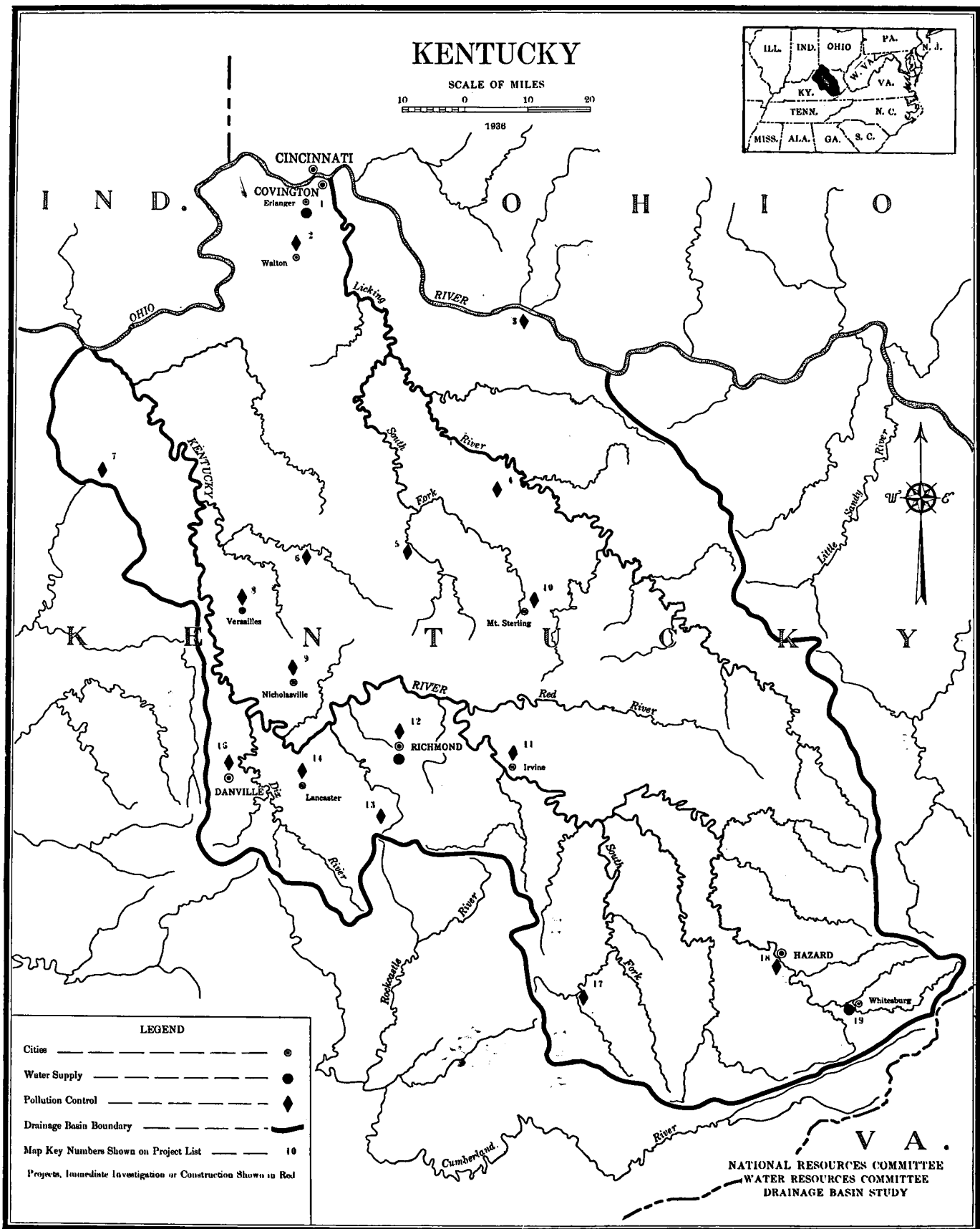
With proper planning, the water resources of this area could be extensively developed without the large expenditures often required to correct the results of

unplanned growth. In general, further encroachment on the flood plains should not be permitted. Those few structures which must be erected on a river bank should be designed to withstand floods without excessive damage. New highways should be located so far as practicable above the reach of flood waters. Pollution should be controlled or avoided. Provision of means for treatment of sewage should accompany the installation of sewers. Where dilution would be inadequate, such provision should include treatment works, or storage reservoirs to increase the minimum stream flow. Water-power sites should be developed in the light of multiple possibilities for the use of water, and with due regard to an integrated regional plan.

The area will some day afford favorable opportunities for combined-use projects with benefits to water supplies, sanitation, power, and navigation, and a degree of flood control. Planning, to be effective, will need long-term records of stream flow, rainfall, and ground-water levels; collection of such data on an adequate scale should be prosecuted.

Malaria is prevalent in western Kentucky along the lower reaches of the Cumberland and Green Rivers, where swamp areas provide breeding grounds for the anopheles mosquito. A malaria-control project of drainage works costing \$2,400,000 is recommended for the State of Kentucky; a small portion of this project is outside the Ohio Basin.

Water supplies from streams are used by most of the larger cities. Communities using the Ohio River must exercise extreme vigilance in the operation of their plants to prevent water-borne diseases. Underground water is abundant at Louisville and is extensively used for various industrial purposes. The principal water-bearing formation is about 60 feet thick and 50 to 60 feet below the surface. Elsewhere little is known about the ground water; lack of adequate information on the location, depth, and occurrence of water-bearing formations has been responsible for the drilling of many unsuccessful wells by farmers. To provide information for intelligent local as well as general planning of the use of water in the region, an intensive study of the ground-water situation is needed. This should be followed by the keeping of continuous records. Stream gaging, abandoned at many points in 1916, should be resumed. Ground



water is highly mineralized and, where used, is generally softened. Water supplies and sewer systems are lacking for many of the small communities.

Stream pollution is not a serious problem on the principal tributaries in this area, but sewage-treatment plants are needed for a few communities situated on small streams, where nuisances occur.

A number of places are in need of sewer systems, including three large suburbs of Louisville which still depend on private septic tanks. Their sewage should not, however, be added to that of Louisville until the whole can be treated before discharge into the Ohio River.

Distillery waste has caused serious difficulties at some places. Although not a direct menace to public health, its reduction of available oxygen in the stream is damaging to fish life, and at critical points may cause nuisances, including foul odors. Several distilleries have been ordered to cease operation until a suitable method of disposal is provided. Distillery waste is used to some extent as cheap fattening food for cattle and hogs. The Kentucky State Department of Agriculture has made some promising experiments with its use as a fertilizer. Research in this problem should be continued.

The discussion of acid-mine waste and mine sealing in the section of this report on the general problems

of the basin as a whole applies with special force to the headwaters of the Cumberland, Kentucky, and Big Sandy Rivers, where the streams are small and the mines numerous.

The only important *navigation* problem is on the Cumberland River. Following the recent provision of a full 6-foot channel, traffic between Nashville and the mouth has notably increased. A 9-foot channel to Nashville, and possibly to Carthage, is now being studied by the Corps of Engineers.

Flood protection requirements and possibilities for various streams within the area have been investigated and reported on by the Corps of Engineers. Two of the fourteen reservoirs authorized by the Flood Control Act of 1936 are situated on the Licking River and will provide protection for that valley. This project will also reduce flood damages due to Ohio River backwater at points near the mouths of the tributaries. Most urban property is, fortunately, located above flood levels. An exception is found at several places on the Cumberland River, where the average annual damage is estimated at \$300,000. The cost of reservoirs adequate to secure proper control appears to be excessive. Levee protection was also studied, but the cost at most points was found to exceed the value of the land. At Middlesboro and Pineville levees have been authorized in the Flood Control Act of 1936.

Big Sandy Project List

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
5 (1)	Williamson, W. Va.: Sewage-treatment plant..... Elkhorn City (8), Fullerton (1), and Raceland (4), Ky.: New water-supply systems.....	\$125,000 250,000	No plans available. Preliminary plans completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Elkhorn City (8), Greenup (2), Jenkins (9), Martin (6), Pikeville (7), Raceland (4), and Worthington (3), Ky.: Sewer system.	\$800,000	Plans ready for Elkhorn City and Martin; preliminary plans for Pikeville, Raceland, and Worthington; others, no plans available.

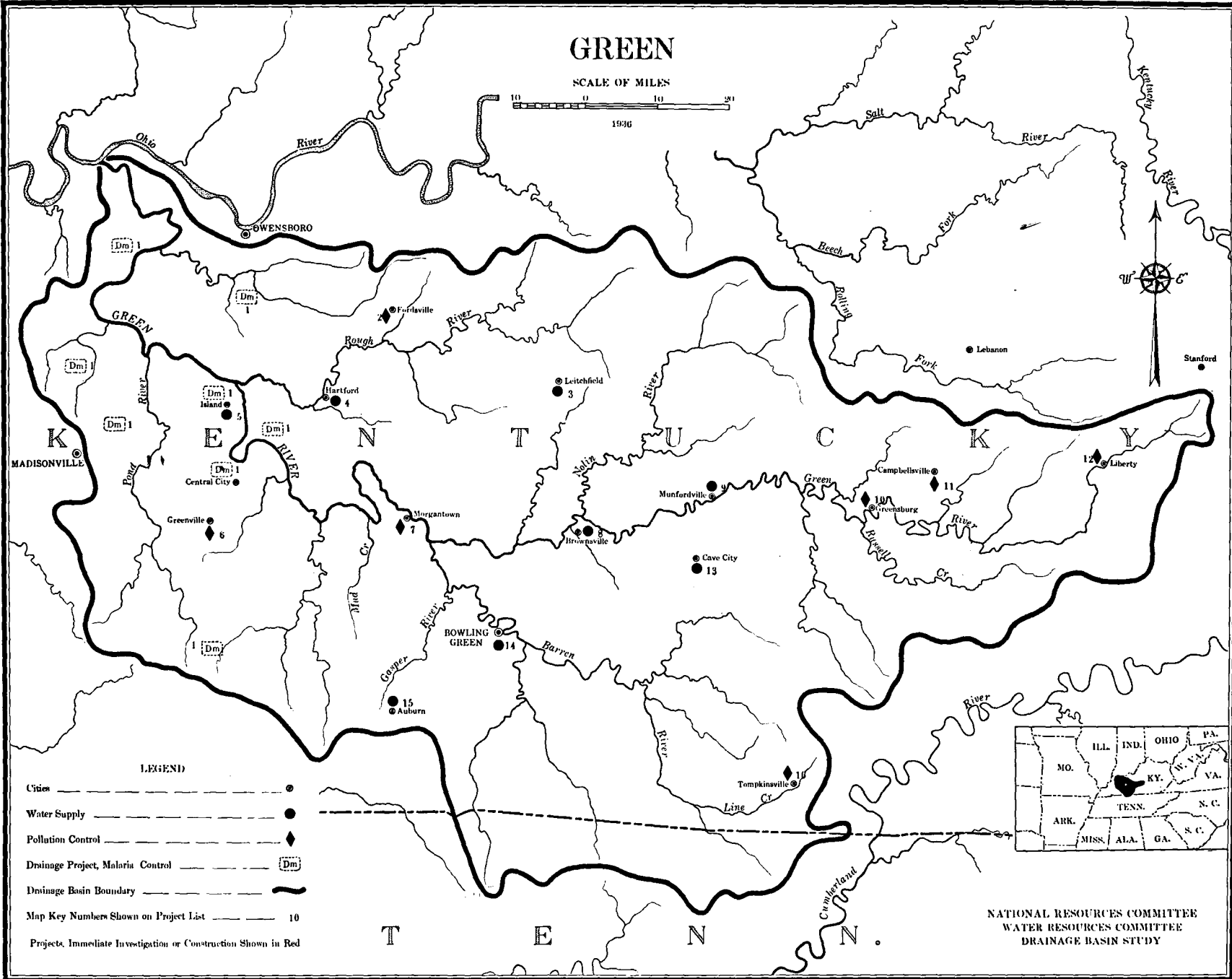
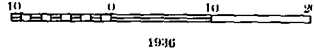
Kentucky Project List

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
12 (1)	Richmond, Ky.: Filter plant to purify supply from stream of poor quality..... Georgetown (6), Hazard (18), Irvine (11), Mount Sterling (10), Nicholasville (9), Paris (5), and Versailles (8), Ky.: Sewage-treatment plants and/or outfall sewers and/or sewer systems.	\$120,000 600,000	Plans ready. Plans partly completed for Hazard, elsewhere plans have not been prepared.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Augusta (3), Berea (13), Carlisle (4), Eminence (7), Lancaster (14), Manchester (17), and Walton (2), Ky.: Sanitary sewer systems.	\$510,000	No plans available.
16	Danville, Ky.: Extension of sewers and a sewage-treatment plant for health and to clean up river.....	100,000	Do.
1	Erlanger, Ky.: Water-supply system. Now using Covington water but needs own supply.....	90,000	Preliminary plans.
12	Richmond, Ky.: Sewage-treatment plant to remove nuisance from small stream.....	70,000	Do.
19	Whitesburg, Ky.: Waterworks.....	60,000	Do.

1 Map key numbers shown following community name.

GREEN

SCALE OF MILES

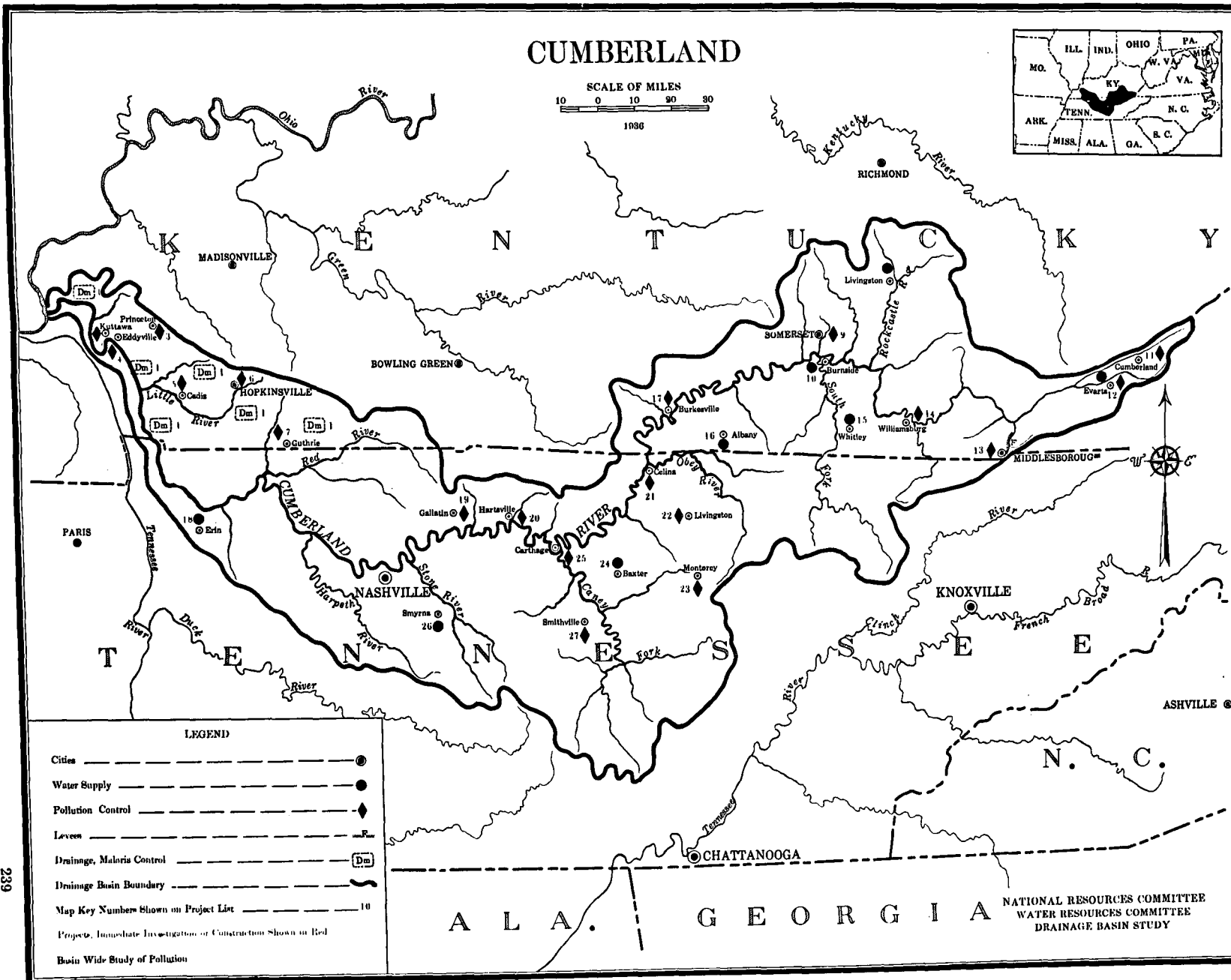
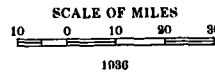


LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Drainage Project, Malaria Control ———— [Dm]
- Drainage Basin Boundary ———— ————
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red

NATIONAL RESOURCES COMMITTEE
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DRAINAGE BASIN STUDY

CUMBERLAND



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ALA. GEORGIA

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Green Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
14	Bowling Green, Ky.: Covering of water distribution reservoirs to safeguard water supply against contamination.	\$44,000	Plans completed.
1	Daviess, Henderson, Hopkins, McLean, Muhlenburg, Ohio; Todd, and Webster Counties, Ky.: Drainage to exterminate mosquitos and control malaria with incidental benefits to farm land.	960,000	A 6-year program now being started.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Auburn (15), Brownsville (8), Cave City (13), Hartford (4), Island (5), Leitchfield (3), and Mundefordville (9), Ky.: Water supply for communities now depending on individual supplies.	\$410,000	Cave City, Hartford, Island, and Leitchfield plans ready. Other towns have no plans available.
11	Cambellsville, Ky.: Sewer system and sewage-treatment plant.....	150,000	Preliminary plans and specifications completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Fordsville (2), Greensburg (10), Greenville (6), Liberty (12), Morgantown (7), Tomkinsville (16): Sewer systems.	\$200,000	No plans available.

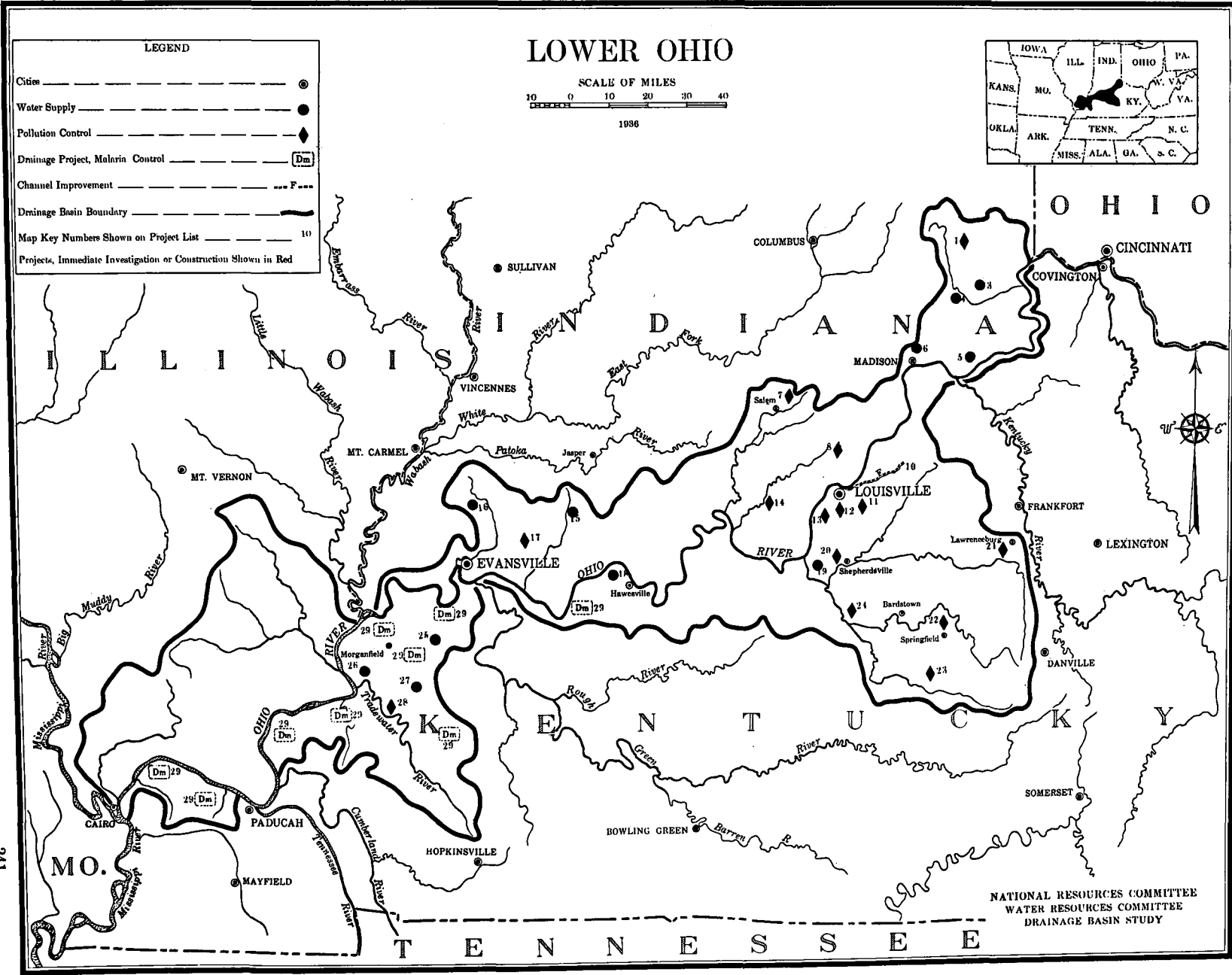
Cumberland Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
1	Pollution stream survey and laboratory tests to obtain adequate information of existing and potential pollution. Also hydrologic study.	200,000	Intensive 2-year program, followed by continuing annual work.
19	Caldwell, Christian, Livingston, Lyon, Todd, and Trig Counties, Ky.: Drainage to exterminate mosquitoes and control malaria with incidental benefits.	\$288,000	A 6-year program now being started.
13	Gallatin, Tenn.: Sewers and treatment plant.....	150,000	Preliminary plans ready.
9	Middlesboro, Ky.: New sewer system for large population without sewers.....	120,000	Plans ready, need urgent.
13	Somerset, Ky.: Sewer system and sewage-treatment plant.....	200,000	Do.
13	Middlesboro, Ky.: Construction of levees to protect property from floods.....	600,000	Preliminary study and plans completed. Detailed plans needed.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Albany (16), Burnside (10), Everts (12), Livingston (8), and Whitley (15), Ky.: Water-supply systems.	\$500,000	No plans available.
(1)	Baxter (24), Erin (18), and Smyrna (26), Tenn.: Water-supply systems.....	135,000	Preliminary plans ready.
6	Hopkinsville, Ky.: Major extension of sewer system and addition of sewage-treatment plant.....	425,000	Plans completed.
3	Princeton, Ky.: Sewage plant for complete treatment of sewage.....	60,000	Preliminary plans ready.
14	Williamsburg, Ky.: Sewage-treatment plant.....	100,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Carthage (25), Celina (21), Hartsville (20), Livingston (22), Monterey (23), and Smithville (27), Tenn.: New sewer systems.	\$240,000	Preliminary plans for all except Livingston.
4	Eddyville, Ky.: Sewer system.....	100,000	No plans available.
(1)	Albany (16), Burkesville (17), Cadiz (5), Cumberland (11), Cuttawa (2), Everts (12), Guthrie (7), and Williamsburg (14), Ky.: New sewer systems.	340,000	Preliminary plans for Burkesville; others, no plans.

Lower Ohio Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
29	Ballard, Crittenden, Daviess, Henderson, Hopkins, Livingston, McCracken, Union, and Webster Counties, Ky.: Drainage to exterminate mosquitos and control malaria with incidental benefits to farm land.	\$640,000	A 6-year program now being started.
(1)	Madison (6), Milan (3) and Vevay (5), Ind.: Chlorination, water-plant improvements, and/or filtration plants.	150,000	Preliminary plans ready.
(1)	Corydon (14) and Salem (7), Ind.: Complete sewage-treatment plants.....	200,000	Plans ready.
1	Batesville, Ind.: Interceptors and complete sewage-treatment plant.....	180,000	Preliminary plans ready.
GROUP B—FOR DEFERRED CONSTRUCTION			
4	Versailles, Ind.: Water supply, wells, pumps, tank and distribution system.....	\$60,000	No plans available.
(1)	Corydon (25), Dixon (27), Lewisport (18), and West Point (19), Ky.: Water-supply systems.....	250,000	Preliminary plans ready.
21	Lawrenceburg, Ky.: Sewer system.....	120,000	Do.

(1) Map key number shown following community name.



Lower Ohio Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
10	Louisville, Ky.: Channel improvements and filling land along Beargrass Creek for flood protection.	\$2,500,000	No plans available.
(1)	Camp Taylor (13), St. Mathews (11), Strathmore (12), Ky.: Sewer system for each of three important suburbs of Louisville without sewers.	400,000	Preliminary plans. Should be deferred until suitable sewage treatment is provided.
26	Sturgis, Ky.: Water-purification plant. Present supply unsatisfactory.	30,000	No plans available.
(1)	Clay (28), Lebanon (23), Lebanon Junction (24), Shepardsville (20), and Springfield (22), Ky.: Sewer systems.	300,000	Preliminary plans for Shepardsville, Lebanon; others no plans available.
(1)	Boonville (17) and Sellersburg (8), Ind.: Sewers and sewage-treatment plants.	200,000	Plans not ready.
(2)	Dale (15) and Elberfeld (16), Ind.: Water-supply systems.	150,000	Do.

¹ Map key numbers shown following community name.

GREAT LAKES DRAINAGE BASINS

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GREAT LAKES

(Navigation and International Waters)

The outstanding project in the international waters of the Great Lakes and the St. Lawrence region is the proposed improvement of the St. Lawrence River for navigation and power. Preservation of the scenic beauty of Niagara Falls is also a matter of international concern.

General Description

The drainage area of the Great Lakes is equal to nearly one-tenth of the entire area of the United States; 58 percent of it lies in the United States and contains about 16,000,000 people. The water surface is almost one-third of the total drainage area, and rather more than five-eighths of this is on the United States side of the international boundary. The Great Lakes and the St. Lawrence River form a navigable water system extending from the interior of the continent to the Atlantic Ocean. The first 115 miles of the St. Lawrence River form the international boundary between the United States and Canada. Navigation uses of this great water system far outweigh all others in present economic importance.

In 1892 traffic on the Great Lakes was about 27,000,000 tons. It reached 161,000,000 tons in 1929 and dropped during the depression to about 100,000,000 tons. The traffic since that period has been steadily increasing and by this date has already exceeded the depression figure of 100,000,000 tons by over 69,000,000 tons. The annual saving to commerce on the Great Lakes due to navigation improvements exceeds the total capital investment made by the Federal Government and others in these improvements. There is nothing to indicate that this commerce of 100 million tons or more per annum will decline in future years.

The annual freight tonnage on the Canadian St. Lawrence canals between 1927 and 1931 ranged from 8,400,000 tons to about 6,000,000 tons. The capacity of the existing Canadian St. Lawrence canals is about 9,000,000 tons, which by this time has probably been exhausted.

In spite of the limiting 14-foot draft through the Canadian St. Lawrence canals, there exists nevertheless a small amount of traffic in trans-Atlantic vessels between European points and Chicago. When the new Welland Canal was deepened to provide an increased draft from 14 to 25 feet there was an immediate increase in its traffic. Traffic along the St.

Lawrence canals, now amounting to nearly 9,000,000 tons per annum, would increase materially after the construction of the St. Lawrence waterway.

Recommended Plan

An outstanding feature of the proposed improvements in this basin is the development of a 27-foot channel for ocean-going vessels from tidewater above Montreal through the Great Lakes. Incidental to the navigation improvement, it is proposed to construct hydroelectric plants in the international section of the St. Lawrence with an installed capacity of 1,640,000 kilowatts, which, if operated on a 40-percent capacity factor, will produce 5,740,000,000 kilowatt-hours annually.

The general layout and controlling features of this project have been embodied in a proposed treaty between Canada and the United States, ratification of which is pending. The project includes construction, jointly by the United States and Canada, of dams and locks in the International Rapids section of the St. Lawrence River, and the construction of locks and dams farther downstream by Canada. Supplementing this project, provision is made for deepening the connecting channels between the Great Lakes from 25- to 27-foot depth.

The total estimated cost to the United States for the St. Lawrence waterway and power development below Lake Ontario is \$265,000,000, based upon a two-stage development in the international section. The project is here listed for construction when the necessary agreement with Canada has been ratified.

Under the Boundary Water Treaty of 1910, Canada may divert the waters of the Niagara River for power purposes at a daily average rate not to exceed 36,000 cubic feet per second, and the United States may divert water at a rate not exceeding 20,000 cubic feet per second.

In an endeavor to lessen the destructive erosion at the scarp of Niagara Falls and to bring about a distribution of the flow more in keeping with the desired scenic effects, the International Niagara Board of Control has recommended the construction of certain works in the channel of Niagara River above the Falls estimated to cost \$1,750,000. It appears that a minimum flow of 115,000 cubic feet per second is required to

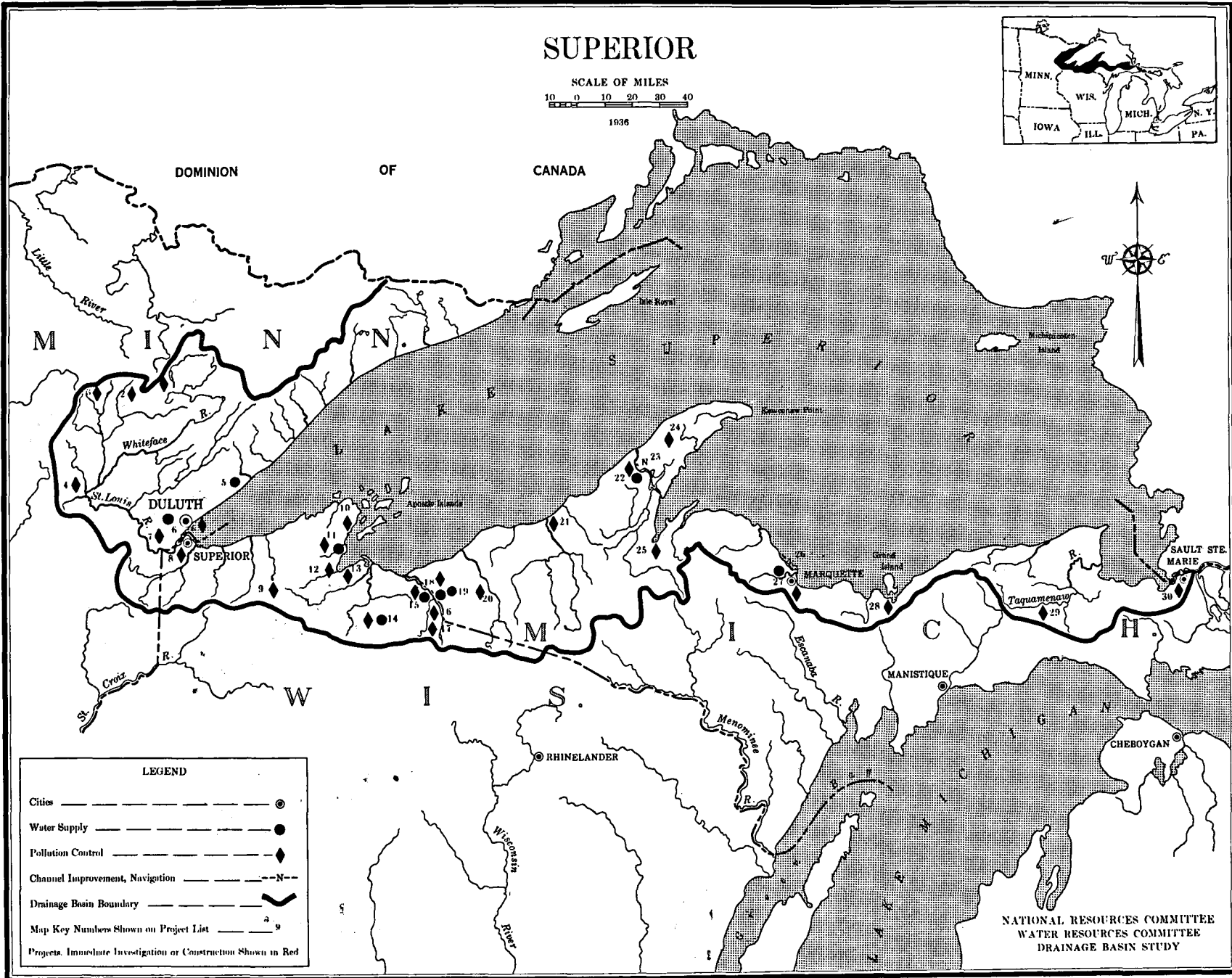
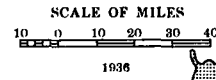
maintain the scenic grandeur of the Falls. No increased diversions for power above the total treaty limit of 56,000 cubic feet per second should be permitted until the authorized remedial works have been installed and tested.

Compensating works at the head of the Niagara and St. Clair Rivers to restore and maintain the natural levels of Lakes Erie, Michigan, and Huron have been designed, but construction must await an international agreement.

Navigation and International Waters Project List

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
3	Niagara River: Compensating works to restore the levels of Lake Erie.....	\$700,000	This may be undertaken as soon as a suitable agreement with the Canadian Government is concluded. Approved by International Joint Commission.
4	Niagara Falls: Preservation of scenic value and power.....	1,875,000	This may be undertaken as soon as a suitable agreement with the Canadian Government is concluded.
1	St. Clair River: Compensating works to restore levels of Lakes Huron and Michigan.....	2,900,000	This may be undertaken as soon as a suitable agreement with the Canadian Government is concluded. Approved by International Joint Commission.
5	GreatLakes-St. Lawrence Deep Waterway.....	265,000,000	Contingent upon ratification of pending International agreement.
2	Including deepening of upper lake channels, navigation canal in international rapids section, and power installations on American side.		

SUPERIOR



NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

1. LAKE SUPERIOR

In the Duluth-Superior region improvements in municipal water supplies and the removal of sewage pollution affecting the lake water intakes are immediate needs. Sewage-treatment plants should be provided for some of the cities. Deeper navigation channels are needed in several harbors to facilitate the heavy Great Lakes traffic in iron ore and coal.

General Description

The land area of the Lake Superior Basin in the United States comprises about 16,700 square miles in Minnesota, Wisconsin, and Michigan. The topography is generally rough. Along the northwest shore of the lake in Minnesota the land rises steeply from the lake level of about 600 feet to altitudes of about 1,200 feet within a distance of 1 to 4 miles and 1,800 and 1,900 feet farther inland. The Wisconsin-Michigan area along the southern shore rises less abruptly from the lake but the height of the escarpment is about the same. In most places the soil is thin. Some of the many water falls are of great beauty.

Practically all of the virgin timber has been cut, but the land is still heavily wooded with second growth. From Duluth all along the northwestern shore and inland from it the basin is generally a wilderness of lakes and streams. Improved farm lands cover only about one-tenth of the total area. Some lands now farmed in Minnesota are unproductive and will probably have to be abandoned.

The principal rivers of the basin are the Pigeon, lying along the international boundary between the United States and Canada; the St. Louis, in Minnesota, emptying into Lake Superior at its extreme western end and forming for a short portion of its length the boundary between Minnesota and Wisconsin; the Bois Brule and Bad Rivers in Wisconsin and the Ontonagon River in Michigan. The largest of these is the St. Louis, with a drainage area of about 3,700 square miles.

The area as a whole is sparsely settled, particularly in Minnesota north of Lake Superior. The total population is about 360,000, with Duluth and Superior as the chief centers.

The mining of iron ore is the principal industry. The mines of the Mesabi Range in Minnesota are the largest producers in the world; considerable quantities

are also mined in the Gogebic and Penokee Ranges of Wisconsin and Michigan. Shipment of the ore over the convenient water route has been the principal factor in the development of the port of Duluth-Superior, which handles the largest tonnage of any port on the Great Lakes. Copper is also mined in considerable quantities. Large amounts of limestone and sandstone and some granite are quarried. Lumbering has lost much of its importance in recent years, but there is a growing pulpwood industry based on second-growth timber.

There are a number of important water-power developments, particularly on the St. Louis River in the vicinity of Duluth. The streams afford opportunities for many additional developments as the power market grows.

The temperature ranges from 95° above zero to 50° below. The average annual precipitation ranges from 24 inches in the Pigeon River Basin to 33 inches in some portions of the Michigan section. The mean annual snowfall is 40 to 80 inches.

Recommended Plan

Water supply needs include an additional water supply reservoir for the high level part of Duluth, a waterworks for Two Harbors, and an additional storage reservoir for the town of Bessemer. Projects in other places are listed for future consideration.

Pollution of Lake Superior affects the water intakes of Duluth, Superior, and other municipalities. Sewage-treatment plants and other sanitary works are recommended for immediate construction at Duluth and at Nopeming, a suburb. Sewers are needed at Hibbing, Floodwood, Virginia, and Aurora, all in the iron-mining region. Sewage-treatment plants for other municipalities are listed for construction when plans are completed.

Navigation projects ready for immediate construction include the deepening to 25 feet of the Keeweenaw Waterway across the northern peninsula of Michigan, connecting Lake Superior and Lake Michigan, at an estimated cost of \$1,985,000; and the deepening of Presque Isle Harbor to 26 and 28 feet, with additional breakwater construction, at an estimated cost of \$350,000 to complete the work now under way.

Superior Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
6	Duluth, Minn.: Reservoir for water supply.....	\$161,000	Ready for construction.
6	Duluth, Minn.: Sewage treatment plant.....	1,166,000	Do.
6	Duluth, Minn.: Sanitary sewers.....	26,000	Do.
6	Duluth, Minn.: Storm sewers.....	194,000	Plans completed.
19	Bessemer, Mich.: Additional water supply.....	124,000	Do.
7	Nopeming, Minn.: Sewage treatment plant.....	27,000	Do.
23	Keweenaw Water Way, Mich.: Deepening waterway to 25 feet.....	1,985,000	Under construction. Sum needed to complete.
1	Aurora, Minn.: Sewers.....	61,000	Do.
4	Floodwood, Minn.: Sewers.....	24,000	Do.
3	Hibbing, Minn.: Sewers.....	14,000	Do.
2	Virginia, Minn.: Sewers.....	7,000	Do.
5	Two Harbors, Minn.: Waterworks.....	111,000	Plans completed.
26	Presque Isle, Mich.: Deepen harbor supplemented by breakwater.....	350,000	Sum needed to complete. Authorized by Congress. Plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Hurley (15), Mellen (14), and Washburn (11), Wis.: Water supply systems.....	\$85,000	
(1)	Ashland (13), Bayfield (10), Hurley (15), Mellen (14), Montreal (16), Pence (17), and Superior (8), Wis.; Sault Ste. Marie (30), Mich.; and Washburn (11), Wis.: Sewage treatment plants.	1,105,000	
(1)	Calumet (24), Houghton (22), Ironwood (18), L'Anse (25), Marquette (27), Munising (28), Newberry (29), Ontonagon (21), and Wakefield (20), Mich.: Sewers and sewage treatment plants.	1,050,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Barksdale (12) and Iron River (9), Wis.: Sewage treatment plants.....	\$20,000	
18	Ironwood, Mich.: Additional water supply.....	15,000	
22	Houghton, Mich.: Water supply.....	10,000	
27	Marquette, Mich.: Improvement to water supply.....	100,000	

¹ Map key number shown following community name.

2. LAKE MICHIGAN

An outstanding problem of the Lake Michigan Basin is the pollution of water supplies, especially at the south end of the lake where more than 4,000,000 people depend upon the lake for water. The solution is to provide adequate treatment for all sewage entering Lake Michigan from the Indiana cities, and to prevent the reversal of flow by floodwaters in the Calumet River, which receives the sewage effluent and sometimes discharges it into Lake Michigan instead of into the Chicago Sanitary Canal. A similar reversal of flow in the Chicago River will be prevented by the lock now under construction near its mouth in Chicago Harbor.

The second problem of the basin is the construction of suitable filter plants for communities whose water is polluted by raw or treated sewage discharged into the lake or into streams above them.

A third problem is the improvement of navigation by deepening and enlarging the harbors to care for the heavy water-borne traffic and by the provision of harbors of refuge, advantageously located.

General Description

The Lake Michigan Basin is about 384 miles long and averages 180 miles wide. The total area is about 69,000 square miles, including 22,400 square miles of water surface in Lake Michigan itself.

The average annual temperature ranges from 41° to 49°. The maximum is 105°, and the minimum 36° below zero. The average annual precipitation is 29.5 to 33.2 inches, with snowfall of 53 to 58 inches.

The population in 1930 was about 7,350,000, including the metropolitan section at the southern end of the lake with some 4,000,000 people. The northern parts of the basin are sparsely settled. The principal cities are Chicago with 3,376,438 in 1930, Milwaukee with 578,249, and Grand Rapids with 168,592. There are 13 other cities with populations of more than 40,000 each.

Agriculture is important in the middle and southern parts of the basin. In the peninsula between Green Bay and Lake Michigan and on the east shore of the lake the climate is suitable for fruit growing, and valuable fruit crops are produced. Commercial fishing on Lake Michigan is an extensive activity. Iron ore is mined in the Menominee Basin in the Upper Peninsula of Michigan, and oil is produced in the Muskegon Basin. Lumbering is still carried on but is not nearly as important as formerly.

Chicago, Milwaukee, and other cities are centers for the manufacture of a wide variety of products. The

industrial importance of the region will probably increase. There are two general types of lake commerce—the cross-lake car ferries carrying more than 3,000,000 tons a year of coal and general merchandise, and the north-and-south traffic in iron ore, coal, limestone, grain, and general merchandise amounting to more than 24,000,000 tons a year.

Important to the heavy shipping on Lake Michigan are the many improved harbors, the Sturgeon Bay Canal, the upper end of the Chicago Sanitary District Canal, the Sag Canal, the Calumet River, and the Indiana Harbor Canal.

Plans have been made to improve Chicago Harbor so that lake vessels ultimately will not have to use the Chicago River. Much of the traffic now using Chicago Harbor would be diverted to the proposed Illiana Harbor providing transfers of cargo from ship to shore or from ship to barge for the most direct transport through the Illinois waterway. The industrial harbor at Lake Calumet can also provide facilities for transfer from ship to barge or from ship or barge to shore. Increasing traffic on the Illinois waterway will make necessary improved terminal facilities at or near the Chicago city limits in the main canal.

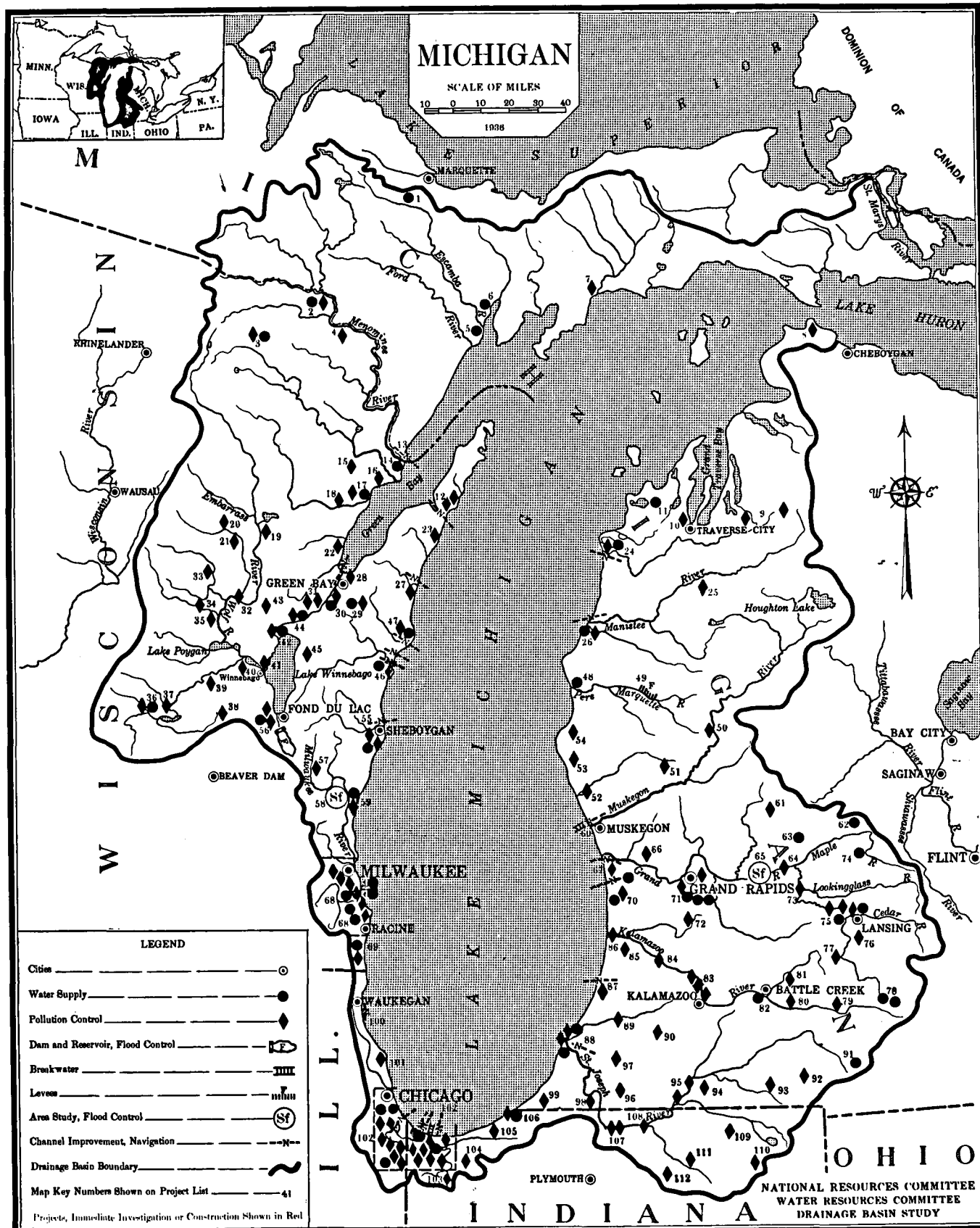
There are large areas suitable to fishing and hunting, especially in the northern peninsula of Michigan and the northern part of Wisconsin. Excellent recreational beaches are provided near the cities on the lake.

Underground water is available throughout the region. All of the cities on the lake shore use lake water and most of them discharge sewage into the same body of water.

Recommended Plan

A large number of projects involving the use of water are listed for construction in this basin. Some are in the line of normal natural progress due to the growth of population and in good time can be carried through to completion. Others, however, affect the public health and are in the nature of vital remedial measures justifying the earliest possible action. These remedial measures involve sewage and pollution.

Sewage and pollution problems were most acute in the concentration of population at the southern end of Lake Michigan until the construction of the Chicago Drainage Canal, which immediately diverted the sewage of these millions of people from Lake Michigan to the Illinois River. Because of the reduction that was ordered by the Supreme Court in the amount of water diversion, the sanitary district must presently com-



plete facilities for adequate treatment. Thus, so far as this area is concerned, the situation in the Des Plaines and Illinois Rivers will be satisfactory.

In 1900, when the Chicago sewage was diverted from lake water supply, the cities along the Indiana shore of Lake Michigan were very small—Hammond, 5,428; Whiting, 1,408; and East Chicago, 1,255. Gary did not exist. In 1930 the population of these Indiana cities was over 230,000, or about 25 percent as large as that of Chicago at the time the plans for the drainage canal were started. The raw sewage of these Indiana cities now flows into the Grand Calumet River and thence into Lake Michigan at Indiana Harbor and at Calumet Harbor, except for a small diversion from the Little Calumet to the Chicago Drainage Canal in the Calumet-Sag Channel.

The northwestern section of Indiana possesses so many natural advantages for steel making that the population will probably continue to increase. The Indiana cities have long had plans and estimates for sewage treatment works to remedy their intolerable pollution of drinking water for themselves and the south intake of Chicago. Immediate construction is recommended for these projects.

The addition of a guard gate in the Indiana Harbor Canal where it joins the Grand Calumet River will prevent pollution from being carried into Lake

Michigan at times of high water in the Grand Calumet River.

Sewage-treatment plants or other works are recommended in the project list at many other cities for immediate or later construction, according to the urgency of the need.

Flood control investigations are listed to determine the proper corrective measures on the Grand River in Michigan and the Milwaukee River in Wisconsin. Reservoir dams and channel changes are needed for flood control on the east and west branches of the Fond du Lac River to protect the city of Fond du Lac, Wis.

Navigation improvements are advisable to serve the heavy traffic in various ports and channels, and also to provide harbors of refuge. Their navigable capacities should be maintained or increased as traffic demands.

Water supply extensions or improvements are needed at many places. A large project is recommended for Chicago, which uses Lake Michigan water.

Treatment of Indiana sewage will not wholly safeguard the Chicago intake. The treated effluent may still be a minor health menace. Chicago has complete plans and authorization for building a full-sized filtration plant for the south intake based on the results of operating an experimental plant for several years. This project should go forward at once.

A wildlife refuge in the Seney Marsh is now being constructed by the Biological Survey.

Lake Michigan Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
102	Chicago Sanitary District, Ill.: Completion of sewage treatment construction program.....	\$40,940,000	Under construction. Work pursuant to Supreme Court decree. Specific reference to Lansing and Grand Rapids.
65	Grand River, Mich.: Flood control study.....	\$40,000	
58	Milwaukee River, Wis.: Flood control study.....	5,000	
103	Crown Point, Ind.: Sewage treatment plant.....	45,000	
102	Chicago, Ill.: Filtration and metering project.....	20,392,000	
107	South Bend, Ind.: Interceptors and sewage treatment plant.....	3,000,000	
107	Mishawaka, Ind.: Interceptors and sewage treatment plant.....	974,000	
108	Elkhart, Ind.: Interceptors and sewage treatment plant.....	1,000,000	
110	Kendallville, Ind.: Interceptors and sewage treatment plant.....	70,000	
88	St. Joseph, Mich.: Additional sewage treatment plant.....	200,000	Preliminary report made.
88	Benton Harbor, Mich.: Additional sewage treatment.....	180,000	Preliminary reports made.
68	Racine, Wis.: Primary sewage treatment plant.....	450,000	
102	Whiting, Ind.: Interceptors and sewage treatment plant.....	335,000	
102	Hammond, Ind.: Interceptors and sewage treatment plant.....	2,950,000	
102	East Chicago, Ind.: Interceptors and sewage treatment plant.....	1,330,000	
102	Gary, Ind.: Interceptors and sewage treatment plant.....	2,300,000	
102	Hobart, Ind.: Interceptors and sewage treatment plant.....	90,000	
102	East Gary, Ind.: Sewers and sewage treatment plant.....	60,000	
102	Griffith, Ind.: Sewers and sewage treatment plant.....	29,000	
102	Highland, Ind.: Sewers and sewage treatment plant.....	30,000	
104	Valparaiso, Ind.: Interceptors and sewage treatment plant.....	125,000	To prevent pollution of Lake Michigan.
106	Michigan City, Ind.: Additions to sewers and sewage treatment plant.....	145,000	
68	South Milwaukee, Wis.: Primary sewage treatment plant.....	66,000	Plans completed.
75	Lansing, Mich.: Sewage treatment plant.....	900,000	Plans being made.
67	Grand Haven, Mich.: Interceptors and sewage treatment plant.....	200,000	Plans completed.
55	Sheboygan Falls, Wis.: Complete sewage treatment plant.....	73,000	Do.
40	Omro, Wis.: Sewer system and primary sewage treatment plant.....	75,000	Do.
68	Milwaukee Harbor, Wis.: Deepening to 21 feet.....	50,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$75,000. Authorized by Congress.
102	Calumet Harbor, Ind.: Breakwater construction and dredging.....	890,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$1,735,000. Authorized by Congress.
46	Manitowoc Harbor, Wis.: Deepen and widen channel in harbor.....	77,000	Cost given is for first 2 years. Additional needed to complete, \$68,000. Authorized by Congress.
102	Indiana Harbor, Ind.: Widening and deepening, Indiana Harbor Canal.....	240,000	Cost given is for first 2 years. Additional needed to complete, \$493,500. Authorized by Congress.
27	Kewaunee Harbor, Wis.: Deepening harbor to 20 and 22 feet.....	60,000	Cost given is for first 2 years. Additional needed to complete, \$224,000. Authorized by Congress.
13	Menominee River and Harbor, Mich. and Wis.: Deepening to 21 feet.....	83,000	Authorized by Congress.
12	Sturgeon Bay and Lake Michigan: Wisconsin ship channel, deepen and widen.....	1,125,000	Cost given is for first 2 years. Additional needed to complete, \$250,000.

Lake Michigan Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
55	Sheboygan Harbor, Wis.: Deepen and widen entrance channel.....	45,000	
47	Two Rivers Harbor, Wis.: Deepen channel and inner basin.....	30,000	
60	Muskegon Harbor, Mich.: Repair revetment.....	28,000	Authorized by Congress.
26	Manistee Harbor, Mich.: Dredging harbor 21 and 23 feet.....	60,000	Do.
87	South Haven, Mich.: Deepening to 21 feet.....	25,000	Cost given is for first 2 years. Additional needed to complete, \$32,000.
88	St. Joseph, Mich.: Improving harbor.....	75,000	
46	Manitowoc Harbor, Wis.: Dredging to 21 feet.....	115,000	
102	Cook County, Ill.: Channel improvement.....	1,240,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
56	Fond du Lac County, Wis.: Reservoir dams, etc.....	186,000	Flood control on East and West branches of Fond du Lac River.
24	Frankfort Harbor, Mich.: Dredging to 18 feet.....	69,000	
67	Grand Haven Harbor, Mich.: Dredging channel to 18 feet.....	25,000	
28	Green Bay, Wis.: Dredging turning basin 20 feet deep.....	27,000	Recommended, Rivers and Harbors Committee.
102	Indiana Harbor Canal, Ind.: Construction of a guard gate across Indiana Harbor Canal where it joins the Grand Calumet River.	150,000	
102	Grand Calumet River, Ill. and Ind.: Extension of Illinois Waterway System through Grand Calumet River to Gary.	500,000	
68	Milwaukee, Wis.: Addition to sewage treatment plant.....	8,670,000	
46	Manitowoc, Wis.: Interceptors, sewers and sewage treatment plant.....	690,000	
8	Mackinac City, Mich.: Sewage treatment plant.....	60,000	
69	Kenosha, Wis.: Sewage treatment plant.....	1,250,000	
(1)	Port Washington (59) and West Allis (68), Wis.: Interceptors, sewers and sewage treatment plants.....	397,000	
(1)	Cudahy (68) Neenah (42), Port Washington (59) and Two Rivers (47), Wis.: Water treatment plants.	498,000	
55	Sheboygan, Wis.: Additions to sewage treatment plant.....	585,000	
71	Grand Rapids, Mich.: Secondary sewage treatment plant.....	725,000	
83	Kalamazoo, Mich.: Sewage treatment plant.....	480,000	
(1)	Albion (79), Allegan (84), Bronson (93), Centerville (94), Constantine (95), Dowagiac (97), Eaton Rapids (77), Frankfort (24), Hart (54), Ionia (64), Kalkaska (9), Lake Odessa (72), Lawton (90), Manistee (26), Montague (52), Otsego (83), Three Rivers (95), Traverse City (10), White Cloud (51) and Zeeland (70), Mich.: Interceptors, sewers, and sewage treatment plants.	1,152,000	
(1)	Berlin (39), Chilton (45), Fond du Lac (56), Hortonville (43), Kimberly (44), Montello (36), New London (32), North Fond du Lac (56), Princeton (37), Sturgeon Bay (12), and Waupaca (34), Wis.: Sewage treatment plants.	696,000	
(1)	Big Rapids (50), Cassopolis (96), Coldwater (92), Coopersville (66), East Lansing (75), Fennville (85), Grand Ledge (75), Hartford (89), Marshall (80), Mason (76), Olivet (81), Plainwell (83), Portland (73), Sheridan (61), Saugatuck (86), Shelby (53) and Three Oaks (99), Mich.: Sewage treatment plants.	1,019,000	
(1)	Chesterton (105), Lagrange (109), Ligonier (111), and Syracuse (112), Ind.: Interceptors, sewers, and sewage treatment plants.	287,000	
42	Neenah, Wis.: Sewage treatment plant.....	227,000	
29	DePere, Wis.: Interceptors, sewers, and sewage-treatment plant.....	367,000	
(1)	Ashley (62), East Grand Rapids (71), Ludington (48), and Manistee (26), Mich.: Water supplies, additions and improvements.	198,000	
46	Manitowoc, Wis.: Water-treatment plant.....	482,000	
68	Racine, Wis.: Water-treatment plant.....	1,000,000	
69	Kenosha, Wis.: Water-treatment plant.....	750,000	
55	Sheboygan, Wis.: Water-treatment plant.....	600,000	
14	Marinette, Wis.: Water supply, additions and improvements.....	210,000	
88	Milwaukee, Wis.: Water-treatment plant.....	5,780,000	
(1)	DePere (29), Oconto (17), and Sturtevant (68), Wis.: Water supplies, additions and improvements.....	207,000	
1	Negaunee, Mich.: Water supply, additions and improvements.....	240,000	
(1)	Escanaba (5) and Gladstone (6), Mich.: Water-treatment plants.....	112,000	
98	Niles, Mich.: Interceptors and sewage-treatment plant.....	370,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(21)	Allouez Township and Ashwaubenon Township, Brown County, Wis.: Lateral and intercepting sewers.	\$420,000	
56	Fond du Lac, Wis.: Water-softening plant.....	390,000	
100	Waukegan, Ill.: Dredging harbor to authorized dimensions.....	25,000	Authorized by Congress.
102	Chicago, Ill.: Addition to water-pumping station.....	1,222,000	
(1)	Midlothian (102) and Oaklawn (102), Ill.: Mancelona (9), and Manton (25), Mich.; Montana and Wrightstown Township (30), and Crandon (3), Wis.: Sewer systems and sewage-treatment plants.	326,000	
38	Ripon, Wis.: Secondary sewage-treatment plant.....	150,000	
47	Two Rivers, Wis.: Interceptors and primary sewage treatment plant.....	350,000	
68	Milwaukee, Wis.: Extension of waterworks system.....	500,000	
68	Benton Harbor (88) and St. Joseph (88), Mich.: Additions to water-treatment plants.....	1,000,000	
(1)	Battle Creek, Mich.: Additions to water supply; new wells.....	295,000	
82	Hammond, Ind.: Water-treatment plant.....	600,000	
102	Gary, Ind.: Water-treatment plant.....	650,000	
102	Michigan City, Ind.: Water-treatment plant.....	1,000,000	
106	Michigan City, Ind.: Water-treatment plant.....	280,000	
(1)	Jackson (78) and Lansing (75), Mich.: Water-softening plants.....	750,000	
70	Holland, Mich.: Dredging Holland Harbor to 21 and 23 feet.....	125,000	
71	Grand Rapids, Mich.: Improvements in filtration plant, reservoir, and extensions to mains.....	650,000	
49	Lake County, Mich.: Bank protection of the Pere Marquette River for erosion control.....	10,000	
(1)	Boula (11), Caledonia (71), Elsie (74), Grass Lake (78), Hillsdale (91), Hubbardstown (63), Hudsonville (70), and Williamson (75), Mich.; and Combined Locks (44), Crandon (3), Montello (36), and Wrightstown (30), Wis.: Waterworks systems.	406,000	
(1)	Blue Island (102), Ill.; Frankfort (24) and Zeeland (70), Mich.; and Florence (2), Wis.: Waterworks improvement.	209,000	
(1)	Deerfield (101), Flossmoor (102), Lansing (75), South Chicago (75), and Thornton (102), Ill.; Manistique (7) and South Haven (87), Mich.; and Algona (23), Kewaskum (57), and Kewaunee (27), Wis.: Interceptors, sewage-treatment plants, and extensions.	484,000	
17	Oconto, Wis.: Primary sewage-treatment plant.....	125,000	
(1)	Clintonville (21) and Shawano (19), Wis.: Primary sewage-treatment plants.....	215,000	
(1)	Florence (2), Iola (33), Marion (20), Niagara (4), Oconto Falls (18), Peshtigo (16), Pound (15), Pulasaki (22), and Weyauwega (35), Wis.: Sewage-treatment plants.	345,000	
12	Sturgeon Bay, Wis.: Sewage-treatment plant.....	150,000	
68	Lake, Wis.: Storm sewers to relieve flood conditions.....	143,000	
41	Oshkosh, Wis.: Extensions to sewer system.....	100,000	
71	Grand Rapids, township, Mich.: Intercepting sewers to connect to Grand Rapids sewers.....	50,000	

¹ Map key number shown following community name.

3. HURON

In the productive southern end of the Huron Basin many new or improved water-supply and sewage-treatment plants are essential projects. Flood-damage liability of the Saginaw and tributaries warrant careful investigation. In the forested and sparsely settled area north of Saginaw Bay wildlife preservation and the control of many lakes and streams as State parks are desirable. The summer resorts of Michigan are a valuable asset to the State; the submarginal lands should be developed by conserving the natural and the wild.

General Description

The Lake Huron Basin is an area of about 18,340 square miles in Michigan along Lake Huron and Saginaw Bay. The region is drained mainly by the Sheboygan River at the north, the Thunder Bay River, Au Sable River, and the Saginaw River at the south. From 10 to 25 percent of the area of the tributary basins is in swamps or marshes. The Saginaw Valley is a growing industrial district which includes the cities of Flint, Saginaw, and Bay City, with a total population of some 600,000. Improved farm land comprises nearly 70 percent of the Saginaw Basin. All of the upper part of the region is sparsely settled, with its population concentrated mostly in the cities of Sheboygan and Alpena. Agriculture in the northern section is not important; most of the land is relatively poor. Lumbering is not now important. There are five State forests and two game refuges within the Cheboygan and Thunder Bay River Basins. There will always remain a large area of wild land. Boating, hunting, and recreation are of growing significance.

The mean annual temperature ranges from about 42° in the north to 47° in the Saginaw River Basin. The annual precipitation is 27 to 30 inches, snowfall 40 inches in the south to 65 inches in the north.

Underground water supplies are of adequate quantity and generally satisfactory quality, except as to hardness, which ranges from 195 to 530 parts per million. Studies of the underground water resources are being made.

A number of towns have underground water supplies from glacial drift. Alpena (population 12,166) and Hillman (population 289) take their water from Thunder Bay, which is subject to pollution. Three small towns get water from the Au Sable River.

Recommended Plan

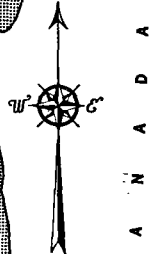
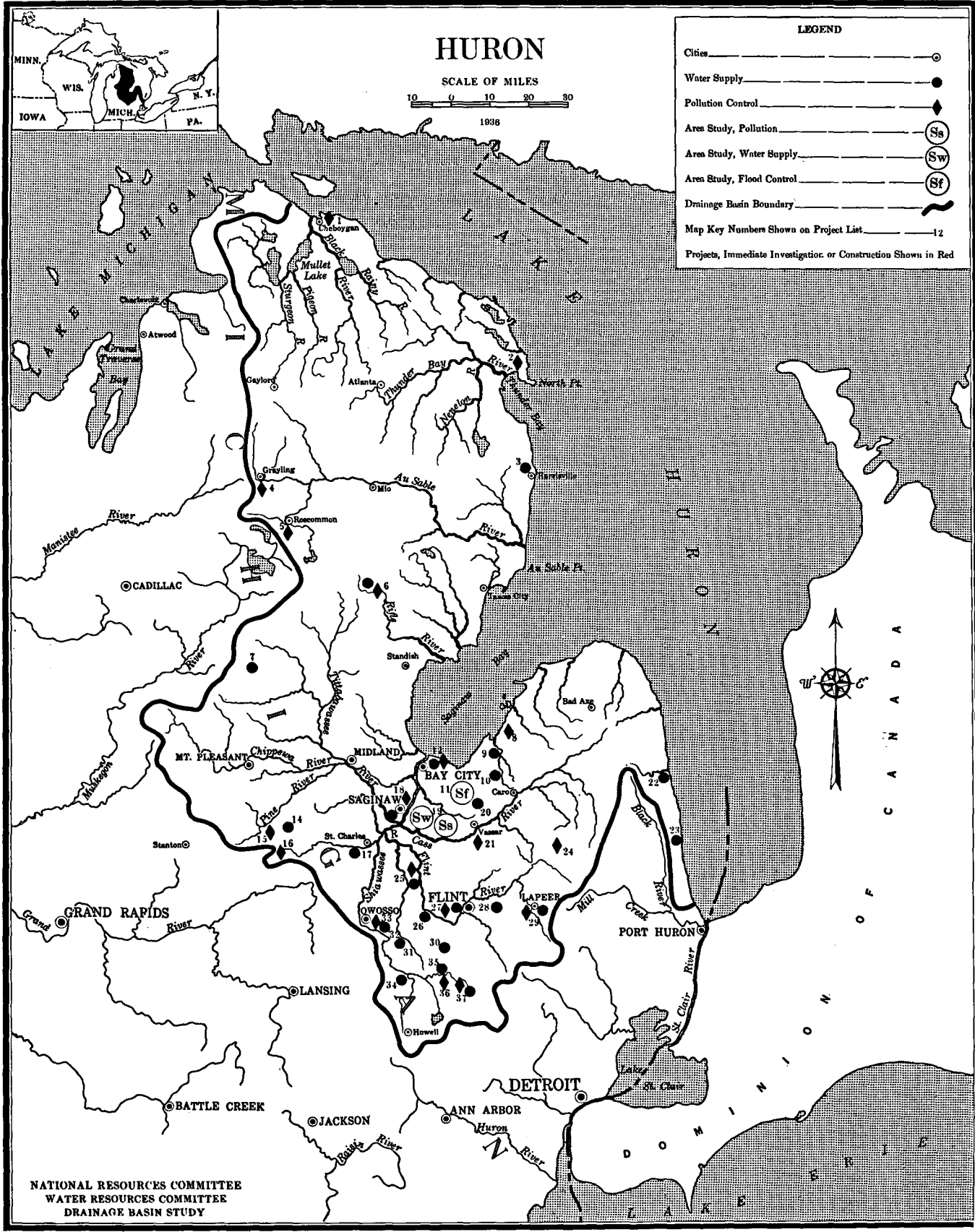
Water supply treatment, for hardness, is needed at Flint. New sources of supply or treatment are needed at St. Charles, Davison, and Bay City.

Industrial waste control or a new source of water supply should be provided at Saginaw, and investigation is recommended to determine the best procedure. Smaller projects for new water supply or treatment will be wanted in the future at some 20 other towns.

Michigan is active in preventing *stream pollution*. The Saginaw River Basin is noteworthy because of the comparatively extensive treatment of the sewage discharged into surface waters. With an average density of population of 56 per square mile, 42 percent of the sewage is given primary treatment and 2 percent secondary treatment.

Eighteen municipal sewage treatment plants are proposed for this basin. Establishment of legislative and administrative machinery is essential to permit proper regulation and disposal of chemical-plant, beet-sugar-plant, and oil-field wastes. The Saginaw Valley Commission is now making an extensive engineering investigation.

Flood control studies are needed to determine the possibilities of flood remedial works in the built-up basins of the Saginaw and Sebawaing Rivers.



Huron Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
11	Saginaw and Sebewaing Rivers: Flood-control studies.....	\$45,000	To determine the imminence of flood hazards and best method and cost of abatement, with special reference to Saginaw, Bay City, Sebewaing River, and Sebewaing Village.
19	Saginaw, Mich.: Study of water-supply and industrial-waste control or a new source of water supply..	10,000	Preliminary studies have been undertaken.
27	Flint, Mich.: Water-softening plant.....	500,000	Plans being prepared.
12	Bay City, Mich.: Water supply or treatment.....	73,000	Plans completed.
28	Davison, Mich.: Water supply or treatment.....	50,000	Do.
17	St. Charles, Mich.: Water supply or treatment.....	25,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
27	Flint, Mich.: New sewage-treatment plant enlargement.....	\$285,000	Plans not available.
2	Alpens, Mich.: Sewage-treatment plant.....	80,000	Preliminary estimate.
18	Saginaw, Mich.: Interceptors and sewage-treatment plant.....	2,000,000	Plans not available.
12	Bay City, Mich.: Sewage-treatment plant.....	850,000	Plans not available.
(1)	Grayling (4), and Roscommon (5), Mich.: Sewage-treatment plant§.....	64,000	Roscommon: Preliminary plans complete. Grayling: Plans not available.
(1)	Sebewaing (8), and West Branch (6), Mich.: Sewage-treatment plants.....	80,000	Plans not available.
(1)	Corunna (33), Fenton (36), Holly (37), Ithaca (16), Lapeer (29), Marlette (24), Montrose (25), St. Louis (15), and Vassar (21), Mich.: Sewage-treatment plants.	285,000	Plans completed for St. Louis. Preliminary plans completed for Vassar and Corunna. Plans not available for Fenton, Ithaca, Holly, Marlette, and Montrose.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Cheboygan (1), Mich.: Sewage-treatment plant.....	\$100,000	
(1)	Breckenridge (14), Byron (34), Durand (31), Flushing (26), Grand Blanc (30), Harrison (7), Holly (37), Lapeer (29), Linden (35), Montrose (25), Saginaw (18), and Vernon (32), Mich.: New water supplies or treatment plants.	486,000	
(1)	Akron (10), Fair Grove (20), Harrisville (13), Lexington (23) Midland (13), Port Sanilac (22), Unionville (9), and West Branch (6), Mich.: Water supplies.	315,000	

† Map key number shown following community name.

4. ERIE

Adequate and safe water supply is of immediate importance among the needs of the Lake Erie Basin. The problem of adequate water supply in this densely populated area involves the proper control of domestic sewage and industrial waste to avoid contaminating the sources. Of somewhat lesser immediate importance, but nevertheless of great social and economic value, is the abatement of pollution in streams and lakes. Problems and works relating to navigation rank high in economic importance; Lake Erie carries the heaviest traffic of all the Great Lakes.

General Description

The Lake Erie drainage basin includes parts of five States—New York, Pennsylvania, Ohio, Indiana, and Michigan. Most of the area is in Ohio. The principal river basins are the Maumee, Clinton, Rouge, Raisin, Huron, Cuyahoga, Sandusky, Grand, Buffalo, and Tonawanda. Their general natural features are much alike. The streams, with the exception of the Maumee, are mostly small and their courses irregular. The elevation above the lake level is, in general, not over 20 to 40 feet. The average annual temperature ranges from 44° to 50°, and the average annual rainfall is about 35 inches.

The nature of its soil, topography, and rainfall have helped to make the Lake Erie Basin a rich agricultural area. Manufacturing industries, nevertheless, outrank agriculture in importance.

The proportion of improved farm lands ranges from about 24 percent in the Grand River Basin to more than 60 percent in the vicinity of Detroit, the general average being about 48 percent. Pasture lands cover from 18 to 25 percent; timberlands only 10 to 15 percent. There are many small lakes available for recreation purposes in the Michigan section. The shores of Lake Erie and the adjacent woodlands are also a valuable recreational asset.

All of the larger cities in the basin except Toledo now use lake water for municipal supplies. Almost all of the other cities and villages use underground water sources. The underground water supply is adequate but usually needs treatment for softening and removing iron. The surface water supply usually requires treatment to free it from pollution.

The basin has a population of about 6,000,000 people. The area is predominantly urban, including such large cities as Detroit, Cleveland, Buffalo, Toledo, Akron, and many important smaller communities. More than

65 percent of the total population live in towns of 2,500 and over.

The cities of Detroit, Toledo, Cleveland, and Buffalo, all in this basin, are among the principal ports for the huge water traffic on the Great Lakes.

Recommended Plan

Municipal water supplies call for a number of important projects for additional or improved facilities in this basin. The water supply at Toledo, Ohio, now taken from the Maumee River, is not satisfactory or adequate. The city should have a supply from Lake Erie, which involves the construction of extensive intake works. Cleveland, Ohio, needs an extension to its Lake Erie intake works at Nottingham to supplement the present water supply. Lakewood, Ohio, should have additional waterworks. Akron, Ohio, has ready a project for construction of a reservoir for additional industrial supply; water from this source will be used without treatment for industrial purposes only. Adrian, Ann Arbor, and Pontiac, Mich., and numerous smaller towns also have projects for additional water supply or treatment.

Pollution problems, closely allied with those of water supply, make desirable a number of projects of almost equal urgency to remove contamination affecting or threatening to affect municipal water supplies. Chief of these is the project for Detroit and environs involving about \$14,000,000. Detroit and other cities in Wayne County, Mich., as well as a number of smaller towns below Detroit, derive their water from the Detroit River and also discharge their untreated sewage into it. If uncorrected, the situation may in the future involve a question of pollution of international boundary waters. Construction of two sewage-treatment plants at a cost of about \$4,000,000 should proceed at once. Some \$10,000,000 worth of intercepting sewers to the treatment plants and along the Detroit River have been carefully studied, but construction may involve some delay pending decision as to the program of work between Detroit and the outlying municipalities.

Cleveland, Ohio, has long suffered by sewage contamination of its Lake Erie intake. The city has already done considerable sanitary work to lessen this evil and has recently arranged to build an additional sewage-treatment plant at a cost of about \$600,000. Many other towns need or will soon need sewage-treatment plants to prevent objectionable or dangerous stream pollution.

Navigation improvements for the heavy traffic of the Lake Erie ports include mainly the deepening of channels and harbors to accommodate lake vessels. Projects for such work are listed for Ashtabula, Lorain, Conneaut, Fairport, and Huron, Ohio; Tonawanda and Buffalo, N. Y.; and Erie, Pa. Projects for the improvement of the Detroit and St. Clair Rivers are included under "Navigation and International Waters."

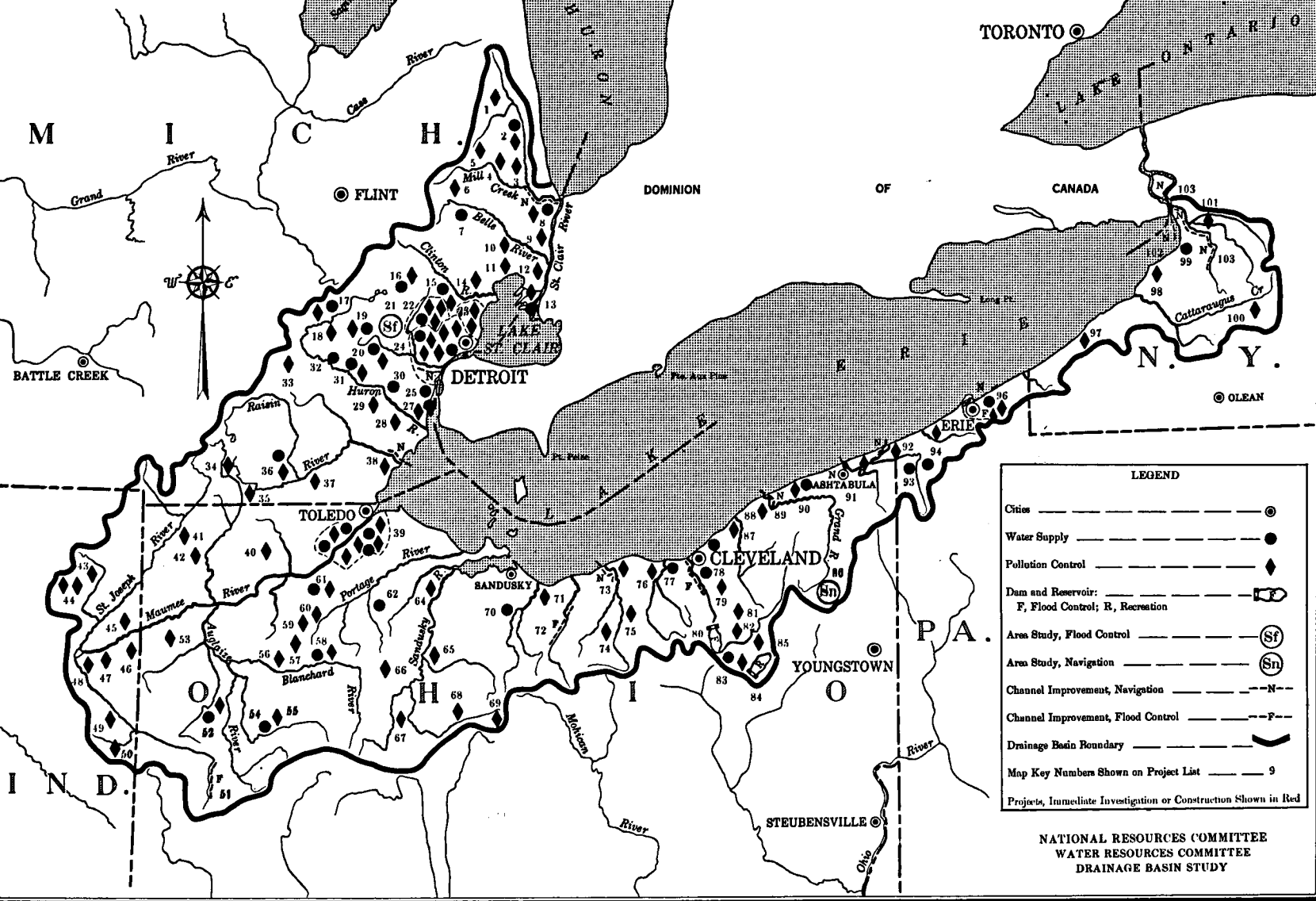
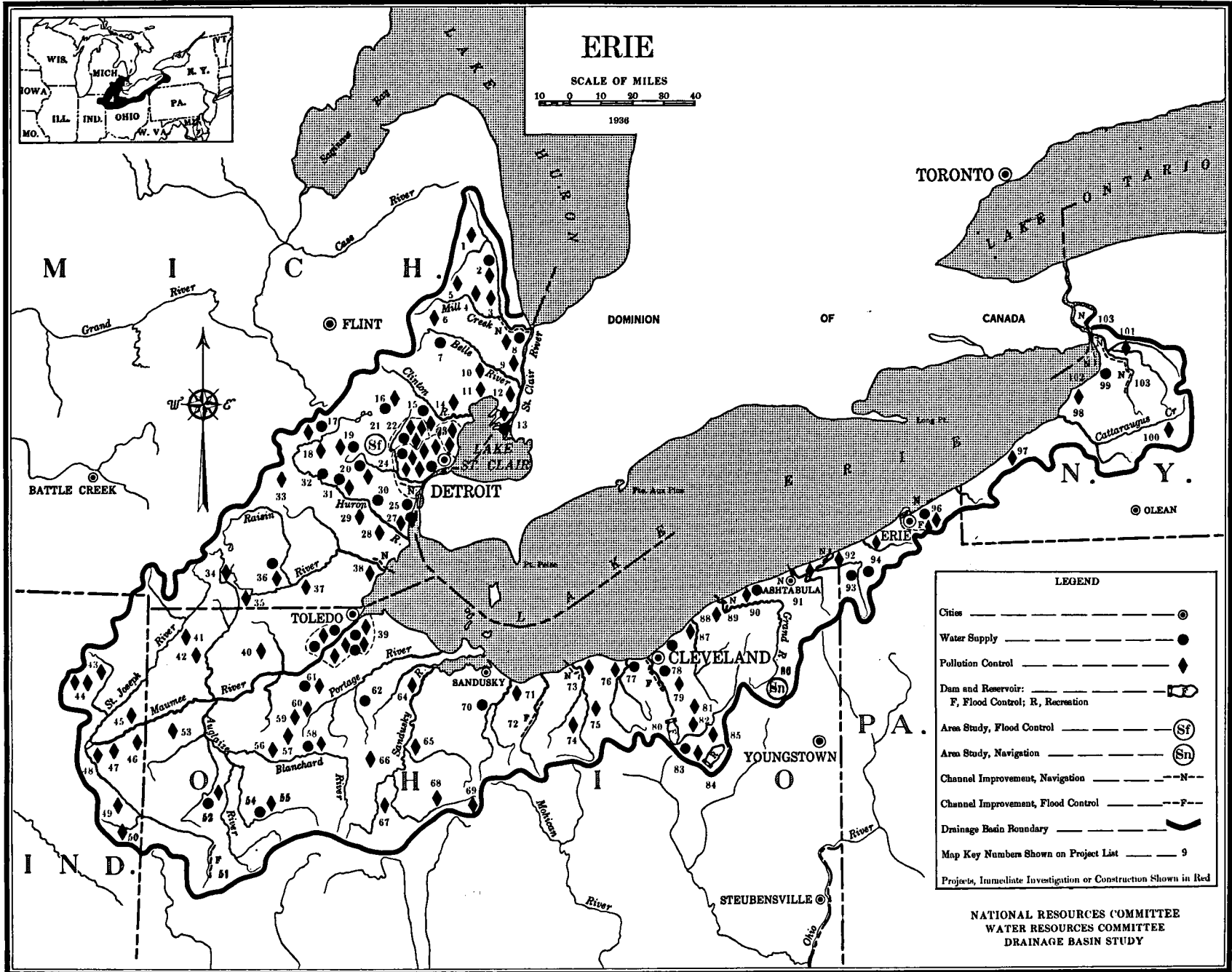
For many years studies and surveys have been made for a barge canal connecting Lake Erie with the Ohio

River. An enormous tonnage of iron ore brought to Lake Erie ports is destined for Pittsburgh and other points on the Ohio River. There is likewise a very large traffic in coal from the Ohio River and tributaries to Lake Erie points for shipment to other Great Lakes ports. Several routes for such a canal have been proposed ranging in cost from about \$86,000,000 to about \$163,000,000. The entire matter is now under review by the Corps of Engineers.

Erie Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
21	Clinton, Huron, Raisin, and Rouge Rivers, Mich.: Flood-control studies	\$5,000	
86	Lake Erie-Ohio River Canal through Youngstown, Ohio, via Mahoning and Beaver Run	50,000	A study to extend the review now being made by the Corps of Engineers to provide consideration of alternate routes.
39	Toledo Ohio: Water supply from Lake Erie	7,654,000	Plans completed.
24	Wayne County, Mich.: 2 sewage-treatment plants	4,000,000	Do.
(1)	Ann Arbor (32) and Waterford (24), Mich.: Water supplies	518,000	Do.
99	Hamburg, N. Y.: Water-supply reservoir	122,000	Plans under way.
48	Fort Wayne, Ind.: Interceptors and sewage-treatment plant	5,000,000	Plans prepared.
96	Erie, Pa.: Sanitary and storm sewers	787,000	Ready for construction.
94	Girard, Pa.: Secondary sewage-treatment plant	20,000	Do.
91	Ashtabula Harbor, Ohio: Deepening channels, and constructing breakwater, additions, etc.	360,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$508,000. Authorized by Congress.
102	Buffalo Harbor, N. Y.: Construction of breakwater and deepening channels	1,081,000	Authorized by Congress. Sum needed to complete.
77	Lakewood, Ohio: Waterworks	1,629,000	Plans completed.
83	Akron, Ohio: Reservoir for water supply	454,000	
96	Erie, Pa.: Water main to Presque Isle	50,000	Do.
93	Albion, Pa.: Water mains	10,000	Do.
62	Bradner, Ohio: Water-supply system	45,000	Do.
78	Garfield Heights, Ohio: Water-supply system	44,000	Do.
58	Findlay, Ohio: Secondary sewage-treatment plant	212,000	
79	Bedford, Ohio: Sewage-treatment plant	156,000	Plans completed.
83	Akron, Ohio: Sanitary sewers	164,000	Do.
96	Erie Harbor, Pa.: Deepening channels to 21 and 25 feet	375,000	Cost given is for first 2 years. Additional needed to complete, \$289,000. Authorized by Congress.
103	Black Rock Channel and Tonawanda Harbor, N. Y.: Deepening and widening channels	225,000	Authorized by Congress.
80	Cuyahoga River, Ohio: Dam for flood control	173,000	Approved.
80	Cuyahoga River, Ohio: Flood-control reservoir	749,000	
73	Lorain Harbor, Ohio: Deepening channels to 25 and 26 feet and widening 2 river bends	950,000	Authorized by Congress. Estimated cost is amount necessary to complete.
92	Conneaut Harbor, Ohio: Deepening harbor	1,104,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$113,000. Authorized by Congress.
24	Rouge River, Mich.: Deepening channels to 18, 21, and 25 feet	228,000	Authorized by Congress. Partly completed. Sum needed to complete.
GROUP B—FOR DEFERRED CONSTRUCTION			
38	Monroe, Mich: Harbor improvement	\$233,000	
89	Fairport Harbor, Ohio: Deepening channels, constructing bulkhead and extending breakwater	462,000	Authorized by Congress.
78	Cleveland, Ohio: Supplementary water supply	6,000,000	Plans completed.
(1)	Adrian (36), Birmingham (22), Northville (19), Plymouth (20), Pontiac (16), and Rochester (15), Mich.: Public water supply, softening and iron removal	609,000	Plans not available.
(1)	Grosse Isle (25), Highland Park (24), Rockwood (26), and Romulus (30), Mich.: Public water supply plants	470,000	Do.
70	Monroeville, Ohio: Water purification plant	30,000	Do.
24	Detroit, Mich.: Intercepting sewers to sewage treatment plant	10,000,000	Plans partly made but scope of project not yet definite.
(1)	Adrian (36), Blissfield (37), Chelsea (33), Mount Clemens (14), Royal Oak (22), Royal Oak Township (22), and Ypsilanti (31), Mich.: Sewers and sewage treatment plants	1,316,000	Plans not available.
96	Erie, Pa.: New construction, extension and repairs, sanitary and storm sewers	435,000	Plans not completed.
(1)	Angola (98), Brocton (97), and Depew (101), N. Y.: Sewage treatment plants	534,000	Plans approved.
(1)	Maumee (39) and Toledo (39), Ohio: Sewage treatment plants, construction and repairs	1,000,000	Plans not available.
49	Decatur, Ind.: Intercepting sewers and sewage treatment plant	135,000	Do.
103	Erie County, N. Y.: Channel improvements, dredging, water diversion, and storage	445,000	Do.
(1)	Deshler (59), Leipsic (57), and North Baltimore (60), Ohio: Complete sewage treatment plants	200,000	Plans not prepared.
(1)	Hudson (34) and Morenci (35), Mich.: Sewers and sewage treatment plants	210,000	Plans not available.
50	Berne, Ind.: Interceptors and sewage treatment plant	45,000	Do.
(1)	Fremont (64), Tiffin (65), and Upper Sandusky (67), Ohio: Sewage treatment plants	395,000	Do.
(1)	Geneva (90), Harbor View (39), and Lucas County (39), Ohio: Water mains, sewage treatment plants, and sewer systems	190,000	Do.
91	Ashtabula, Ohio: Primary sewage treatment with added chlorination	450,000	Do.
(1)	Auburn (43) and Garrett (44), Ind.: Interceptors and sewage treatment plants	140,000	Do.
73	Lorain, Ohio: Primary sewage treatment plant with added chlorination	700,000	Do.
74	Wellington, Ohio: Sewage treatment plant	130,000	Do.
87	Willoughby, Ohio: Primary sewage treatment plant	150,000	Do.
75	Grafton, Ohio: New sewers and complete sewage treatment plant	130,000	Do.
88	Painesville, Ohio: Complete sewage treatment plant	400,000	Do.
39	Toledo, Ohio: Water mains and sanitary sewers	185,000	Plans not completed.

¹ May key number shown following community name.



Erie Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION—Continued			
(1)	Bryan (42), Bluffton (55), Ottawa (56), Paulding (53), and Wauseon (40), Ohio: Complete sewage treatment plants.	\$288,000	Plans not completed.
71	Huron, Ohio: Interceptors and primary sewage treatment plant.	50,000	Plans not available.
(1)	Bucyrus (68), Carey (66), and Crestline (69), Ohio: Sewers and/or sewage treatment plants.	474,000	Do.
(1)	Cuyahoga Falls (82), Hudson (81), Kent (85), and Rocky River, (76), Ohio: Interceptors, Cuyahoga Falls to Akron; improvement of existing plants and sewage treatment plants for first-mentioned four cities.	855,000	Plans not fully developed.
51	St. Marys River, Ohio: Clearing channel for flood control.	192,000	Plans not available.
92	Conneaut, Ohio: Primary sewage treatment plant with chlorination.	220,000	Do.
(1)	New Baltimore (11), Richmond (10), Sandusky (1), St. Clair (23), St. Clair Shores (23), and Yale (4), Mich.: Sewers and sewage treatment plants.	208,000	Do.
(1)	Algona (13), Applegate (2), Brown City (5), Capac (6), Croswell (3), Mich.: Sewers and sewage treatment plants.	112,000	Do.
(1)	Lochmoor (24), Marine City (12), Marysville (9), and Port Huron (8), Mich.: Sewer systems and sewage treatment plants.	830,000	Do.
(1)	Brighton (17), Carleton (28), Monroe (38), Rockwood (27), and South Lyon (18), Mich.: Sewers and sewage treatment plants.	233,000	Do.
(1)	Birmingham (22), Melvindale (24), Northville (19), Pontiac (16), Plymouth (20), Rochester (15), and Wayne (29), Mich.: Sewage treatment plants, intercepting sewers, construction and improvement.	514,000	Do.
8	Black River, Mich.: Deepen channel to 20 feet.	112,000	Authorized by Congress.
84	Summit County, Ohio: Recreation Lake.	870,000	Plans not available.
78	Cuyahoga County, Ohio: Creek improvements.	47,000	Do.
96	Erie County, Pa.: Channel improvement.	32,000	Do.
72	Huron County, Ohio: Drainage improvement.	30,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Applegate (2), and Imlay City (7), Mich.: New water supplies.	\$15,000	Plans not available.
8	Port Huron, Mich.: Water filtration plant.	350,000	Do.
(1)	Algona (13), and Ypsilanti (31), Mich.: Waterworks systems or improvements.	135,000	Do.
(1)	Brighton, Mich.: Water supply and sewers.	100,000	Do.
(1)	Bowling Green (61), Delphus (52), Montpelier (41), and Perrysburg (39), Ohio: Sewage treatment plants.	725,000	Do.
(1)	Bowling Green (61), Delphos (52), Findlay (58), and Lima (54), Ohio: New water supply and softening plants.	740,000	Do.
(1)	Avilla (44), Harlan (45), Monroeville (46), and New Haven (47), Ind.: Sewer systems and sewage treatment plants.	85,000	Do.
96	Erie, Pa.: Sanitary and storm sewers.	443,000	Do.
94	Cranesville, Pa.: Waterworks system.	40,000	Do.
100	Arcade, N. Y.: Sewage treatment plant.	175,000	Plans not prepared.

¹ Map key number shown following community name.

5. ONTARIO

The plan for immediate development of the Lake Ontario Basin includes the improvement of existing navigation facilities of the New York State Barge Canal and of the ports on the lake, works for the regulation of the flow of certain streams for water power and the reduction of flood stages, new or improved public water supplies, and the provision of sewage treatment in several places to abate nuisances or danger to public health.

General Description

The Ontario Basin extends from the head of Niagara River to the outlet of Lake Ontario. There is a strip of nearly level land along the lake; usually narrow, rising to a much broader, rolling tableland which in turn rises to hills as high as 2,500 feet in the Adirondack highlands at the eastern corner of the region. The total area is about 10,700 square miles.

The population of the Lake Ontario Basin is about 1,310,000 mostly urban and industrial. Rochester and Syracuse are the leading centers. The cities and towns have grown rapidly but the farm population has remained practically stationary during the past 30 years. More than two-thirds of the land area is devoted to agriculture, chiefly dairying, truck farming, and fruit growing.

Water supplies are abundant in quantity and excellent in quality. Scenic and recreational values are of major importance, particularly in the Adirondack highlands, the Finger Lakes region, on the shores of Lake Ontario, and along the Niagara River.

The annual range of temperature is from 100° above to 58° below zero, the extreme low temperatures occurring in the Adirondack highlands. Precipitation ranges from 58 inches in some portions of the Adirondack Plateau section to 30 inches in the lowlands along Lake Ontario.

One of the outstanding features of this region is the group of long, narrow lakes known as the Finger Lakes. They are spread fanwise across the basin from the vicinity of Syracuse to a point almost directly south of Rochester, their northern ends converging toward Lake Ontario. The recreational facilities provided by these many square miles of water have been much exploited. The waters are soft, of excellent quality, and widely used for public water supplies.

The principal streams of the basin are the Oswego, Genesee, and Black Rivers. There are many smaller streams emptying into Lake Ontario.

The Oswego River drains about 5,100 square miles in the middle of the area, including most of the Finger Lake region. To the south the Oswego Basin is hilly, with a series of north-and-south ridges and intervening valleys of glacial origin which have formed the setting for the Finger Lakes. The northern portion is generally level, except in the narrow valley of the Oswego River, and contains large areas of swampy land. In spite of storage in numerous lakes, swamps, and artificial reservoirs, the area is subject to destructive floods. Many of the swamp lands have been drained, but other large areas can be reclaimed if future conditions warrant. Preserving or increasing these swamp areas as wildlife refuges is widely advocated.

The Genesee River rises in the hills of northern Pennsylvania and flows almost due north across New York to empty into Lake Ontario. The area of its basin is about 2,460 square miles. The upper reaches lie in wooded highlands, the lower in an area of rolling farm lands. The river flow is highly variable, ranging from a maximum flood in 1865 of 54,000 cubic feet per second to less than 100 cubic feet per second in dry periods.

The Black River drains an area of about 1,900 square miles on the westerly slope of the Adirondack Plateau. The upper reaches of the basin consist of a mountainous, densely wooded highland with an average altitude of about 1,700 feet and a few peaks exceeding 2,500 feet in height. The original heavy growth of timber has been cut off, but about half the area is still wooded. About one-fourth is in farm and pasture lands, mainly in the valley floor. Floods in spring and droughts in summer are often severe. Extremes of stream flow have been recorded of 49,000 and 600 cubic feet per second. The upper basin includes a portion of the Adirondack State Park, with many lakes and small streams. There are 16 hydroelectric plants in operation and 38 mills and factories operated by water power. The existing turbine installation is 133,000 kilowatts, of which 86,000 kilowatts is used in the production of electric energy.

The Niagara River and Niagara Falls, bordering the western extremity of the Ontario Basin, are of major scenic and economic importance. The hydroelectric development in the United States at Niagara Falls has an installed capacity of 424,000 kilowatts. This development is subject to treaty regulation, being on international waters. A fuller discussion of the river and falls, together with projects affecting them, is given under "Navigation and International Waters."

The New York State Barge Canal runs from Tonawanda and the Tonawanda River at the western edge of the State eastward through the Clyde, Seneca, and Oswego Rivers into Oneida Lake, southward through Oneida Lake, thence through Rome to the canalized Mohawk and the Hudson River. The canal system connects with Lake Ontario at Oswego by means of the canalized Oswego River and with Cayuga and Seneca Lakes by means of the Seneca River Channel.

All of the principal streams of the Ontario Basin are subject to extremes in flow. Heavy rains and melting snow bring rapid rises and serious floods. The control of this condition demands consideration and, in some localities, prompt action. Record floods in upper central New York in July 1935 produced great damage and some loss of life.

Recommended Plan

Navigation improvement by the deepening of the New York State Barge Canal from Oswego through Oneida Lake to Rome and Albany on the Hudson River is under way. Other navigation projects include the improvement of Owasco Lake outlet, and Great Sodus Bay Harbors.

Flood control is an immediate and general need throughout the region; floods are responsible for many of the recommended projects.

Channel improvement is needed in the Genesee River at Rochester to provide a channel with a flood-carrying capacity of 90,000 cubic feet per second. Floods in Onondaga Creek, which flows through the middle of Syracuse, have caused great damage and occasional loss of life. Plans for protective measures are under study by the Corps of Engineers. The Panther Mountain Reservoir on the south branch of Moose River, the largest and most important of such projects in the Black River Basin, will have a capacity of 276,000 acre-feet. All necessary preliminary work has been completed, including a topographic survey, underground exploration by test pits, wash borings, and diamond drillings, and detailed cost estimates. The total cost is placed at \$4,000,000 or \$14.50 per acre-foot. Construction is recommended as soon as financing can be arranged.

Seneca, Cayuga, and other lakes are natural storage reservoirs whose safe available capacity has not been fully utilized. Outlet control works are being investigated.

The Hawkinsville Reservoir in Oneida County, recommended for deferred construction, will create a reservoir with a capacity of 126,000 acre-feet. Two dams will be required, a main regulating dam of earth

across the Black River and a spillway dam of reinforced concrete. Topographic surveys and preliminary estimates which place the cost at about \$3,000,000 have been prepared.

Construction of a low submerged weir about 100 feet long in the Middle Branch of Moose River between Thendara and Old Forge, at a point about 1 mile below the Old Forge Dam, and a lock in the dam to permit the passage of boats between Lake Thendara and the Fulton Chain Lakes, are listed also for deferred construction.

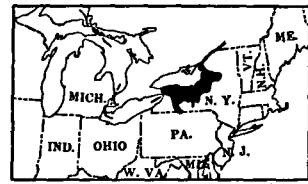
Projects of indeterminate construction date include the Sperryville Reservoir project on the Independence River, and the Lake Moulin project providing for a reservoir for flood control and recreation on the North Branch of the Moose River.

Hydroelectric power can be developed in connection with flood control, particularly in the Black River Basin. Full consideration should be given to this possibility in the construction of flood-control reservoirs. Regulation of streams will increase the extreme low flows of water in summer which, as in the Black River, seriously hamper the operation of industries dependent upon water power.

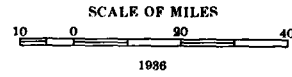
Water supplies are generally abundant in quantity and high in quality except in the area west of the Genesee. Filtration and other types of purification plants are needed in some places, especially west of the Genesee. Projects are listed to care for the principal needs. Two projects have been investigated for water supply for the city of Rochester. Both of these provide reservoirs at Honeoye Lake. One proposal, costing about \$12,000,000, would provide a storage capacity of 262,000 acre-feet, of which about one-third would be reserved for flood control and the remainder used for water supply. The other proposal, recommended herein for deferred construction, is for water supply alone and contemplates a reservoir of 70,000 acre-feet capacity at an estimated cost of \$4,500,000.

Pollution of lakes and streams by domestic sewage and industrial wastes is a serious problem in some areas, notably in certain lakes of the Oswego Basin. Treatment plants should be constructed to abate pollution where it has become a menace. Priority is given to places where domestic water supply is threatened.

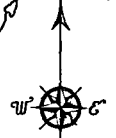
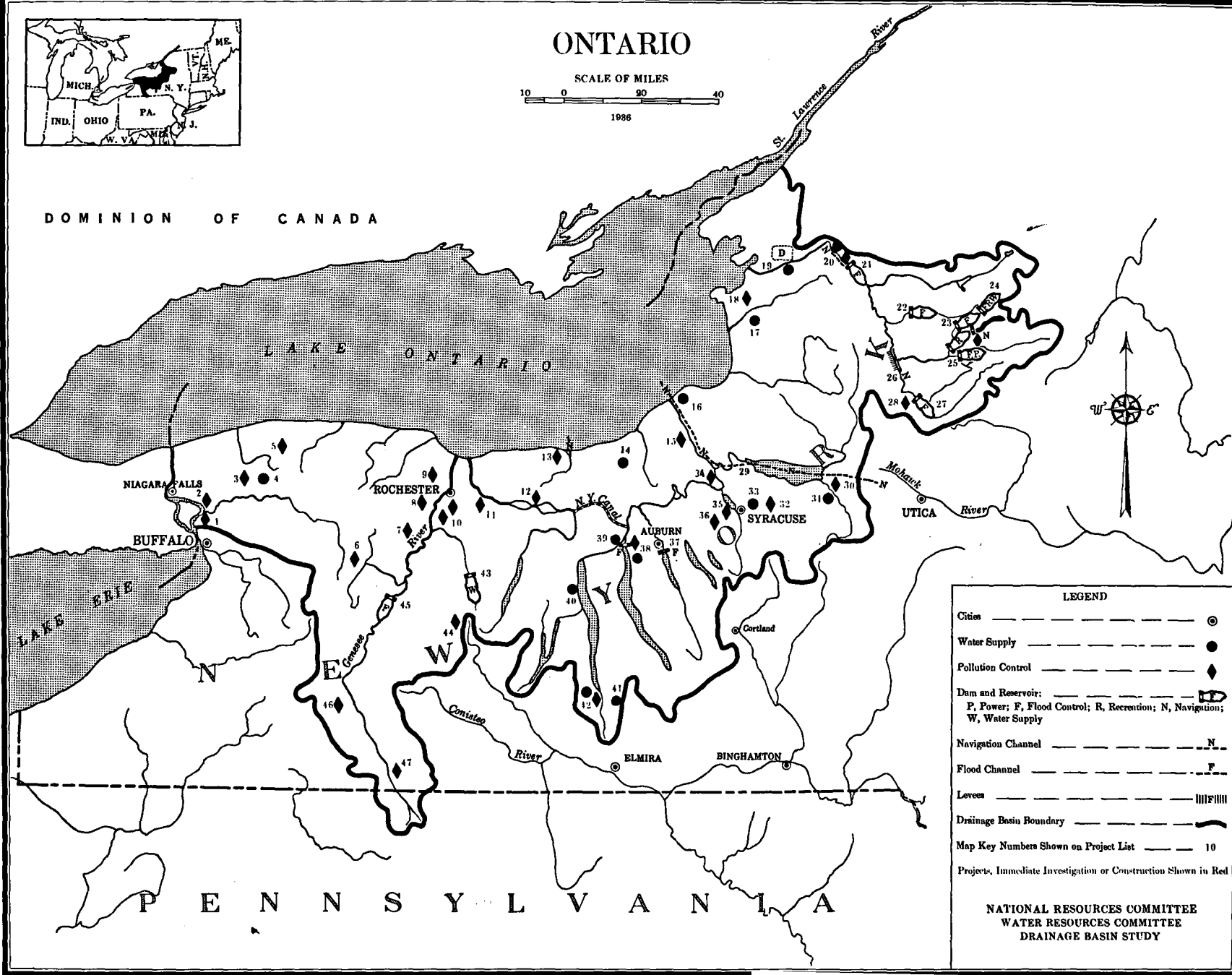
Recreation projects include the Lake Thendara Reservoir on the Moose River and the Lake Nelson project to increase the area of Lake Nelson at the junction of the middle and south branches of the Moose River. Scenic and recreational values should be given careful consideration in connection with all projects to utilize the water resources of this area.



ONTARIO



DOMINION OF CANADA



LEGEND

Cities ———— ⊙

Water Supply ———— ●

Pollution Control ———— ◆

Dam and Reservoir: ———— D

P, Power; F, Flood Control; R, Recreation; N, Navigation; W, Water Supply

Navigation Channel ———— N

Flood Channel ———— F

Levees ———— |||||

Drainage Basin Boundary ————

Map Key Numbers Shown on Project List ———— 10

Projects, Immediate Investigation or Construction Shown in Red

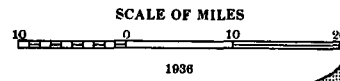
**NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY**

Ontario Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
20	Deferiet, N. Y.: New water supply.....	\$42,000	Present supply bad.
40	Dresden, N. Y.: New water supply system.....	54,000	
17	Madison Barracks, N. Y.: Water supply.....	85,000	Plans completed.
41	Odessa, N. Y.: New water supply system.....	70,000	Plans not approved.
34	Baldwinsville, N. Y.: Sewage treatment plant.....	215,000	Plans completed.
28	Boonville, N. Y.: Sewage treatment plant.....	87,000	Do.
12	Palmyra, N. Y.: Sewage treatment plant and sewer system.....	194,000	Do.
47	Wellsville, N. Y.: Sewage treatment plant.....	350,000	Authorized by village.
39	Seneca Falls, N. Y.: Relocating water intake.....	100,000	Improvement of water supply.
38	Union Springs, N. Y.: Water supply and sewer system.....	150,000	Plans completed.
29	New York Barge Canal: Deepening of Oswego-Rome-Albany section to 14 feet.....		Work now under way. See Hudson River Basin, North Atlantic District.
GROUP B—FOR DEFERRED CONSTRUCTION			
25	Black River, Panther Mountain, N. Y.: Reservoir for stream regulation and power.....	\$4,000,000	Plans completed.
45	Genesee River, N. Y.: Mount Morris Reservoir stream flow regulation.....	6,500,000	
(1)	Black River, N. Y.: Removal of bars in river at Lyons Falls (26), and Carthage (21), and construction of embankments.....	75,000	
21	Carthage, N. Y.: Dam in Black River.....	75,000	
37	Owasco Lake, N. Y.: Outlet channel and control works.....	100,000	Do.
38	Seneca River, N. Y.: Regulating outlet of Seneca River, at Cayuga Lake.....	10,000	
13	Great Sodus Bay Harbor, N. Y.: Increase depth in lake approach to 20 feet.....	148,000	Sum needed to complete.
25	Lake Thendara, N. Y.: Recreation project.....	300,000	Plans completed.
43	Rochester, N. Y.: Honeoye Lake Reservoir for water supply.....	4,500,000	
4	Gasport, N. Y.: Water supply system.....	96,000	Plans made.
31	Oneida, N. Y.: Filtration plant.....	125,000	
14	Port Byron, N. Y.: Water supply system.....	100,000	
10	Caledonia, N. Y.: Sewage treatment plant.....	120,000	
36	Camillus, N. Y.: Sewage treatment plant.....	60,000	
44	Dansville, N. Y.: Sewage treatment plant.....	150,000	Plans approved.
10	Geneseo, N. Y.: Sewage treatment plant.....	95,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Cazenovia (32), Fulton (15), and Solvay (35), N. Y.: Sewage treatment plants.....	\$447,000	Preliminary studies made or plans prepared.
27	Hawkinsville, N. Y.: Dam across Black River for flood control and stream regulation.....	3,000,000	Preliminary studies made.
25	Old Forge, N. Y.: Lock in Old Forge Dam and weir in Moose River to improve navigation.....	25,000	Preliminary plans made.
19	Jefferson County, N. Y.: Drainage of flood water from farm lands in Black River Flats 12 miles above Watertown.....	300,000	Preliminary studies made.
33	Syracuse, N. Y.: New intake and conduit for water supply.....	240,000	Plans prepared.
1	Tonawanda, N. Y.: Sewage treatment plant.....	600,000	Preliminary studies made.
2	North Tonawanda, N. Y.: Sewage treatment plant.....	800,000	Do.
3	Lockport, N. Y.: Sewers and sewage treatment plants.....	465,000	
11	Pittsford, N. Y.: Sewers and sewage treatment plant.....	271,000	Plans approved.
8	Leroy, N. Y.: Sewer system and sewage treatment plant.....	268,000	
21	Carthage, N. Y.: Sewage treatment plant.....	225,000	
5	Medina, N. Y.: Sewer system and sewage treatment plant.....	180,000	
(1)	Churchville (9), Friendship (46), Old Forge (25), Perry (7), Sherrill (30), Warsaw (6), and Watkins Glen (42), N. Y.: Sewage treatment plants.....	417,000	
(1)	Adams (18) and Sodus (13), N. Y.: Sewer system and sewage treatment plants.....	177,000	
42	Watkins Glen, N. Y.: New water filtration plant.....	20,000	
16	Oswego, N. Y.: Water filtration plant.....	135,000	
19	Black River, N. Y.: Inlet for water supply.....	60,000	
22	Sperryville, N. Y.: Dam for flood control and flow regulation of Independence River.....	1,000,000	Preliminary studies made.
23	Lewis County, N. Y.: Dam and reservoir for flood control and recreation at Lake Moulin at Indian Rapids on North branch of Moose River.....	280,000	Do.
24	Lewis County, N. Y.: Dam at outlet of Lake Nelson on Moose River, for recreation.....	175,000	Do.

¹ Map key number shown following community name.

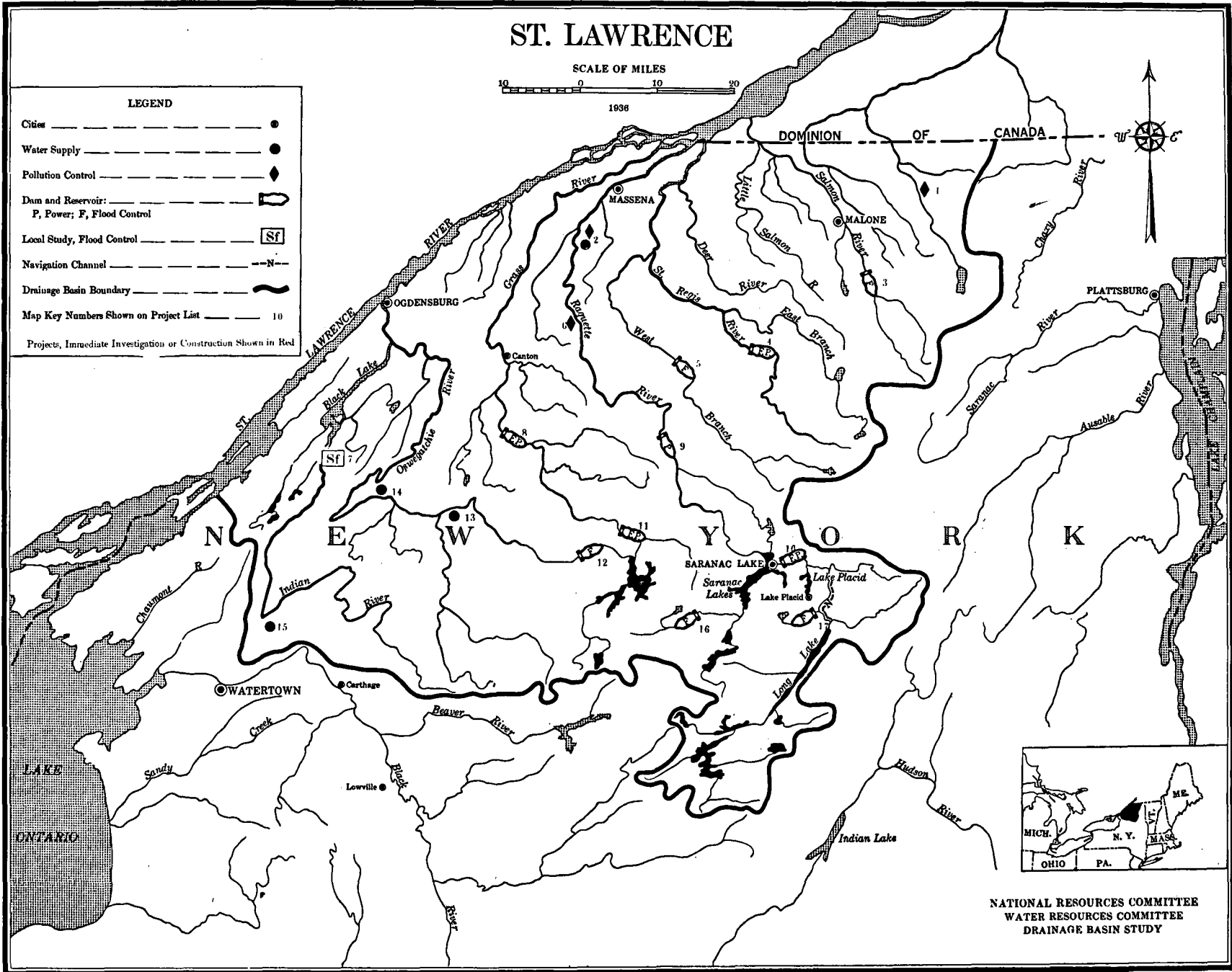
ST. LAWRENCE



LEGEND

- Cities
- Water Supply
- Pollution Control
- Dam and Reservoir:
 - P, Power; F, Flood Control
- Local Study, Flood Control
- Navigation Channel
- Drainage Basin Boundary
- Map Key Numbers Shown on Project List

Projects, Immediate Investigation or Construction Shown in Red



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

6. ST. LAWRENCE

Stream-flow regulation is the outstanding water problem in this rather sparsely settled basin, for the control of floods and the improvement of power production.

General Description

The St. Lawrence tributary basin in northern New York is an area of about 5,400 square miles, drained by many streams running northeastwardly into the St. Lawrence River. Chief among these tributaries are the Oswegatchie, Grass, Raquette, St. Regis, Salmon, and Chateaugay Rivers, some of which rise in the Adirondack highlands at altitudes of 2,000 to 3,000 feet. The topography is rugged or mountainous and wooded with second-growth timber. There are many lakes in the headwaters, surrounded by wooded growth, important as recreational centers and as refuges for wildlife.

The mean annual temperature is about 40°. Extreme temperatures of 60° below zero and 100° above have been registered. The average annual precipitation ranges from 32 inches at Ogdensburg on the St. Lawrence River to as much as 50 inches in the Adirondacks.

The basin is sparsely settled. Ogdensburg has a population of about 17,000, Gouverneur about 4,000, and Massena about 11,000. The population has remained nearly stationary since the beginning of the century. The development of the St. Lawrence for ocean navigation may provide an industrial stimulus and an outlet for the mineral and agricultural products of the region. Ogdensburg is a manufacturing city and a distributing point for the adjacent territory. Gouverneur is the center of the talc industry in New York. Edwards is in the midst of a zinc-mining region. Paper mills are situated at Ogdensburg, Gouverneur, Newton Falls, and Harrisville. St. Lawrence County ranks high in dairy production.

Commercial navigation from the Great Lakes now extends to Ogdensburg. Regular passenger excursion boats traverse the rapids of the St. Lawrence to Montreal. All of the through commercial traffic between

the Great Lakes and Montreal now passes through the existing 14-foot canals of Canada. At Massena, near the St. Lawrence River, the channel of the Grass River has been deepened and enlarged for a distance of about 8 miles to permit the delivery of aluminum ore by ocean-going vessels to the large hydroelectric aluminum plant at this point.

There is an abundance of water for domestic and industrial use in this basin, and the quality of both surface and underground water is generally good. Stream pollution and the need for sewage treatment have not yet become acute. A considerable amount of water power has been developed and there is much more potentially available. Local flood problems may be coupled advantageously with stream-flow regulation for power production on some of the rivers.

Recommended Plan

An investigation is recommended to outline a program of construction to regulate the flow of the several streams for protection from floods and for additional or improved power production. In general, the economic aspects rather than the engineering aspects of the various proposed projects require study. Among the projects so far promulgated are the Titusville Reservoir on Salmon River to provide 92,000 acre-feet of storage and 12,000 kilowatts of power, eliminating flood hazards at Malone and other points; the Bog River reservoir above Big Tupper Lake on the Raquette River; the Stark and Oxbow Reservoirs, also on the Raquette; the Newton Falls and Harrisville Reservoirs on the Oswegatchie River; the McAleese and Clare Reservoirs for flood control on the Grass River; the Five Mile Reservoir on the West Branch, and the St. Regis Falls Reservoirs on the East Branch of the St. Regis River. Most of these projects would definitely improve the output from present or potential power installations below them, as well as remove or reduce the danger of floods.

The large and growing value of the rivers, lakes, and woods of the region suggests the importance of conserving these natural assets in connection with plans for future exploitation for other purposes.

St. Lawrence Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
7	Indian River branch of the Oswegatchie River, N. Y.: Stream regulation study.....	\$25,000	
15	Evans Mills, N. Y.: New well and water supply system.....	60,000	
2	Norfolk, N. Y.: Water supply and sewer system.....	119,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
12	Newton Falls, N. Y.: Flood control reservoir.....	\$870,000	
3	Titusville Reservoir, Salmon River, N. Y.: Flood relief and low water control.....	918,000	
14	Gouverneur, N. Y.: New water supply.....	114,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
16	Bog River, N. Y.: Dam and reservoir for stream control.....	\$218,000	
9	Starke, Raquette River Basin, N. Y.: Dam and reservoir for power.....	1,000,000	
17	Long Lake, N. Y.: Excavation of floodway and navigation channel, and restoration of old dam, at head of Raquette Falls.	112,000	
13	Edwards, N. Y.: New water supply.....	40,000	
11	Deerlick Rapids, Grass River Basin, N. Y.: McAleese Dam and Reservoir for flood control and power.....	1,000,000	
8	Russell, N. Y.: Clare dams and reservoir, on Grass River for flood control and power.....	1,000,000	
6	Potsdam, N. Y.: Sewage treatment plant.....	100,000	
5	West branch of St. Regis River, N. Y.: Five Mile Dam and reservoir for stream regulation and flood control.	1,200,000	
4	St. Regis Falls, N. Y.: Dam and reservoir on St. Regis River for flood control and power.....	1,490,000	
1	Chateaugay, N. Y.: Sewage treatment plant.....	40,000	
10	Oxbow, N. Y.: Dam and reservoir for flood control, power, and recreation.....	3,425,000	

7. LAKE CHAMPLAIN

The principal problems in connection with the water resources of the Champlain Lake Basin relate to the regulation of stream flow for flood protection and for improved utilization of existing and potential water-powers and the abatement of pollution in lakes and streams where it has become a serious menace to health in several of the more populous districts. Conservation of the important recreation values on the shores of Lake Champlain and tributary waters should be given attention.

General Description

Lake Champlain, the dominant feature of the basin, lies at the bottom of the broad valley between the Adirondack highlands in New York and the Green Mountain Range in Vermont and forms the boundary between these States for nearly 100 miles. Its total length is about 107 miles, including 5 miles in Canada; its maximum width 12 miles, and its water area about 435 square miles. The lake empties into the Richelieu River, which flows due north for about 75 miles into the St. Lawrence and drains the entire basin.

The total drainage area is about 9,000 square miles, including 1,000 square miles in Canada, 3,000 in New York, and 5,000 in Vermont. About half of Vermont is included.

Except for the rolling, sandy plains along the north border, the topography is mountainous and wooded. Altitudes range from the mean level of Lake Champlain, 95 feet, to the 4,393-foot elevation of Mount Mansfield. There are few smaller lakes in the Vermont section but several in the Adirondacks. The larger of these are Lake George, Lake Placid, and the three Saranac Lakes.

The average annual temperature ranges from about 46° in the southwestern part of the basin to 37° in the mountains. Extreme temperatures of 48° below zero and 98° above zero have been recorded. The rainfall varies from 30 inches along the lake to 45 inches or more in the mountains, the general average being about 40 inches. Snowfall ranges from 60 inches on the lake to 120 inches in the mountains. The runoff is notably high.

The principal tributary streams are the Saranac and Au Sable Rivers and the Lake George Outlet in New York, the Missisquoi, Lamoille, and Winooski Rivers and Otter Creek in Vermont.

The Saranac River drains the three Saranac Lakes which are devoted almost wholly to recreation.

In the New York portion of the basin the proportion of improved farm lands is about 10 percent in the mountain section and 70 percent in the northern lowlands, the general average being about 30 percent. In the Vermont portion about 67 percent is in pasture and farms. Dairying is the chief farm activity.

There are about 305,000 permanent inhabitants, 75,000 in New York and 230,000 in Vermont. The summer population is much larger.

Recreational facilities are of major importance in the economic life of the area. In the New York portion particularly, catering to wants of vacationists is the chief commercial activity. In the Vermont portion there is, in addition, a considerable industrial development representing much of the total industry of the State. The principal products are stone, wood, textiles, iron, steel, food, and paper. Marble, granite, slate, and talc are quarried in Vermont; limestone, granite, and abrasives in New York.

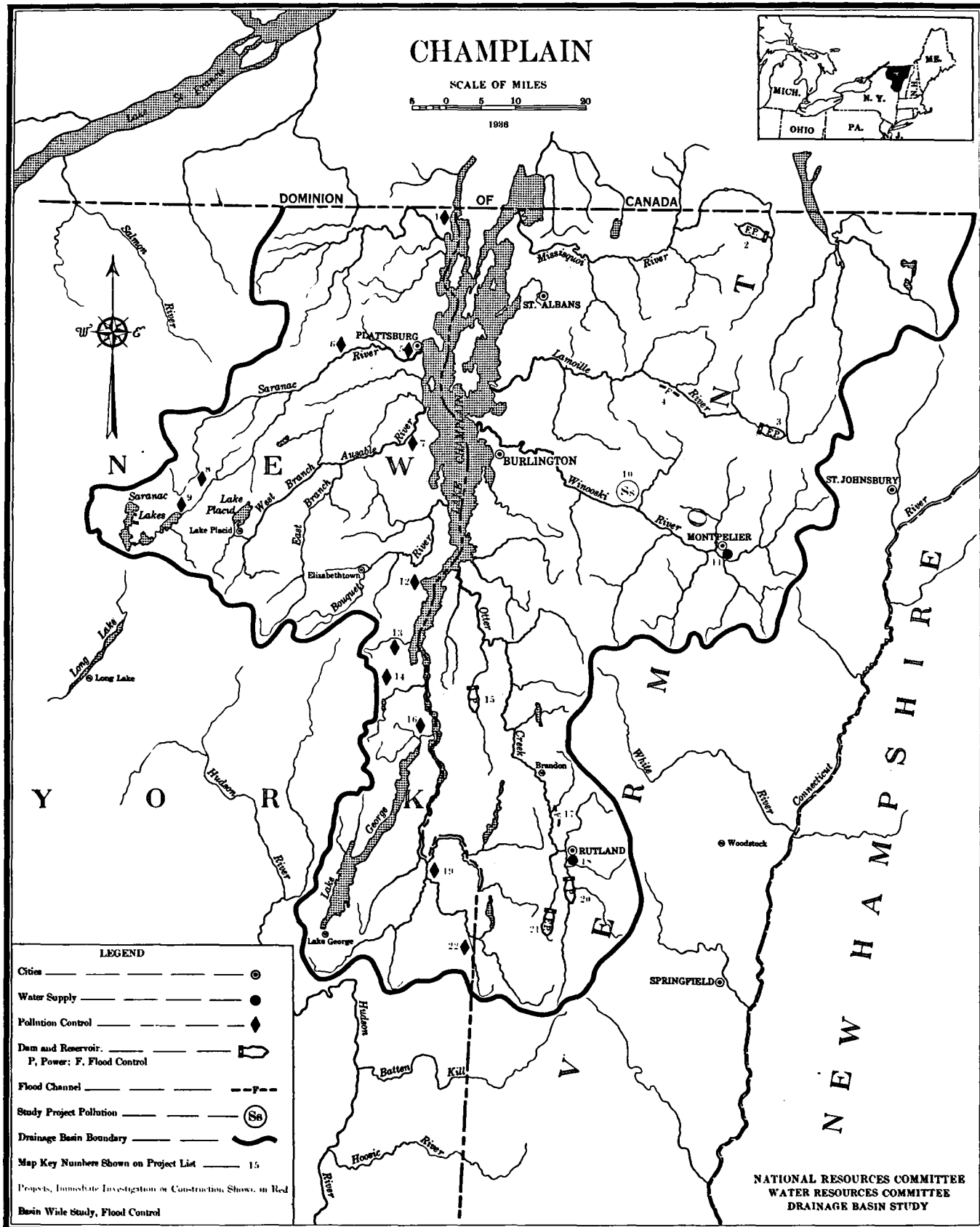
Water power developed in the basin amounts to 111,000 kilowatts, of which 84,000 kilowatts is in Vermont. All of the power streams are subject to extremes in flow and to destructive floods.

The hazard of flood damage was forcibly called to public attention in the floods of 1927 and 1936, with the rapid run-off from rainfall and melting snow. The 1927 floods caused property damage of about \$21,000,000 and cost 65 lives. At present only the Winooski Basin is provided with flood-control reservoirs.

Recommended Plan

Stream-flow regulation.—The outstanding problem of this region in both Vermont and New York entails a series of projects for flood control, power, or both, whose relative economic merits should form the subject of special investigations for the purpose of setting up definite construction programs. Pending the results of such investigations, the several proposed projects are listed as deferred or indeterminate in point of time. Some of these flood-control works involve the regulation of streams used or useful for power production. The possibilities for disposing of the additional output from new power installations or from improved performance at existing installations should be weighed in estimating the power values of the proposed construction.

Stream pollution has not yet reached a critical degree in this region of many rivers and uncongested population but should be anticipated to preserve the waters for the future.



Champlain Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	New York: Flood control investigation.....	\$15,000	
	Vermont: Flood control investigation.....	15,000	
10	Vermont: Study of stream pollution and economic usefulness of remedial measures.....	25,000	
4	Johnson, Vt. (also other points on Lamoille River): Channel improvements, bank revetment and flood gates for flood control on the Lamoille River.....	66,000	Authorized by Congress.
17	Proctor, Vt.: Channel improvement on Otter Creek.....	23,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
21	Tinmouth, Vt.: Dam and storage reservoir on Clarendon branch of Otter Creek for flood control and power.....	\$690,000	
20	East Clarendon, Vt.: Dam and reservoir on Otter Creek for power.....	895,000	
18	Rutland, Vt.: Storage reservoir on Otter Creek and pipe line for additional water supply.....	280,000	
15	Addison County, Vt.: Dam and storage reservoir on Lemon Fair River for power.....	875,000	
3	Lamoille and Caledonia Counties, Vt.: Dam and reservoir on Lamoille River at Garfield and Green River for power and flood control.....	728,000	Preliminary plans prepared.
2	Orleans County, Vt.: Dam and reservoir on Jay Branch of Missisquoi River for power and flood control.....	1,531,000	Do.
(1)	Bloomington (8), Dannemora (6), Plattsburg (5), and Saranac Lake (9), N. Y.: Sewage-treatment plants.....	210,000	
7	Keesville, N. Y.: Sewage treatment plant.....	100,000	
(1)	Granville (22), Port Henry (13), Rouses Point (1), Ticonderoga (16), Weedsville (14), Westport (12), and Whitehall (19), N. Y.: Sewage-treatment plants.....	350,000	
11	Montpelier, Vt.: Water filtration plant on Winooski River for municipal water supply.....	160,000	

¹ Map key number shown following community name.

UPPER MISSISSIPPI-RED RIVER OF THE NORTH

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1. RED RIVER OF THE NORTH

The principal water problem of the Red River Basin is the development of a dependable flow in the major streams during the dry months of the year. Stream flow, except in the spring months, depends largely on the issuance of ground water in the upper part of the basin, supplemented by occasional summer storms. Since 1922 the flow has been below the average. For considerable periods and at critical points the streams have been dry.

Large population centers are situated on the floor of the valley. Underground water is small in quantity and in various places is too highly mineralized to be satisfactory for domestic use. The concentrated population depends for its water supply on streams, the flow of which in the dry season has been inadequate for municipal needs during recent years. As a result, water from the streams has been reused so many times as to become largely sewage.

The average annual rainfall within the basin is barely sufficient to meet the needs of vegetation for water. The principal water requirement is provision for storage in lakes and reservoirs, with regulated release of water to produce sufficient dry weather flow to meet public needs. Incidentally, such provision would improve hydroelectric power production. Low water channels should be improved so as to avoid losses of water between places of storage and points of use. Present unsatisfactory ground-water supplies of small towns and rural districts should be replaced by supplies of better quality from subsurface sources or be superseded by surface water from reservoirs or ponds where practicable. Flood-flow conditions in parts of the basin require correction. Certain water areas previously available for recreation and conservation of wildlife should be restored and stabilized. Some existing drainage works should be abandoned and others should be reconstructed for efficient operation.

General Description

The Ottertail and Bois de Sioux Rivers unite to form the Red River of the North, which flows northward between North Dakota and Minnesota into Canada, where it discharges into Lake Winnipeg. The portion of the basin in the United States area tributary to the river at the international boundary contains about 35,500 square miles and lies almost entirely in Minnesota and North Dakota.

The central lowland of the Red River Basin is the bed of ancient Lake Agassiz. Westward from the edge of the old lake bed the surface rises rather

abruptly to the undulating drift-mantled watershed of the Dakota plain, which divides the Red River drainage from that of the Missouri and Souris Rivers. Eastward from the old lake bed the valley wall rises steeply to a hilly area dotted with numerous lakes and marshes.

The soils of the basin are fertile clays and loams which contain considerable humus. On the lowland the rich black clay-loam is underlain by heavy clay subsoil.

Agriculture has been the principal industry in the basin since the founding of its first settlement. During the 30 years following 1880, large-scale bonanza wheat farming developed rapidly. Since 1910, when the farming boom reached its peak, sugar beets and potatoes have become important crops, dairying and stock raising have become well established, and small farms have increased in number.

In 1930 the population was 489,000, of which number about 190,000 lived in cities, towns, and villages. The future growth of population probably will be slow, with most of the increase in the larger cities. The outlook with respect to population and land utilization suggests only a moderate increase in the aggregate water requirements for essential purposes; but an increased and reliable supply for domestic consumption and for processing industries is necessary to take care of the growth of the larger cities.

The average run-off of the whole basin is only 1.25 inches out of a rainfall of about 20 inches. Most of the run-off occurs in March, April, May, and June. The stream flow during the rest of the year is extremely low. Since 1929 the run-off for the dry 8 months has been practically negligible.

Recommended Plan

A closely coordinated plan for the basin is necessary because of the scarcity of water for essential services, especially for municipal and domestic supplies and for sewage disposal. Opportunities for storage are found mainly in the upper reaches of the streams, where artificial lakes can be made, or natural lakes can be regulated by outlet works. With one exception the larger cities depend on streams for water supply and dilution of wastes. Sewage pollution and the resultant growth of organisms have contaminated the surface water available to the municipalities of this area to an extent that is not approached in most parts of the United States. In order to correct this condition sewage-treatment plants are needed and, in addi-

tion, the stream flow should be increased sufficiently to furnish a satisfactory oxygen balance and to make the streams suitable for water supply and recreation. The minimum flow during the winter below Breckenridge, Minn., and below Fargo, N. Dak., should be 145 cubic feet per second. Below the mouth of the Sheyenne the minimum flow should be 400 cubic feet per second, and below Grand Forks, N. Dak., 640 cubic feet per second. On the Red Lake River below Crookston, Minn., a flow of 100 cubic feet per second is needed. For open river conditions during the summer and fall a flow of half these amounts will be sufficient, except in the Red Lake River, where the full 100 cubic feet per second flow will be needed at all times. Low-water channels need to be straightened and cleared, so as to deliver water from storage to the valley towns with a minimum of delay and evaporation. The system must be administered as a unit not only to resolve conflicts between alternative uses of water but also to prevent waste.

The *chief storage projects* consist of regulating works at Red Lake, the construction of 51 small dams for controlling natural lake levels in the Ottertail Basin, and the proposed Bald Hill Reservoir on the Sheyenne River above Valley City, N. Dak. In addition, numerous minor storage works are planned for localities scattered throughout the basin. An inch and a half of additional storage on the Red Lakes would furnish, if regulated, a minimum flow of 100 cubic feet per second in the lower Red Lake River, a trivial amount in comparison with evaporation losses. An effective storage of more than 100,000 acre-feet in the lakes of the Ottertail-Pelican chain will maintain the required flow from Breckenridge to Fargo. The projected Bald Hill Reservoir on the Sheyenne River would have been filled in wet years and would have provided, if properly operated, a continuous release of 50 cubic feet per second throughout the recent drought. With this release there would have been a reliable flow at West Fargo of nearly 100 cubic feet per second. The plan includes a small diversion channel from the Sheyenne River, which will convey part of the regulated Sheyenne flow into the Red River above Fargo at times of low water. Other reservoirs proposed for later construction have not been evaluated in detail.

Part of the Sheyenne Basin lies in the Dakota high plains and is not connected closely with the Red River Valley. The construction of a small dam near Sheyenne, N. Dak., and of other small storage dams in the upper Sheyenne Valley will meet adequately the water needs of this sub-basin. The Bald Hill Reservoir would furnish an adequate water supply to the Sheyenne Valley from Valley City to the outlet. The benefits of diverting water from the Missouri River or

from other streams into this valley would not justify any considerable part of the expense.

The provision of a regulated minimum flow on certain rivers of the basin will improve the conditions of *hydroelectric power* production at existing plants. There are a few sites where new plants may be found economically feasible with regulated flow.

The *low-water channels* in the stream beds, by which water is carried from the reservoirs to the principal cities, should be improved. These streams have low gradients and some of them have tortuous channels which are wide and shallow. Losses from the low-water flow in the Red River between Breckenridge and Fargo have been as high as 28 cubic feet per second.

Small water supply intake dams in the channels of the streams above the principal cities have been extended and enlarged in recent years in order to hold as much as possible of the scanty flow. These dams are not in harmony with a general water plan, because of the evaporation from the enlarged water surface. They are also detrimental in time of flood, since they occupy part of the valley storage and obstruct the channels. The development of a reliable low-water flow would permit the removal or reduction in height of some of these dams, as at Fargo; and no new dams should be built in the streams used to convey water to the cities, except possibly one on the Ottertail for power purposes.

On the other hand, small-channel dams are desirable on certain streams which are normally dry during the summer so that some of the small towns and rural communities may substitute surface water for underground water that is unsatisfactory. Small dams on the very small tributaries are desirable for stock watering. At certain sites dams may properly be constructed to produce lakes for recreational use and the preservation of wild fowl. Wherever appropriate, dams should be equipped with outlet control works to make their use conform to the necessity of maintaining a satisfactory low-water stream flow.

Water from many wells in this area is unsatisfactory, and in such instances subsurface supplies should be supplanted by surface supplies if practicable. For cities and towns situated on the larger streams, the regulated flow should provide sufficient water. For cities and towns at a considerable distance from such streams, no practicable substitute can be found for underground water. In general, the rural water supply must continue to come from subsurface sources.

Subsurface water may be increased by percolation of stored water provided in accordance with the plan and by relocation or readjustment of wells to draw from the more satisfactory sources. Supplies from the

deeper formations may be improved in quality by casing off certain of the more objectionable water-bearing strata or by re-drilling to penetrate better strata.

A detailed geological investigation should be made to determine the ground water conditions from point to point and to identify the more satisfactory water-bearing strata. This work should be undertaken promptly in order to permit early reduction in the use of highly mineralized waters by small cities and rural communities. Some of these waters contain dangerous amounts of fluorine.

Sewage-treatment plants capable of a high degree of purification have been built or are being built by some of the larger cities. Because of the excessively bad quality of available surface waters, many cities have had to install water-treatment processes to an extent not normally required. The plan provides for the ultimate installation of complete sewage-treatment works for all cities and towns of the basin and for the extension and reconstruction of most of their water-works. It includes in many cases a change in the source of supply. The general health and sanitation of the area require immediate action along these lines at many towns.

Flood control as contemplated by the plan would be sufficient to prevent serious damage to urban property and also to reduce the frequency of flooding agricultural lands. The water-storage feature of the coordinated plan will in itself be effective in reducing the number of minor floods. It will not appreciably reduce the stage of major floods.

The plan of flood-flow correction includes the construction of Lake Traverse Dam and Storage Reservoir, the normal water level of which would be so fixed as to produce a desirable area for recreation and wildlife conservation. There would be provision for an additional 5 feet above normal level for flood storage. This reservoir would satisfactorily reduce flood stages along the Bois de Sioux, but would not be sufficiently effective at and below Fargo.

The plan also includes a floodway from the Dakota Wild Rice River to the Sheyenne River, so that a part of the flood water of the Wild Rice may be diverted past Fargo by use of the channel of the Sheyenne. The peak flood flow also would be reduced by construction of the Bald Hill Dam.

Below the mouth of the Sheyenne River some improvement of the channel of Red River is necessary. This should take the form of a partial clearing of the present flood channel. It should include the removal of heavy timber 30 feet or more on each side of the edge of the low-water channel. Tree growth generally extends for some distance on each side of the stream and should be so cleared as to leave a satisfactory

stand. Bridges and other channel obstructions in the principal cities should be reconstructed or removed in certain instances. The execution of this part of the program would reduce flood stages in the lower Red River by increasing flood-channel capacity. From a point somewhat south of Grand Forks northward to the Canadian border the floodway should be cleared more extensively to permit free passage of ice. Serious floods in the northern section have resulted from ice gorges. The spring break-up comes relatively early in the southern end of the basin, and flood waters arrive at the northern part while it is still icebound.

It is proposed to avoid an increase in flood flow at the Canadian border by reduction of flood flows from certain tributaries. In particular, a flood-control dam is proposed on the Pembina River at Walhalla, N. Dak. This dam should be constructed before channel improvements are made along the Red River.

Flood conditions on the Red Lake River would be alleviated substantially by regulation of the outflow from Red Lake; further improvement would be obtained if the drained marshes west and north of Red Lake should be restored to their original condition. The Roseau project would correct the flood conditions on the Roseau River and would abate frequent and extensive damages to a large acreage of agricultural lands lying south of the river. Part of the Roseau flood waters would be diverted into Two River, thus reducing flood heights at the Canadian border. Plans are available for this project, and work on it should be started at an early date.

Wildlife conservation is being developed by the Bureau of Biological Survey at and near Mud Lake and Tamarac Lake and in the headwaters area of the Dakota Wild Rice. These conservation measures are desirable and in harmony with the general plan, provided the improvements under way can be so regulated that in periods of extreme drought, water can be used for controlling stream flow.

The Resettlement Administration has a project in the Lake of the Woods drainage area which overlaps into the Red Lake drainage basin. This project involves blocking old drainage ditches, spreading flood waters, and installing control dams on the smaller streams. Its principal values would be in forest and wildlife conservation, but it also would have some value as a regulating agency for Red Lake. The restoration of marsh conditions in other areas north and west of Red Lake would have a similarly desirable result and would help to correct floods on the Red Lake River and the lower Red River. If practicable, these marshes should not be so developed, however, as to involve duck-nesting unit which cannot be reduced in size during periods of severe drought when the water is needed elsewhere.

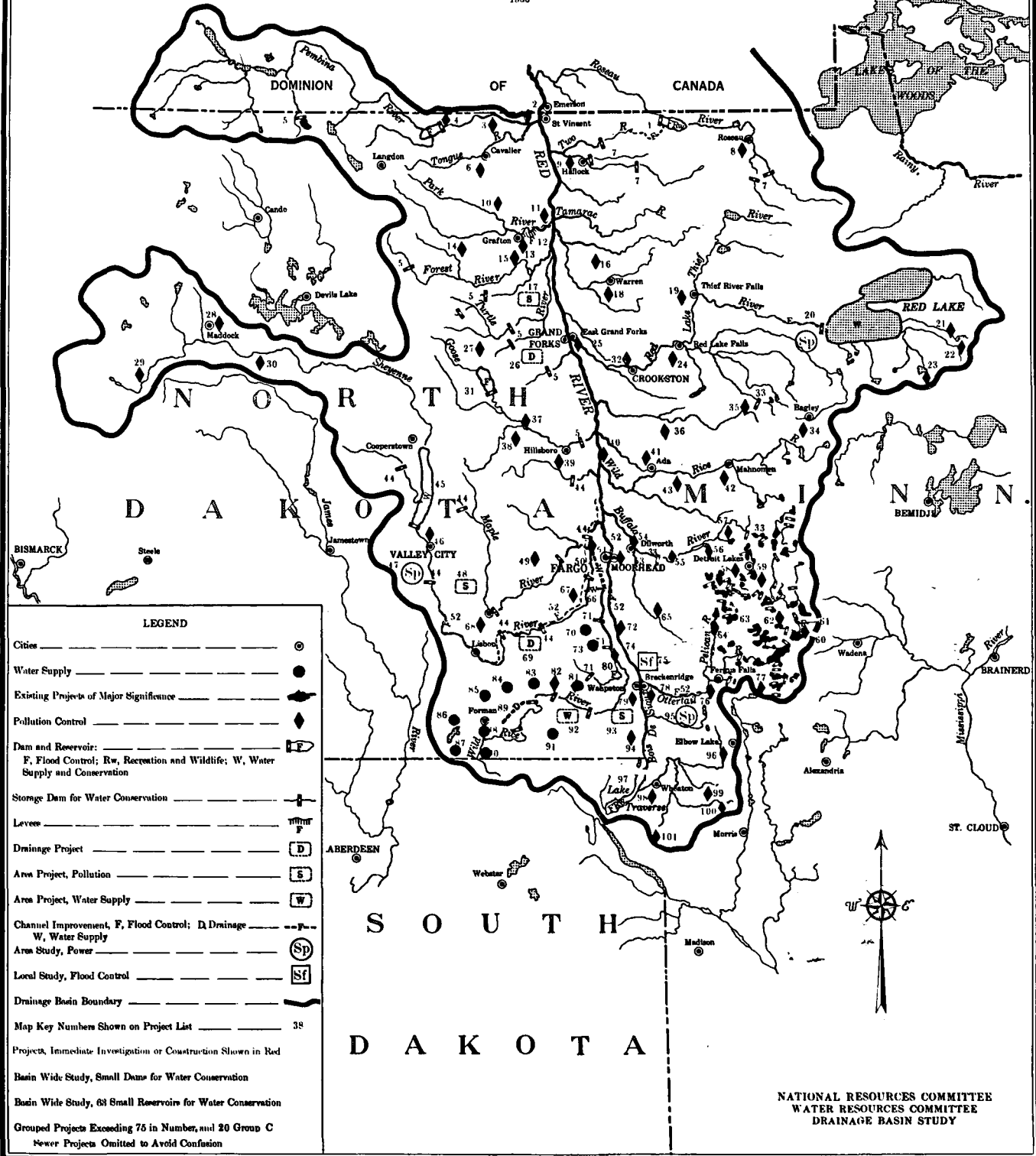
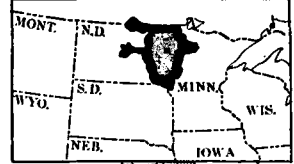
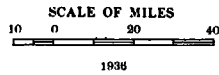
The Lake Traverse project is important for flood control, desirable for recreation, and of prospective benefit to the propagation of wildlife.

Readjustment of land drainage in parts of the area is an essential part of the plan. Certain areas that have been drained should be reflooded for recreation and wildlife conservation. In some places drainage works that facilitate the movement of flood waters from stream channels into areas of drained land should be altered appropriately. Other drainage structures should be rehabilitated and put in efficient condition, and there may be areas where at some future time new drainage works may be justified, as in parts of the Bois de Sioux section.

The Red River Basin presents an interstate problem. The urban population is divided about equally be-

tween Minnesota and North Dakota. The principal sources of water are in Minnesota. Storage of flood waters in North Dakota is an essential part of the plan. Effective operation under the plan will necessitate cooperation by the two States in the best interest of the valley as a whole. The adequate maintenance of low-water channels and of other features of the plan can be guaranteed only through the medium of an interstate compact. Accordingly it is essential that a permanent interstate agreement for the execution and operation of the water plan be adopted and that some agency be established with sufficient authority and power to construct, maintain, and operate the contemplated works for the storage and movement of water. Without such an agreement the consummation of the plan cannot be assured.

RED RIVER OF THE NORTH

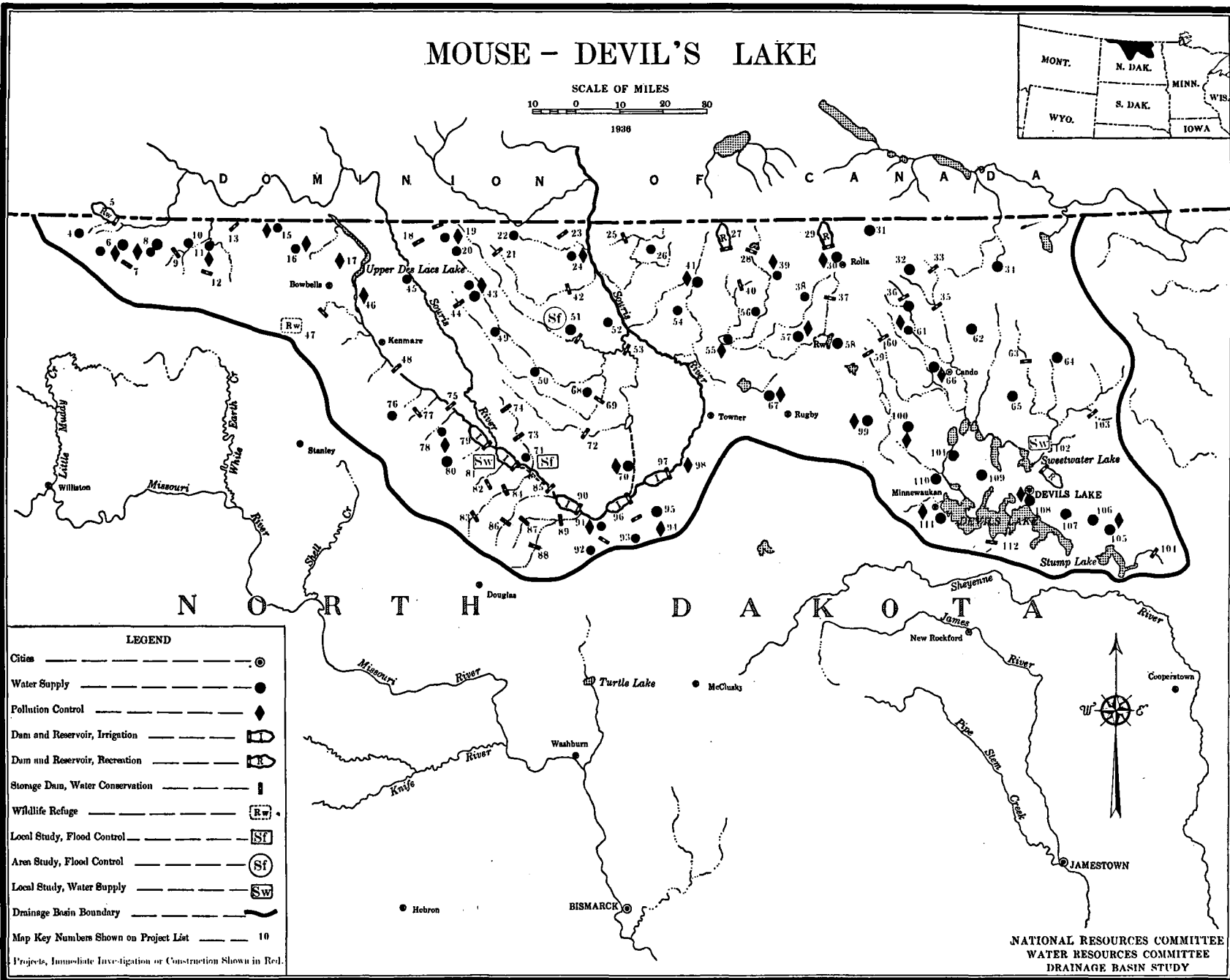
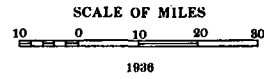


Red River of the North Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
75	Study for flood channel improvement of Red River below Ottortail River.....	\$20,000	
	Survey and plans, small conservation dams.....	20,000	
(1)	Study of the Ottortail (95), Red Lake (20), and Sheyenne (47) Basins to determine the possibilities for new water-power developments and for improvement in existing developments.....	5,000	
63	Ottortail and Pelican Rivers, construction of 51 small dams for water conservation and control.....	244,000	
20	Red Lake River: Channel improvements and control works.....	437,000	Plans available. Project urgent.
52	Ottortail, Red, and Sheyenne Rivers: Channel improvements for low-water flow.....	355,000	Surveys and plans are available.
1	Roseau Reservoir and Diversion, on Roseau River, for flood control, recreation, wildlife conservation, and water conservation.....	1,301,000	Plans ready.
(1)	Dakota Wild Rice (71), Goose-Pembina (5), Red Lake (33), Sheyenne (44), and Snake-Roseau (7) Basins: 36 small dams and reservoirs on principal streams for water conservation, local water supply, and recreation.....	436,000	
20	Abercrombie, Alice, Ameal, Aneta, Anselm, and Ardoch, N. Dak.; Argyle, Minn.; Ayr, N. Dak.; Bagley, Barnesville, and Battle Lake, Minn.; Blabon, N. Dak.; Blackduck, Minn.; Blanchard and Bowsmont, N. Dak.; Breckenridge, Minn.; Buffalo, Buttsville, and Buxton, N. Dak.; Callaway and Campbell, Minn.; Casselton, Cayuga, Cavalier, Chafee, Christine, Clifford, Cooperstown, Colgate, and Conway, N. Dak.; Crookston, Minn.; Crystal, Cummings, and Dasey, N. Dak.; Detroit Lakes and Donnelly, Minn.; Drayton, N. Dak.; Dumont, Minn.; Dwight, N. Dak.; East Grand Forks, Minn.; Ekelson, N. Dak.; Elbow Lake, Minn.; Elliot, Enderlin, Engelvale, Erie, and Fairdale, N. Dak.; Fergus Falls and Fertile, Minn.; Fingal and Finley, N. Dak.; Fosston, Minn.; Fordville and Forest River, N. Dak.; Frazee, Minn.; Galesburg, Glasston, Grafton, and Great Bend, N. Dak.; Hallock and Halstad, Minn.; Hamar, Hamberg, Hamilton, Hannaford, Hansboro, and Hastings, N. Dak.; Hawley, Minn.; Heimdal and Hensel, N. Dak.; Herman, Minn.; Hope, Hoople, Hunter, Kathryn, and Kindred, N. Dak.; Lake Park, Minn.; Langdon, Lankin, Lisbon, Litchville, Maddock, Manvel, and Martin, N. Dak.; Matton, Minn.; McCanna, N. Dak.; McIntosh, Minn.; McLeod, McHenry, Mekinock, Michigan, and Minto, N. Dak.; Moorhead, Minn.; Mooreton, Mountain, and Neche, N. Dak.; New York Mills, Minn.; Niagara and Nome, N. Dak.; Northome, Minn.; Northwood, N. Dak.; Oklee, Minn.; Oriska, Orr, Page, Park River, and Pekin, N. Dak.; Pelican Rapids, Minn.; Pembina, N. Dak.; Perham, Minn.; Pillsbury, Pisek, and Portland, N. Dak.; Red Lake Falls, Minn.; Reynolds, N. Dak.; Roseau, Minn.; Rutland, Sanborn, Sharon, Sheldon, Sheyenne, and St. Thomas, N. Dak.; Thief River Falls, Minn.; Thompson, Tolna, and Tower City, N. Dak.; Twin Valley, Minn.; Valley City, Wahpeton, and Walnut, N. Dak.; Warren, Minn.; Wellsburg, Wetman, and Wheatland, N. Dak.; Wheaton, Minn.; Wimbledon, N. Dak.; Wolverton, Minn.; Wyndmere, N. Dak.: Water supply and water-treatment plants.....	2,358,000	
(1)	Abercrombie (74), N. Dak.; Ada (41), Argyle (16), Bagley (34), Barnesville (65), Battle Lake (77), Blackduck (23), Breckenridge (78), and Callaway (57), Minn.; Casselton (49) and Cavalier (6), N. Dak.; Crookston (32), Detroit Lakes (58), Dilworth (54), and Donnelly (100), Minn.; Drayton (11), N. Dak.; East Grand Forks (25) and Elbow Lake (96), Minn.; Enderlin (68) and Fairmount (94), N. Dak.; Fergus Falls (76), Fertile (36), Fosston (35), Frazee (59), and Graceville (101), Minn.; Grafton (13), N. Dak.; Hallock (9) and Halstad (40), Minn.; Harvey (29), N. Dak.; Hawley (55), and Herman (99), Minn.; Hillsboro (39), N. Dak.; Kelliher (21), Minn.; Kindred (67), N. Dak.; Lake Park (56), Minn.; Larimore (27) and Maddock (28), N. Dak.; Mahnomen (42), Minn.; Mayville (37) and Minto (15), N. Dak.; Moorhead (53), Minn.; Neche (3), N. Dak.; New York Mills (60) and Northome (22), Minn.; Park River (14), N. Dak.; Pelican Rapids (64), Minn.; Pembina (2), N. Dak.; Perham (82), Minn.; Portland (38), N. Dak.; Red Lake Falls (24) and Roseau (8), Minn.; Sheyenne (30), and St. Thomas (10), N. Dak.; Thief River Falls (19) and Twin Valley (43), Minn.; Wahpeton (79) and Walhalla (4), N. Dak.; Warren (18), Minn.; West Fargo (51), N. Dak.; Wheaton (98), Minn.; Wyndmere (82), N. Dak.; Wolverton (72), Minn.; Valley City (46), N. Dak.: Sewer systems and sewage-treatment plants.....	2,546,000	
45	Baldhill Reservoir on Sheyenne River near Valley City for water conservation, stream regulation, and pollution reduction.....	778,000	
66	Sheyenne River diversion. Ditch to divert low waterflow from Sheyenne River to Dakota Wild Rice River including diversion dam.....	95,000	
12	Park River Levee and Channel straightening for flood control.....	45,000	Survey being made.
GROUP B—FOR DEFERRED CONSTRUCTION			
97	Lake Traverse—Bois des Sioux Reservoir for flood control and game refuge and recreation.....	\$1,400,000	Authorized by Congress.
4	Walhalla Reservoir on Pembina River for flood control and water conservation.....	395,000	
31	Steele County Reservoir on Goose-Pembina River for water conservation and flood control.....	195,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Construction of 63 small dams in Red Lake, Dakota Wild Rice, Sheyenne, and Goose-Pembina Basins for water conservation, recreation, and game refuges.....	\$490,000	
50	Dakota Wild Rice River diversion, ditch to divert flood waters from Dakota Wild Rice River to Sheyenne River.....	350,000	
80	Lake Elsie improvement by dredging for storage.....	1,000	
89	Sargent County drainage ditches, to drain farm lands.....	20,000	
69	Sheyenne drainage, rehabilitation of ditches to improve drainage of farm lands in Sheyenne River Basin.....	10,000	
26	Goose-Pembina drainage, rehabilitation of ditches for improving drainage of farm lands in Goose-Pembina Basin.....	40,000	
	Study—Hydroelectric survey in the Ottortail, Red Lake, and Sheyenne Basins to ascertain opportunities for water power development.....	5,000	
(1)	Sewer system and sewage-treatment plants in Dakota Wild Rice (93), Sheyenne (49), and Goose-Pembina (17) Basins.....	730,000	20 projects varying in estimated cost from \$2,215 to \$20,000.
92	Municipal water supply systems in Dakota Wild Rice Basin.....	12,000	11 projects varying in estimated cost from \$700 to \$2,500.
61	Ottortail Channel, clearing to improve flow from upper watershed into Ottortail Lake.....	40,000	
(1)	Barney (81), Brampton (87), Cogswell (86), Colfax (73), Delamere (83), Forman (88), Gwinner (85), Havana (90), Lidgerwood (91), Milnor (84), and Walcott (70), N. Dak.: Water supply.....	12,000	
	Aneta, Buxton, Cogswell, Cooperstown, Finley, Forman, Gwinner, Hankinson, Hatton, Hope, Hunter, Langdon, Lidgerwood, Litchville, McVile, Michigan, Northwood, Page, Tower City, and Wimbledon, N. Dak.: Sewer systems and sewage-treatment plants.....	710,000	

¹ Map key number shown following community name.

MOUSE - DEVIL'S LAKE



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir, Irrigation ———— [D]
- Dam and Reservoir, Recreation ———— [R]
- Storage Dam, Water Conservation ———— [S]
- Wildlife Refuge ———— [RW]
- Local Study, Flood Control ———— [SF]
- Area Study, Flood Control ———— [SF]
- Local Study, Water Supply ———— [SW]
- Drainage Basin Boundary ———— [Wavy Line]
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red. ———— [Red]

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

2. MOUSE-DEVILS LAKE

The more important water needs of the Mouse-Devils Lake areas are improved municipal water supplies, the treatment of sewage, and the construction of small reservoirs to serve stock and small-scale irrigation. The city of Devils Lake has a particularly serious water supply problem. The recreational possibilities of a number of small lakes should be developed.

General Description

The Mouse-Devils Lake areas lie in North Dakota along the boundary between the United States and Canada. They have an area of 12,682 square miles in the United States, and are composed of a series of irregular ridges and valleys resulting from glacial action. The Souris (Mouse) River loops into North Dakota, entering from Canada and returning there. Its channel within the United States is 360 miles long. It enters at an altitude of 1,605 feet and leaves at an altitude 216 feet lower. In the Devils Lake Basin the drainage is principally to the southeast from Turtle Mountains. The lake once covered 142 square miles; now it is only 30 square miles in extent. The entire region, except in deep coulees, is mantled by drift which is underlain by coal and petroleum-bearing formations. The drift ranges in thickness from a few feet to 150 feet and is composed of clays, sands, and gravels which absorb precipitation readily and constitute the chief sources of underground water.

The population of the area was about 131,000 in 1930, with a density of 10 per square mile. About one-sixth of the total population is in the two chief cities, Minot and Devils Lake.

Because of the large wheat crops yielded by the brown loam soils, this region underwent a rapid change from open range to wheat cultivation. The frequency of droughts, however, has resulted in a trend toward stock grazing, supplemental by wild and tame hay crops. Lignite and petroleum are obtained in the Souris River Basin but not in the Devils Lake area.

The climate is semiarid with short summers. The average annual temperature is 38°. The monthly temperature extremes range from 11° below zero in January to 74° above in July. The average annual precipitation is 14.6 inches, of which 84 percent falls during April to October, inclusive. Severe droughts occur in each decade, some covering several years. Because of the nature of the soil of this area, the greater part of the precipitation is directly absorbed. Surface run-off results primarily from melt-

ing snow and, to a minor extent, from local storms. The annual average run-off at controlling points in the Devils Lake basin is estimated at less than one-fourth inch.

Under normal conditions, underground water supplies from the drift are reliable, and in some parts of the region they can be satisfactorily supplemented by deep wells. All rural water supplies and nearly all urban supplies are from underground sources.

Recommended Plan

The water plan for these basins involves conservation of the available water supply and its distribution to the best advantage among the various uses. It is presumed that there will be no importation of water from other basins because of excessive costs. The plan involves some additional minor storage on the tributaries of Des Lacs River for irrigation and wildlife conservation. It proposes an augmentation of the system of small reservoirs on the tributaries of the Souris River entering below Minot and in the Devils Lake Basin in order to provide additional water for stock and for irrigation of small plots for the production of forage and subsistence crops. Protection and further regulation of the available supply through an agreement as to type of water use in the headwaters area in Canada and possible participation in water-storage development in Canadian territory should be considered, together with the relation of the proposed reservoirs to existing works for wildlife conservation.

Water supply.—Improvement is urgently needed in the water supply for the city of Devils Lake. Water-supply improvements are also needed at Bisbee, Minot, Burlington, and many smaller communities.

Sewage treatment.—Until the development of storage at Lake Darling there was a serious situation with regard to deficient stream flow for the dilution of wastes, particularly at and below Minot. While the passage of water from Lake Darling down the river to the lower Souris will automatically take care of this difficulty during the greater part of the year, the problem may not be solved thus during the winter months. Sewer systems and sewage-treatment plants are recommended for various communities within the area.

Flood protection.—Occurrence of relatively high spring floods at Minot presents a serious problem. While the operation of the Lake Darling Reservoir will protect the city against normal floods, this protection

should be further improved by an increase in channel capacity at Minot. This improvement may be obtained by cutting loops of the Souris River and constructing low levees.

Recreation and wildlife.—In several parts of the area lakes used for recreation have been materially

lowered. In some instances they may be restored either by storage of water or by diversion from adjacent drainage areas within the basin. The Bureau of Biological Survey has developed wildlife marsh areas of more than 40,000 acres in the upper and lower Souris Basin.

Mouse-Devils Lake Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
71	Minot, N. Dak.: Investigation flood prevention.....	\$5,000	
81	Burlington, N. Dak.: Investigation further water supply.....	5,000	
51	Collection of factual data concerning the flow of the Souris River with thorough consideration of its international aspects.....	40,000	
102	Devils Lake City, N. Dak.: Investigation to revise water supply with consideration of Sweetwater Lake as a possibility.....	6,000	
(1)	Berthold (78), Columbus (11), Dunseith (39), Portal (15), Westhope (24), and Willow City (55), N. Dak.: Urban water supply improvements and water-treatment plants.....	203,000	
(1)	Berthold (78), Bowbells (17), Columbus (11), Dunseith (39), Kenmore (46), Portal (15), Towner (98), Velva (91), Westhope (24), and Willow City (55), N. Dak.: Sewer systems and sewage-treatment plants.....	345,000	
79	Burlington, N. Dak., on Des Lacs River: Water storage for irrigation.....	90,000	
(1)	Lake Metigoshe (27), and Upsilon (29), N. Dak.: Regulation of lake levels for recreational use, Carpenter Lake, Rost Lake and Long Lake.....	25,000	
47	Burke County, N. Dak.: Water improvements in Lostwood migratory waterfowl refuge.....	46,000	Plans completed.
97	Eaton irrigation district, N. Dak.: Water storage.....	75,000	
(1)	Ambrose (4), Antler (22), Balfour (93), Berthold (78), Columbus (11), Crosby (6), Deering (68), Flaxton (16), Gardena (54), Glenburn (50), Lansford (49), Larson (10), Loraine (20), Mohall (43), Newburg (52), Noonan (8), Overly (56), Portal (15), Ruso (92), Sherwood (19), Souris (26), Tagues (76), Thorne (38), Tolley (45), and Velva (91), N. Dak.: Surveys and new wells.....	26,000	
71	Minot, N. Dak.: Water-treatment plant.....	20,000	
(1)	Ambrose (5), Balfour (93), Deering (69), Donnybrook (48), Eckman (51), Foxholm (75), Hartland (77), Kenaston (47), Logan (85), Maxbass (42), Sherwood (19), and Upham (53), N. Dak.; Bottineau (23), (25), (40), Burke (12), (13), McHenry (92), Rolette (37), (28), and Ward (72), (75), (82), Counties, N. Dak.: 23 small dams for recreation and water conservation.....	152,000	
61	Bisbee, N. Dak.: Water-supply improvement.....	37,000	
(1)	Bisbee (61), Cando (66), Devils Lake (108), Lakata (105), and Leeds (100), N. Dak.: Sewage-treatment plants.....	190,000	
(1)	Nelson (104), Ramsey (63), (102), (103), Rolette (59), (60), and Towner (33), (35), (36), Counties, N. Dak.: 9 small dams for recreation and water conservation.....	39,000	
112	Devils Lake City, N. Dak.: Improvement of Sullys Hill Game Preserve at Fort Totten.....	34,000	
102	Sweetwater Lake, N. Dak.: Increased tributary drainage to raise lake to higher level for better quality of water, recreational use and possible water supply to Devils Lake City.....	10,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
	Sand Hill Region, N. Dak.: Minor irrigation project for 2,000 acres. Wells and equipment for small individual farm projects.....	\$100,000	
71	Minot, N. Dak.: Straighten and improve channel of Souris River.....	250,000	
58	Rolette County, N. Dak.: Diversion ditch to Long Lake for wildfowl conservation.....	5,000	
(1)	Bartlett (106), Brinsmade (110), Churches Ferry (101), Crary (107), Devils Lake (108), Edgeland (62), Hampden (61), Hansboro (31), Lakota (105), Leeds (100), Minnewaukan (111), Mylo (58), Perth (36), Penn (109), Rock Lake (37), and Starkweather (65), N. Dak.: Surveys and new wells.....	30,000	
GROUP C—TIME OF STARTING INDETERMINATE			
(1)	Bottineau (41), Crosby (6), Drake (94), Flaxton (16), Granville (70), Mohall (43), Noonan (8), Rolette (57), Rugby (67), and Sherwood (19), N. Dak.: Sewers and sewage-treatment plants.....	\$320,000	No available water supply in valley.
96	Dam near Verendrye, N. Dak., in Souris River: To divert excess flow of river by canal to Buffalo Lodge Lake for irrigation.....	100,000	
(1)	Footo-Graham (81) and Sawyer Velva (90), N. Dak.: Irrigation.....	150,000	Do. Amount of participation in cost probably justified by flow-regulation benefits in North Dakota; subject to appropriate international agreements.
(1)	Estevan, Long Creek, and Mountain Creek, Saskatchewan, Canada: Reservoirs for power and flood control.....	125,000	
(1)	Bottineau (21), Burke (14), Divide (a), Renville (b), and Ward (c), Counties, N. Dak.: Dams for water conservation, recreation, and wildfowl conservation.....	49,000	
(1)	Bottineau (41), Crosby (6), Des Lacs (80), Eckman (51), Flaxton (16), Granville (70), Karlsruhe (95), Mohall (43), Noonan (8), Rolette (57), Rugby (67), Sherwood (19), N. Dak.: Water-treatment plants and distribution systems.....	165,000	
(1)	Bisbee (61), Calvin (34), Cando (66), Devils Lake (108), Lakota (105), Leeds (100), Minnewaukan (111), Rolla (30), and York (99), N. Dak.: Waterworks, distribution systems, and treatment plants.....	180,000	
(1)	Minnewaukan (111), Rolla (30), York (99), N. Dak.: Sewers and sewage-treatment plants.....	95,000	

¹ Map key number shown following community name.

² Map key number shown following county name, except where there is more than one project in a county, as follows: (a) 7, 9; (b) 18, 44; (c) 73, 74, 83, 84, 86, 87, 88, 89.

3. RAINY

A complete plan of control of lake levels is essential to proper development and use of recreational properties and facilities of the Rainy River-Lake of the Woods Basin. Hydroelectric power development also is involved. This matter has been studied extensively by the International Joint Commission and left open for further consideration. It is important that a full plan of development be determined.

Pollution in the Rainy River should be reduced. This can be accomplished immediately as to urban wastes, but further study of the more serious industrial waste pollution is needed. The work of restoring to marsh and forest large areas of poor land heretofore drained should be continued. The possibility of developing a waterway between the Lake of the Woods and Rainy Lake should be kept under consideration in connection with possible power development.

General Description

The Rainy River Basin, as considered here, includes the watersheds of Lake of the Woods and of Rainy River and all tributaries within the boundaries of Minnesota. The area of the basin in Minnesota is 9,700 square miles. Characteristic of the basin are the extremely rocky regions with comparatively heavy forest cover in the east and south, and the flat regions of peat bogs and muskegs in the northwest. Agriculture is concentrated along the lower course of the Rainy River from Lake of the Woods to International Falls, along the Little Fork River, and along parts of Big Fork River, as well as near the Mesabi and Vermilion ranges.

The Rainy River rises in Rainy Lake and flows into Lake of the Woods. It forms part of the boundary between Minnesota and Ontario. There is a chain of "border lakes" above Rainy Lake. The total fall through this chain is 444 feet, from 1,550 feet above sea level at North Lake to 1,106 feet at Rainy Lake, a distance of 160 miles. The chief tributaries of the Rainy River and the boundary waters are the Big Fork, Little Fork, Kawishiwi, Vermilion, Rat Root, Black, Rapid, and Warroad Rivers. The basin slopes generally to the northwest, at an average of about 12 to 15 feet per mile.

The region north and east of Net Lake, Pelican Lake, Vermilion Lake, and Birch Lake is covered by rock outcrops. The soils of many parts of the basin are very poor. Exceptions are the areas along the lower course of the Rainy River and its lower tributaries.

The average annual precipitation is about 24 inches, but it decreases west of International Falls to about 21 inches near Lake of the Woods. Temperature extremes range from 49° below zero to 100° above. The average annual temperature is about 37° and the length of the growing season is about 110 days. The greater part of the precipitation falls during the growing season.

Important industries are mining, lumbering, agriculture, and tourist trade. The production of iron ore from the Vermilion Range fluctuates between 1 and 2 million tons per year. The Vermilion Range produces about 1 percent of the total iron ore output of the world.

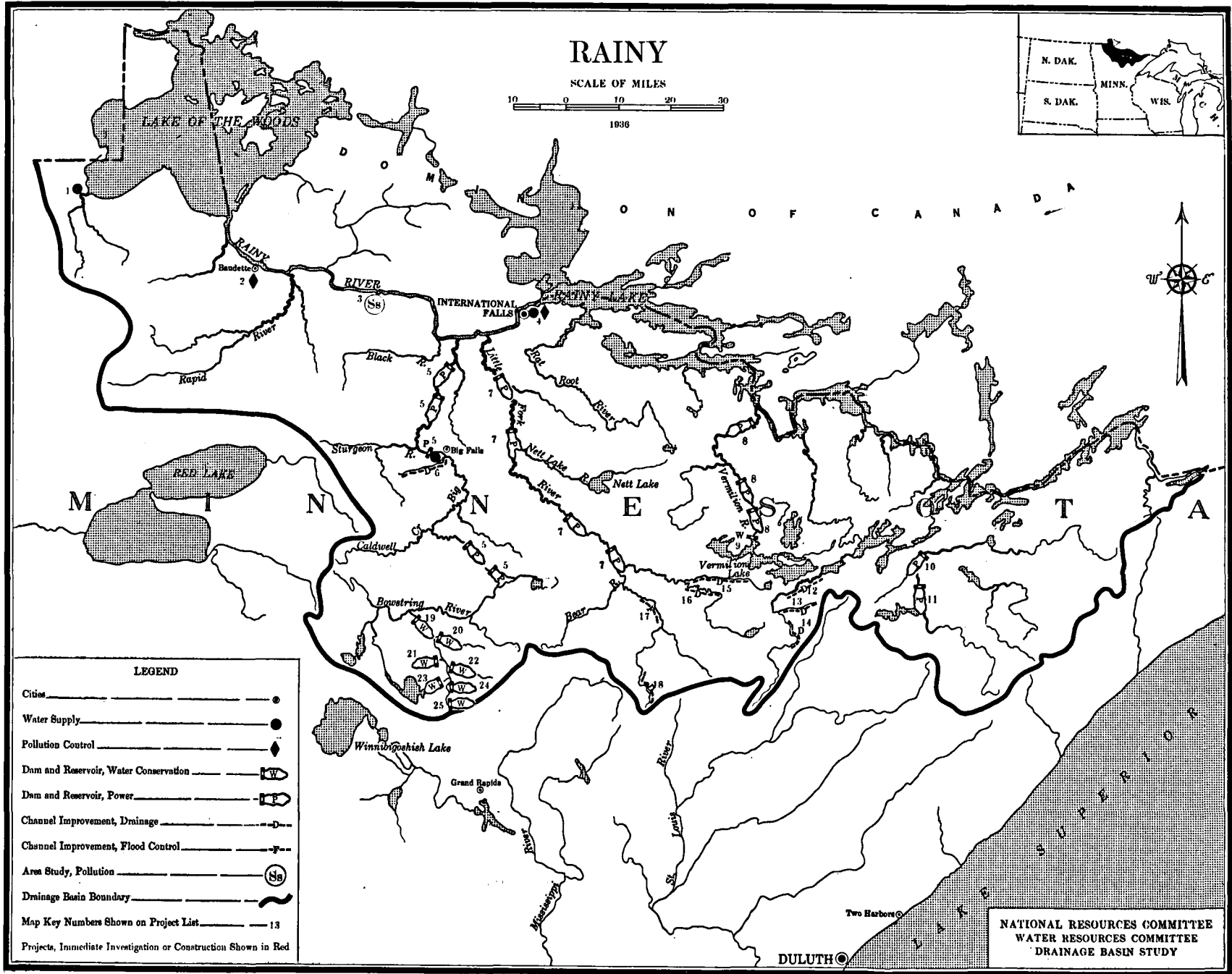
The center of the lumber industry is at International Falls. Most of the Superior and Chippewa National Forests is within this basin. Land that has proved unsuitable for agricultural purposes is being withdrawn for forests. Timber areas are approaching their original extent.

Farming generally is confined to areas along the lower course of the Rainy River, around Lake of the Woods, and just north of the Mesabi Range along the southern border of the basin. Dairying is the major farming enterprise. Specialty crops, such as alfalfa and clover seed, are produced.

The Rainy River Basin includes some of the finest recreational areas in Minnesota. Lake of the Woods, Rainy Lake, and the lake regions to the east and south are well stocked with game and fish. The forests and lakes are ideal for canoe trips, fishing, camping, and other summer recreational purposes. The wilderness area to the north and east is almost inaccessible except by boat or canoe. Its remoteness is its particular attraction. It is preserved practically in its original state.

The population of the basin in 1930 was 45,042, of which 27,124 lived on farms. The more important cities are Ely, with a population of 6,156 in 1930, and International Falls, 5,036.

The Rainy River at its discharge into the Lake of the Woods has an average flow of about 11,000 cubic feet per second. About 60 percent of this flow is discharged from Rainy Lake. The average flow of the Kawishiwi River at Garden Lake is 771 cubic feet per second. The Vermilion River, below Vermilion Lake, has a steep gradient with a fall of more than 100 feet in one reach of 42 miles. Little Fork River has an average fall of 1.62 feet per mile in its lower section.



Big Fork River includes one drop of 36 feet in three-tenths of a mile.

Recommended Plan

Navigation.—Lake of the Woods and the Rainy River to the foot of Long Sioux Rapids are navigable, with harbor development at Warroad for 7-foot draft. Upper Rainy River and Rainy Lake are now used for navigation largely for the floating of sawlogs. A continuous water route from the head of Rainy Lake at Kettle Falls to Keewatin at the outlet of the Lake of the Woods could be provided for boats of 7-foot draft by constructing a dam and lock below the rapids on Rainy River and by providing locking facilities at International Falls. This would fit in with the development of hydroelectric power below International Falls. This proposal may be given consideration as part of the long-range plan, but there appears to be no present need for its development.

Water supply.—Along the boundary waters, where is concentrated the greater part of the population, there is an ample supply of soft water. In the western part of the area underground water is ample, but it is rather hard.

Pollution.—The waters of the Rainy River above International Falls are polluted by domestic wastes and below International Falls by both domestic and industrial wastes. Relocation of waterworks intakes and the treatment of domestic sewage are required. The Rainy River below International Falls has been badly polluted by wastes from pulp and paper mills. This pollution consists of chemical waste, bark, and other materials, which tend to develop floating sludge masses and injure fish life. The matter is being studied between the State of Minnesota and the Province of Ontario. If a satisfactory solution is not arrived at in a reasonable time, reference to the International Joint Commission may be indicated.

Drainage.—Large areas south of the Lake of the Woods and the Rainy River, originally consisting of one great swamp, were drained between 1911 and 1916 at great cost. The land proved unsuitable for cultivation. The drying out of the area has created serious difficulties in the controlling of forest fires. Three widespread and disastrous fires have occurred. Four towns were destroyed. The restoration of the marsh area has been undertaken by the Resettlement Admin-

istration, which is constructing control dams in the ditches and on the principal water courses.

Water power.—Existing hydroelectric developments include a 22,600 kilowatts installation at International Falls and one of 3,750 kilowatts on the Kawishiwi River at Winton.

An additional plant of 2,100 kilowatts has been proposed on the Kawishiwi, with storage in Birch Lake of 124,000 acre-feet. Storage of 67,000 acre-feet in Gabro and Bald Eagle Lakes also has been proposed. Three projects have been proposed on the Vermilion River having a total head of 215 feet, the probable market for this power being in the Iron Ranges. On the Little Fork and Big Fork Rivers run-of-the-river plants are possible; on the latter stream, five sites have been studied.

Undeveloped power possibilities of the boundary waters have been extensively investigated for the International Joint Commission. Proposals involve the control of various lake outlets and flow equalization. Further regulation would be beneficial to the existing installation at International Falls, and would improve the prospects for an installation below International Falls.

Certain of the proposals studied appear to be feasible. Others require further investigation.

Recreation.—The recreational possibilities of this area are probably its greatest asset. The lakes and streams are among the more beautiful in the United States and game and fish abound. The best use of the lakes for recreation requires that the fluctuation in lake levels be as small as possible. Because of this, there is a serious conflict between the interests of recreation and those of power development.

The level of the Lake of the Woods is controlled in accordance with the treaty of 1925. Some measure of control has been established at Rainy Lake, Namakan, and a number of lakes on the Namakan chain. The International Joint Commission has studied these lakes. It concluded in 1934 that it was not then desirable, nor practicable, to regulate the levels of the upper chain of lakes, but it left the matter open. A long range plan requires the elimination of uncertainties of this kind. The ultimate desirable regulation of lake levels in the best combined interests of recreation and power development should be determined in the near future.

Rainy Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
4	International Falls, Minn.: Water-supply system.....	\$187,000	Plans made.
(1)	Big Falls (6) and Warroad (1), Minn.: Water-supply systems.....	15,000	Do.
3	Study of pollution problems in Rainy River, Minn.....	5,000	
(2)	Belows Lake (21), Grove Lake (25), Horseshoe Lake (20), Jack-the-Horse Lake (22), Little Turtle Lake (23), Maple Lake (19), and North Star Lake (24), Minn.: Water supply.....	14,000	Do.
(1)	Baudette (2) and International Falls (4), Minn.: Sewer systems and treatment plants.....	41,000	
9	Lake Vermillion, Minn.: Outlet works, water conservation.....	19,000	Plans made. Pending acquisition of land.
GROUP B—FOR DEFERRED CONSTRUCTION			
(2)	Big Falls Village (6), Boriin Creek (18), Little Fork River (15), Luoma Creek, (13), Owens Township (16), Pike River (12), (14) and Sturgeon Township (17), Minn.: Drainage by channel clearance.	\$67,000	
GROUP C—TIME OF STARTING INDETERMINATE			
(2)	Birch Lake (11) and Gabiro Lake (10), Minn.: Water power.....	\$1,600,000	
8	Vermillion River, Minn.: Water power.....	1,400,000	
7	Little Fork River, Minn.: Water power.....	1,600,000	
5	Big Fork River, Minn.: Water power.....	1,400,000	

¹ Map key number shown following community name.

² Map key number shown following lake name.

³ Map key number shown following name.

4. MISSISSIPPI HEADWATERS¹

The small excess of minimum flow of the Mississippi River over the demands of St. Paul and Minneapolis for water, the protection of a large investment by the United States in navigation improvements, and the existing and potential water-power development are factors which indicate that maximum benefits would accrue from a water plan which is primarily directed at correction of the low flow in the river. Such a program, if supplemented by the complete treatment of wastes discharged into the main stream and its tributaries, would be consistent with and promote the improvement and expansion of recreational facilities already attracting extensive tourist traffic to this basin. Lack of sites for providing large volumes of storage, except for those now operated by the United States, low run-off from the drainage area, and difficulties from ice in the winter season make flow correction difficult of accomplishment. However, under a comprehensive plan and integrated operating schedule, a considerable volume of storage in many small lakes would provide not only better regulation of existing lake levels for recreational purposes, but also contribute a proportional share of stored water to stream flow to increase the usual low summer discharge.

The water problems may be summarized as follows: (1) low flows which restrict stream development for water supply, water power, and navigation; (2) serious pollution of surface water by sewage and industrial wastes; (3) recession of lake levels which impair their value for recreational and wildlife purposes; and (4) frequent but relatively small flood damage on the main stream in the vicinity of Aitkin, Minn.

General Description

The upper Mississippi Basin includes the drainage area of the Mississippi River and all its tributaries above the mouth of the Minnesota River on the right bank and above the mouth of the St. Croix River on the left bank. The basin contains about 20,000 square miles, entirely within Minnesota, comprising 32 counties in whole or in part. The basin, roughly rectangular, is about 260 miles long and 100 miles wide.

The course of the Mississippi River from Lake Hernando de Soto, above Lake Itasca, to Hastings, is about 587 miles in length and resembles a huge question mark in pattern. There is a total fall of 796 feet

from its source (altitude 1,461 feet) to the Hastings gage (altitude 665 feet). In the course from Hernando de Soto to Brainerd, a distance of 280 miles, there is a fall of 145 feet, and from Brainerd to Hastings, a distance of 170 miles, a fall of 489 feet. The section from Brainerd to Hastings has sufficient gradient to provide many power sites, particularly at St. Anthony's Falls, about 50 feet, and at the "Twin City" lock and dam, about 20 feet.

The drainage pattern of the area consists principally of large and small lakes and muskegs, connected by rivers and creeks which weave a network of waterways. The major right-bank tributaries are the Leech Lake, Willow, Pine, Crow Wing, Sauk, and Crow Rivers, and those on the left bank are the Prairie, Sandy, Nokasippi, Platte, Elk, and Rum Rivers. Notable among the lakes are Mille Lacs, Leech, and Winnibigoshish, the second, third, and fourth largest lakes in Minnesota. In some places between the lakes and rivers there are smooth or gently rolling plains, while in other places there are irregular ridges and patches of hills. Erosion by the major streams has exposed portions of the uneven bedrock surface in a few places.

Most of the soils, derived from glacial drift, are good and have a heavy clay subsoil. Throughout the area there are numerous large and small old lake plains with rich muck soils. In the muskeg areas the large amount of peaty material is a handicap to agriculture. There are great resources of granite, notably near St. Cloud, and of iron ores in the Mesaba and Cayuma Ranges.

The average annual precipitation is about 26 inches, ranging from 28 inches in the southeast to 24 inches in the northwest. The maximum precipitation occurs during the short growing season of 140 days, late May to early September. The average snowfall is about 33 inches. The average annual temperature for the area is about 42°, ranging from 44° at St. Paul to 40° at Bemidji. The July average is 70° and the January average is 15°. Extreme temperatures of 50° below zero and 100° above are common in the area.

The native vegetation of the basin consists mainly of two types of forest; coniferous in the northern two-thirds, and hardwoods, mostly oak, in the southern part. Locally there are stands of pine on sandy soils, and tamarack on moist soils. Practically the entire basin has been cut over and second growth is quite typical. Large expanses of muskeg are common in the

¹This report does not cover the main stream below St. Anthony Falls, since that section is discussed in the report on the Upper Mississippi Western Tributaries.

northern part. The forests, lakes, and streams, with their game and fish, afford valuable recreational resources.

As the cut-over areas extended, farmers cleared the stumps and carried on mixed general farming. Many such areas have evolved important dairy activities which are the basis of numerous creameries and cheese factories. Most of the areas suitable for such utilization are now developed.

In addition to the processing of raw materials, there has been the establishment of numerous manufacturing plants to provide consumers goods for this and adjacent basins. On account of the focus of transportation facilities, both water and rail, at the "Twin Cities", a large group of manufacturing plants has been developed on an interregional and international scale. The principal plants include flour milling, meat packing, brewing, woolen, iron and steel foundry, and woodworking.

With the growing appreciation of the economic value of recreational resources and facilities, the upper Mississippi Basin has assumed outstanding prominence as a resort region. Summer resort hotels, tourist camps, tourist cabin camps, golf courses, hunting and fishing lodges, and communities of summer residences have been established throughout the basin, notably in the vicinities of Brainerd, Walker, and Bemidji.

The mining of iron ore on the Mesabi Range since 1890 from Coleraine to Keewatin has produced a string of towns and cities of several thousand inhabitants possessing decidedly modern urban characteristics. To a less degree similar development has occurred on the Cayuna Range in the vicinity of Aitkin.

The total population of the upper Mississippi Basin in 1930 was about 1,202,000, of which about 836,000 was urban (Minneapolis-St. Paul, 736,000). There are 24 urban centers with more than 2,500 inhabitants; most of these have reflected the general flattening of growth curves of their vicinities indicating the approach of economic maturity. The "Twin Cities", because of their interregionally and internationally important activities, have prolonged their period of rapid growth.

Since 1884 the flow of the Mississippi has been regulated by reservoirs. The present gross storage capacity is 2,200,000 acre-feet. These reservoirs are operated primarily in the interest of navigation, but are also used for other flow-correction purposes. The flow of the stream is affected by freezing and ice from late November to the middle of March. The flow at Minneapolis fluctuates from more than 43,000 cubic feet per second to less than 500 cubic feet per second. Navigation facilities are highly developed below Minneapolis. A number of potential water-power sites exist above Minneapolis. The streams provide water

supplies for the "Twin Cities" and a number of smaller urban centers. The peak water requirements of St. Paul and Minneapolis are equal to about 50 percent of the minimum flow of the stream at the intakes. Peak demands and minimum flow are quite likely to be coincident.

Much sewage and industrial waste is discharged untreated or partially treated into the streams. This situation creates serious pollution problems and reduces the value of the streams for two of the more important functions they should have—namely, furnishing municipal water supplies and providing recreational facilities.

The many lakes provide natural storage facilities for conservation purposes and in conjunction with favorable summer and autumn temperatures form the basic attraction which supports the prosperous tourist industry. The lake levels are subject to considerable fluctuation except where regulating devices have been installed. Such fluctuation is detrimental to the recreational and storage values of the lakes.

The capacity of the channels is sufficient to carry maximum flow except on the main stream in the vicinity of Aitkin. At this place from 2,500 to 30,000 acres are subject to frequent flood damage. Extensive use of artesian waters in St. Paul and Minneapolis has lowered the static levels.

Recommended Plan

The dangerously close approach of and the very probable coincidence of the maximum water demand of St. Paul and Minneapolis and the minimum flow of the Mississippi River, together with the large investment in navigation facilities on the lower river by the United States and the potential and existing water power production, point to the fact that flow correction by storage development is the fundamental need on the Mississippi River above St. Paul.

A review of the relevant data suggests that the minimum flow of 460 cubic feet per second can be increased to at least 1,000 cubic feet per second.

The large amount of relatively cheap storage which could be made available by regulating the levels of the numerous lakes in the region appears to offer excellent possibilities of achieving the desired flow correction without damaging the recreational assets of the area. In many instances, these assets would be increased.

Any appreciable increase in minimum flow would be favorable to navigation, power development, municipal water supplies, and sanitation. The use of the lakes for storage might increase or decrease their recreational value, depending upon the general method of development and the schedules of storage release. On account of the large number of lakes, it seems probable that by judicious operation of storage release the lakes could

be held at average levels higher than that permitted by natural conditions. Because of the accumulation of water in the spring from melting snow, and because most of the precipitation occurs in summer a portion of the storage capacity could be used twice in one year. Further study of the water problems of the area, in their interlocking relationships, is recommended.

The complete treatment of sewage and industrial wastes discharged into the streams should be undertaken because of the general recreational character of the region and the large dependence upon surface water supplies.

Regulation of lake levels.—There are a number of lake-level regulation projects ready for construction which are included in the project lists. The proposed projects are in harmony with future flow correction and need not await the completion of the proposed studies. The potential contributions of storage to a general flow-correction program should be anticipated in the construction plans for these works. It is recommended that the six storage reservoirs now operated by the United States be utilized to their maximum capacity for flow correction. The interests of water supply, sanitation, and power are in harmony with their primary purpose of increasing flow for navigation purposes.

Pollution.—The recreational character of the area, together with the large dependence of urban centers upon surface water supplies, makes adequate treat-

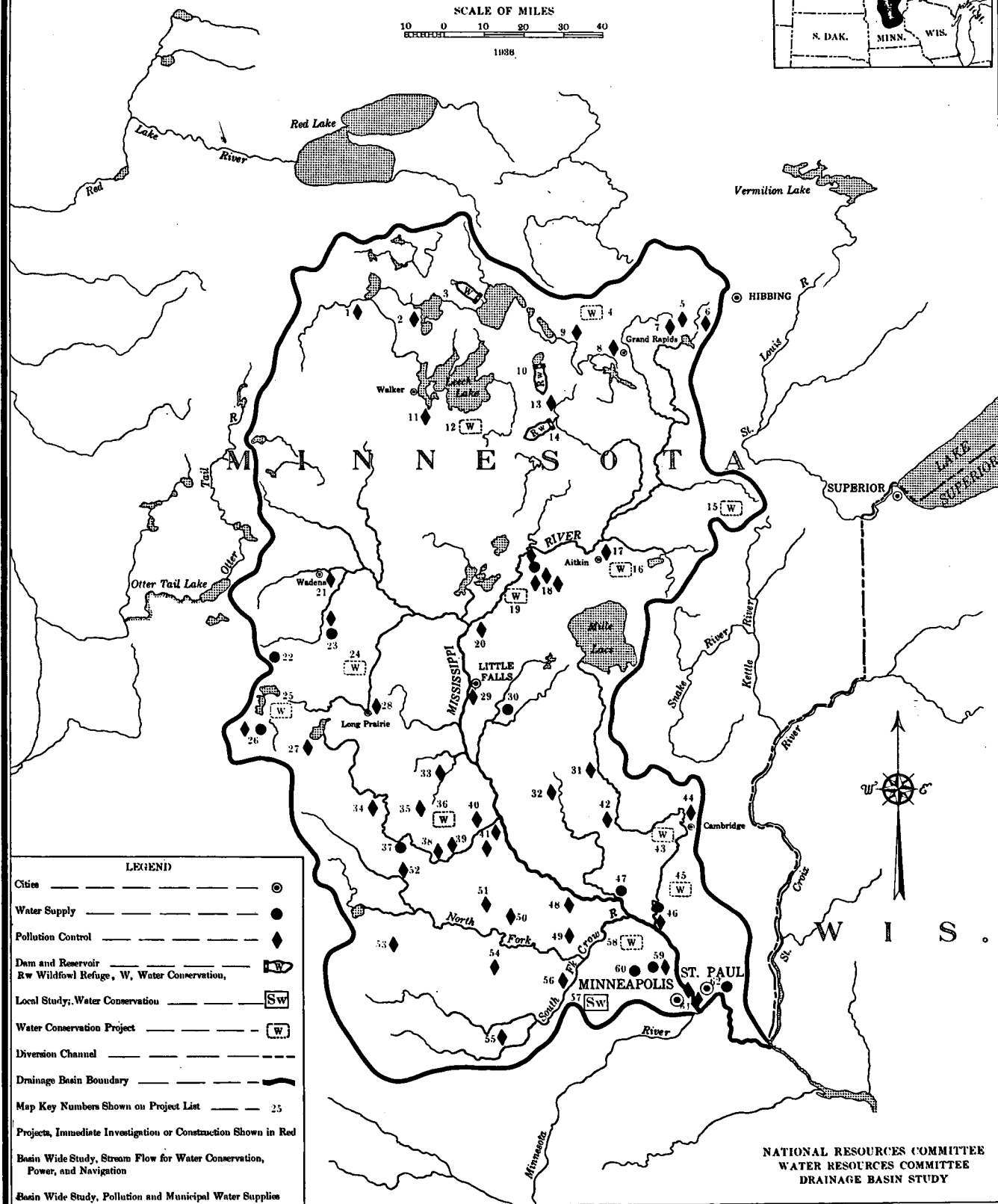
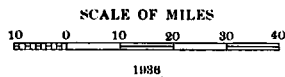
ment of wastes immediately desirable. Serious pollution exists at several points owing to untreated or partially treated wastes from cities, State institutions, and industrial plants. Several projects for pollution abatement are included in the project lists.

The outstanding *water-supply* problem of this basin concerns the future needs of St. Paul and Minneapolis. The present peak demand is about 50 percent of the minimum flow of record. Predictions of future demands indicate that it may be possible for the demand to exceed the minimum flow. These cities may be required to go to Lake Superior or the St. Croix River to satisfy future needs. Either of the alternate sources would be costly to develop and would involve either international or interstate diversions of water.

Other urban centers are in need of extensions or new supply systems.

Water power.—The Corps of Engineers has reported on 12 sites on the main stream above Minneapolis. For the period of record studied and the conditions assumed, the Corps of Engineers reports that these plants may produce about 87,000,000 kilowatt-hours of primary power and 314,000,000 kilowatt-hours of secondary power annually. Augmentation of minimum flow would increase the capacity of these plants. If the construction and operation of power plants were coordinated with a progressive program of flow correction, the sale of power should assist in financing the cost of the program.

MISSISSIPPI HEADWATERS



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Mississippi Headwaters Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A--FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of flow regulation by review of existing data and reports and collection of new data to determine means for increasing the minimum stream flow and to provide for water conservation, power development and navigation.	\$25,000	
	Study of existing water supplies and of urban centers not now supplied with waterworks to determine needs and make recommendations to improve supplies. Also to make studies and recommendations for the abatement of pollution from domestic and industrial wastes.	5,000	
57	Study and survey to determine the economic value of the Minnetonka Water Conservation project, which plans to raise the water level of Lake Minnetonka by the diversion of water from the Crow River.	5,000	
41	St. Cloud, Minn.: Sewage-treatment plant.....	420,000	Plans completed.
62	St. Paul, Minn.: Additional water treatment.....	227,000	Plans completed and ready for construction.
(1)	Anoka (46), Bertha (23), Elk River (47), Alexandria (26), Parker Prairie (22), Pierz (30), Robinsdale (59), St. Martin (37), Trommald (18), and Wayzata (60), Minn.: Water supply.	138,000	Do.
(1)	Alexandria (26), Bertha (23), Cohato (54), Glencoe (55), Grove City (53), Ah-Gwah-Ching (11), Little Falls (29), Nashwauk (5), and St. Paul (62), Minn.: Sewer systems.	114,000	Do.
(1)	Anoka (46), Bemidji (1), Robinsdale (59), Wadena (21), and Waite Park (41), Minn.: Storm sewers.	129,000	Do.
49	Buffalo, Minn.: Sewage-treatment plant.....	8,000	Plans completed.
(1)	Aitken (16), Anoka (45), Carlton (15), Cass (12), Crow Wing (19), Douglas (25), Hennepin (58), Isanti (43), Itasca (4), Stearns (36), and Todd (24) Counties, Minn.: Water-conservation projects at 108 points.	228,000	Plans completed and ready for construction.
GROUP B--FOR DEFERRED CONSTRUCTION			
(1)	Aitkin (17), Albany (35), Annandale (51), Brainerd (20), Calumet (7), Cambridge (44), Cass Lake (2), Coldsprings (39), Crosby (18), Deer River (9), Deerwood (18), Foley (32), Grand Rapids (8), Holdingford (33), Ironton (18), Keewatin (6), Long Prairie (28), Maple Lake (50), Melrose (34), Milaca (31), Monticello (48), Osakis (27), Paynesville (52), Princeton (42), Remer (13), Richmond (38), St. Joseph (40), Trommald (18), and Watertown (56), Minn.: Complete sewage-treatment plants.	\$769,000	
3	Itasca County, Minn.: Water conservation and stabilization of water levels of Sugar Lake by means of a dam.	10,000	
10, 14	Cass County, Minn.: Dams across the outlets of each of Mud and Rice Lakes to form refuges and sanctuaries for waterfowl.	20,000	
GROUP C--TIME OF CONSTRUCTION INDETERMINATE			
62	Minneapolis, St. Paul, Minn.: Addition to sewage-treatment plant for complete treatment.....	\$4,000,000	

¹ Map key number shown following community name.

5. MINNESOTA

A comprehensive plan for development of the basin's water resources must take into consideration the highly developed agricultural, dairying, and livestock industries, recreational activities, and extensive wildlife interests. Expansion and protection of the latter features are retarded by the erratic flow of the streams and fluctuations of lake levels. The principal objectives of the water plan should be (1) the correction of the present widely variant stream flow for purposes of flood control, urban water supply, and dilution of waste; (2) the preservation and enlargement of recreational and wildlife areas; and (3) the development of minor water-power projects which are widely distributed throughout the basin.

General Description

The Minnesota River Basin extends generally to the southeast across the southern part of Minnesota and comprises an area of 16,147 square miles, nearly 90 percent of which lies in Minnesota and the remainder in Iowa and South Dakota.

The Minnesota River heads in the northeast corner of South Dakota and flows into the Mississippi River at the "Twin Cities." The principal tributaries from the south, named in order downstream, are the Whetstone, Yellow Bank, Lac qui Parle, Yellow Medicine, Redwood, Cottonwood, and Blue Earth Rivers; and from the north, the Pomme de Terre and Chippewa Rivers.

Several aspects of glaciation are reflected in the general topography of the basin. Low rolling hills and smooth outwash plains are most pronounced in the west and southwest, while steep hills, lake-dotted moraines, and marshes abound in the eastern and northeastern parts. The Minnesota River follows a trough some 200 feet deep and one-half mile to 2 miles wide, eroded at the end of the last glacial period. In the headwaters and from Granite to Minnesota Falls the gradients are steep, but the river generally has a rather flat slope. Elevations of the surface range from 700 to 1,900 feet above sea level.

Flow habits of the Minnesota River and its tributaries are very erratic. Damaging floods have occurred more frequently than once in 3 years, yet at certain periods of most years there is practically no water in the river. Some flow-correction works are under construction and others have been completed, but these will have to be supplemented extensively before the floods are sufficiently controlled. Reservoirs con-

structed in this basin should be operated to serve the dual purpose of reducing flood peaks and later releasing storage to augment low-water flow and thereby to improve sanitary conditions. A complete study should be made of flow-correction possibilities, particularly in connection with tributary regulation by reservoir control. This should include a search for available reservoir sites on all rivers and should consider the development of water power concurrently with other features.

The lakes of this basin, while not extensive in area, have existing and potential value for water conservation, stream regulation, recreational centers, and wildlife habitats. Lake surfaces are normally subject to considerable lowering during drought periods, and some conservation projects have already been constructed to regulate these levels. Others that are built should be planned so that some of the lake storage may be used when most needed to increase stream flow. A study should be made of existing and future lake-level regulation projects, particularly in connection with the feasibility of their use and method of operation, for flow-correction, wildlife, and recreational purposes.

Soils of the basin are fertile and are usually composed of black clay with a sand, gravel, or mixed loam. Soil erosion presents a serious problem in various localities. The water table is close to or at the surface in the Minnesota trough and morainic basins, thus necessitating considerable land drainage, but in most of the area the soils are naturally self-draining to a water table many feet below the surface.

Climatically the basin is located in the transition belt between the humid and semiarid continental short summer types. The mean annual precipitation is approximately 25 inches, of which about two-thirds occurs during the growing season from May to September. Deciduous forests originally covered much of the eastern part of the basin, giving way to prairies in the western part.

Economic development is dependent almost entirely upon agriculture. About 90 percent of the area is available for farm use and the per-annum value of farm products has exceeded \$200,000,000. The principal crop is grain, with forage, vegetables, and sugar beets secondary. Dairying, livestock, and poultry raising are becoming increasingly important. Processing of food products is the principal manufacturing industry and an important factor in maintaining the urban population. Mineral industries are of minor

importance. The lack of known deposits of coal, petroleum, and natural gas in this basin emphasizes the necessity for careful scrutiny for water power.

Inordinately low flows of the streams, together with increasing urbanization and the presence of creamery, cannery, and other organic wastes, are creating serious problems in waste disposal which will grow more acute than at present. Many existing treatment plants are inadequate and it is important that additional waste-treatment facilities be added to many existing systems and that complete treatment be included in all new sewage systems constructed. Flow correction will alleviate present conditions, but will not remove the need for further abatement. A complete sanitary survey should be conducted in connection with the study of water supply, waste disposal, and stream pollution in urban and rural areas.

The basin's population of less than a half million is practically the same as that of New Hampshire. Less than one-fifth of the people live in urban centers of more than 2,500 population, and the population may be considered relatively stable numerically.

Recommended Plan

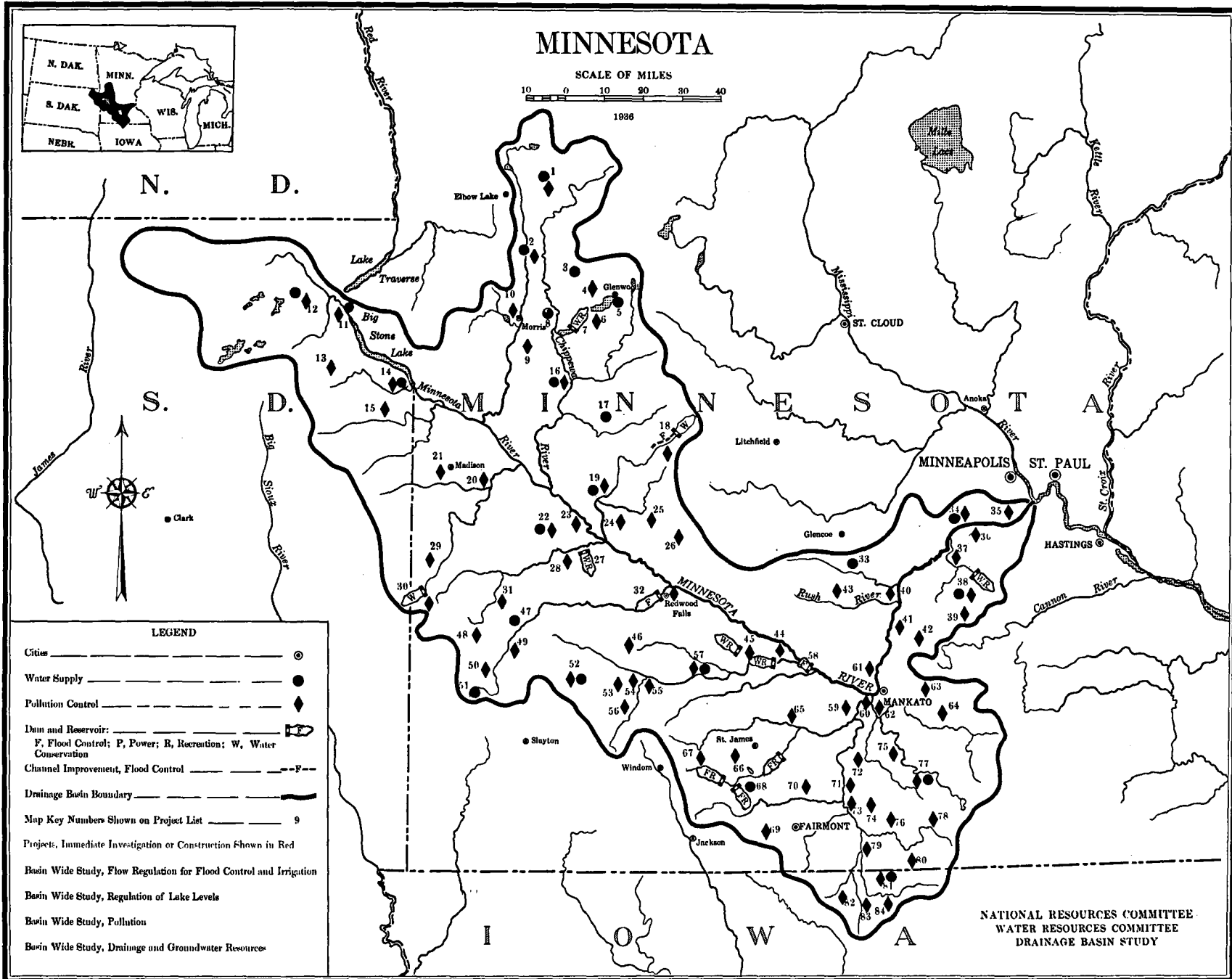
Minnesota agencies administering water resources are fully cognizant of their problems, but more information is needed to formulate a complete plan and operate it effectively. Additional hydrologic data are necessary to evaluate more accurately the gross and net amount of water resources, and a study is required of several phases of water-resource development before completely definite and specific recommendations for the long-range plan are warranted. It is expected that the need for some of the construction projects listed in this report will be modified by the information revealed by the study projects. These latter investigations should, therefore, be undertaken immediately in order to achieve the best coordination of the proposed construction program.

Water supply.—A trend exists in other sections of the United States which have underground water resources of hardness similar to those in the Minnesota River Basin to abandon ground-water supply in favor of surface supply when the latter can be developed eco-

nomically. It is quite possible that this trend will develop here, particularly in localities where ground water sources are relatively poor in quality. This contingency should therefore be anticipated in the long-range plan. Treatment plants for both softening and demineralizing ground water supplies should be provided as rapidly as they are warranted. Towns and villages which do not possess water-supply systems should be provided with such facilities when conditions warrant.

Drainage.—The region is supplied with adequate land-drainage facilities, except in small scattered areas, and in general the land-drainage program is complete. Drought and adverse financial conditions have resulted in the deterioration of some of the systems by growth of vegetation, clogging of tile, and other causes. Such works as need rehabilitation and repair should be restored to a satisfactory condition and all systems should be maintained in good order. New drainage problems may develop in connection with flow correction and water conservation projects where the raising of stored-water levels affects the elevation of the underground-water table to the detriment of agricultural land. An examination of existing land-drainage works should be conducted to determine the character and extent of the required rehabilitation and to formulate a program for its accomplishment. The study should also include an investigation of the possibilities and agricultural value of controlling water-table levels in free drainage soils to provide sub-irrigation during drought periods. In this latter connection an investigation would be desirable to determine the feasibility of supplying supplemental irrigation during drought periods by using portable pumping in the limited areas close to streams or reservoirs.

Navigation.—The Minnesota River formerly carried freight traffic and is susceptible to some development along with stream regulation. An excellent potential terminal site exists near the mouth of the river at the "Twin Cities." This site is being considered as one possibility for the development of a needed expansion of terminal facilities at Minneapolis on the Mississippi River.



Minnesota Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of flow regulation throughout basin including study to determine the functional utility of headwaters reservoirs in South Dakota.....	\$105,000	
	Study of regulation of lake levels to determine best development for each lake.....	25,000	
	Study of sanitary conditions of rivers and condition of ground waters throughout entire basin.....	40,000	
	Study and survey of land-drainage works.....	30,000	
44	New Ulm, Minn.: Complete sewage-treatment plant.....	131,000	Preliminary plans completed.
(1)	Benson (16), Dalton (1), Henderson (40), Morris (10), and Wells (78), Minn.: Sewage treatment.....	76,000	Do.
(1)	Clara City (19), Clarkfield (22), Hancock (9), and Lowry (4), Minn.: Sewer systems and sewage-treatment plants.....	127,000	Do.
(1)	New Ulm (44) and Willmar (18), Minn.: Sewer-system extensions.....	4,000	Do.
(1)	Danube (26), Delavan (74), Elysian (63), Good Thunder (72), and Hoffman (2), Minn.: Sewer systems.....	13,000	Do.
12	Sisseton, S. Dak.: Waterworks system.....	80,000	Do.
(1)	Farwell (3), Hoffman (2), and Ruthton (51), Minn.: Waterworks.....	22,000	Do.
14	Big Stone City, S. Dak.: Water-supply system.....	70,000	Do.
(1)	Benson (16), Browns Valley (11), Chaska (34), Clara City (19), Clarkfield (22), Cyrus (8), Glenwood (5), Marshall (47), New Prague (38), Tracy (52), and Triumph (68), Minn.: Water-treatment plants.....	104,000	Do.
1	Dalton, Minn.: Water-supply system and treatment plant.....	24,000	Do.
22	22 small dams and channel improvement for water conservation and flow correction in Minnesota.....	68,000	Do.
18	Willmar, Minn.: 6 dams and 6 channel improvement projects in chain of lakes for water conservation.....	135,000	Do.
(1)	Cedar (38), New Ulm (44), Scandinavian (7), Sleepy Eye (45), and Wood Lake (27), Minn.: Dams and reservoirs for water conservation and recreation.....	170,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
66	Watowwan County, Minn.: 3 dams and 2 channel improvement projects for recreation and flood control.....	\$126,000	Preliminary plans completed.
58	New Ulm, Minn.: Dam on Minnesota River below the mouth of the Cottonwood River for flood control.....	750,000	Preliminary plans completed.
15	Millbank, S. Dak.: Sewers and sewage-treatment plant.....	50,000	Preliminary plans completed.
12	Sisseton, S. Dak.: Sewage-treatment plant.....	28,000	Preliminary plans completed.
(1)	Browns Valley (11), Chaska (34), Dawson (20), Gaylord (43), Good Thunder (72), Granite Falls (23), Hopkins (35), Jamesville (64), Madison (21), Morris (10), Olivia (25), Redwood Falls (32), and Renville (24), Minn.: Sewage-treatment plants.....	304,000	Preliminary plans completed.
(1)	Big Stone City (14) and Wilmot (13), S. Dak.: Sewers and sewage treatment plants.....	48,000	Preliminary plans completed.
(1)	Amboy (71), Blue Earth (79), Bricelyn (80), Butterfield (66), Canby (29), Easton (76), Hanley Falls (28), Henderson (40), Hendricks (30), Ivanhoe (48), Jordan (37), Lake Crystal (59), Lambertson (64), Le Center (42), Le Seur (41), Madelia (65), Mankato (62), Mapleton (75), Minneota (31), Minnesota Lake (77), Montgomery (39), Mountain Lake (67), New Prague (28), North Mankato (60), Russell (49), St. Peter (and State institutions) (61), Sanborn (55), Shakopee (36), Sleepy Eye (45), Springfield (57), Starbuck (6), Tracey (52), Truman (70), Tyler (50), Wabasso (46), Walnut Grove (53), Welcomes (69), Westbrook (56), and Winnebago (73), Minn.: Sewage-treatment plants.....	1,005,000	Preliminary plans completed.
81	Rake, Iowa: Water-supply system.....	25,000	Preliminary plans completed.
30	Lincoln County, Minn.: Dam for water conservation in Lake Hendricks.....	20,000	Preliminary plans completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Buffalo Center (84), Lakota (83), Ledyard (82), and Rake (81), Iowa: Sewer systems.....	\$57,000	Preliminary investigation made.
(1)	Green Isle (33), Minnesota Lake (77), Murdock (17), and Springfield (57), Minn.: Waterworks systems.....	156,000	Preliminary investigation made.
32	Redwood Falls, Minn.: Dam for flood control.....	500,000	Preliminary investigation made.

¹ Map key number shown following community name.

6. UPPER MISSISSIPPI: EASTERN TRIBUTARIES

A general program of small works to restore the natural levels of the many lakes and to regulate their outflow is an outstanding water need of this region. Objectives of such a program include the reduction of damaging soil erosion, the lessening of the silt burden of the streams, the preservation of important recreational values, and the improvement of power production. Certain projects fitting into this general program can be recommended for immediate construction. A special investigation should be made to complete the plan. Pollution by sewage and industrial wastes should be corrected in some places and a general study should be instituted to plan similar measures for future needs. Improvements to water supplies are locally needed. Present and potential water-power development should be investigated with reference to the power market.

General Description

The group of tributary basins comprising this region covers most of northeastern Wisconsin and a part of Minnesota, an area of about 22,600 square miles, northward from La Crosse, Wis. The principal streams from south to north along the Mississippi are the La Crosse, the Black, the Trempealeau, the Buffalo, the Chippewa, and the St. Croix Rivers.

The St. Croix and the Chippewa have their headwaters in the many lakes and swamps of the Superior Highlands at altitudes of about 1,600 feet—rough, wooded country. Toward the south the land is rolling with occasional patches of prairie. The entire region was originally clothed with forests, which supported its early development. Lumbering has long since declined to insignificance.

The cut-over lands in early days were quickly cleared and occupied for farming. Much of this land has since turned out to be submarginal in quality and has been abandoned or converted to dairying—an adaptation successful in only the better districts. Only in the area between the lower St. Croix and the Chippewa River are more than one-third of the farms listed as first class. Since 1920 the southern marginal land has continued to lose value.

In the northern country, rich in rivers, lakes, forests, and game, recreational activities have provided new values. Summer homes, cottages, resorts, clubs, camps, and game preserves afford the basis for a highly profitable industry which supports a large proportion of the permanent population. The recession of lake

shore lines due to lowered levels in recent years has impaired some of these recreational values.

The population of the combined basins in 1930 was 583,000 of which 374,000 was rural. Only four cities had a population greater than 7,000, La Crosse (39,600); Eau Claire (26,300); Chippewa Falls (9,500); and Stillwater (7,200). The urban population increased slowly from 1920 to 1930, reflecting manufacturing and commercial growth. The rural population as a whole decreased slightly in the same period. In many places the summer influx is greater than the permanent population. Only at La Crosse has the early activity in lumbering been replaced by a diversity of modern manufacture.

The average annual rainfall is about 30 inches for the region. Average annual temperatures range from 46° at the south to 39° at the north.

The topography and stream flow are favorable for the development of relatively small water-power installations. A considerable capacity has been installed and many more or less advantageous sites remain.

All of the communities of more than 1,000 population have public water supplies, nearly all of which come from underground sources. Water from shallow wells is hard and is rather highly mineralized with iron and magnesium. Shallow sources are quite generally polluted and are difficult to obtain in many places in the uplands. Artesian sources are satisfactory, except possibly for hardness. The relatively small draft upon the artesian supply has so far had little effect upon the water level.

Clearing of the original forests has probably contributed to the erratic variations in stream flow. Wrong cropping methods applied to the cleared land have aggravated the serious soil erosion, apparent particularly in the southern part of the region. As should be expected, the silt load of the streams is very high, especially after storms.

Recommended Plan

Regulation of lake levels and stream flow is the purpose of many of the recommended projects and of an investigation intended to determine a general program of such works. The required installations are small and scattered but are important in their cumulative effect.

Water-supply improvements are recommended for immediate or deferred construction, according to the

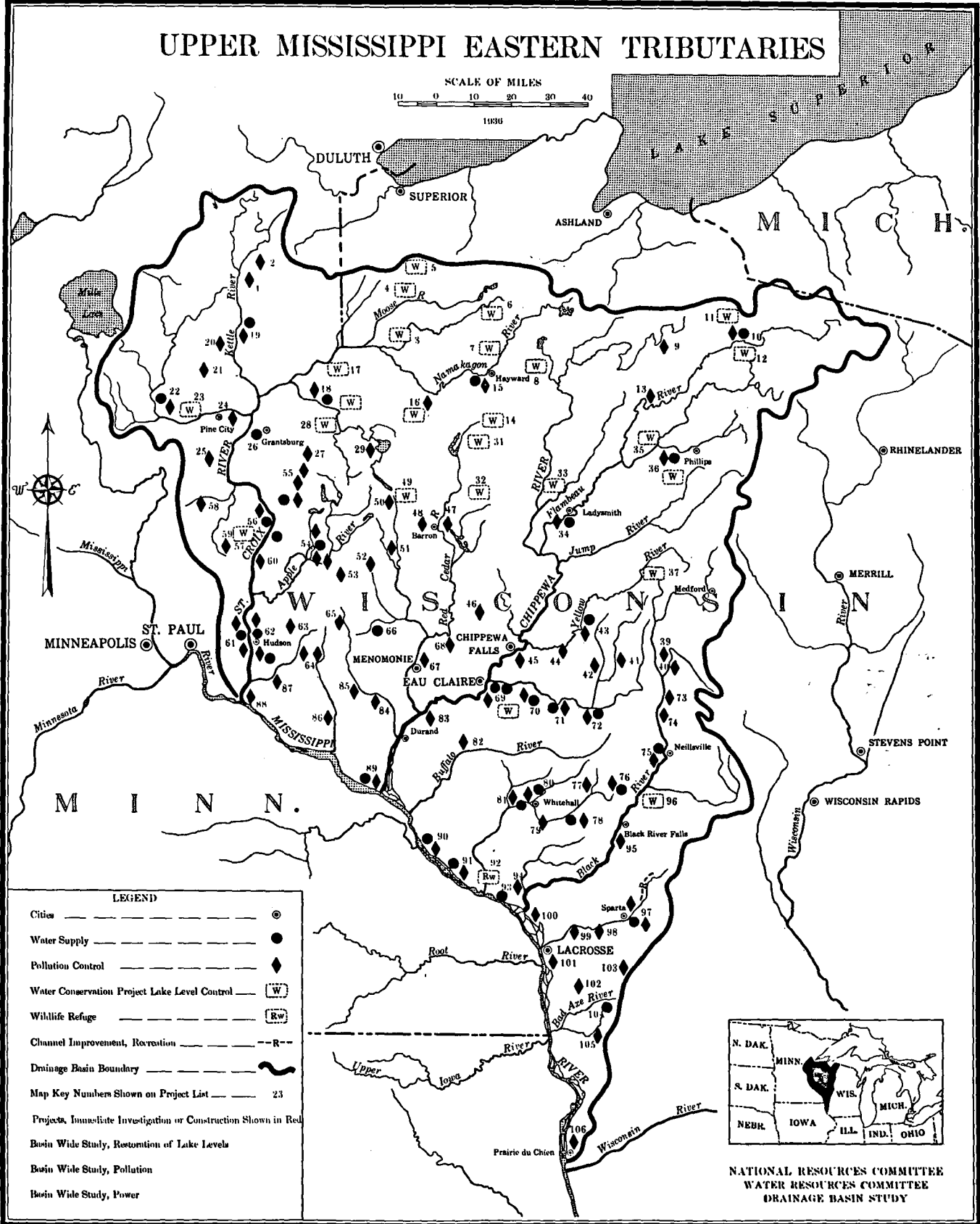
urgency of the need. Treatment plants to remove mineral content are quite generally desirable.

Sewer systems or sewage-treatment plants are needed at many places where the waste discharge militates against other uses, and they will be more widely needed if the population and recreational activities of the region increase. Industrial wastes constitute a problem, not yet acute, but worthy of attention in precaution against future pollution. An investigation is recommended to form a basis for intelligent future action in these matters.

Water-power potentialities of the streams, developed and undeveloped, should be considered in connection with the regulation of stream flow and lake levels as well as in their own right. At some of the more desirable sites market conditions for power will govern; at others the possibilities of multiple use for regulation, power, and recreational benefit may combine to justify construction. In order to harmonize the possibly conflicting interests of diverse use and to rationalize the exploitation of these power resources, a study is recommended to formulate an orderly program for their development.

UPPER MISSISSIPPI EASTERN TRIBUTARIES

SCALE OF MILES
0 10 20 30 40



LEGEND

- Cities ———— ○
- Water Supply ———— ●
- Pollution Control ———— ◆
- Water Conservation Project Lake Level Control ———— [W]
- Wildlife Refuge ———— [Rw]
- Channel Improvement, Recreation ———— -R-
- Drainage Basin Boundary ———— ~~~~~
- Map Key Numbers Shown on Project List ———— 23
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Restoration of Lake Levels
- Basin Wide Study, Pollution
- Basin Wide Study, Power



NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Upper (Mississippi) Eastern Tributaries Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of lake levels and storage by review of existing data and reports and the collection of new data to form the basis for a program designed to restore lake levels and increase storage of precipitation.	\$10,000	
	Study of general sanitation conditions in urban and rural areas to determine needs, and to make recommendations for abatement of pollution from domestic and industrial wastes.	10,000	
	Study to determine potential water-power developments and their interrelation with existing developments.	15,000	
(1)	Bolger (32), Clam Lake (28), Lake of the Falls (11), Minerva (17), and Nancy (3), Wis.; Pokegama Lake (Pine County) (23), Minn.; and Round Lake (8), St. Croix (4), Sissabagama (14), and Totogatic (7), Wis.: Water conservation.	430,000	Ready for construction.
97	Sparta, Wis.: Water supply system and sewage treatment, including tanks for Camp McCoy.....	27,000	
(1)	Askov (19), Minn.; Baldwin (64), Wis.; Bayport (State prison) (61), Minn.; Bloomer (46), Clear Lake (53), Frederick (27), Coon Valley (102), Glenwood (65), Hammond (64), Hayward (15), Hudson (62), and Medford (38), Wis.; Mora (22) and Pine City (24), Minn.; St. Croix Falls (54), Wis.; Stillwater (61), Minn.; Webster (18), Wis.: Sewers or sewage treatment.	666,000	Do.
(1)	Askov (19), Minn.; Augusta (71), Wis.; Bayport (State prison) (61), Minn.; Dresser Junction (56), and Eau Claire (69), Wis.; Mora (22), Minn.; North Hudson (62), Wis.; Taylor's Falls (56), Minn.; and Webster (18), Wis.: Water-supply systems or water-treatment plants.	179,000	Do.
57	Chisago County, Minn.: Chisago Chain of Lakes project for conservation of water.....	260,000	Ready for construction pending legal settlement.
(1)	Bayfield (6), Douglas (6), Eau Claire (69), Iron (12), Price (36), Rusk (33), Sawyer (35), and Washburn (16), Counties, Wis.: Lake-level control and water conservation in 13 lakes	28,000	Surveys made, plans not complete.
92	Buffalo and Trempealeau Counties, Wis.: Trempealeau River Migratory Waterfowl Refuge project.	150,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
45	Chippewa Falls, Wis.: Primary sewage treatment plant.....	\$143,000	
69	Eau Claire, Wis.: Primary sewage treatment plant.....	394,000	
(1)	Alma Center (77), Amery (54), Augusta (71), and Bangor (58), Wis.; Barnum (2), Minn.; Barron (48), Black River Falls (95), Blair (79), Cadott (44), Cameron (47), Cashton (103), Colfax (68), Cornell (43), Cumberland (50), Durand (83), Ellsworth (86), Elmwood (84), Fairchild (72), and Fall Creek (70), Wis.; Forest Lake (59), Minn.; Fountain City (91), Galesville (94) and Glidden (9), Wis.; Hinckley (21), Minn.; Independence (81), La Crosse (101), Ladysmith (34), Loyal (74), Menomonie (67), Merrillan (76) and Mondovi (82), Wis.; Moose Lake (1) and Mora (22), Minn.; Neillsville (75) and New Richmond (83), Wis.; North Branch (58), Minn.; North Hudson (62), Onalaska (100), Osceola (60), Owen (40), Park Falls (13), Pepin (89), Prairie du Chien (106), Prescott (88), Rice Lake (47), and River Falls (87), Wis.; Rush City (25) and Sandstone (20), Minn.; Shell Lake (29), Sparta (97), Spooner (16), Spring Valley (85), and Stanley (42), Wis.; Taylors Falls (56), Minn.; Thorp (41), Viroqua (105), West Salem (99), and Whitehall (80), Wis.: Sewer systems and primary or secondary sewage treatment plants.	2,030,000	Plans completed.
(1)	Askov (19), Minn.; Clear Lake (53), Hayward (15), and Hudson (62), Wis.; Mora (22), Minn.; and St. Croix Falls (54), Wis.: Sewage treatment plants.	83,000	
(1)	Altoona (69), Boyceville (66), Centuria (55), Cochrane (90), Cornell (43), Fairchild (72), Fall Creek (70), Fountain City (91), Independence (81), Ladysmith (34), Merrillan (76), Neillsville (75), Pepin (89), Phillips (36), St. Croix Falls (54), Taylor (78), Trempealeau (93), Westby (104), and Whitehall (80), Wis.: Water-supply systems and water-treatment plants.	635,000	
(1)	Lakes: Bashaw (18), Briggs (18), and Devils (18), Burnett (18) County; Duck (49), Barron County; Dunham (18), and Eagle (18), Burnett (18) County; East Fork Rolling (31), Sawyer County; Eau Claire Lakes (6), Bayfield and Douglas (6) Counties; Echo (12), Iron County; Fifield (36), Price County; Fisher Rolling (12), Iron County; Flambeau Rolling (36), Price County; Glen Flora (33), Rusk County; Grassy (36), Price County; Hawkins (33), Rusk County; Horseshoe (49), Barron County; Josie (33), Rusk County; Little Elk #1 (36), Price County; Long (18) and Loon (18), Burnett (18) County; Mackey Brook (16), Washburn (16) County; Middle (33), Rusk County; Mud (18), Burnett (18) County; Ojibwa Rollings (31), Sawyer County; Oxbow (12), Iron County; Parks Falls (36), Price County; Pas Wa Wong (31), Sawyer County; Pike Rolling (12), Iron County; Parks Falls (36), Rusk County; Radigan (6), Douglas (5) County; Radisson Rolling (31), Sawyer (31) County; Rice (12), Iron County; Rice (33), Rusk County; Sand (31), Sawyer (31) County; Shell (16), Washburn (16) County; Silver Creek (37), Taylor County; Spider (12), Iron County; Squaw Creek (36), Price County; Taber (18), Burnett County; West Fork Rolling (31), Sawyer County; Wigoor (33), Rusk County, Wis.: Lake level control dams for water conservation.	270,000	
(1)	Centuria (55), Clayton (52), Cochrane (90), Greenwood (73), Luck (55), Mercer (10), Milltown (55), Phillips (36), Taylor (78), Turtle Lake (51), and Withee (39), Wis.: Sewers and sewage treatment plants.	200,000	
(1)	Grantsburg (26), Hayward (15), Hudson (62), and Mercer (10), Wis.: Water-supply systems and water-treatment plants.	60,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Amery (54), Augusta (71), Bangor (98), Barron (48), Black River Falls (95), Blair (79), Cameron (47), Chippewa Falls (45), Colfax (68), Cornell (43), Durand (83), Eau Claire (69), Elmwood (84), Fountain City (91), Galesville (94), Glidden (9), Independence (81), Ladysmith (34), Loyal (74), Menomonie (67), Merrillan (76), Mondovi (82), Neillsville (75), New Richmond (83), North Hudson (62), Onalaska (100), Osceola (60), Owen (40), Park Falls (13), Prairie du Chien (106), Pepin (89), Prescott (88), Shell Lake (29), Sparta (97), Spring Valley (85), Thorp (41), West Salem (99), and Whitehall (80), Wis.: Complete sewage treatment.	\$1,000,000	Rough estimate of work desirable within 5 to 10 years.
96	Clark and Jackson Counties, Wis.: 15 timber dams for water conservation.....	24,000	
96	Clark and Jackson Counties, Wis.: 85 concrete dams for water conservation.....	445,000	
97	Sparta, Wis.: Trout stream improvement at Camp McCoy.....	7,000	

1 Map key number shown following community name.

7. UPPER MISSISSIPPI: WESTERN TRIBUTARIES

The high economic value of the extensive agricultural and related industrial interests of the basins of the upper western tributaries of the Mississippi River in southeast Minnesota and northeast Iowa warrants an intensive development of the water resources of this area. The outstanding water problems grow out of low summer flow, excessive pollution, some diminishing of sub-surface urban water supplies, recurrent damage from floods, and limited recreational facilities. Minor problems include rehabilitation of drainage projects and development of water power. The long range water plan contemplates the complete treatment of wastes, the treatment of urban water supplies for hardness and mineral removal, levee construction and channel modification to effect flood correction, expansion of recreational facilities, and drainage rehabilitation. The plan also includes the construction of such flow correction works, water-power developments and improvements of surface water supply sources as are found, by special studies, to be warranted.

General Description

The southeast Minnesota-northeast Iowa minor drainage basins tributary to the Mississippi River comprise an area of 14,350 square miles, of which 8,235 are in Iowa and 6,295 in Minnesota. The Mississippi River forms the northeastern boundary from South St. Paul, Minn., to Clinton, Iowa. The northwestern boundary is the Minnesota River Basin, and the southwestern is the Cedar River Basin divide. The longer rivers rise in a lake land about 1,400 feet above sea level in southeastern Minnesota. The Cannon River flows northeastward; the Sumbro, Root, and upper Iowa, eastward; and the Turkey and Wapsipinicon, southeastward to the Mississippi River, which has altitudes at South St. Paul of 685 feet, and at Clinton of 615 feet.

The basin is rugged along the Mississippi River from Winona to Clinton, consisting of wooded bluffs and hills. Stream valleys are steep and narrow.

The total population of the area is about 580,000, of which about 46 percent is urban.

Dairy and stock farming are common agricultural activities and creameries are found in nearly every city. Cheese factories are numerous in the Minnesota section; South St. Paul, Faribault, and Winona, Minn., and Dubuque, Iowa, have meat-packing plants. There are breweries at Faribault, Mantorville, and Winona, Minn., Dubuque and Clinton, Iowa. Winona, Dubuque, and Clinton have wood-working plants. South St.

Paul, Red Wing, Wabasha, Winona, Dubuque, and Clinton have railroad shops and yards. Rochester, Minn., is a medical center.

The annual range of temperature is from below zero to 100° above. The average annual rainfall varies from 35 inches in the south to 27 inches in the north. Steep slopes and scarcity of natural storage in lakes cause rapid run-off and reduce percolation. The run-off averages about 7 inches. A wide range exists between maximum and minimum flows.

Water supplies for urban centers come entirely from underground sources. Rural areas are dependent upon shallow wells, the quality of which ranges from poor to average.

Recommended Plan

The *water supply* in Iowa appears to be adequate for future needs. In parts of Minnesota there is evidence of dangerous depletion of the deep ground water. Some of the existing subsurface sources may eventually have to be supplemented or replaced by surface supplies. A long-range plan should anticipate this contingency. Necessary additions should be provided for existing water systems and new facilities constructed as rapidly as communities can afford them. Provision for softening and demineralizing the water supplies should also be anticipated.

Pollution abatement is essential not only for preservation of health but also for the purpose of realizing the full value of the recreational facilities afforded. The seasonal low river flow intensifies pollution problems on the tributary streams. Sewage-treatment facilities being constructed by St. Paul and Minneapolis will partially alleviate existing pollution conditions on the Mississippi River. River flow correction by reservoir control, though expensive, would create values in improved sanitation, recreational development, and possible future water power as well as water supply. There are many communities in this basin that are in immediate need of sewer systems or sewage treatment plants.

Flood control.—The streams are rather flashy in character as a result of steep slopes, narrow valleys, and a scarcity of natural and artificial storage. Periodic flood damage occurs to croplands and to urban, railway, and highway property. The high ratio of length to width of areas damaged by floods makes flood correction by levees and channel straightening expensive. The bottom lands along the Mississippi in Iowa

are more or less effectively protected by levees from overflow.

Flow correction by reservoir control probably will be costly on all of the streams. However, the possibilities should be carefully studied.

A few water-conservation and flow-regulation projects involving lake-level regulation have been constructed on the Cannon River, principally near the headwaters. It is proposed to construct 11 additional dams on this river. Proposals also have been made that certain sections of existing levees at Green Island, Iowa, be raised and enlarged. Cleaning and straightening the channel below Cascade, Iowa, has been suggested.

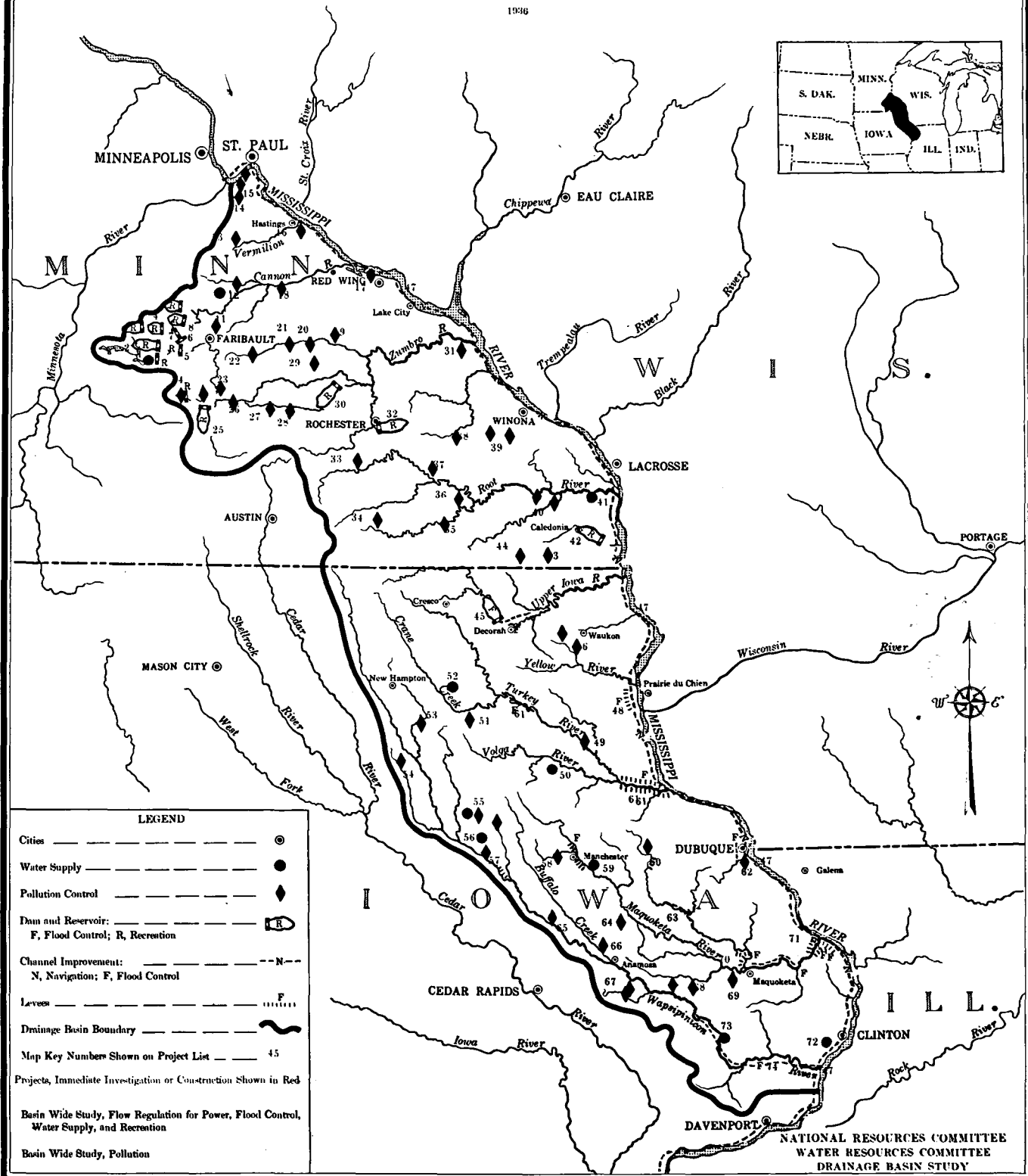
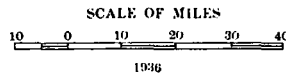
Water-power development beyond present installations is uneconomical unless such development can be coordinated with flow correction to reduce flood damage. Lack of regulation facilities to increase extremely low river flows reacts to the disadvantage of water-power development in this region.

Recreational facilities should be expanded in this basin. Several small State parks with other small areas surrounding artificial and natural lakes on the

Cannon River, and parks and bathing beaches along the Mississippi River, are the only public recreational facilities in this region. The upper reaches of the tributary streams and some of the Mississippi sloughs that are unaffected by pollution provide good fishing. The upper Mississippi wildlife refuge, created by the Congress, straddles the Mississippi River in the eastern part of this basin. The navigation pools now being created in the river will be more valuable for wildlife if pollution is prevented. Bathing in the Mississippi River is hazardous on account of the pollution brought in from Minneapolis, St. Paul, South St. Paul, and other river towns and by the tributaries from the upland urban centers. Lake Pepin on the Mississippi River affords recreational possibilities which are not as yet completely developed. Three dams for creation of artificial lakes in this area are proposed.

Excessive *soil erosion* causes the heavy silt loads carried by the streams following severe storms. This condition is detrimental to the canalization of the Mississippi River and contributes to the pollution of the streams.

UPPER MISSISSIPPI WESTERN TRIBUTARIES



Upper (Mississippi) Western Tributaries Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
47	Mississippi River from mouth of the Missouri River to Minneapolis: 9-foot navigation channel including 26 dams and locks. Study to determine the economic feasibility of works for flow improvement in combination with water power, flood control, future water supplies, and recreation throughout the basin. Study of sanitation conditions in urban and rural areas to determine needs for abatement of pollution from domestic and industrial waste.	\$35,000,000	Under construction: Estimated cost needed to complete project.
(1)	Houston (40), Lewiston (39), and Owatonna (23), Minn.: Sewage treatment plants for partial treatment.	30,000	
(1)	Anamosa (66), Dyersville (60), Elkader (49), Independence (57), Manchester (58), Maquoketa (69), and Monticello (64), Iowa: Complete sewage treatment plants.	5,000	
(1)	Central City (65), Iowa; Fairbault (11), Minn.; Fredericksburg (53) and Hawkeya (51), Iowa; South St. Paul (14), Minn.; Tripoli (54), Iowa; and West St. Paul (15), Minn.: Sewage treatment plant extensions.	253,000	Plans completed.
31	Kellogg, Minn.: Sewer system and sewage treatment plant.	297,000	Preliminary plans only.
(1)	Olin (67) and Oxford Junction (68), Iowa: Primary sewage treatment plants.	39,000	Partial only; plans completed.
(1)	Oelwein (55) and Waukon (46), Iowa: Preliminary treatment plants for industrial waste from creamery.	33,000	Plans completed.
(1)	Colamus (73), Comanche (72), Delhi (59), and Hazelton (56), Iowa; Hokah (41) and Northfield (12), Minn.; Oelwein (55) and Volga (50), Iowa; Waucoma (52), Minn.; and Waterville (1), Iowa: Water supply systems.	9,000	Preliminary plans only.
(1)	Houston County, Beaver Valley Dam (42); Le Sueur County, Volney (4), and Dora (3), dams; Olmsted County, Shady Lake (30), and Silver Creek (32), dams; Rice County, Cedar (2), Dudley (7), French (6), Lower Hatch (1), Mazoska (8), Union (9), and Willings (5), dams; Steele County, Owatonna (25), dam; Waseca County, Watkins (24), dam, Minn.: Dams for water conservation and recreational purposes.	10,000	Do.
45	Decorah, Iowa: Reservoir at mouth of Dry Run and channel enlargement on Upper Iowa River.	252,000	Partial plans only.
48	McGregor, Iowa: Construction for flood control.	156,000	Preliminary plans completed.
71	Green Island, Iowa: Iowa levee and drainage district No. I: Improvement to levee.	120,000	Detail plans being prepared. Authorized by Congress.
63	Cascade, Iowa: Cleaning and straightening channel North Fork of the Maquoketa River for flood control.	115,000	Authorized by Congress. Detail plans being prepared.
		68,000	Necessary sum to complete project now under way.
		20,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Caledonia (42), Cannon Falls (18), Chatfield (37), Claremont (26), Dodge Center (27), Farmington (13), Hastings (16), Houston (40), Kasson (28), Kenyon (22), Lanesboro (36), Mabel (44), Mazeppa (19), Northfield (12), Pine Island (29), Preston (35), Red Wing (17), St. Charles (38), South St. Paul (14), Spring Grove (43), Spring Valley (34), Stewartville (33), Wanamingo (21), Waseca (24), and Zumbrota (20), Minn.: Sewage treatment plants.	\$577,000	
(1)	Houston (40) and Lewiston (39), Minn.; Oelwein (55), and Olin (67), Iowa; Owatonna (23), Minn.; Oxford Junction (68) and Waukon (46), Iowa: Secondary sewage treatment plants.	410,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
58	Manchester, Iowa: River wall for flood protection.	\$200,000	Plans not available.
60	Dyersville, Iowa: River wall for flood protection.	30,000	Do.
57	Independence, Iowa: Levee for flood protection.	15,000	Do.
62	Dubuque, Iowa: Diversion to Little Maquoketa River of storm run off from Couler Valley for relief of storm sewers.	18,000	Do.
61	Turkey River, Iowa: Levees from the mouth to Volga, and levees and channel straightening from Clermont to Eldorado for flood protection.	1,579,000	Do.
(1)	Maquoketa River, Iowa: 25 miles of new levee and 8 miles of channel straightening between Rockaway and Maquoketa (71); 15 miles of levee and 1 mile of straightening channel on North Fork from mouth to Fulton (70).	1,738,000	Do.
74	Wapsipinicon River, Iowa: Straightening river channel between mouth and Oxford Mills for flood protection.	1,736,000	Do.

1 Map key number shown following community name.

8. WISCONSIN RIVER

The control of pollution by sewage and industrial wastes is needed in the Wisconsin River Basin to protect the recreational and also the industrial uses of the water. Improved regulation of the stream flow will increase power production at the extensive installations already developed and at future installations, for which there are several favorable sites. Such regulation would serve also to reduce the degree of pollution at low water and would materially benefit the recreational facilities that support an important part of the economic activity of the region. Investigations are recommended to determine coordinated plans for stream flow regulation and power development, and to formulate a program for improving sanitary conditions. Study of a local flood problem affecting some of the lands should also be undertaken. New or improved water supply systems are listed for construction at many small communities.

General Description

The basin of the Wisconsin River is a long narrow area extending through the middle of Wisconsin. The river rises in a maze of streams, lakes, and swamps in the glacial drift near the northern edge of the State, flows southward through a rolling country for most of its length, and curves to the west to join the Mississippi. Its principal tributaries are the Tomahawk, Rib, Eau Claire, Lemonweir, Baraboo, and Kickapoo Rivers. The total area here considered is about 12,800 square miles, including 1,100 in minor basins draining into the Mississippi.

Most of the region was originally forested. The native timber has been cut and second growth now covers large sections where the soil is inferior. Lumbering is no longer important but is being replaced in some degree by woodworking, pulp and paper making, and other forest-products industries, aided by the availability of water power. A long-range program of forest conservation and power development would encourage further growth of such activities.

With some exceptions, the lands are not particularly favorable for agriculture, but dairying is carried on throughout the basin—usually in combination with one or more other farming operations. Agricultural products and especially milk products are the basis of most of the manufacturing. A few of the cities have exploited the recreational advantages and scenic beauty of the forests, lakes, and streams, and service summer

visitors in numbers greater than their permanent population.

Average annual temperatures range from 47° in the south to 39° in the north. The growing season is relatively short. Average annual precipitation is 29 to 32 inches, with snowfall of 50 inches in the north.

The total population is about 385,000, about half of which is urban. Communities of more than 10,000 population are Wausau (23,760) and Stevens Point (13,620); there are 10 others with more than 3,000. The rural areas are sparsely settled with about 6 per square mile in the north and 14 in the south.

The Wisconsin River at its mouth discharges an average of nearly 10,000 cubic feet per second, or about 7,000,000 acre-feet per year. The flow of the main stream is fairly regular because of the extensive natural storage provided by the lakes and also because of some artificial regulation. Flood danger is not of consequence except on the Kickapoo and Galena Rivers. Levees have removed the threat of flood damage at Portage.

The river falls 1,021 feet in its 428-mile course. There are many water-power stations on the main stream and on the tributaries; the total developed capacity is nearly 155,000 horsepower. More than half of this is operated by paper companies. There are many undeveloped sites.

Stream pollution is extensive from the discharge of untreated urban sewage and of industrial wastes from paper mills, canneries, and milk-product plants. Treatment plants are widely needed to protect health, recreational values, and industrial water uses.

Most of the urban and rural water supplies are derived from underground sources, which in general are somewhat hard and contain iron and manganese. Land drainage in some places has lowered the underground water level in drought years. To correct this, small dams and control works in drainage ditches have been quite generally and successfully constructed; the resulting partial stream control has proved useful also in storing water for fighting peat fires and forest fires. The central Wisconsin game projects of the Resettlement Administration are restoring marsh conditions by damming small streams and drainage ditches.

Recommended Plan

Regulation of stream flow is the objective of a group of recommended projects. Lake levels in the upper basin are rather closely regulated, naturally or by

storage operations. In some parts of the middle basin there is still a considerable fluctuation. A private company controls and operates 208,300 acre-feet of storage in the headwaters. The Big Eau Pleine Reservoir, now under construction by private interests, will add 100,000 acre-feet early in 1937 under a charter empowering the company to collect tolls from power operations in proportion to benefits received. Excellent potential storage sites are available to bring the total storage to 2,060,000 acre-feet, which would control the entire drainage area above Table Rock, would be equivalent to 9,500 cubic-feet per second for 120 days, neglecting evaporation losses, and would provide nearly complete control over 6,900 square miles, or about 60 percent of the total drainage area of the basin.

According to the proposed plan, 35 percent of the available storage would be operated to improve the primary output of eight existing power plants and one proposed plant at Knowlton. All of the storage would benefit the existing plants at Kilbourn and Prairie du Sac and the proposed plants at five new sites. These five proposed plants could develop, under present flow conditions, without any improvement, 40,000 kilowatts 90 percent of the time, according to estimates by the Corps of Engineers. Seven additional reported sites, and others, should also be considered.

Because of its magnitude and regional significance, public participation seems necessary in such an ex-

tensive plan and operating control should be exercised by some public agency in the general interest. Other values than those of power production are to be considered, including the large but intangible values of recreation. An investigation is recommended to determine a program for the orderly development of these possibilities.

Pollution abatement measures should be carried through as rapidly as funds are available, for adequate treatment of wastes and protection of urban and rural water supplies. Specific projects in many places are recommended for construction. Conditions are not sufficiently understood to plan a course of action for the region as a whole, and a special study is therefore recommended to define the problem and to indicate a rational program of corrective construction.

Water supply projects recommended for construction include extensions to existing systems and improvements where the need is indicated. Protection of present and future supplies should be considered in connection with the study of stream pollution just mentioned.

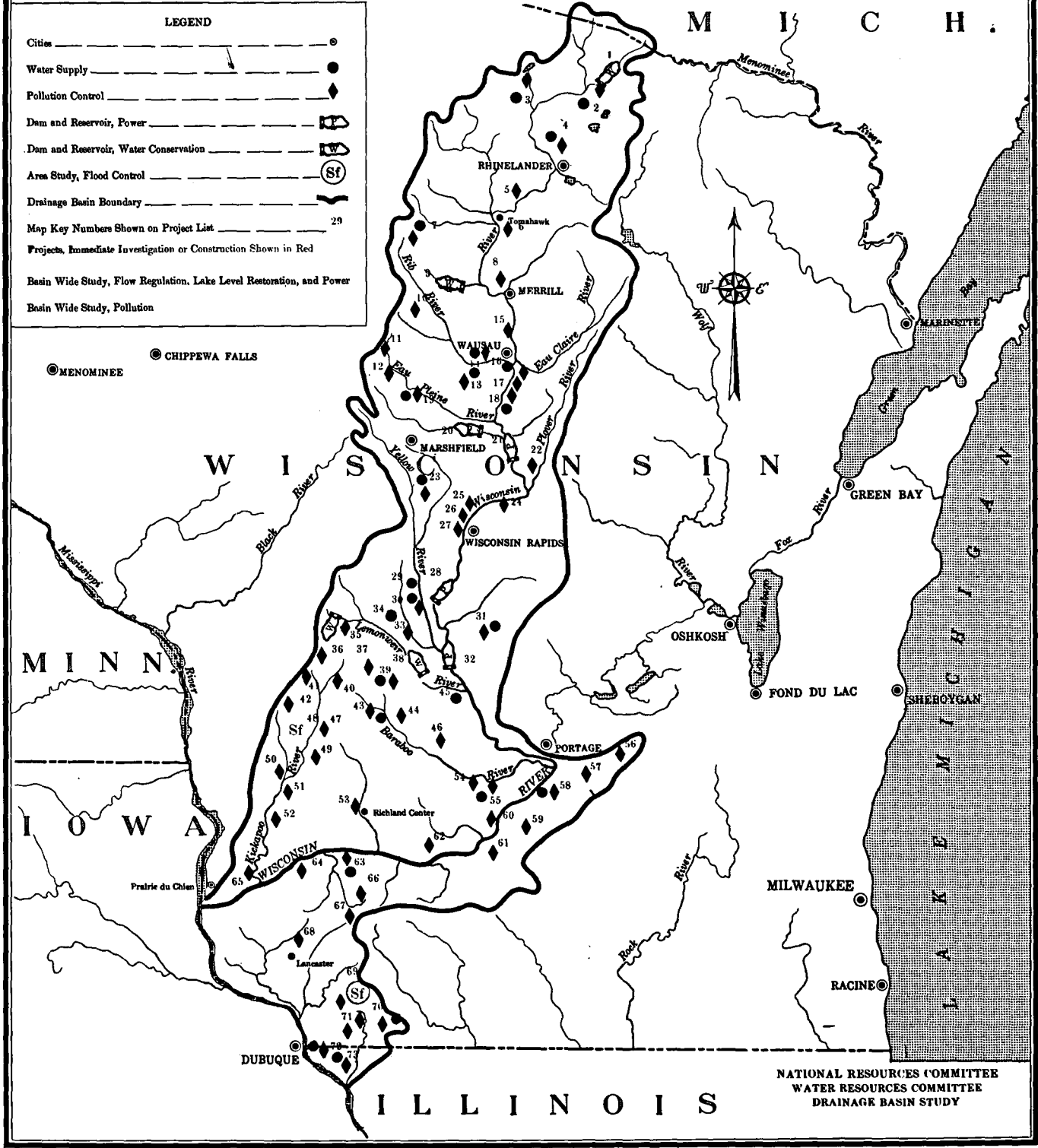
Flood control in sections threatened by the Kickapoo and Galena Rivers should be provided for in a plan to result from a third investigation to determine the most practical and economical means of protection.

WISCONSIN



LEGEND

- Cities _____ ●
- Water Supply _____ ●
- Pollution Control _____ ◆
- Dam and Reservoir, Power _____ [Dam Symbol]
- Dam and Reservoir, Water Conservation _____ [Dam Symbol]
- Area Study, Flood Control _____ (Sf)
- Drainage Basin Boundary _____ [Wavy Line]
- Map Key Numbers Shown on Project List _____ 29
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Flow Regulation, Lake Level Restoration, and Power
- Basin Wide Study, Pollution



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Wisconsin Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION AND CONSTRUCTION			
	Study of flow regulation and power development problems; lake level regulation and the possibilities of diverting part of the Wisconsin flow into the Fox River to increase its low flows for sanitary purposes.	\$50,000	
(9)	Study of waste disposal and pollution of water supplies in the basin to supplement existing information and to formulate a program for improved sanitary conditions throughout entire basin	10,000	
	Study to determine most practical and economical means of effecting flood control in Kickapoo (48) and Galena (69) Rivers.	10,000	Should be coordinated with study of Wisconsin River regulation.
38	New Lisbon, Wis.: Dam to control lake level and restore old flowage.....	35,000	
35	Monroe County, Wis.: Dam to create new lake at Tomah Lake.....	36,000	No plans reported. Cost estimates only are available.
(1)	Abbotsford (11), Colby (12), and Eagle River (2), Wis.; Galena (73), Ill.; Lodi (59), Minocqua (3), Prairie du Sac (60), Tomah (35), and Wonowoc (44), Wis.: Sewer systems and/or sewage treatment plants.	357,000	Preliminary plans and estimates completed.
(1)	East Dubuque (72) and Galena (73), Ill.: Water treatment plants.....	42,000	Field surveys not made.
(1)	Friendship (31) and Marathon (14), Wis.: Sewer systems.....	28,000	Rough cost estimates only are available. No plans reported.
(1)	Benton (71), Cuba (71), Edgar (13), Gays Mills (52), Hazel Green (71), Mazomanie (61), Merrill (8), Muscodah (63), Necedah (30), North Freedom (54), Pittsville (23), Poynette (58), Readstown (50), Rhinelander (4), Rib Lake (7), Rio (57), Schofield (16), Soldiers Grove (51), Spring Green (62), Wausau (15) and Wilton (40), Wis.: Sewer systems and sewage treatment plants.	925,000	Do.
(1)	Athens (10), Biron (24), Baraboo (55), Cambria (56) and Cashton (41), Wis.: East Dubuque (72), Ill.; Elroy (39), Hillsboro (43), Lancaster (68), La Farge (47), Mauston (5) Mosinee (18) Nekoosa (27), New Lisbon (33), Port Edwards (26), Reedsburg (46), Richland Center (53), Rothschild (17), Stevens Point (22), Stratford (19), Tomahawk (6), Wauzeka (65), Wisconsin Dells (42), Wisconsin Rapids (25), and Viola (49), Wis.: Sewage treatment plants.	420,000	Rough cost estimates only are available. No plans reported.
(1)	Baraboo (55), Camp Douglas (34), Camp Williams (29), Edgar (13), Elroy (39), Friendship (31), Hillsboro (43), Lyndon Station (45), Marathon (14), Mosinee (18), Muscodah (63), Necedah (30), Pittsville (23), Poynette (58), Rib Lake (7), Rhinelander (4), Schofield (16), Shullsburg (70), and Stratford (19), Wis.: Water supply systems or improvements to water supply.	644,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Eagle River (2) and Minocqua (3), Wis.: Water supply improvements.....	\$19,000	Rough cost estimate.
(1)	Knowlton (21), Portage County; Little Eau Pleine (20), Marathon and Portage Counties; Petenell (28) and Table Rock (32), Adams County, Wis.: 4 dams and reservoirs on Little Eau Pleine and Wisconsin Rivers for flow regulation and water-power development.	14,300,000	Cost estimate for completion.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Copper Dam on Copper River, Lincoln County (9); Deerskin Dam on Deerskin River, Vilas County (1); Dams for control of lake level.	\$70,000	Rough cost estimate.
(1)	Boscobel (64), Highland (66), Kendall (37), Monfort (67), Norwalk (36), and Shullsburg (70), Wis.: Sewer system, extensions, sewage-treatment plants.	130,000	Rough cost estimate.

¹ Map key number shown following community name.

¹ Map key number shown following community name.

² Map key number shown following river name.

9. ROCK RIVER

The principal water needs of the Rock River Basin include assurance of adequate and satisfactory water supplies for urban centers, abatement of serious pollution of surface and underground water, protection from floods, and provision of recreational areas in places not now readily accessible to the more densely populated sections. Flow correction will afford relief from floods and enhance the value of existing and potential water power.

General Description

The Rock River Basin comprises an area of 12,086 square miles, of which 6,550 are in Illinois and 5,536 are in Wisconsin. The area is rectangular in shape, 185 miles north-south by 65 miles east-west, with the Rock River meandering some 285 miles along the north-east-southwest diagonal. The east and west forks of Rock River unite in Horicon Marsh about 25 miles southwest of Fond du Lac, Wis., at an altitude of 850 feet. The river falls 305 feet in its course to the Mississippi River 3 miles below Rock Island, Ill. (altitude 545 feet).

Left bank tributaries, namely, Sugar River, Pecatonica River, rise in maturely dissected glacial hills, about 1,200 feet above sea level. Right bank tributaries, Kishwaukee and Green Rivers, rise in the Illinois glacial prairies.

The soils of the upper basin are fairly fertile and deep on the undulating summit lands, but are rocky and thin on the hilly valley walls. There are many lakes and bogs in this region. In the lower basin the lands are gently undulating and the soils are fine prairie loam.

The average annual temperature in the southern part is 49° and in the northern part 45°. The extremes range from 104° above zero to 29° below. The average annual precipitation over the basin varies from 29 inches to 34 inches. There is normally abundant rainfall from April to September. The annual run-off averages 9 inches and the water losses due to transpiration, evaporation, and deep seepage are about 22 inches. The average annual discharge at Lyndon, 60 miles above the mouth, is about 6,100 cubic feet per second. The annual yield is close to 4,500,000 acre-feet. Because of the storage effect of the lakes in the headwaters, the stream has a moderately steady flow.

Agriculture, manufacturing, and trade are important economic activities and are intimately interrelated.

Mixed livestock and dairy farming is the dominant type of agriculture. Field crops are consumed on the farms by livestock and some wheat and feed grains are marketed in the Illinois portion of the area. Industrial activities include the processing of farm products and the fabrication of tools and equipment for farm use. Both highways and railways are highly developed.

The total population of the area was about 843,000 in 1930, of which 473,000 were in Illinois and 370,000 in Wisconsin. The urban population was 55 percent in Illinois and 59 percent in Wisconsin. The Illinois urban population increased 15 percent in the last decade, nearly four times the rural increase. In Wisconsin the larger cities increased 20 percent while the rural population increased 1 percent. The principal cities are Rockford (85,000), Rock Island (37,000), Moline-East Moline (42,000), Freeport (22,000), Sterling (10,000), Dixon (9,000), De Kalb (8,000), and Belvidere (8,000) in Illinois; and Madison (57,000), Beloit (23,000), Janesville (21,000), and Beaver Dam (9,000) in Wisconsin.

Heavy draft on the artesian-water resources is causing a severe lowering of the water-table levels. The water from most of the water-bearing rock strata is hard and some of it too highly mineralized for use. Drift wells, furnishing part of the urban and rural supplies, are, in general, adequate but are also mineralized and quite hard. Few urban communities depend on surface water, and water-treatment facilities are inadequately developed. Rural areas are dependent mainly upon underground water from the glacial drift.

Serious pollution exists in surface streams and in some of the underground water derived from the drift. A cooperative clean-up program has been inaugurated by Wisconsin and Illinois.

Urban centers and farm land on the main stream from Janesville to the mouth are subject to recurrent flood damage. The most serious conditions exist in the middle reaches and are caused chiefly by the rapid run-off of the Pecatonica. Cities and rural areas along this tributary experience severe flood damage. The Pecatonica also delivers a large silt load to the Rock as a result of excessive soil erosion.

About 20,000 acres of land can be improved by drainage and some existing drainage works need rehabilitation, particularly on the Green River. Certain lands now drained should be allowed to revert to natural conditions by placing dams or control works

in drainage ditches. Drainage operations have intensified the flood problems in the Pecatonica Basin.

Recreational facilities are abundant in the upper portion of the basin, but are rather scarce in the more densely populated lower basin. Inherent recreational values are destroyed by the highly polluted conditions of the streams. Poor use is being made, from a recreational point of view, of the scenic landscape with which the region is endowed.

Horicon Marsh and surrounding areas were formerly feeding and breeding grounds for wild fowl. This value was destroyed by drainage operations to reclaim land which proved to be submarginal for farming purposes.

Recommended Plan

Sufficient data are not available to present a detailed list of the works necessary to accomplish a long-range water plan. Additional studies accordingly are recommended.

Water supply.—A large part of the population and many industries are supplied from artesian sources which are rapidly being depleted. Furthermore, these waters have a high mineral content and are hard. The lowering levels and probable increase of water use indicate that many of these sources must be supplemented or replaced by surface water supplies in the relatively near future. The river will furnish adequate surface supplies for urban centers on or near it. Some supplies may be obtained from reservoirs located on tributaries. All surface supplies will require treatment. Various communities must depend on underground water sources. Most of these supplies should eventually be provided with treatment for softening and demineralization.

Flood protection.—Considerable damage occurs to urban property and cropped lands from rather frequently recurrent floods. Development of storage by lake-level regulation and reservoirs, the construction of levees, increase of channel capacity, and elimination of channel encroachment are needed to relieve flood dangers. Seven major reservoir sites in addition to lake-level regulation afford the possibility of developing 600,000 acre-feet of storage for flow regulation. Three of these sites are on the Pecatonica River. Reservoir storage in this drainage area will provide flow correction and, coupled with soil-erosion control, will reduce the silt loads materially. Furthermore, rapid run-off of the Pecatonica is also the cause of much flood damage in the middle basin. Control of the Pecatonica is therefore quite important.

Particular attention is directed to the possibilities afforded by the large number of narrow valleys, ravines, and upland gullies for the development of small reservoirs. This type of development affords a low-cost method for the accomplishment of water conservation, flow correction, and creation of recreational areas.

Pollution.—Closely spaced urban centers with their domestic and industrial wastes and lack of treatment plants create rather serious pollution conditions. Such conditions are objectionable, not only from a sanitary point of view, but also because they detract from the possibilities of realizing full value from river bank development for recreation which is warranted by the natural scenic beauty. The silt load of the Rock River is derived mainly from the Pecatonica. This silt pollution has killed fish life in the streams and is reducing pondage capacity at existing hydroelectric plants.

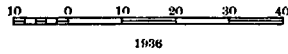
Water power.—The relatively steady flow of the Rock River, due to natural storage in the headwaters, makes it an excellent water-power stream. Steady flow and scarcity of pondage facilities make it more suitable for base load power than for peak loads. About 80,400,000 kilowatt-hours are produced annually in 79 existing plants, having an installed capacity of 21,400 kilowatts. According to the Corps of Engineers, eight promising potential sites would afford 140,000,000 kilowatt-hours annually under present unregulated flow conditions, with an installed capacity of 28,000 kilowatts. Flow correction primarily for flood protection and reduction of silt would materially increase the firm power possibilities of both existing and potential water-power sites.

Recreation.—The rather thickly settled nature of the basin tends to restrict the area available for recreational use. The banks of the main river and minor tributaries are attractive and afford excellent possibilities for recreational development. Furthermore, a number of the proposed small reservoir sites on tributaries afford means of supplying water areas for recreation, which at the present time are scarce in the middle and lower parts of the basin but more abundant in the upper.

Wildlife.—Horicon Marsh, near the headwaters, was an excellent breeding ground for wild fowl before the inauguration of drainage operations. The marsh is included as one of the seven potential storage sites for flow regulation. By proper coordination of interests, the restoration of this marsh for wildlife preservation might be made to serve purposes of flow correction. Similar characteristics are ascribable to Lake Koshkonong.

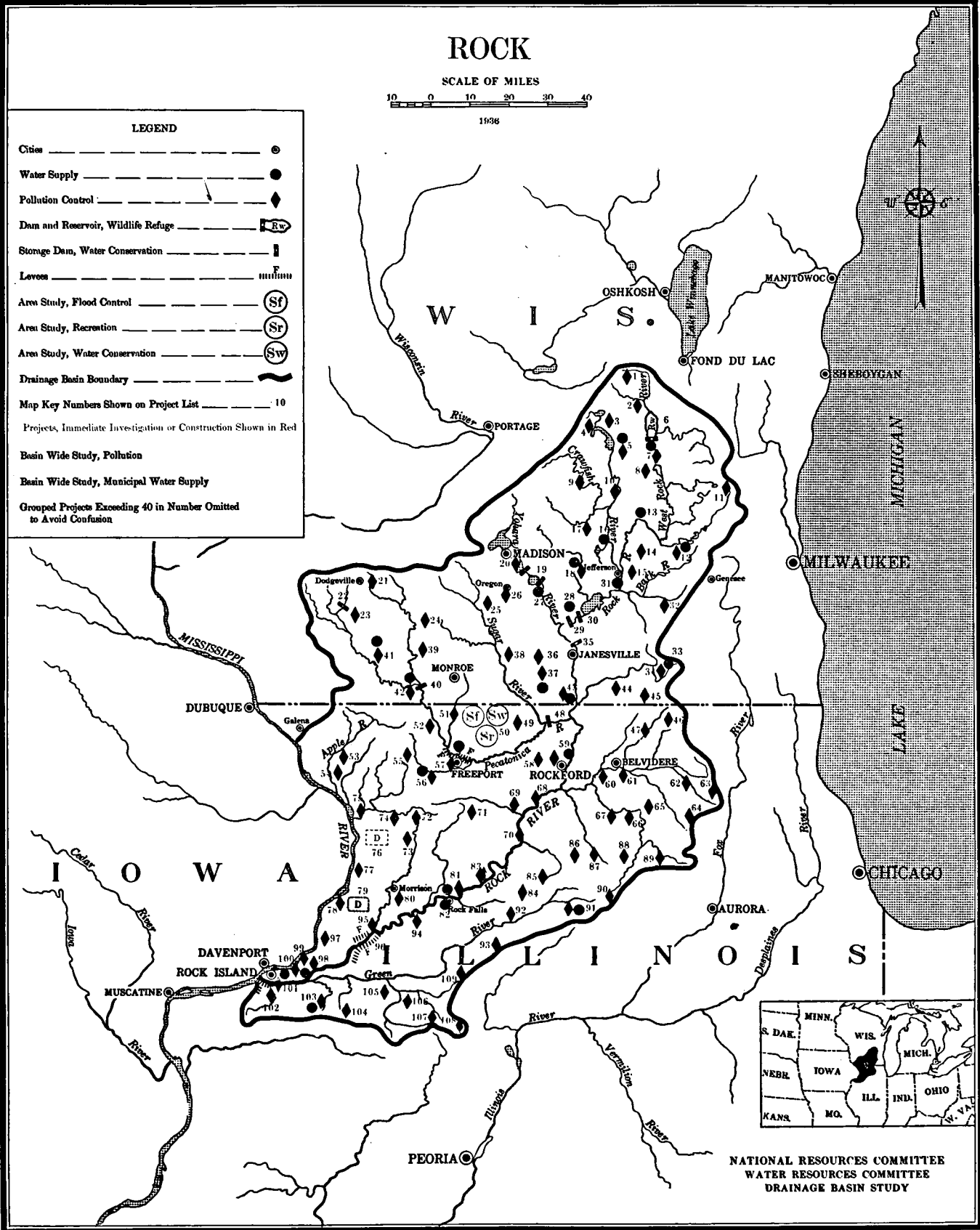
ROCK

SCALE OF MILES



LEGEND

- Cities _____ ●
- Water Supply _____ ●
- Pollution Control _____ ◆
- Dam and Reservoir, Wildlife Refuge _____ [Rv]
- Storage Dam, Water Conservation _____ [I]
- Levees _____ [F]
- Area Study, Flood Control _____ [St]
- Area Study, Recreation _____ [Sp]
- Area Study, Water Conservation _____ [Sw]
- Drainage Basin Boundary _____ [Wavy Line]
- Map Key Numbers Shown on Project List _____ 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution
- Basin Wide Study, Municipal Water Supply
- Grouped Projects Exceeding 40 in Number Omitted to Avoid Confusion



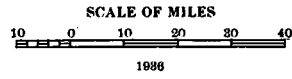
NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Rock Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
50	Studies of flow regulation to determine the most feasible plan for minimizing flood damages and increasing low flows in the Rock River basin with particular emphasis on the Pecatonica River; including an investigation of tributary reservoir sites possible of development for water supply, flow regulation, or recreation.	\$60,000	
	Study of existing water supplies and of urban centers not now supplied with water works to determine needs and make recommendations to supplement previous study. Also studies and recommendations for the abatement of pollution from domestic, industrial, and mine wastes, and aquatic growths.	15,000	
101	Rock Island, Ill.: Sewer extensions and sewage treatment plant.....	3,700,000	Preliminary plans prepared.
100	Moline, Ill.: Sewer extensions and sewage treatment plant.....	3,250,000	
57	Freeport, Ill.: Sewer extensions and sewage treatment plant.....	1,900,000	Do.
81	Sterling, Ill.: Sewer extensions and sewage treatment plant.....	1,045,000	Do.
99	East Moline, Ill.: Sewer extensions and sewage treatment plant.....	654,000	
(1)	Amboy (92), Harvard (46), Oregon (70), Prophetstown (94), and Stockton (55), Ill.: Sewer systems or extensions and sewage-treatment plants.....	897,000	Do.
100	Moline, Ill.: Water treatment and extensions.....	929,000	Plans prepared.
(1)	Argyle (39), Beloit (43), Fox Lake (3), Johnson Creek (14), Juneau (8), Madison (20), Oconomowoc (12), Oregon (26), and South Wayne (42), Wis.: Sewer systems, extensions, or sewage-treatment plants.....	698,000	Preliminary plans prepared.
(1)	Albany (78), Ashton (85), Atkinson (105), Buda (106), Byron (68), Cambridge (104), Capron (47), Carbon Cliff (98), Chadwick (73), Cherry Valley (60), Compton (91), Creston (87), Durand (49), Elizabeth (53), Erie (95), Forreston (71), Franklin Grove (84), Genoa (65), Hampshire (64), Hanover (54), Huntley (63), Kingston (66), Kirkland (67), Lanark (72), Leaf River (69), Lee (90), Lena (52), Malta (88), Manlius (109), Maple Park (89), Marengo (62), Milan (102), Morrison (80), Mount Carroll (74), Ohio (93), Orangeville (51), Orion (103), and Pearl City (56), Ill.: Sewer systems and/or sewage-treatment plants.....	1,871,000	
101	Rock Island, Ill.: Water treatment plant and water extensions.....	995,000	
57	Freeport, Ill.: Water treatment plant and water extensions.....	609,000	
81	Sterling, Ill.: Water treatment plant and water extensions.....	283,000	
1	Brandon, Wis.: Sewage treatment plant.....	102,000	Plans prepared.
82	Rock Falls, Ill.: Water treatment plant and water extensions.....	165,000	
59	Rockford, Ill.: Water treatment plant and water extensions.....	126,000	
12	Oconomowoc, Wis.: Water treatment plant for softening and iron removal.....	61,000	
	Amboy, Annawan, Apple River, Ashton, Belvidere, Buda, Byron, Cambridge, Camp Grant, Carbon, Cliff, Chadwick, Cherry Valley, Creston, De Kalb, Dixon, Durand, East Moline, Elizabeth, Erie, Forreston, Franklin Grove, Fulton, Geneseo, Genoa, Hampshire, Hanover, Harvard, Huntley, Kirkland, Lanark, Lena, Manlius, Marengo, Milan, Milledgeville, Morrison, Mount Carroll, Mount, Morris, Neponset, Ohio, Oregon, Pecatonica, Polo, Poplar Grove, Port Byron, Prophetstown, Rochelle, Rock Island Arsenal, Rockton, Savanna, Shannon, Sheffield, Silvis, South Beloit, Stockton, Sycamore, Tampico, Walnut, Warren, West Brooklyn, Winnebago, and Winslow, Ill.: Water supplies and/or water treatment plants.....	1,208,000	
76	Carroll County, Ill.: Levee and drainage district no. 1, raising and enlarging existing levee system....	13,000	Authorized by Congress.
96	Hillsdale, Ill.: Penny Slough levees and drainage ditches to protect agricultural lands.....	109,000	Do.
(1)	Fort Atkinson, Wis.: Flood gates for Indianford (29) and Janesville (35) dams on Rock River.....	29,000	Do.
(1)	Albany (38), Belleville (25), Beaver Dam (5), Blanchardville (24), Cambridge (18), Clinton (44), Columbus (9), Darlington (41), Delavan (34), Dodgeville (21), Horicon (7), Jefferson (15), Mineral Point (23), Orfordville (37), Palmyra (32), Randolph (4), Reeseville (10), Sharon (45), Slinger (11), Waterloo (17), and Waupun (2), Wis.: Sewer systems and/or sewage-treatment plants.....	674,000	
(1)	Annawan (106), Belvidere (61), Fulton (77), Neponset (107), Fort Byron (97), Rochelle (86), Savanna (75), and Winnebago (58), Ill.: Sewer systems or sewage-treatment plants.....	459,000	
(1)	Beaver Dam (5) and Cambridge (18), Wis.; Compton (91), Ill.; Edgerton (28), Elkhorn (33), Fort Atkinson (31), Horicon (7), and Lake Mills (16), Wis.; Orion (103) and Pearl City (56), Ill.; Stoughton (27) and Watertown (13), Wis.: Water supply improvements and/or treatment plants.....	473,000	
(1)	Darlington (41), Orfordville (37), and South Wayne (42), Wis.: Water supply systems.....	77,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
59	Rockford, Ill.: Sanitary sewers.....	\$137,000	
83	Dixon, Ill.: Combined sewers.....	285,000	
36	Footville, Wis.: Sewage treatment plant.....	10,000	
43	Beloit, Wis.: Water softening plant.....	200,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
57	Freeport, Ill.: Channel rectification of Pecatonica River through city.....	\$566,000	
40	La Fayette County, Wis.: Dill storage reservoir for flow regulation.....	4,374,000	
48	Winnebago County, Ill.: Rockton storage reservoir for flow regulation.....	5,902,000	
22	Iowa County, Wis.: Mineral Point storage reservoir for flow regulation.....	300,000	
6	Dodge County, Wis.: Horicon marsh reservoir for wildlife conservation and flow regulation.....	500,000	
30	Jefferson County, Wis.: Koshkonong storage reservoir for flow regulation.....	700,000	
101	Rock Island County, Big Island Levee and drainage district near mouth of Rock River: Levees for flood protection and also drainage.....	300,000	
19	Lakes Kegonsa and Waubesa, Wis.: 2 dams for lake level control.....	27,000	
79	Rock Island and Whiteside Counties, Ill.: Improvement to drainage.....	104,000	

¹ Map key number shown following community name.

IOWA—CEDAR



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir, Water Supply ———— [W]
- Flood Control, Channel Improvement ———— F—
- Wildlife Refuge ———— [Rw]
- Power Development ———— [Z]
- Drainage Basin Boundary ———— ~~~~~
- Map Key Numbers Shown on Project List ———— 10

Projects, Immediate Investigation or Construction Shown in Red

Basin Wide Study, Project for Flood Control, Power, Pollution, and Water Supply

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

10. IOWA - CEDAR

The most pressing water problem of the basin of the Iowa and Cedar Rivers is stream pollution, followed in order of importance by water supply, recreation and wildlife conservation, flood protection, rehabilitation and changes in land drainage, and possibly water-power development.

General Description

The Iowa and Cedar Rivers flow parallel to each other from the middle of the northern boundary of Iowa to the southeast corner of the State, where they join before entering the Mississippi. There is included with this basin in this report a strip of land draining directly into the Mississippi, about 6 miles wide and 60 miles long, consisting partly of alluvial plain and extending past deeply eroded bluffs to the edge of the prairie. The total area is about 12,950 square miles, lying mostly in Iowa, with a small headwaters section in Minnesota.

The two rivers flow for the most of their length through typical glacial country, rounded gently rolling hills interspersed with many lakes and marshes. The original soils are deeply buried in glacial drift, through which the rivers have cut channels in many places to the underlying rock. In the southern part the valley is subject to flooding from high water originating in the Iowa or Cedar Rivers or from backwater from the Mississippi River. Headwaters of the rivers are 1,200 or 1,300 feet above sea level. The Iowa joins the Mississippi at an altitude of about 530 feet.

Most of the population of 670,000 is urban, with nearly one-half in the eight largest cities having populations between 10,000 and 60,000. Ninety-five percent of the area is in farms, producing chiefly animal products—hogs, cattle, sheep, butterfat, poultry, and eggs—together with corn and oats. There is a considerable manufacturing industry, which largely consists of the processing of farm products or the fabrication of goods for farm consumption.

Rainfall, varying from an annual average of 30 inches in the north to 36 inches in the south, is so distributed that about 60 percent of the annual total occurs in the spring and summer months. The annual run-off varies from 1.5 to 12.5 inches, with a discharge diminishing to small amounts during prolonged droughts. Violent thunderstorms are common. The river flow shows wide variations.

Recommended Plan

Stream pollution is the most serious water problem of the region. There are 21 municipalities of over 350 people with inadequate sewage-treatment plants or none at all. Eight large industrial plants, including creameries, canneries, meat-packing plants, and sugar mills, discharge wastes that create as much pollution as the sewage from 160,000 people. The State health department reports that both the rivers are, in general, unfit for domestic water supply, stock watering, fish culture, or recreational uses. The variability of flow makes low-water stages particularly objectionable, and high water prevents some towns from discharging their sewage. Plans are complete for treatment plants at several towns, and immediate action is recommended. At Davenport and Muscatine present conditions will be aggravated by the construction of navigation dams in the Mississippi and the construction of sewage-treatment plants at these cities will be necessary.

With all proposed sewage-treatment plants in operation the Iowa River will still need a minimum summer flow of about 80 cubic feet per second to assure proper dilution. This will require a storage reservoir of at least 9,000 acre-feet capacity, which should be included in the basic plan.

Further study is needed with regard to additional projects in order to encourage the preparation of engineering plans and to secure necessary legislation.

Municipal water supplies are almost universally drawn from underground sources, which have so far proved equal to the demands. There is danger that underground waters may be polluted through abandoned wells. Legislation is needed to enable such pollution to be controlled.

Three-fourths of the urban population have water supplies approved by the State board of health, but there are 76 cities and towns with substandard systems and 15 towns of more than 350 people with no public water supplies. Three of the latter group—Kalona, Buffalo, and Le Claire—are growing rapidly and should supply this utility at once.

In order to guard against pollution, waste, or exhaustion of the underground water supplies, a quantitative and qualitative investigation should be made throughout the basin.

Recreation and wildlife have been injured by the silting or the drainage of many small lakes and marshes

in the northern part of the basin. In all cases where drainage works are unprofitable the original conditions should be restored. Wildlife will be benefited to some extent by reforestation and bank stabilization, but principally by the abatement of stream pollution.

Flood control will be justified in a few cases where urban property is endangered. At Waterloo the pend-

ing sewage treatment project should be considered with flood protection. There are lesser problems at several other towns.

Drainage works now in existence cover 1,300,000 acres. Future work will consist principally of rehabilitation and maintenance. A few extensions of the drained area may be justified.

Iowa-Cedar Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study to determine projects economically sound for flood control and water power; and a continuing study of water supply and sanitation; and an analysis of hydrologic data already collected on Ralston Creek.	\$60,000	
26	Waterloo, Iowa: Sewage treatment plant.....	1,051,000	Plans completed.
31	Marshalltown, Iowa: Sewage treatment plant.....	464,000	Do.
2	Austin, Minn.: Sewage treatment plant.....	325,000	Do.
(1)	Columbus Junction (52) and Gladbrook (34), Iowa; Glenville (3) and Hayfield (1), Minn.; La Porte City (35), Manly (14), Nora Springs (15), Northwood (8) Riverside (44), Shellrock (24), and Wapello (53), Iowa: Sewage-treatment plants.	197,000	Preliminary plans completed.
(1)	Alden (20), Belmont (19), Clarksville (23), Clear Lake (13), Forest City (11), North English (42), State Center (29), Waverly (25), and West Liberty (46), Iowa: Treatment plants for industrial waste.	100,000	No plans available. Estimates only rough.
49	Davenport, Iowa: Storm sewer for flood control.....	358,000	Plans completed.
49	Davenport, Iowa: Sewage-treatment plant.....	792,000	Do.
(1)	Belle Plaine (37), Cedar Falls (27), and Marengo (38), Iowa: Sewage-treatment plants.....	132,000	
26	Waterloo, Iowa: Channel improvement for sanitation.....	300,000	No plans available.
51	Muscatine, Iowa: Sewage-treatment plant.....	200,000	Do.
(1)	Buffalo (50), Kalona (43), and Le Claire (48), Iowa: Water-supply systems.....	140,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Albion (30), Britt (12), Cedar Rapids (40), Floyd (16), Garrison (36), Grafton (7), Le Grand (32), Montour (33), Nichols (45), Oakville (54), Princeton (47), Steamboat Rock (28), Thornton (18), Iowa: Water-supply systems or improvements.	\$463,000	No plans available.
(1)	Butler (22), Cedar (41), Cerro Gordo (17), Franklin (21), Winnebago (10), and Worth (9) Counties, Iowa: Small dams and planting for bank protection, stream development, and to provide wildlife refuges.	70,000	
4	Mower County, Minn.: Improving banks of Cedar River, Dobbin Creek Lake, and Sutton Park Lake.	19,000	Preliminary plans made.
39	Johnson County, Iowa: Storage dam on Iowa River above Iowa City to augment low water flow for pollution correction.	350,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Amana (39), Cedar Falls (27), Nora Springs (15), Otranto (5), Shell Rock (24), St. Ansgar (6), Iowa: Additions to water-power plants.	\$327,000	Preliminary plans made.
28	Eldora, Iowa: Rehabilitation of existing water-power plant.....	110,000	Do.

¹ Map key number shown following community name.

11. DES MOINES-SKUNK

Projects of immediate importance in this area include sewage-treatment plants to alleviate pollution where it is serious, and water-supply systems for several small communities. In addition, studies are recommended for the development of a long-range water plan which will include considerations of flow correction, pollution, municipal water supplies, water power, land drainage, recreation, and wildlife conservation.

General Description

The area of 19,070 square miles covered by this report includes 14,540 in the Des Moines Basin, 4,325 in the Skunk Basin, and 205 in the Mississippi Trough. The area is in Iowa with the exception of 1,525 square miles of Des Moines drainage in Minnesota and 90 square miles in extreme northeastern Missouri.

The Des Moines River rises in the hills of southwestern Minnesota. The lakes and meadows in the headwaters are at an altitude of about 1,850 feet and the altitude at the confluence with the Mississippi River, just below Keokuk, is 476 feet, giving a fall of 1,374 feet in a 535-mile course.

The soils of the area are derived from glacial deposits and wind-blown dust from farther west, and are generally fertile. In its natural condition the land was covered with grass, except for patches of woods in the river valleys and along the bluffs. There were many thousands of acres of lake and marsh, which have been greatly reduced by silting and artificial drainage. Mineral resources include numerous clay deposits, coal, which is mined in southern Iowa, and gypsum deposits, which are quarried in the vicinity of Fort Dodge.

The total population of the basins was 862,000 in 1930. About 60 percent of the inhabitants lived in 283 incorporated municipalities, including 234,000 in the 5 cities of Des Moines, Ottumwa, Burlington, Fort Dodge, and Keokuk, Iowa. The rural population has decreased about 7 percent during the past 40 years, while the urban has increased in about the same proportion.

The economic background is predominantly agricultural, with 64 percent of the farm land devoted to crops and 29 percent used as pasture. The manufacturing activities include the processing of farm and mineral products, and numerous consumer goods manufacturing plants, such as farm equipment and machinery, washing machines, and cosmetics, some of which have attained national distribution. Railway

lines and highways are well developed throughout the basin.

The temperature in this region varies from a July average of 76° to a January average of 20°; average annual precipitation ranges from 36 inches in the southeast to 28 inches in the northwest, about 70 percent of it coming from April to September with a normal maximum in June. Losses from transpiration, evaporation, and deep seepage are estimated at about 24 inches. The average flow ranges from about 0.1 cubic foot per second per square mile near the headwaters to about 0.5 cubic foot per second per square mile near the mouths of the two rivers. The average annual yield of the Des Moines River at Keosauqua is nearly 4,000,000 acre-feet and that of the Skunk River at Augusta is nearly 1,600,000 acre-feet.

The underground water resources are generally poor in quality except in a few counties. The calcium hardness ranges from about 200 to 2,000 parts per million and fluorine is present in undesirable amounts in a number of areas. The region is largely dependent on surface water supplies in which serious pollution exists in numerous localities.

The average annual flood damage amounts to around \$300,000, of which 75 percent is crop damage and the remainder property damage in urban and rural sections.

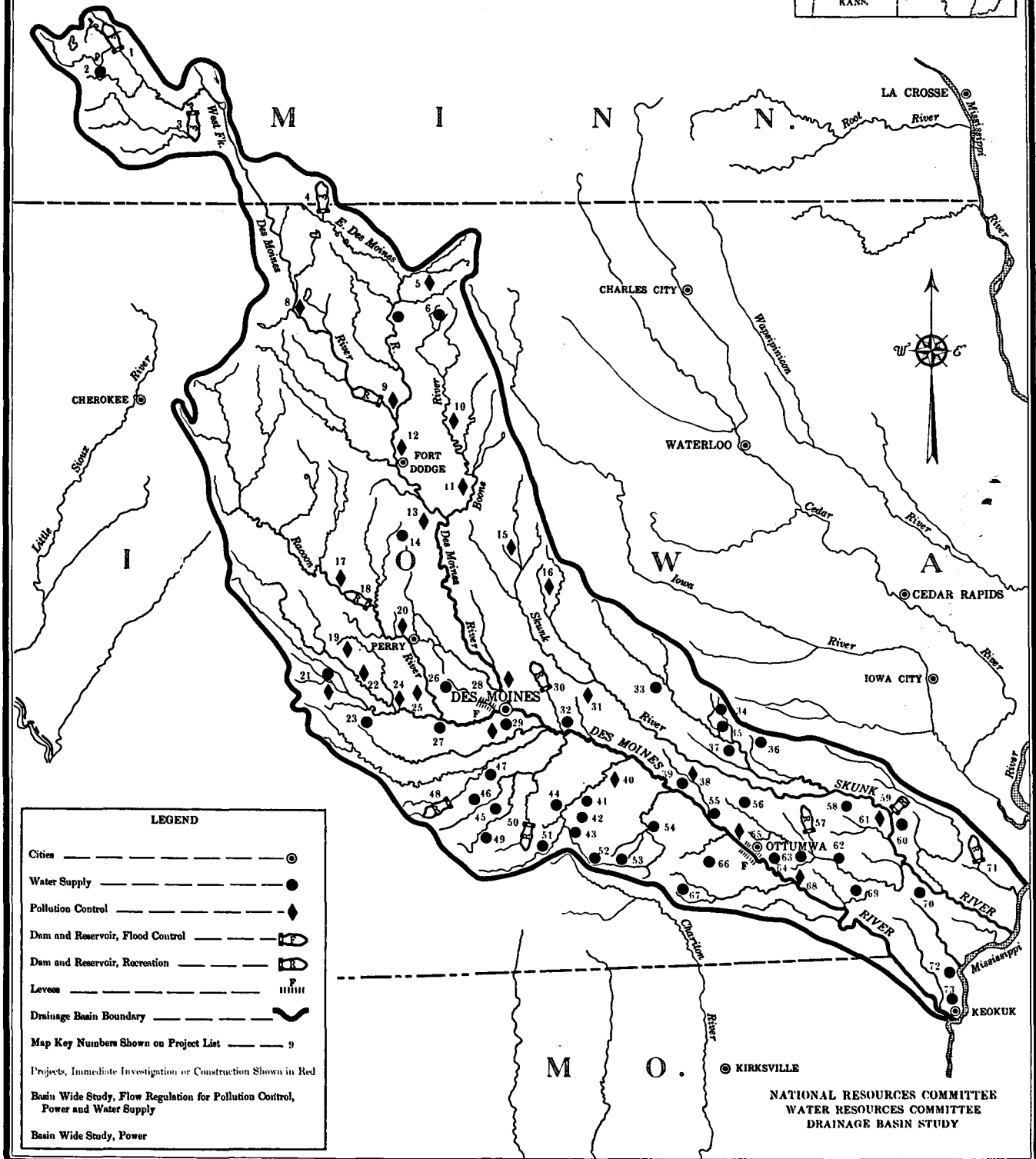
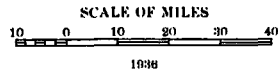
Recommended Plan

A long-range water plan for this area would be based upon the ultimate achievement of as much stream-flow correction as it is reasonably possible to attain. Due to the more suitable conditions and greater benefits to be realized, such an objective is more important in the Des Moines Basin than in the Skunk Basin. The existing information needs amplification, analysis, and correlation in order to establish a program of progressive development and operation of flow-correction structures and to harmonize interstate interests.

Storage can be developed on the Des Moines River above Des Moines in existing lakes and swamp areas in the headwaters and at dam sites on the main river. Storage possibilities on the Skunk River are less promising, but should be investigated further.

Pollution will be alleviated by the increase in low-water stream flow resulting from the operation of the storage reservoirs. Sewage-treatment works are recommended for immediate construction at certain localities where pollution is now serious. The basic study should

DES MOINES—SKUNK



LEGEND

- Cities ———— ○
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir, Flood Control ———— [Dam Symbol]
- Dam and Reservoir, Recreation ———— [Dam Symbol]
- Levees ———— [Levee Symbol]
- Drainage Basin Boundary ———— [Wavy Line Symbol]
- Map Key Numbers Shown on Project List ———— 9
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Flow Regulation for Pollution Control, Power and Water Supply
- Basin Wide Study, Power

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WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

include additional surveys of pollution, particularly of industrial wastes, and should serve to effect an interstate agreement with regard to pollution abatement on the Des Moines River.

Water supplies, which are now obtained from underground sources, are, in general, poor in quality, and may ultimately be replaced by surface supplies. Flow-correction measures and pollution abatement will simplify these problems.

Power sites are available on the Des Moines and Skunk Rivers which would be appreciably affected by any increase in low-water flow resulting from the operation of storage reservoirs. They should be considered in connection with the development of the long-range water plan.

Land drainage works have deteriorated, probably due to drought and adverse financial conditions. Some new drainage may be required, particularly after the construction of storage reservoirs.

Recreation and wildlife conservation are in charge of the Iowa conservation commission which is proposing an extensive program of lake dredging and land reclamation to provide additional areas for recreation. Such of these projects as will achieve permanent benefits at reasonable cost will be in harmony with the

water plan. They cannot, however, be considered as part of the plan unless they are to be provided with regulating devices to assist in flow correction during periods of extremely low flows. The flow-correction facilities will be in general in harmony with the development of recreational facilities and wildlife areas. It is believed that the regulation of lake levels will create a volume of effective storage for flow correction and at the same time make it possible to hold the general level of the lakes higher than natural conditions permit during dry seasons. Artificial reservoirs, on the other hand, will have little value for recreational purposes, but an increased minimum flow and reduced maximum flow will afford considerable opportunity for river bank development, particularly in urban areas. The pools formed by the power dams below Des Moines offer a chance for extensive recreational development on account of the relatively small fluctuation in water level that would be necessary under improved flow conditions.

Flood protection by means of levees could be afforded to areas near the mouth of the Skunk as well as to about 70,000 acres along the main streams. Levee protection along the streams is, however, too expensive in relation to benefits, except through urban areas.

Des Moines-Skunk Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of flow regulation in entire basin to determine economical minimum flows and storage facilities and their interrelation with water power, waste disposal, water supply and the adequacy of water for agricultural needs in dry years; and a continuing study of water supply and sanitation; and a study to determine best ultimate use of area known as Green Bay Levee and Drainage District.	\$32,000	
	Study of possible new water power developments and of redevelopments of existing water powers.	70,000	
(1)	Algona (7), Eagle Grove (10), Emmetsburg (8), Jefferson (17), and Webster City (11), Iowa: Sewage treatment plants.	260,000	No action has been taken.
(1)	Adel (25), Colfax (31), Eldon (68), Lehigh (13), Panora (22), and Redfield (24), Iowa: Primary sewage treatment plants.	46,000	No action has been taken. Colfax plans may call for complete sewage treatment at cost of \$35,000 instead of \$12,000.
(1)	Bagley (19), and University Park (38), Iowa: Secondary sewage treatment or new plants.	20,000	No action has been taken.
20	Perry, Iowa: Additional sewage treatment, new settling tank, and additional filters.	72,000	
40	Knoxville, Iowa: New sludge bed and drain for sewer system.	2,000	Land acquired and surveys begun.
(1)	Dallas (41), Eddyville (55), Lovilia (54), Melcher (42), Richland (58), and Williamson (43), Iowa: Water supply and distribution systems.	444,000	No reports available. Surface storage probably will be developed except at Eddyville where infiltration galleries are possible. Dallas system might combine with that of Melcher.
(1)	Fairfield (62), and Wayland (60), Iowa: Water supply systems.	76,000	Plans available.
28	Des Moines, Iowa: Sewage treatment plant for domestic and industrial wastes.	2,000,000	Plant ordered by board of health, city has appealed to district court.
65	Ottumwa, Iowa: Sewage treatment for domestic and industrial wastes.	750,000	Plant ordered by board of health, city has appealed to district court. Design should include flood-control features.
12	Fort Dodge, Iowa: Sewage treatment plant for domestic and industrial wastes.	490,000	Plans filed with board of health.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Brighton (61), Nevada (16), and Story City (15), Iowa: Preliminary sewage treatment plants.	\$100,000	No plans, rough estimate.
(1)	(a) Agency (64), Barnes City (34), Blakesburg (66), Batavia (63), Beacon (39), Birmingham (69), Delta (37), Fremont (56), Keswick (36), Lacona (44), Lucas (51), Lynnville (33), Melrose (53), Menlo (23), Milo (29), Montrose (72), Moravia (67), New Virginia (45), Oseola (49), Runnells (32), Russell (52), St. Charles (47), Salem (70), Truro (46), Van Meter (27), Waukeo (26), and What Cheer (35), Iowa: Water supply and distribution system.	1,035,000	No action taken. Surface supply is probable in most cases. Rivers available in several cases.
65	Ottumwa, Iowa: Levees and channel alignment for flood protection on Des Moines River.	600,000	Some work completed in protective works. Protection proposed as part of a sewage disposal plant system. Additional study and plans necessary.
28	Valley Junction, Iowa: Levee and channel alignment for flood protection on Walnut Creek.	25,000	Preliminary plans prepared. Petition submitted for formation of Levee district in Valley Junction and Des Moines.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
1	Shetek Reservoir, Murray County, Minn.: For flow regulation.	\$35,000	
4	Okamanpadu Reservoir, Martin County, Minn. and Emmet County, Iowa: For flow regulation.	48,000	
3	Heron Reservoir, Jackson County, Minn.: For flow regulation.	110,000	
9	Near Humbolt, Iowa: Stream development on West Des Moines River by low head dams to improve fish habitat.	10,000	Preliminary plans and report complete.
(1)	Fort Des Moines (29), Guthrie (21), Humboldt (9), and Titonka (5), Iowa: Sewers and sewage treatment plants.	168,000	
73	Keokuk, Iowa: Waterworks.	250,000	
(1)	Algona (7), Guthrie (21), Harcourt (14), Iowa; Slayton (2), Minn.; and Wesley (6), Iowa: Waterworks and water supply.	192,000	
(1)	7 miles on South Otter Creek, Clarke County (50); Cedar Creek, Des Moines County (71); 9 miles south of Jefferson, Green County (18); Mud Creek, Jasper County (30); Northern Jefferson County (57); Tom Creek, Madison County (48); and near Brighton, Washington County (59); Iowa: Artificial lakes for recreation and wildlife.	1,000,000	Preliminary studies and surveys made.

¹ Map key number shown following community name.

12. ILLINOIS RIVER

The Illinois River Basin presents a complex pattern of water utilization problems ranging from the restoration of marsh lands for the preservation of wildlife to the extension of sanitation and transportation facilities for the second largest city in the United States. Between these extremes lie intricate problems of sanitation and water supplies for urban areas and for rural areas densely populated and highly industrialized, protection for valuable agricultural lands against floods and water logging, maintenance of a major waterway for navigation, development of water power, and the maintenance and expansion of recreational facilities.

The outstanding water problem is the deplorable degree of stream pollution. The primary objectives of a water plan for this region should be: (1) the abatement of stream pollution; (2) the provision of adequate and potable urban and rural water supplies; (3) protection against floods; (4) the expansion of facilities for recreation and for the propagation of wildlife; (5) the correction, rehabilitation, and construction of drainage systems; (6) the improvement of existing navigation facilities; and (7) the development of water power. Some of these objectives are interdependent and involve multipurpose projects. Much additional information should be collected and correlated with available data before an integrated plan and program is completed.

General Description

The area of 31,650 square miles here considered comprises the basins of the Illinois River and of smaller adjacent streams directly tributary to the Mississippi River. Most of the land surface is in Illinois.

The Illinois River is formed by the confluence of the Des Plaines and Kankakee about 45 miles southwest of Chicago and 273 miles above its mouth at Grafton on the Mississippi River. The Des Plaines rises in southeastern Wisconsin just west of Racine and is about 110 miles long. The Kankakee River rises in northern Indiana just south of South Bend, and is about 135 miles long. The Fox, Vermillion, Mackinaw, Spoon, Sangamon, Crooked, and Macoupin are important tributaries.

An outstanding feature of the Illinois River is its low gradient. The fall is 75 feet in 273 miles, with 18 feet of it in the vicinity of Marseilles. The trough of the valley is flat floored, 150 to 250 feet below the general Prairie Plains level of about 750 feet. Upstream from Peoria there are ridges of gently undulating

hills of glacial origin, interspersed with basins containing many lakes and marshes. Along the Mississippi River there are deeply dissected bluffs mantled by loess. The middle part of the basin is underlain with coal and with glass sand. The soils of the area are generally excellent.

Because of its location, the Illinois Basin has been a focal area for Middle West development, economically stimulated by the growth of trade, manufacture, and transportation incident to the urbanized district around the south end of Lake Michigan. The farm, factory, and mine activities require and support highly developed transportation facilities.

The total population of the basin is a little more than 2,000,000, of which over half are in places of more than 2,500 inhabitants. These figures do not include the great urban population in the Lake Michigan drainage basin, which controls much of the economic life of the Illinois Basin and complicates the problems of the Illinois River.

The discharge of the river is now augmented by diversion of water from Lake Michigan at Chicago. The natural flow ranged between 1,000 and 120,000 cubic feet per second. At the present time an average diversion of 5,000 cubic feet per second is permitted from Lake Michigan for dilution of sewage, and during the summer or low-flow season the diversion for water supply amounts to an average of about 1,700 cubic feet per second, most of which reappears as stream flow. Because of a ruling of the Supreme Court, the diversion at Chicago, including water supply, will probably be about 2,500 cubic feet per second after December 31, 1938.

The Illinois River and its tributaries carry the sewage wastes from nearly 5,000,000 persons and a large amount of industrial activity. Industrial wastes from the Chicago area alone are probably equivalent to the sewage from 1,500,000 people. Clean-up programs have improved conditions on the Fox River, and the gradual development of treatment facilities at Chicago is mitigating the situation on the Illinois and Des Plaines, but the effect of the Chicago improvement will be offset partially and perhaps wholly by the reduction in 1938 of the allowable diversion from Lake Michigan. The pollution in the river threatens public health. The deposition of solid matter from sewage may interfere with the maintenance of a navigation channel. Additional pollution abatement is badly needed.

Most of the municipal and rural water supplies are drawn from underground sources. Excessive drafts required to meet increasing needs have caused serious lowering of the deep-water levels—as much as 375 feet in the past 75 years in the area between Chicago and Peoria. Many of the cities are facing the problem of developing other sources to supplement or replace deep wells. Several urban centers have, in recent years, abandoned underground water sources and replaced them with surface supplies. All of the surface supplies must be treated, and most of the subsurface supplies should be treated. Great care is necessary to exclude pollution from shallow subsurface sources used in the rural sections.

With the exception of certain areas near Burlington, Wis., on the Fox River, there are no serious flood problems above La Salle. Below La Salle the gradient of the river is nearly flat, the banks are low, the flooded bottoms range from 1½ to 7 miles in width, and the subsoils are relatively impervious. The slopes of the tributary drainage area are fairly steep and there are few lakes to afford natural storage. These factors combine to produce relatively rapid run-off, which cannot be quickly handled by the main stream with its low gradient and the limitation imposed on the channel capacity by the encroachment of levees. Serious flooding, therefore, occurs on the main stream below La Salle and on the lower reaches of the tributaries. Some of the areas now partially protected by levees are submarginal and should be allowed to revert to their original state to increase the channel capacity.

Land drainage has been extensively provided. About 2,000,000 acres lie within organized drainage and levee districts. Like many levee projects, some drainage projects have been undertaken without due consideration of the value of the lands reclaimed and without regard to the effect of the projects upon other sections of the basin.

Navigation facilities are highly improved on the Illinois River, which is a part of the Great Lakes to the Gulf waterway. An elaborate system for slack-water navigation by means of locks and dams has been constructed and additional structures are now being built. A 9-foot channel of adequate width and free of fixed bridge obstructions is contemplated. The sanitary condition of the stream is important in connection with its utility for navigation.

A few water-power plants are in operation in the basin. The largest, at Lockport, is now being modernized. Other developments are located on the main stream and on the Fox, Kankakee, Des Plaines, and minor tributaries. The amount of available power on the main stream is greatly affected by the Lake Michigan water diversion.

Recommended Plan

Pollution.—The high density of population, the probable increasing dependence on surface water for future supplies, the scarcity of recreation facilities, and the commercial importance of navigation demand a comprehensive program of sanitation that will eventually provide adequate treatment of all domestic and industrial wastes.

The effects upon the sanitary condition of the river, of the large-scale sewage-treatment works for the Chicago area and the curtailment of the allowable Lake Michigan diversion have not yet been determined.

Projects for treatment of wastes for all urban centers which now have sewers or may be provided with them are included in the project lists.

Water supply.—Depletion of deep-well sources will compel a number of municipalities to seek surface-water supplies. This contingency should be anticipated by studies to determine the probable needs and also by expediting the sanitation program to improve the quality of available surface sources. Underground waters in the basin are generally hard and highly mineralized. Treatment is desirable and should be provided for certain places as rapidly as the improvements can be financed.

Flood damage is a major problem in the area. There is need for the construction of new levees and the reinforcement of existing levees to provide protection for the more valuable farm lands and urban property. The long-range plan should not, however, include the protection of submarginal lands. The general studies should include a careful scrutiny of existing levees which protect submarginal areas and involve encroachment on the floodway. Considerable flood correction may be accomplished by the restoration of marshes, particularly the Kankakee marsh in Indiana, and by small reservoir construction.

Recreational facilities are inadequate for the large population. Natural endowments for recreational purposes are rather meager. Improvement by artificial means is therefore indicated if reasonable facilities are to be made available. Much additional information will be required before a specific program can be formulated. Collection of the needed data is included in the general study project. Full exploitation of natural recreational facilities is recommended, including the restoration of wildlife habitats, insofar as this can be harmonized with other water programs in the region, particularly farm drainage.

Drainage.—The long-range plan should provide for the rehabilitation of existing drainage works and for new works as they may become warranted. Information on existing needs should be obtained in connection with the general studies.

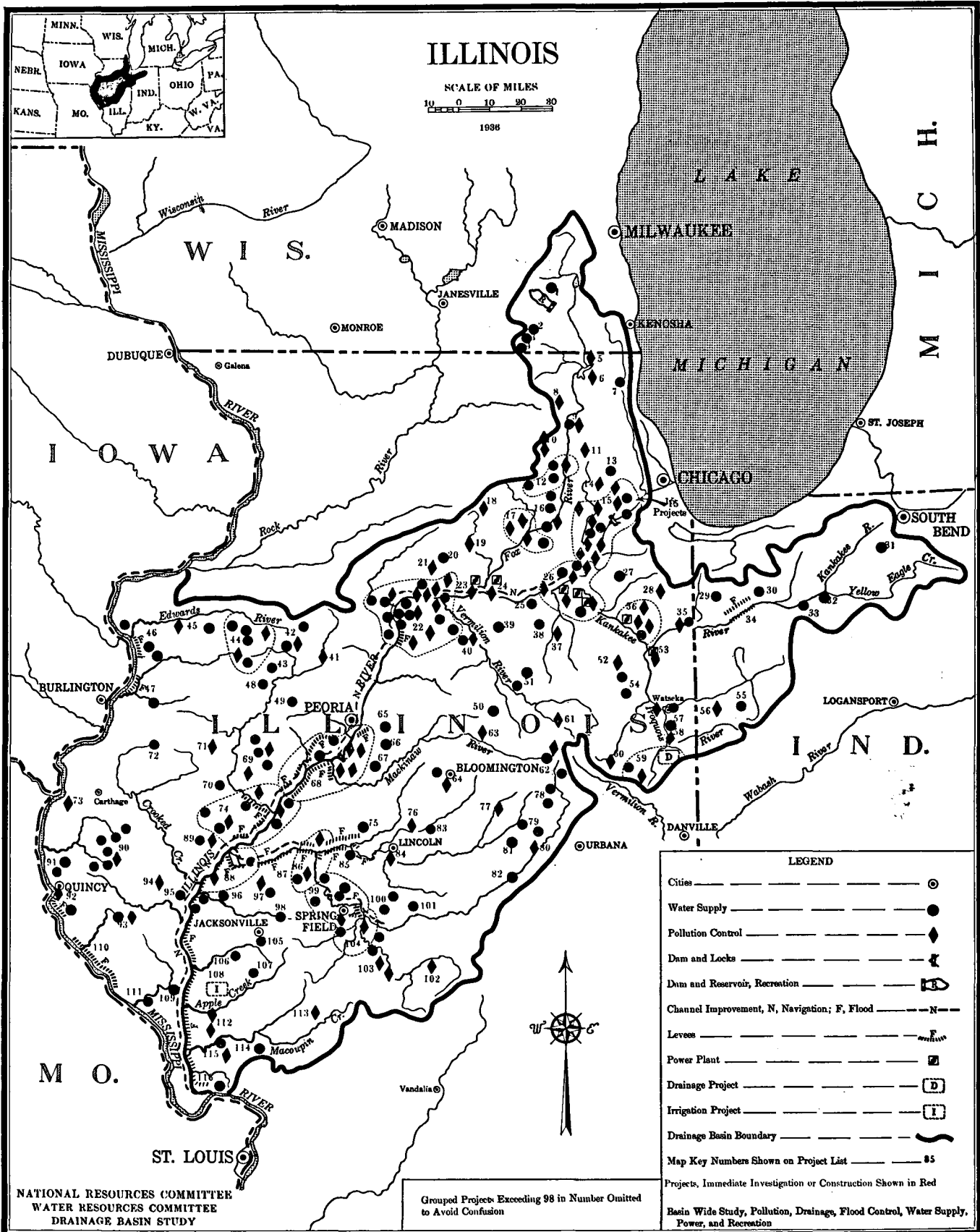
Navigation-improvement work is being carried on toward the development of the plan of the Corps of Engineers in harmony with the interests of flood protection, recreation, drainage, and water power. Sanitary aspects affecting navigation will be indeterminate until the effects of the treatment plants and the Lake Michigan diversion are known.

Water power is available at many potential sites. The more promising of these are at existing navigation dams at Brandon Road, Dresden Island, Bells Island, and Starved Rock, with a proposed capacity of 73,000 kilowatts. The water plan should contemplate construction of these plants. Twenty-one small sites are available on the Fox River, four on the Kankakee.

Illinois Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	General studies as a basis for a coordinated program of sanitation, drainage, flood correction, water supply, waterpower, and recreation.	\$200,000	
	Aledo (46), Antioch (5), Assumption (102), Astoria (74), Atlanta (78), Barry (93), Beardstown (88), Bensenville (15), Bloomington (64), Bourbonnais (36), Bradley (36), Bushnell (71), Canton (69), Carlinville (113), Carrollton (112), Cedar Point (22), Coal City (26), Crystal Lake (8), Cuba (69), Depue (22), Downers Grove (15), Dwight (37), East Dundee (10), East Peoria (68), Earlville (19), Elgin (12), Farmer City (77), Forrest (14), Galesburg (49), Galva (49), and Golden (90), Ill.; Goodland (56), Ind.; Hamilton (73), Itasca (17), Havana (74), Herscher (52), Jerseyville (115), Joliet (36), Kincaid (103), Lake Villa (8), LaSalle (22), Lemont (15), Lewistown (74), Lexington (63), Lincoln (84), Lockport (15), Manteno (36), Marseilles (24), Mason City (86), Mendota, (21), Milford (53), Momence (35), Monticello (80), Mount Sterling (94), Morris (26), Morton (68), North Utica (22), Oglesby (22), Oswego (16), Ottawa (—), Palatine (11), Peotone (28), Pekin (92), Peru (22), Petersburg (86), Plainfield (15), Plano (17), Quincy (32), Rankin (59), Roberts (60), Rochester (104), Rockdale (26), Rushville (89), St. Anne (53), Sandwich (17), Shabbona (18), Sibley (62), Soldiers Home (92), Springfield (99), Spring Valley (22), Streator (40), Taylorville (103), Toluca (22), Toulon (42), Villa Park (15), Virginia (97), Washington (68), Watseka (57), Wauconda (5), Wenona (22), West Chicago (15), West Dundee (10), Westmont (15), Wheaton (15), Whitehall (112), Wilmington (26), Wyoming (41), and Yorkville (17), Ill.: Sewer extensions and/or sewage treatment plants.	19,470,000	
	Alexis, Alpha, Ashland, Athens, Anburn, Avon, Bartonville, Benson, Biggsville, Bradford, Braidwood, Buckingham, Buckley, Bureau, Cerro, Chatham, Chatsworth, Chebanse, Chenoa, Cherry, Chillicothe, Cissna Park, Colchester, Colfax, Crescent City, Crotty, Cullon, Danforth, Dear Creek, Delavan, Divernon, Donovan, Eileen, Elburn, Elmwood, El Paso, Eureka, Fairbury, Flanagan, Forest View, Fox Lake, Frankfort, Gibson City, Gilman, Girard, Glasford, Gordo, Grand Ridge, Grant Park, Granville, Greenfield, Gridley, Griggsville, Gurnee, Hardin, Hebron, Hennepin, Henry, Heyworth, Hinckley, Hopedale, Hull, Ipava, Joy, Keithsburg, Kempton, Kirkwood, Knoxville, La Harpe, Lake Zurich, Lamoille, Leland, LeRoy, Little York, Loda, London Mills, Lorrain, Lostant, Mackinaw, Manhattan, Marco, Mark, McLean, Metamora, Minier, Minooka, Mokena, Marseilles, Mason City, Maywood, McHenry, McLean, Melrose Park, Moline, Moweaqua, New Holland, North Chillicothe, Odell, Onarga, Oquawka, Pawnee, Paw Paw, Payson, Pearl, Piper City, Plano, Rantoul, Roanoke, Roodhouse, Roseville, San Jose, Saunemin, Saybrook, Seaton, Secor, Sheldon, Somonauk, South Jacksonville, South Pekin, South Wilmington, Standard, Stonington, Strawn, Stronghurst, Sublette, Tiskilwa, Tremont, Vermont, Viola, Verden, Washburn, Waterman, Waynesville, Weldon, Wheeling, Williamsville, Winchester, Winfield, Woodhull, and Woodland, Ill.: Sewer systems and sewage treatment plants.	10,138,000	
	Abington, Addison, Aledo, Alexis, Algonquin, Arlington Heights, Assumption, Atlanta, Aurora, Avon, Barrington, Bartlett, Bartonville, Beardstown, Bensenville, Berkeley, Blue Mound, Bourbonnais, Bradley, Braidwood, Brookfield, Buckley, Bushnell, Cabbery, Campus, Carlinville, Carpentersville, Carrollton, Cary, Cerro Gordo, Chatsworth, Chenoa, Chillicothe, Cissna Park, Clarendon Hills, Clinton, Coal City, Colfax, Crescent City, Crystal Lake, Cuba, Cullon, Dallas City, Danforth, Danvers, Delavan, Depue, Donovan, Downers Grove, Dwight, Earlville, East Dundee, East Peoria, Elburn, Elmhurst, Elmwood, El Paso, Eureka, Farmer City, Forrest, Fox Lake, Fox River Grove, Frankfort, Franklin Park, Galesburg, Galva, Gibson City, Gilman, and Glen Ellyn, Ill.; Goodland, Ind.; Grand Park, Grays Lake, Greenview, Griggsville, Hamilton, Hardin, Hebron, Henry, Herscher, Heyworth, Hillside, Hinckley, Hopedale, Hull, Ipava, Itasca, Jacksonville, Jerseyville, Joy, Keithsburg, and Kempton, Ill.; Kentland, Ind.; Kewanee, Kincaid, Kinsman, Kirkwood, Knoxville, Lacon, Ladd, La Grange, La Grange Park, La Harpe, Lake Zurich, Lamoille, La Salle, Leland, Lemont, Le Roy, Lewistown, Lexington, Libertyville, Lincoln, Lockport, Lombard, London Mills, Lyons, Mackinaw, Macomb, Macon, Manhattan, Manteno, Marco, Marseilles, Mason City, Maywood, McHenry, McLean, Melrose Park, Mendota, Metamora, Milford, Minier, Mokena, Monmouth, Montgomery, Ill.; Morocco, Ind.; Morris, Morrisonville, Morton, Mount Prospect, Moweaqua, Mount Pulaski, Mount Sterling, Nauvoo, Nebo, Normal, North Chillicothe, North Utica, Onarga, Oquawka, Ottawa, Palatine, Pana, Pekin, Peoria, Peoria Heights, Peotone, Peru, Petersburg, Piper City, Plainfield, Plano, Princeville, Rankin, Rantoul, Richmond, Riverside, Roanoke, Roberts, Rockdale, Roodhouse, Roselle, Roseville, Sandwich, San Jose, Saybrook, Schiller Park, Shabbona, Sheldon, Somonauk, South Jacksonville, South Pekin, South Wilmington, Stanford, St. Anne, St. Charles, Spring Valley, Stronghurst, Sublette, Table Grove, Taylorville, Toluca, Tremont, Villa Park, Viola, Virginia, Warsaw, Washburn, Washington, Waterman, Wenona, West Chicago, West Dundee, Westmont, Wheaton, White Hall, Wilmington, Winfield, Wyandot, and Wyoming, Ill.: Water treatment plants.	4,566,000	

¹ Map key number shown following community name.

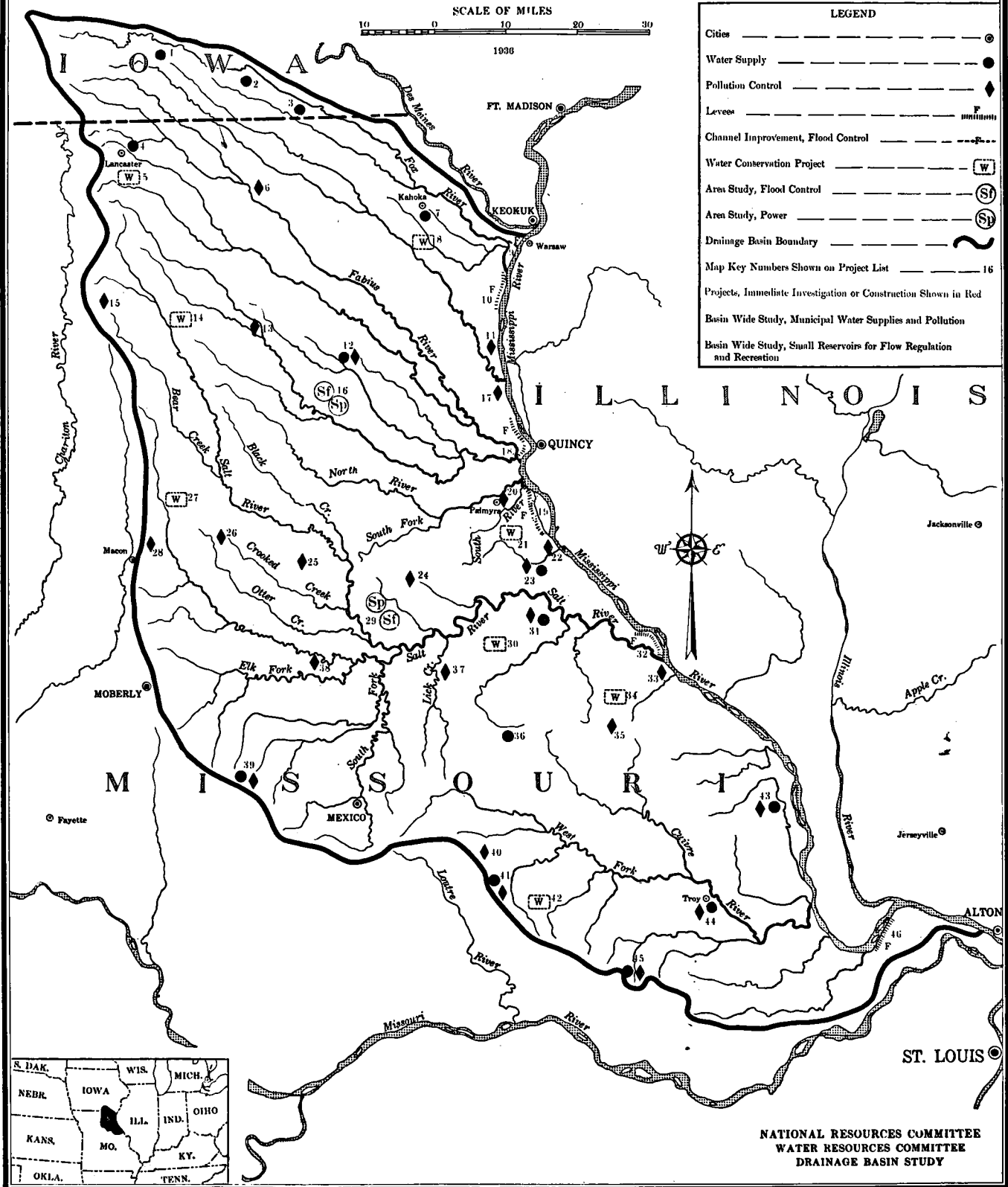


Illinois Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
(1)	Ashland (97), Athens (98), Augusta (90), Batavia (16), Bellewood (15), Berwyn (15), Blandinsville (72), Bloomington (64), Bluffs (95), Bowen (90), Bradford (42), Broadview (15), Brimfield (49), Camp Point (90), Canton (69), Chandler (87), Chapin (96), Chebanse (54), Cicero (15), Clayton (90), Clifton (54), Daltzell (22), De Land (79), Des Plaines (13), East Galesburg (44), Edinburg (103), Elgin (12), Elliot (62), Elmwood Park (15), Fairview (69), Fisher (78), Forest Park (15), Forest View (15), Franklin (98), Gardner (38), Geneva (12), Golden (90), Gurnee (7), Hanna City (68), Hinsdale (15), Humphreys (103), Iliopolis (100), Industry (74), Joliet (26), Kane (115), and Kankakee (36), Ill.; Kouts (30), Ind.; Loda (59), Ill.; Lowell (29), Ind.; Mahomet (78), Manito (74), Mansfield (79), Maton (25), Mendon (91), Meredosia (95), Middletown (85), Momence (35), Murrayville (106), Naperville (15), New Berlin (99), New Boston (46), Niantic (101), and North Aurora (16), Ill.; North Judson (33), Ind.; North Riverside (15), Oak Park (15), Oglesby (22), Oneida (44), Palmyra (107), Park Ridge (15), Pleasant Hill (111), Plymouth (90), Pontiac (51), and Prairie City (70), Ill.; Remington (55), Ind.; River Forest (15), River Grove (15), Riverton (90), Rushville (89), St. David (69), South Elgin (12), Sparland (22), Spring Forest (15), Stickney (15), Streator (40), Summit (15), Tallula (86), Thayer (104), Tiskilwa (22), Tonica (22), Vermont (74), Versailles (75), Wapella (83), Warrensburg (100), Watska (57), Wauconda (9), Waverly (105), Westchester (15), Williamsfield (43), and Yates City (48), Ill.; Water supply systems.	\$13,813,000	
	La Grange (15) and Peoria (68), Ill.: Lock and dams and channel improvement of Illinois River from mouth to Lockport, Ill. 115 to 15.	10,391,000	Under construction. Estimated cost to complete project. Authorized by Congress.
34	Baum's Levee between Shelby Bridge and Baum's Bridge on Illinois River, Ind.: For flood protection of farm lands.	177,000	Authorized by Congress.
95 to 116	Illinois River, Ill.: Levee set backs and floodway improvement from Beardstown to mouth of river.	1,100,000	Do.
88	Sangamon River, Ill.: Clearing and enlarging flood channel.	136,000	Do.
99	Sangamon River, Ill.: Straightening channel from mouth of Salt Creek to Roby.	773,000	Do.
	Sangamon River, Ill.: Levees or channel improvements at 15 localities on Sangamon River and its tributaries in Illinois for flood protection. (85), (86)-(88)-(87)-(99).	903,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Algonquin, Augusta, Bladenville, Blumound, and Bluffs, Ill.; Bremen, Ind.; Brimfield, Ill.; Brook, Ind.; Burlington, Wis.; Cabery, Camp Point, Campus, Carbon Hill, Carthage, Cary, Chandler-ville, Chapin, Cisco, Clayton, Clifton, Dallas City, Daltzell, Danvers, and De Land, Ill.; Earl Park, Ind.; East Galesburg, Edinburg, Elsay, Fairview, Farmersville, and Fisher, Ill.; Fowler, Ind.; Franklin, Gardner, Geneva, Grafton, Greenview, and Hanna City, Ill.; Hebron, Ind.; Hum-phreys, Iliopolis, Industry, and Kane, Ill.; Kentland, Ind.; Kewanee and Kinsman, Ill.; Knox and Kouts, Ind.; Lake Geneva, Wis.; Lenore, Libertyville, and Lombard, Ill.; Lowell, Ind.; Macon, Mahomet, Manito, Mansfield, Mazon, Mendon, Meredosia, and Middletown, Ill.; Morocco, Ind.; Mukwonago, Wis.; Murrayville, Nauvoo, New Berlin, and New Boston, Ill.; New Carlisle, Ind.; Niantic, Ill.; North Judson and North Liberty, Ind.; Oneida and Palmyra, Ill.; Pewaukee, Wis.; Pittsfield, Pleasant Hill, and Plymouth, Ill.; Plymouth, Ind.; Prairie City, Ill.; Remington, and Rensselaer, Ind.; Riverton, Shipman, South Elgin, Sparland, Spring Forest, Symerton, Tallula, Thayer, Tonica, and Versailles, Ill.; Walworth, Wis.; Wapella, Warrensburg, and Warsaw, Ill.; Waterford, Wis.; Waverly and West Dundee, Ill.; Westville, Ind.; Wyanet and Yates City, Ill.; Sewer systems and treatment plants.	\$5,107,000	
	Alpha (49), Astoria (74), Barry (93), Benson (65), Biggsville (47), Bureau (22), Cedar Point (22), Cisco (81), Decatur (82), Deer Creek (67), Elean (26), and Elsay (116), Ill.; Fontana (4), Wis.; Glas-ford (68), Grand Ridge (39), Granville (22), Ordley (50), Havana (74), and Hennepin (22), Ill.; Knox (32) and Lakeville (31), Ind.; Lake Geneva (2), Wis.; Little York (46), Lorraine (91), Lost-ant (22), Mark (22), Mimmooks (26), Monee (27), New Holland (75), Odell (51), Oswego (16), Paw Paw (20), Payson (92), Pearl (109), Seaton (46), Secor (66), Shipman (114), Sibley (62), Standard (22), and Toulon (42), Ill.; Waukesha (1), and Williams Bay (3), Wis.; Williamsville (99), Windsor (45), Woodhull (44), Woodland (57), and Yorkville (17), Ill.; Water supplies and im-provements and treatment plants.	823,000	
26	Power development 2 miles below Willis-Kankakee County line in Illinois.	1,473,000	
26	Kankakee River: Power development below Wilmington, Ill.	624,000	
53	Kankakee River: Power development near Aroma Park, Ill.	302,000	
(1)	Banner special drainage and levee district (68), Big Lake drainage and levee district (74), East Liver-pool drainage and levee district (68), East Peoria drainage and levee district (68), Henderson County drainage district no. 3 (47), Hennepin drainage and levee district (22), Keithsburg drain-age and levee district (46), Mississippi River; Kelly Lake drainage and levee district (74); Lacey Langellier, West Matanzas, and Kerton Valley, drainage and levee district (74); Liverpool drainage and levee district (68); Lost Creek drainage and levee district (88); Pekin and La Marsh drainage and levee district (68); Rocky Ford drainage and levee district (68); Seahorn drainage and levee district (74); Sny Island levee district, Mississippi River (110); South Quincy drainage and levee district, Mississippi River (92); Spring Lake drainage and levee district (68) and Thomson drain-age district (74) Ill. Levee (new or additional) and channel improvements on the Illinois River and that part of Mississippi River included in this report, for flood protection.	2,040,000	Authorized by Congress.
108	Green County, Ill.: Irrigation projects.	29,000	Plans completed.
59	Vermilion County, Ill.: Drainage projects.	29,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
26	Brandon Road power development on Des Plaines River, in Illinois at existing dam.	\$1,186,000	
26	Dresden Island power development at existing dam on Illinois River in Illinois.	1,317,000	
24	Starved Rock power development at existing dam on Illinois River in Illinois.	1,697,000	
23	Marseilles power development at existing dam on Illinois River in Illinois.	927,000	
26	Power development 2 miles below Willis-Kankakee County line in Illinois.	1,473,000	
1	Mukwonago Marsh, Wis.: Dam with boat lock to create artificial lake for recreational purposes.	150,000	

1 Map key number shown following community name.

WESTERN TRIBUTARIES KEOKUK—ALTON



13. WESTERN TRIBUTARIES: KEOKUK-ALTON

A long range water plan for minor tributaries of the Mississippi River in northeastern Missouri and southeastern Iowa should contemplate complete treatment of domestic wastes, purification and softening of water supplies, construction of small reservoirs on the tributaries of the main streams, creation of recreational facilities, and the possibility of reservoir regulation of main streams for minor flood correction and improved sanitation.

A shift of land use from crop farming to livestock raising and dairying has brought about a need for conserving water resources in small ponds and minor reservoirs for stock-watering purposes and possible raising of underground water levels.

General Description

The basins comprise an area of 7,560 square miles in Missouri and 416 square miles in Iowa, a total of 7,980 square miles, or about one-tenth of the total area of Missouri. The area is about 175 miles long and 55 miles wide, and is drained by several minor streams, including the Fox, Wyaconda, Fabius, and Salt Rivers, which empty into the Mississippi River.

Above the Mississippi flood plain is an upland country, flat or rolling, through which the streams have cut deep valleys. In the northern part the upland is mantled with glacial drift and the soil is of fair quality for agriculture, but on some of the plateau land in the south the soil is a heavy, infertile gray clay. Steep limestone bluffs along the Mississippi are capped with rich soil deposited by the wind, but the slopes are generally too steep for cultivation. The hills were originally covered with dense oak-maple forest; the uplands had a cover of prairie grass. Unwise clearing and over-grazing have resulted in severe sheet erosion and gullying.

The population has decreased from 269,543 in 1900 to 230,818 in 1930. Some of the towns, of which Hannibal is the largest, show a slow growth. The population of other towns and the rural area has decreased.

On account of poor soils on much of the level land suitable for cultivation, the farming trends are toward pasture and hay-fed stock, rather than grain-fed stock. This trend will favor the return of some cultivated lands to pasture and woodlots, particularly those subject to soil erosion. There are favorable opportunities for the construction of stock-water ponds. Orcharding is highly developed at the town of Louisiana, Mo., and

could be expanded along the bluffs, where air drainage is an asset.

There are many manufacturing plants in Hannibal and a few in each of the major cities—shoe, clothing, button, and metal goods factories. The quarrying of limestone and the manufacture of fire clay at Mexico are important. Hannibal and Moberly are railroad division points, with shops and yards, and are wholesale centers on a small scale.

The average annual rainfall is about 37 inches. The average run-off is estimated at about 10 inches and the water losses at 27 inches. All streams of the basins have records of practically zero flow. The maximum recorded flows range from 30 to over 50 cubic feet per second per square mile. Temperatures on record vary from minus 28° to plus 113°.

The quality and quantity of underground water resources vary, depending upon the level from which the water is obtained. Hardness and high mineralization are characteristic of many water-bearing strata. Shallow wells quite generally supply the rural areas, but considerable dependence is placed upon ponds as a source of stock water.

Recommended Plan

Seventeen of the twenty-eight towns having *municipal water supplies* depend on surface sources. The discharge of untreated wastes into streams at points upstream causes additional loads on treatment plants. Only 4 towns have complete treatment facilities, and 13 have partial treatment.

Sewage treatment is the first objective of a long-range water plan. Complete treatment of wastes to abate nuisances and to improve surface-water supply sources should be provided, and projects for 24 towns in Missouri are listed for immediate construction.

Water conservation may be accomplished by the construction of small reservoirs in the many ravines and gullies of the area. Such reservoirs would serve not only for water conservation but also for purposes of flow correction, recreation, and alleviation of pollution. Special studies to determine the specific features of such a program are recommended. Provision for malaria control should be anticipated in connection with any reservoirs constructed.

Flood damage to crops, railway property, and highways is recurrent in the area. Flood correction is desirable, but the excessive ratio of cost to benefits precludes its present consideration except for the possible

control of Salt River, the incidental benefits to be derived from small-reservoir construction, and the reconstruction and maintenance of levees to protect against Mississippi River overflow.

Completion of the canalization of the Mississippi River probably will affect water-table levels in the flood

plain. This may give rise to drainage problems on lands farmed in this section. Correction and rehabilitation of drainage systems should be undertaken in all sections where maintenance and reconstruction are warranted.

Western Tributaries Keokuk-Alton Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of existing water supplies and of urban centers not now supplied with waterworks to determine needs. Also studies to make recommendations for the abatement of pollution from wastes.	\$10,000	
(1)	Study of flood correction and water power on the Salt (29), and Fabius (16), Rivers in Missouri.	25,000	
	Study of all possible reservoir sites for flow regulation and recreation.	20,000	
(2)	Canton (11), Hannibal (22), La Belle (12), and Louisiana (33), Mo.: Complete sewage treatment plants.	208,000	
(3)	Elsberry (43), La Grange (17), Memphis (6), New London (31), Oakwood (23), ¹ Paris (38), and Perry (37), Mo.: Sewer systems and sewage treatment plants.	365,000	
(4)	Bowling Green (35), Centralia (39), Clarence (26), Edina (13), Kirksville (15), Macon (28), Monroe City (24), Montgomery City (41), Palmyra (20), Shelbina (25), Troy (44), Warrenton (45), and Wellsville (40), Mo.: Improvement to sewage treatment plants.	639,000	
(5)	Elsberry (43) and Oakwood (23), Mo.: Development of source of water supply probably by deep well and chlorination.	85,000	
(6)	Centralia (39), Montgomery City (41), New London (31), Troy (44), Vandalia (36), and Warrenton (45), Mo.: Improvement to existing water supply by chlorination.	214,000	
(7)	La Belle (12) and Kahoka (7), Mo.: Improvement to existing water supply by treatment and chlorination.	130,000	
(8)	Milton (2), Iowa, and Lancaster (4), Mo.: Construct waterworks system including supply and distribution.	90,000	
(9)	Cantril (3) and Pulaski (1), Iowa: Development of water supply and construction of distribution system.	67,000	
(10)	Gregory drainage district, Lewis and Clark Counties (10), Fabius River drainage district, Marion County (18); South River drainage district, Marion County (19); Riverland levee district, Pike County (32); Wiedmer chemicals drainage and levee district, St. Charles County (46), Mo.: Raising and enlarging existing levee systems to improve protection against floods.	314,000	Authorized by Congress.
GROUP B—FOR DEFERRED CONSTRUCTION			
9	Clark County, Mo.: Diversion of lower Fox River to protect farm lands.	\$60,000	
14	Adair County, Mo.: Channel improvement and dam construction for water diversion and storage.	167,000	
(2)	Macon (27), Montgomery (42), Ralls (30), and Schuyler (5) Counties, Mo.: 6 water conservation projects, dam construction and improvements and reservoir construction.	75,000	
(3)	Clark (8), Marion (21), and Pike (34), Counties, Mo.: 3 flood correction projects; levees and river improvements.	76,000	

¹ Map key number shown following river name.

² Map key number shown following community name.

14. ST. LOUIS

The major aspects of the metropolitan St. Louis area and the Meramec and adjacent minor Mississippi basins water plan center on the problems of metropolitan St. Louis with its large population.

Flood protection by raising levees in the American bottoms industrial district and by flow correction of the Meramec River is needed. Other requirements are improvement of sanitation facilities; improvement and extension of water supplies for suburban cities, and for farmsteads and recreational areas; development of a reliable navigation channel in the port of St. Louis, and maintenance of low-water flow channels in the Meramec Basin streams; improvement of handling storm drainage in covered channels or in open diversion canals; and development of lakes and streams for recreational facilities in urban, suburban, rural, and national-park areas.

A Meramec conservancy authority is desirable for the efficient execution of the plan involving that basin.

General Description

The area considered here includes approximately 5,330 square miles, of which about 4,530 are in Missouri and 800 in Illinois. In Missouri the Meramec Basin includes 3,980 square miles and the minor tributaries to the Mississippi River 550 square miles. In the vicinity of the confluence of the Missouri and Mississippi Rivers the St. Louis metropolitan area occupies 840 square miles, of which 450 are in Missouri and 390 in Illinois.

The Mississippi River flows southward through the metropolitan area and along the eastern border of the Meramec Basin in a trough some 100 to 200 feet below lands on either side. The channel follows the western valley wall rather closely, in many places undercutting precipitous bluffs. In the northern part, the flood plain expands to a width of 10 miles and is called the American bottoms. In the southern part, the flood plain narrows to about 3 miles.

The northeastern drainage in Illinois consists of the Piasa, Wood, and Cahokia Rivers. They have cut deep notches in the bluff. On the west side of the Mississippi River south of the metropolitan area, many small streams including Sandy, Plattin, and Joachim Creeks have eroded the eastern flanks of the Ozarks into rounded hills and steep bluffs.

The Meramec River rises in the northern part of the St. Francois Mountains and Ozark Plateau at altitudes of from 1,250 to 1,700 feet, and flows 207 miles to the Mississippi River, which it joins about 20 miles below

St. Louis at an altitude of 450 feet. Its principal tributaries are Bourbeuse, Big, and Huzzah-Curtois Rivers. The Meramec and its major tributaries meander through troughs averaging 1 to 2 miles in width.

In the southeast is the largest lead-producing district in the United States. Glass sand is mined and stone quarried in the St. Peter sandstone at the base of the Crystal City escarpment. In the vicinity of Potosi and Old Mines, most of the barite produced in this country is mined in small diggings and large open strip pits. There are numerous iron deposits in the area and many are worked in pits and shafts. The production is not large. In a few places special types of clay are mined, as at Rolla. The St. Peter and Roubidoux formations are important water-bearing strata. In the metropolitan area and the Illinois districts, Pennsylvanian shales, fire clays, and coal are mined.

The Ozark soils are generally thin, rocky, and poor. The flood plains have some good soils, but commonly they are too sandy or gravelly. The loessial soils of the uplands and the alluvial soils in the American bottoms are excellent and are the basis of intensive truck and dairy farming. A large part of the Meramec Basin has a cover of hardwood forests. Much of the cleared land should be returned to forests as in the Meramec State Park and Federal Clark Purchase Unit.

The mean annual temperature is about 56°, with a January mean of about 32° and a July mean of 78°. The mean annual precipitation is about 481 inches. The snowfall is light, averaging about 18 inches.

The large acreages of woodland, rivers, springs, hills, and bluffs provide extensive recreational opportunities in the Meramec Basin. Hunting lodges, fishing clubs, cabins, resorts, and hotels are scattered over the basin along railroads and highways which afford ready access for thousands of vacationists from St. Louis.

St. Louis is one of the major transportation centers of the United States. It is the focus of numerous highways, railways, airways, and waterways.

The total population of the area is about 1,450,000, of which about 85 percent live in the St. Louis metropolitan area.

The Mississippi River flows about 25 miles through the metropolitan area. It has a mean flow of 185,000 cubic feet per second, ranging from a minimum of 24,000 to a maximum of 1,300,000. The river is about one-fourth mile wide in the restricted section in the heart of the metropolitan area, about a mile wide below the city, and 3 miles wide, with large islands, above

the city. Alton Dam will pond a large body of water above that city.

At flood stages in the Mississippi River, water backs up the Meramec as much as 40 miles. There are 15 important springs in the basin, the most notable being Meramec Spring, which has a maximum daily flow of 420,000,000 gallons. The Meramec is considered navigable for 21 miles above its mouth. Once 182 miles were navigable. The river bed contains extensive sand and gravel deposits which yield about 2,000,000 tons annually for construction work.

Big River is, in general, shallow and moderately swift. The Bourbeuse River has steep headwaters, but its middle and lower course is tortuous and sluggish.

The Illinois tributaries rise in shallow draws on the upland plains and descend in steep narrow notches to the smooth broad American bottoms. Their upper courses are natural and their lower courses have been straightened and diked. Large diversion channels have been constructed to carry the storm waters to the Mississippi with a minimum of flooding on the American bottoms. The large amount of silt brought down from the uplands and notches chokes the artificial channels. Pumping stations are necessary to raise the water over the Mississippi levees when the Mississippi River is at flood. The Piasa is similar except that it does not cross the American bottoms.

The streams in the Missouri section of the metropolitan area, principally River Des Peres and Maline Creek, are short but have urbanized basins whose tiling, ditches, roofs, and streets increase the rapidity of run-off.

Underground water supplies are obtainable by shallow and deep wells. The shallow wells on the uplands are likely to go dry in drought years. Driven wells in the flood plains are numerous and are generally reliable. Such wells on the American bottoms are heavily mineralized and require treatment. There are several artesian water-bearing strata underlying the basins which are tapped by deep-drilled wells. The wells in the limestone formations are likely to be contaminated.

Recommended Plan

Flood control.—The protection of the American bottoms from flood damage is of much importance. A change in channel of the Mississippi River would make it necessary to raise the levee at least 2 feet along the east side of the river to provide this protection. The present levee was constructed to provide a freeboard of approximately 3½ feet above the flow of the 1844 flood, which is the highest of record. With the changed conditions in the Mississippi River, a repetition of the 1844 flood could be expected to overtop the present levee.

To provide a satisfactory system of drainage for the American bottoms tributary to Cahokia Creek will require pumping stations against high stages of the Mississippi River, basins for storage of run-offs exceeding capacity of the pumping station, and, primarily, the levees.

A comprehensive program for protection of areas in the Meramec River Basin must await creation of conservancy districts. Creation of such districts will require State legislation. Preservation of satisfactory flow conditions and elimination of pollution of the streams are needed. As soon as an agency is created, the improvement of channels in the Meramec River Basin, consisting of removing of snags, straightening of channel, and protection of banks by revetment or with wing dams, should be carried out. Continuous maintenance will be necessary if a satisfactory flow channel for recreational purposes is to be provided. Dredging operations in the lower portion of the Meramec River should avoid injury to recreational facilities.

Pollution.—On the west side of the St. Louis metropolitan area, the natural storm-water channels in St. Louis proper have been eliminated and replaced with large sewers adequately designed to take care of maximum run-offs. In Maline Creek, situated in the northern part of the city itself, and in the River Des Peres, skirting its western and southern limits, open channels have been constructed at relatively flat grades to carry storm waters with sanitary sewers underneath the open channel. In the populous portion of St. Louis County the natural channels carry raw sewage and are seriously polluted. Some progress has been made toward the provision of a system of closed sanitary sewers separate from the natural storm-water channels. On account of the density of population in this area, a complete system of sanitary sewers, discharging into the sewers of the city of St. Louis, is an immediate necessity for the preservation of public health and welfare.

On the east side of the Mississippi the improvement of sanitation in the villages, towns, and rural districts is urgently needed. In the American bottoms, the needs consist of relief sewers and pumping stations where the existing sewers are very much over-charged, and of new sanitary sewers in the areas now densely populated without any sewage facilities.

In the Meramec Basin a study is proposed for the elimination of pollution by domestic and industrial wastes now being discharged directly into the streams. To provide satisfactory sewage facilities to the villages and resort communities in this area, it will be necessary to construct treatment plants.

From a long-range viewpoint, independent of the changes which may occur along the Mississippi River in and below the St. Louis area, it appears that some form of primary sewage treatment will be necessary for

all sewage reaching the main stream. At present all sewage and industrial waste from the communities in the St. Louis area are discharged into the Mississippi without any treatment. Studies should be made to determine whether bar screens and primary treatment of the sewage will be necessary even with the Mississippi continuing as an open river. If navigation improvements result in the construction of locks and dams with the creation of pools in and below St. Louis Harbor, the communities on both sides of the river apparently will be faced with the necessity for construction of intercepting sewers, separation of sewage from the existing combined sewers, and the construction of complete treatment plants.

Water supply.—Adequate water supply and distribution systems now exist in St. Louis and the St. Louis metropolitan area. However, from a long-range viewpoint, extensive improvements to the distribution systems and additions to existing treatment plants, operated by municipal and private agencies, will be required. Whenever metropolitan authorities are created in Missouri and in Illinois for the adjacent areas in these States, desirable coordination of the existing water facilities for the metropolitan area can be perfected. Duplication of existing privately owned facilities by municipalities does not now seem advisable. In the outlying communities beyond the reach of the extensive water-distribution systems, individually operated water plants consisting of wells, treatment, and distribution facilities are necessary.

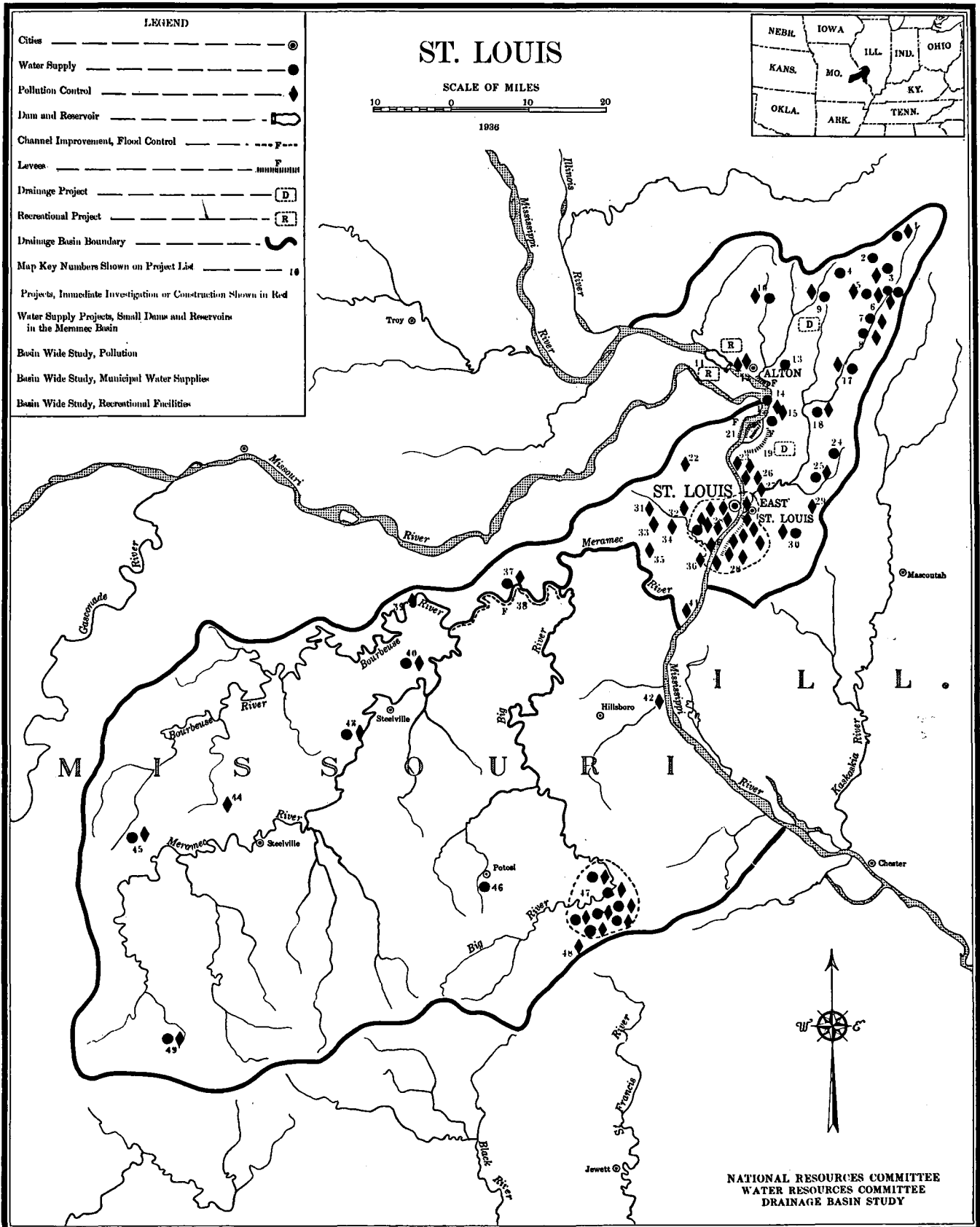
For rural water supply in the Meramec River Basin some distance from the main valleys, where individual

owners can only afford shallow wells or cisterns, a study is needed to determine the quantity and extent of shallow underground water and also the practicability of providing small storage reservoirs.

Drainage.—On the west side of the metropolitan area the straightening, deepening, and widening of the natural channels to provide satisfactory systems of tributary drainage should be undertaken when the construction of complete systems of sanitary sewers has eliminated all sewage from the open streams. In connection with such work, sufficient right-of-way should be acquired in the valleys to provide, in addition to a satisfactory storm-water channel, a system of much-needed parkways throughout the western part of the metropolitan area. Estimates of cost cover closed conduits up to 36 inches in diameter for the upper part of each drainage system and open channels throughout the remaining portion.

Recreation.—Along the Mississippi the construction in the vicinity of Alton will make possible the development of beaches and boating facilities on both sides of the extensive lake to be created.

Along the streams of the Meramec River Basin studies have been made of proposals to combine flood protection for the lower reaches of the Meramec with the creation of lakes for recreational purposes. A further study is recommended to determine the sites for storage reservoirs, which should be designed to retain the peak flood flows so as to keep the Meramec River within its banks for the lower 33 miles, and still provide lake surfaces with a minimum of fluctuation for satisfactory recreational developments.



St. Louis Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Studies to develop recommendations for the abatement of pollution from any source; and studies to ascertain present and probable future water supply needs and to make recommendations.	\$20,000	
	Study for improvement of recreational facilities throughout the entire basin to determine the feasibility of artificial lakes along the Meramec River in conjunction with flood correction and lake developments along the Mississippi.	10,000	
28	East St. Louis, Ill.: Raise and enlarge existing levees.	1,158,000	Authorized by Congress.
21	St. Louis, Mo.: Raise and enlarge existing levees of the St. Louis County drainage and levee district.	270,000	Do.
19	Madison County, Ill.: Raise and enlarge existing levees of the Choteau, Nameoki, and Venice drainage and levee district.	154,000	Do.
28	East St. Louis, Ill.: Sewer system for Lansdowns area in east part of the city.	450,000	Preliminary plans completed.
15	Wood River, Ill.: Combined sewers and pumping station.	400,000	Preliminary plans partly completed.
29	Collinsville, Ill.: Sewer extensions and sewage treatment plant.	160,000	Preliminary plans completed.
31	St. Louis County, Mo.: Sewer system for Ladue-Deer Creek sanitary sewer district.	435,000	Do.
36	St. Louis County, Mo.: Sewer system for the Lemay Ferry sanitary district.	309,000	Petition pending to incorporate district.
22	St. Louis County, Mo.: Sewer system and sewage treatment plant for the Overland sanitary sewer district.	337,000	Subject to incorporation and bond issue election.
28	Webster Groves, Mo.: Extension of sewer system.	200,000	Preliminary plans completed.
42	Crystal City, Mo.: Extension of sewer system.	25,000	Do.
28	University City, Mo.: Sewer system.	159,000	Plans completed.
(1)	Bend (3), Ill.; Bonne Terre (47), Cuba (44), Desloge (47), Elvins (47), Esther (47), Flat River (47), and Leadwood (47), Mo.; Mount Olive (7), Ill.; Pacific (37), River Mines (47), St. Clair (40), St. James (45), and Salem (49), Mo.; Staunton (8), Ill.; Sullivan (43), and Union (39), Mo.: Sewage treatment plants.	831,000	Preliminary plans completed.
45	Bismarck, Mo.: Sewer system and treatment plant.	54,000	
(1)	Granite City (27), Madison (28), Nameoki (23), and Venice (26), Ill.: Combined relief sewers and pumping station.	3,000,000	Preliminary plans completed.
(1)	Bethalto (13), Brighton (10), Bunker Hill (9), Caseyville (30), Edwardsville (18), Gillespie (2), Glen Carbon (24), Maryville (25), Mount Olive (7), Roxana (16), Sawyerville (6), Wilsonville (5), and Worden (17), Ill.: Water supply system.	1,070,000	Preliminary plans completed or under study.
(1)	Bend (3), Ill.; Bonne Terre (47), Desloge (47), Elvins (47), Esther (47), Flat River (47), Leadwood (47), Pacific (37), Potosi (46), River Mines (47), St. Clair (40), St. James (45), and Salem (49), Mo.; Staunton (8), Ill.; Sullivan (43), Mo.; and Wood River (15), Ill.: Water supply improvement or treatment.	652,000	Do.
(1)	Madison (9) and St. Clair (19) Counties, Ill.: Drainage, including control works, intercepting canals, and channel improvements in the East Side levee and sanitary district.	2,500,000	Preliminary plans completed.
26	Brooklyn, Ill.: Sewer system and pumping station.	100,000	Do.
(1)	Edwardsville (18) and Wood River (15), Ill.: Sewer system extensions.	95,000	Do.
(1)	Caseyville (30) and Signal Hill (28) district, Ill.: Sewer system and sewage treatment.	150,000	Do.
28	East St. Louis, Ill.: Sewer system for Edgemont district.	200,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
38	Big, Bourboise, and Meramec Rivers, Mo.: Channel clearance for flood correction and recreation.	\$20,000	
(1)	Deer Creek (34), Huntleigh (33), and Kirkwood (35), Mo.: Sewer systems.	260,000	
28	St. Louis, Mo.: Sewers for area tributary to Gravois Creek, River Des Peres, and Maline Creek.	2,800,000	
(1)	Cahokia (28), East Carondelet (28), and Fairmount (28), Ill.; Herculaneum (41), Mo.; Nameoki (23), National City (28), and Washington Park (28), Ill.: Sewer systems.	453,000	Preliminary plans completed.
28	St. Louis, Mo.: Sewer system replacements.	260,000	
28	St. Louis, Mo.: Relief sewers.	4,800,000	
12	Alton, Ill.: Sewer system in upper Piasa Valley.	90,000	
12	East Alton, Ill.: Storm sewers.	25,000	
28	St. Louis, Mo.: Sanitary-relief sewer for River Des Peres district.	1,000,000	
28	University City, Mo.: Storm sewers and channel improvements for River Des Peres area.	2,000,000	
14	Madison County, Ill.: Levee construction for flood protection in the Wood River drainage and levee district.	131,000	
20	Madison County, Ill.: Improving levees of the Choteau Island drainage and levee district.	213,000	
	Meramec River Basin, Mo.: Storage reservoirs and low dams on tributaries for rural-water supply.	400,000	
11	Alton, Ill.: Lake development above dam no. 26; beaches, boating facilities, drives, and parks.	1,250,000	
11	St. Charles County, Mo.: Lake development above dam no. 26 opposite Alton, Ill.; beaches, boating facilities, drives, and parks.	1,850,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Brighton (10), Bunker Hill (9), Eagerville (1), Sawyerville (6), White City (6), Wilsonville (5), and Worden (17), Ill.: Sewage and sewage treatment.	\$156,000	
(1)	Eagerville (1), Dorchester (4), and White City (6), Ill.: Water-supply systems.	60,000	
28	St. Louis Metropolitan Area, Mo. and Ill.: Water-supply additions and extensions.	5,000,000	Long-time plan for consolidation of public and private facilities into coordinated system.

¹ Map key number shown following community name.

15. KASKASKIA-BIG MUDDY

Water problems in the Kaskaskia and Big Muddy River Basins include pollution, exceptionally acute here because of coal-mining waste; correction of low summer flow; provision of additional surface-water supplies for cities; and protection of agricultural land from overflow, principally along the Mississippi River.

Storage on tributaries of the principal streams would be beneficial in adjusting stream flow to augment low flows and thus abate pollution by additional dilution.

Additional basic data are required in preparation of the long-range plan.

General Description

The Kaskaskia-Big Muddy River Basins include, in addition to the basins of these streams, three portions of the Mississippi Trough known as the Fountain, Marys, and Clear Creek drainage areas. Included are 9,093 square miles, of which about 5,675 are in the Kaskaskia, 2,600 in the Big Muddy, 325 in the Fountain, 352 in the Marys, and 360 in the Clear Creek Basins.

The flood plain of the Mississippi Trough seems flat in contrast with the ruggedly dissected bluffs, which rise abruptly some three or four hundred feet above it. The courses of the Kaskaskia and Big Muddy Rivers on the trough floor have been deflected downstream, and the Big Muddy parallels the Mississippi for about 13 miles. Near Grand Tower a group of hills, Fountain Bluffs, rises precipitously from the middle of the trough floor.

The Kaskaskia Basin is about 180 miles in length, and from 30 to 50 miles wide. The gap it cuts in the bluffs is only 2 miles wide. The channel of the Kaskaskia meanders along the axis of the basin and is 300 miles long. It falls about 390 feet. The upper half of the basin is gently rolling. In the southern part of the basin the glacial drift has been removed. The Kaskaskia and its principal tributaries, Shoal and Crooked Creeks, have cut away the glacial drift in places, but drift-capped hilly ridges remain.

The Big Muddy Basin is about 70 miles long and 50 miles wide, with the trunk stream flowing close to the southern valley wall. The total length of the channel is 111 miles. The total fall is about 90 feet with only 32 feet in the lower 86 miles.

The bed rock of the area contains several valuable coal seams. The soil of the northern half is deep and rich. The southern half has heavy lean soils.

The mean annual temperature ranges from 55° in the south part to 52° in the north, and the average annual precipitation ranges from 41 inches in the south to 37 inches in the north. Precipitation is well distributed throughout the year with a maximum monthly average of 4.11 inches in June and a minimum of 2.16 inches in January.

The upper Kaskaskia Basin has fertile agricultural lands and good land is scattered in other sections. Much of the land in the southern portion is marginal or submarginal. The principal crops are grains, fruit, vegetables, soy beans, and forage. Livestock and dairy farming are relatively important.

This basin lies in the heart of the eastern interior coal fields and contains rich veins. Mining industries are highly developed in the Big Muddy and lower Kaskaskia areas. The mines contribute about 7 percent of the total bituminous production of the United States. Production here reached a peak of about 40,000,000 tons in 1921 and amounted to 25,000,000 in 1935. Minor extractive industries include gravel, limestone, clay, shale, oil, and natural gas.

In 1930 the population of the area was approximately 550,000, divided about equally between the Kaskaskia-Fountain Creek Basins and the Big Muddy-Marys River and Clear Creek Basins. About half of the people live in towns and cities of more than 2,500 population. The population is likely to decrease, since mining is declining and submarginal lands should be retired. About 35 percent of the population is dependent directly or indirectly upon coal mining. The relatively high urbanization of the mining area creates a large demand for public water supply and sewer systems and intensifies the pollution of streams. The latter is further aggravated by wastes from coal production and industrial operations.

Recommended Plan

Storage reservoirs.—Topographic features of the area indicate the availability of a number of effective reservoir sites on tributaries. Storage capacity for all or the major part of the run-off above the dams might be developed at these sites at reasonable cost. Additional engineering data are needed, however, to make close estimates of cost. Special surveys and studies should be made. These surveys should cover all available reservoir sites which have possibility of development for general conservation purposes or as specific

sources of urban supplies. Sufficient information should be obtained to indicate the functional utility and feasibility of the sites and to establish a program of construction. The incidence of malaria and transpiration losses of aquatic plants should be carefully considered in connection with the possible creation of shallow-water areas.

Water supply.—A number of towns need extensions and rehabilitations of existing water-supply systems. Establishment of new water-supply systems is desirable for some towns. This new construction should be started and carried on under a coordinated program developed by a comprehensive study. Many projects, however, are independent of these studies and need not await their completion.

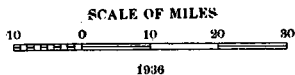
Low-flow correction.—The flow of the Big Muddy River at Murphysboro frequently becomes zero. Release of stored water from tributary reservoirs would correct this condition, partially solve the water-supply problems for parts of the rural areas, and also furnish dilution for effluents from sewage, mining, and industrial-waste treatment plants. The improvement

of deficient stream flow during the summer months is of great importance.

Pollution of streams, particularly in the southern portion, which is highly urbanized and is largely dependent upon surface supplies, is a serious problem in this region. Special studies of pollution should be started immediately. Construction of sewer systems and treatment plants should be started as rapidly as the studies will permit. Prevalence of typhoid and dysentery emphasizes this need. Pollution results from sewage and industrial and mining wastes. Special studies of methods of disposal of mine wastes will be required.

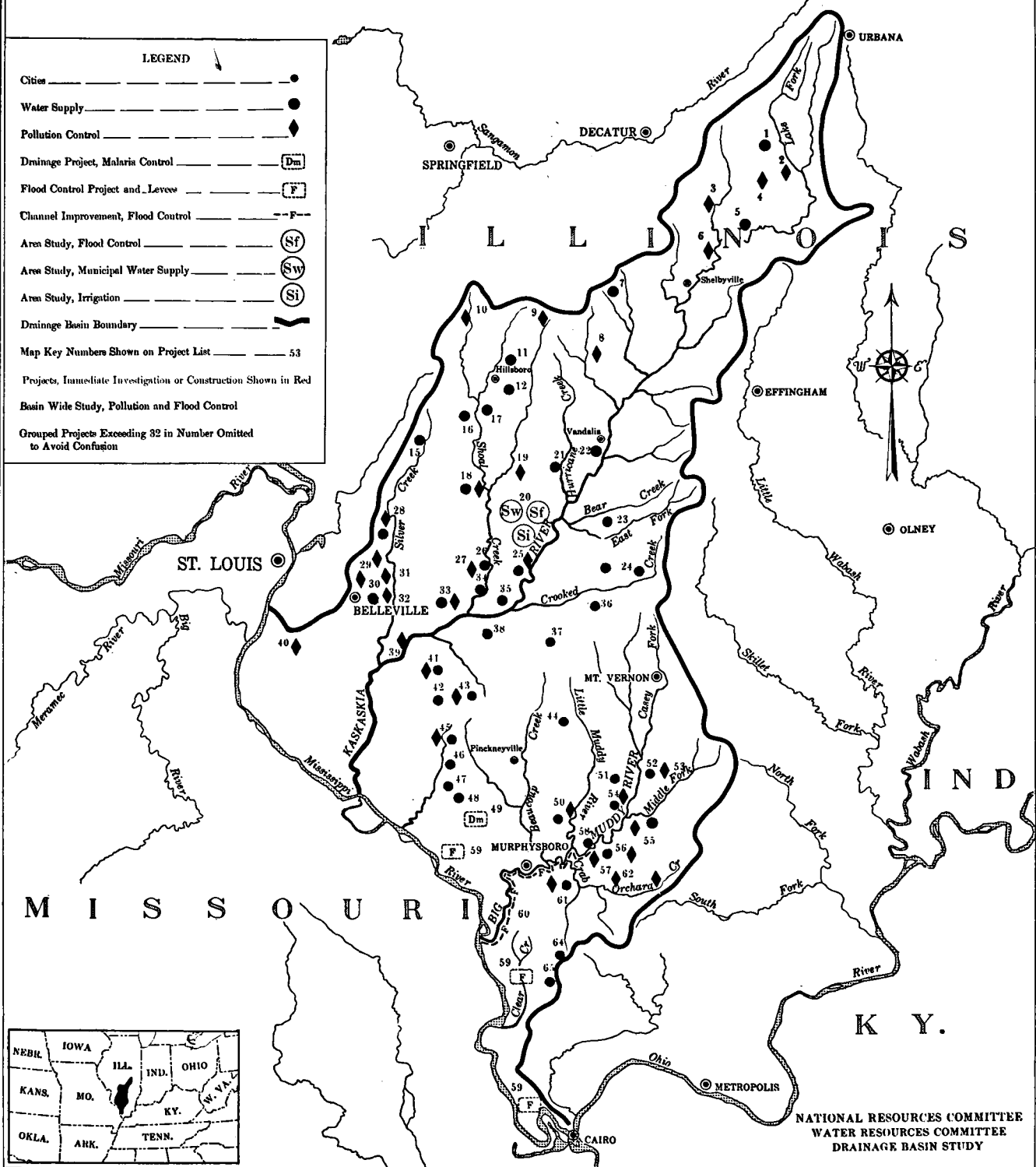
Levees.—Certain areas along the Mississippi River in the vicinities of Fountain Creek, Marys River, and Clear Creek are inadequately protected from overflow at flood stages of the Mississippi. The Congress has authorized improvements in districts now needing protection in these areas. In addition, certain overflowed lands in the Kaskaskia Basin may warrant levee protection. However, a study is needed.

KASKASKIA - BIG MUDDY



LEGEND

- Cities _____ ●
- Water Supply _____ ●
- Pollution Control _____ ◆
- Drainage Project, Malaria Control _____ [Dm]
- Flood Control Project and Levee _____ [F]
- Channel Improvement, Flood Control _____ -F-
- Area Study, Flood Control _____ (Sf)
- Area Study, Municipal Water Supply _____ (Sw)
- Area Study, Irrigation _____ (Si)
- Drainage Basin Boundary _____
- Map Key Numbers Shown on Project List _____ 53
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution and Flood Control
- Grouped Projects Exceeding 32 in Number Omitted to Avoid Confusion



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Kaskaskia-Big Muddy Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
20	Flow regulation studies: (1) To determine the functional utility of any reservoir sites possible of development for general conservation or as specific water supplies; (2) to determine methods of flood correction for agricultural lands along the Kaskaskia; (3) to make recommendations concerning the adequacy of water for agricultural needs in dry years. General study involving procurement, correlation, and analysis of all necessary engineering, economic, and social data; including studies of urban water supply and of stream sanitation to determine needs and make recommendations.	\$32,000 50,000	
30	Belleville, Ill.: Extensions of sewer system and additional treatment.....	1,576,000	Plans completed.
56	Herrin, Ill.: Sewer system and additional treatment.....	685,000	
55	West Frankfort, Ill.: Extension of sewer system and treatment plant.....	373,000	
62	Carterville, Ill.: Sewer system and treatment.....	240,000	
50	Elkville, Ill.: Sewer system and sewage-treatment plant.....	145,000	
53	Benton, Ill.: Extension of sewer system and additional treatment.....	82,000	
40	Columbia, Ill.: Sewer system.....	65,000	
	Maressa (41), New Athens (39), O'Fallon (29), Percy (45), Pocahontas (18), Ramsey (18), and Troy (28), Ill.: Sewers and treatment.....	480,000	
33	New Baden, Ill.: Sewer and treatment.....	104,000	
41	Maressa, Ill.: Development of source and extension of distribution system.....	123,000	
21	Odin, Ill.: Development of source and distribution system.....	102,000	
(1)	Ashley (37), Beckemeyer (35), Breese (26), Buckner (64), Carbondale (61), Carlyle (25), Cobden (64), Colp (57), Coulterville (43), Cutler (46), Elkville (50), Germantown (34), Livingston (15), Mulberry Grove (21), Okawville (38), Panama (17), Patoka (23), Percy (45), Pocahontas (18), Sandoval (24), Schram City (11), Sorento (16), Sullivan (5), Tamarora (44), Taylor Springs (12), Tilden (42), Troy (28), Valier (51), Wamac (36), West City (32), and Willisville (47), Ill.: Waterworks systems or extension to waterworks system and water treatment plants or addition to water treatment plants.	1,533,000	Preliminary plans prepared.
32	Freeburg, Ill.: Development of source, treatment, and extension of distribution system.....	122,000	
(1)	Bethany (3), Carlyle (25), Greenville (19), Lovington (4), Nokomis (9), Raymond (10), Findlay (6), and Trenton (27), Ill.: Sewer systems or extension to sewer system and sewage treatment plants or addition to sewage treatment plants.	465,000	
(1)	Illinois: Levee construction for the protection of bottom lands..... Ava (48), Evansville, Hammond (1), Hurst (58), Jonesboro (65), New Baden (33), and Pana, (7), Ill.: Water supply and improvements.	3,785,000 275,000	Authorized in part by Congress. Plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
55	West Frankfort, Ill.: Waterworks system..... Arthur, Ashley, Atwood, Ava, Beckemeyer, Bennet, Buckner, Bush, Cambria, Carbondale, Central City, Coalton, Cobden, Coffeen, Colp, Coulterville, Cowden, Cutler, De Soto, Dowell, Energy, Farina, Freeburg, Germantown, Grand Tower, Hammond, Hanaford, Highland, Hillsboro, Hurst, Irving, Irvington, Johnston City, Jonesboro, Kimmundy, Lebanon, Livingston, Marine, Marion, Mascoutah, Mount Olive, Mount Vernon, Mulberry Grove, Murphysboro, North City, Odin, Okawville, Orient City, Pana, Panama, Patoka, Pinckneyville, Pittsburg, Royalton, St. Elmo, Sandoval, Schram City, Sesser, Shelbyville, Sorento, Steeleville, Stewardson, Swansea, Tamarora, Taylor Springs, Thompsonville, Tilden, Tower Hill, Valier, Vandalia, Wamac, West City, Williamson, Windsor, and Witt, Ill.: Sewers and sewage treatment plants.	\$675,000 5,137,000	
49	Alexander, Franklin, Hamilton, Jackson, Perry, Randolph, St. Clair, Union, and Williamson Counties, Ill.: Drainage for malaria control.	700,000	
22	Vandalia, Ill.: Additional water treatment and distribution system.....	288,000	
22	Bush, Cambria, Carterville, Chester, Coalton, Coffeen, De Soto, Dowell, Energy, Farina, Grand Tower, Hanaford, Irving, Kimmundy, Lovington, Marine, Murphysboro, North City, Orient City, Pittsburg*, Ramsey, Red Bud, Royalton, St. Elmo, Sesser, Shelbyville, Sparta, Stewardson, Thompsonville, Tower Hill, Trenton, Williamson, Windsor, Witt, and Ziegler, Ill.: Waterworks systems or extension to waterworks systems and water treatment plants or addition to water treatment plants.	1,135,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
60	Jackson and Williamson Counties, Ill.: Cleaning and straightening channel of Big Muddy River for flood prevention.	\$250,000	
(1)	Carbondale (61), Marion (63), and Mascoutah (31), Ill.: Extensions to sewer systems and sewage treatment plants.	425,000	
(1)	Arthur (2), Buckner (54), Colp (57), Coulterville (53), and Freeburg (32), Ill.: Sewer system and sewage treatment plant.	560,000	
	Ashley, Atwood, Ava, Beckemeyer, Bemenr, Bush, Cambria, Central City, Coalton, Cobden, Coffeen, Cowden, Critler, De Soto, Dowell, Energy, Evansville, Farina, Germantown, Grand Tower, Hammond, Hanaford, Highland, Hillsboro, Hurst, Irving, Irvington, Johnston City, Jonesboro, Kimmundy, Lebanon, Livingston, Marine, Mount Olive, Mount Vernon, Mulberry Grove, Murphysboro, North City, Odin, Okawville, Orient City, Pana, Panama, Patoka, Pinckneyville, Pittsburg, Royalton, St. Elmo, Sandoval, Schram City, Sesser, Shelbyville, Sorento, Steeleville, Stewardson, Swansea, Tamarora, Taylor Springs, Thompsonville, Tilden, Tower Hill, Valier, Vandalia, Wamac, West City, Williamson, Windsor, Witt, and Ziegler, Ill.: Sewer system or extension to sewer system or sewage treatment plant or addition to sewage treatment plant.	4,153,000	Individual priorities and costs to be determined by study project under A-2.

* Map key number shown following community name.

MISSOURI DRAINAGE BASINS

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1. MISSOURI HEADWATERS

The chief uses of water in the headwaters of the Missouri Basin are for irrigation and for stock watering. Power comes next in importance. Although there is ample developed water power for present needs, many additional sites are unused. Control of erosion and silting and provision of additional water for stock are important problems in the basin. The livestock of this area was valued in 1929 at nearly \$120,000,000. Flood control, domestic and industrial water supplies, and pollution of streams are minor water problems at present. The largest undertaking in the basin is, of course, the Fort Peck Dam, now nearing completion. It will improve the navigability of the Missouri River.

General Description

This basin lies almost entirely in Montana and includes an area equal to about two-thirds of that State. It contains the area drained by the Missouri River above the mouth of the Yellowstone River, approximately 100,000 square miles. A small area in Canada, drained by the headwaters of the Milk and several minor tributaries entering the Missouri from the north, is included. Altitudes range from 10,000 feet in the extreme western portion to about 3,300 feet in the southern valleys.

The Missouri River is formed by the junction of the Jefferson, Madison, and Gallatin Rivers near Three Forks, which is 785 miles by river above the mouth of the Yellowstone River. These upper streams are typical mountain rivers, draining areas where precipitation occurs largely as snow. This results in fairly well-sustained summer flow. The Missouri flows in canyons to Great Falls. Below Great Falls it has cut a narrow valley in the plains. The Milk River joins the Missouri in eastern Montana.

Great Falls, with a population of about 29,000, is the largest city; Helena, with 12,000, is next in size. Except in the irrigated areas, the population is sparse.

Most crops are raised on irrigated land. Dry farming, although declining rapidly in recent years, is still extensively practiced. Grazing livestock on the public domain is a major activity. Much of the land formerly dry farmed is going back to grazing. About 900,000 acres are now irrigated in this basin, with about 40 percent of the total in the Jefferson Basin. Individual canal systems are generally small.

Mining is active in the upper areas, and oil and gas are produced in parts of the basin. There is some lumbering. Copper smelting and the manufacture of

copper and brass articles form the principal industry of Great Falls, and about 80 percent of the manufactured values of the basin come from that city.

Navigation is nonexistent in the basin, but railroad transportation is adequate, and highways are being improved and are generally satisfactory.

The mean temperature in the basin is about 40° with a wide range from about 40° below zero to 98° above. The average annual precipitation varies from 12 inches in the Marias River Basin to 17 inches near Three Forks. The average annual flow of the Missouri at the Montana line is about 7,500,000 acre-feet.

Recommended Plan

There are current demands in this basin for additional irrigation and for migratory waterfowl conservation. Other uses of water are incidental and are not increasing rapidly.

No interstate difficulties have arisen. Milk River is operated under the terms of a treaty with Canada. The water problems of this basin being local rather than general, each tributary can be developed for the most part independently of the main stream. Some general planning is needed on the headwaters and on some of the larger tributaries, but the conditions are much less complex than those of most western areas.

Irrigation is important as a means of feed production for range stock and of crop production for the maintenance of the present farm population. Readjustment of dry farming and grazing is needed. Irrigation will be most effective and most helpful in the readjustment, if distributed in small projects in grazing areas as widely as the limited water supplies will permit. There are opportunities for some larger irrigation projects to produce general crops, including sugar beets, grain, and forage.

No prior rights on the Missouri River have been asserted or are expected to be asserted to the inflow from any tributary below Three Forks. Above Three Forks there are seven hydroelectric plants on the Jefferson, Madison, and Gallatin Rivers. These have rights which may limit diversion for irrigation. By coordinated development of storage, however, compensation probably can be provided for diversions from any of these streams, since each of them has a total flow in excess of power requirements.

Possible diversion from the Yellowstone River to the Madison River and from the latter to the Snake River is noted also in the report on the Yellowstone. A study

of this possibility is essential to proper planning for a regional development, even though the project may be beyond the scope of present needs and available funds.

Irrigation will demand storage on the Jefferson River. The Montana State water conservation board is now constructing supplemental storage on Willow Creek, and has proposed other similar projects. A large reservoir on Big Hole River, which is a tributary to the Jefferson, has also been proposed. Such storage could be used in the Jefferson Valley and along the Missouri, or it might replace water diverted from Hebgen Reservoir to the Snake River. Such projects require additional study. Smaller projects based on local use can proceed in accordance with local needs where such projects can be worked out at feasible costs.

The Bureau of Reclamation, the Montana State planning board, and the State water conservation board sponsor a number of irrigation works at various points in the basin, some in process of construction and others far in the future. Some of those needed are a reservoir in the Gallatin River at the mouth of West Fork, a study of proposed developments on the Marias River, and an 11,000-acre pumping unit near Saco. The largest project on these upper streams is the proposed Judith River Reservoir and canal systems, but since no studies using the data of recent years of deficient rainfall are available, this project should be deferred until new studies can be made.

Below Great Falls on the Missouri River, conditions do not favor extensive irrigation projects, because of the almost flat grade of the stream and consequent impossibility of diverting water in gravity canals. Regulation of flow by Fort Peck Dam will decrease channel shifting and intake difficulties, thereby making possible some developments by pumping from the river below the dam.

Diversion into the basin from the St. Marys River to the Milk River has been in progress for many years. No transmountain diversions to other basins have been constructed.

Flood-control projects on the Milk River at Saco and Glasgow are authorized by the Congress. There are small and local flood problems at a few towns along Milk River.

Navigation on the Missouri in this basin ceased with construction of the railroads. Fort Peck Dam will provide storage for regulating the low water flow in the navigable river far downstream. All the flow obtainable from Fort Peck Dam may not maintain the desired 30,000 cubic feet per second at Yankton during the navigation seasons of a long period of dry years. In the past development of western streams has not been limited by the requirement that they contribute water for navigation in the Missouri or Mississippi Rivers. This has been a matter of Federal policy rather than a matter of law. The uncertainty regarding a possible future assertion of the rights of navigation to prevent increased use for irrigation or other purposes should be removed. Action may be required by the Congress.

Power development at present is adequate, there being seven hydroelectric plants on the Missouri River above Great Falls with an installed capacity of 235,000 kilowatts. Headwater streams of the Missouri Basin have a large undeveloped capacity. The power plant under construction at Flathead Lake in the contiguous Columbia Basin will supply demands in this basin for the immediate future.

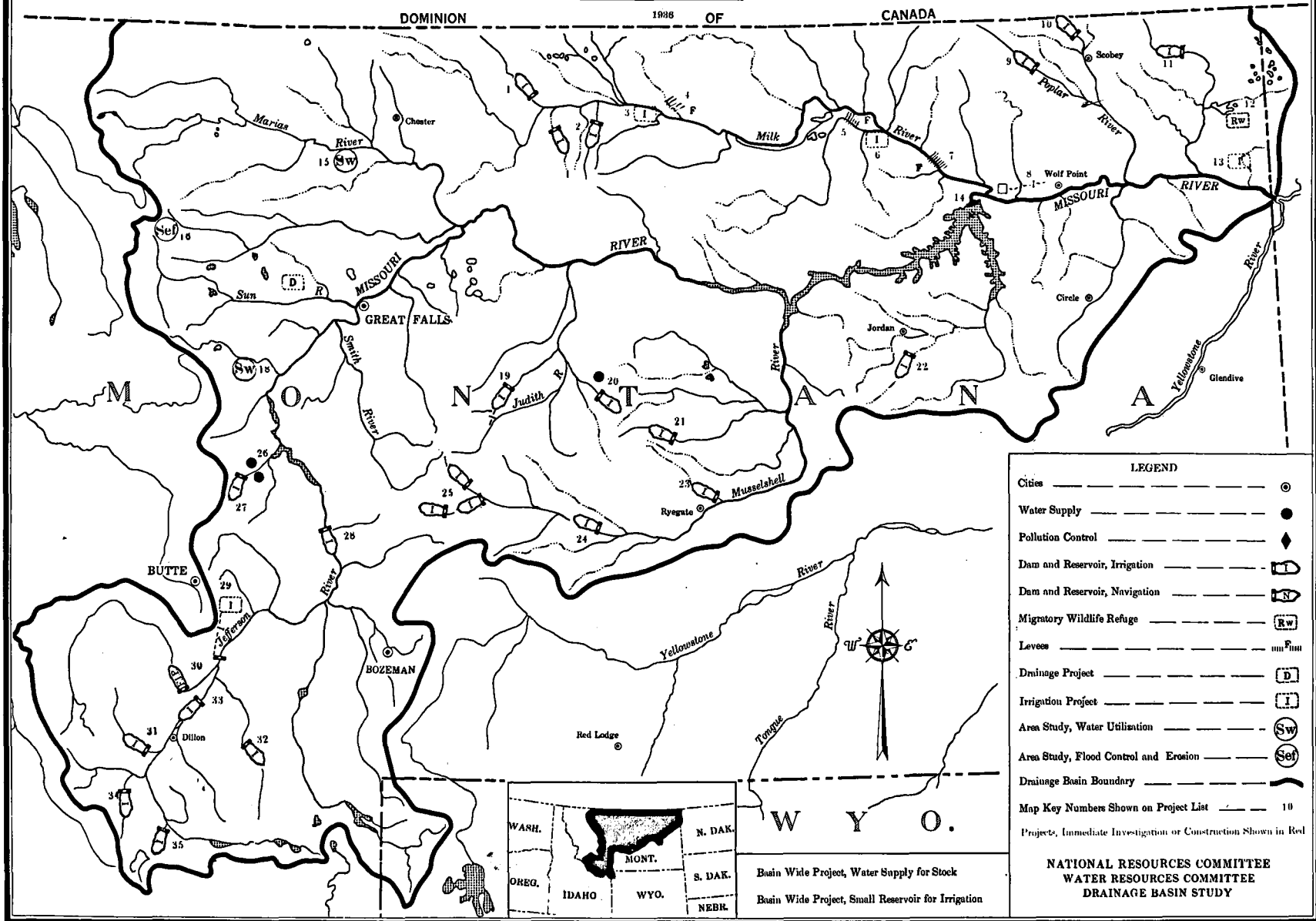
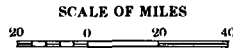
Water supply throughout the basin is, in general, obtainable in adequate quantity.

Artesian water is available in some of the lower parts of the area, but in places it is of poor quality. Shallow wells are generally used for domestic supplies in rural areas. Municipal supplies are obtained from surface streams or wells.

A project for the construction of comparatively small reservoirs costing less than \$25,000 each is recommended. It will provide reservoirs intermediate in size between those needed for stock water and those now being undertaken by the State water conservation board. Some reservoirs of this type are under construction as work relief projects. The project here proposed is one for a permanent organization operating on a repayment basis.

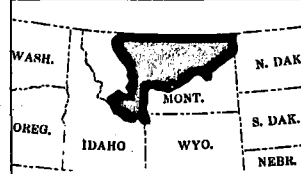
Soil erosion, in its relation to water supply and utilization, is a serious problem in various parts of this basin. The silt load of the Missouri River comes largely from the lower tributaries. Some silting may occur in the Chain of Lakes Reservoir on Milk River and in stream-bed reservoirs on other lower streams.

MISSOURI HEADWATERS



LEGEND

- Cities ———— ○
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir, Irrigation ———— [D]
- Dam and Reservoir, Navigation ———— [N]
- Migratory Wildlife Refuge ———— [RW]
- Levees ———— [L]
- Drainage Project ———— [D]
- Irrigation Project ———— [I]
- Area Study, Water Utilization ———— [Sw]
- Area Study, Flood Control and Erosion ———— [Set]
- Drainage Basin Boundary ———— [thick line]
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red



Basin Wide Project, Water Supply for Stock
 Basin Wide Project, Small Reservoir for Irrigation

**NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY**

Missouri Headwaters Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
18	Study to determine extent and best use of water supply of the Dearborn River, Mont.....	\$25,000	
15	Study to determine extent and best use of water supply of the Marias River, Mont.....	50,000	
25	Durand, Forks, and Martinsdale, Mont.: Reservoirs for irrigation.....	400,000	Cost given is for first 2 years. Additional needed to complete, \$376,000.
24	Barber, Mont.: Outlet tunnel from Deadmans Basin to return water to the river to supply lower Musselshell canals.	300,000	Inlet tunnel from Musselshell River under construction. Sum needed to complete.
3	Fort Belknap Indian Reservation, on Milk River, Mont.: Improvements to present irrigation system.	30,000	Storage in Chain of Lakes is included with Milk River project. Plans completed. Cost given is for first 2 years. Additional needed to complete, \$30,000.
32	Madison County, Mont.: Storage reservoir on Ruby River for irrigation of lands in Ruby and Jefferson Valleys.	527,000	Plans completed.
1	Havre, Mont.: For completion of Chain of Lakes Reservoir by Fresno Dam on Milk River, to conserve and utilize flood waters imported from the St. Marys River.	250,000	Sum needed to complete.
8	Fort Peck Indian Reservation, Mont.: Missouri River pumping plant for stabilizing supply for several units on reservation.	100,000	Cost given is for first 2 years. Additional needed to complete \$100,000.
	Montana: General water supply development consisting of wells, springs, and reservoirs for stock grazing throughout State.	250,000	Survey to be made.
19	Ackley Lake, Mont.: Increased water storage by raising natural outlet of lake and to fill same by feed canal (5 miles long) from Judith River for irrigation supply.	98,000	Plans nearly ready.
22	Jordan, Mont.: Big Dry Creek storage reservoir to be used in conjunction with Wolf Creek Reservoir for irrigation purposes. It also serves town of Jordan.	80,000	Do.
35	Dell, Mont.: Big Sheep Creek Reservoir for supplemental storage in Red Rock Valley.	136,000	
26	Helena, Mont.: Stand-by water service for veterans' hospital and Fort Harrison, including 300,000-gallon reservoir and extension of present water and sewer systems.	35,000	Surveys started.
17	Fairfield, Mont.: Sun River project, canals and drains to complete system.....	400,000	Cost given is for first 2 years. Additional needed to complete, \$500,000.
5	Saco, Mont.: Levees on Beaver Creek for flood protection.....	27,000	Sketch plans completed.
7	Glasgow, Mont.: Levees on Milk River for flood protection.....	26,000	Do.
4	Harlem, Mont.: Levees on Thirty Mile Creek for flood protection.....	10,000	Do.
	Montana: Small reservoirs in several counties, costing less than \$25,000 each, for irrigation and grazing, including Little Dry Creek, Buffalo Hill, Ash Creek, and Clear Lake.	250,000	Plans are incomplete.
27	Upper Boulder, Mont.: Dam to provide supplemental storage for irrigation.....	200,000	
6	Saco, Mont.: Saco Divide pumping division of the Milk River project for irrigating 10,000 acres of land above gravity system.	400,000	Plans in preparation. Cost given is for first 2 years. Additional needed to complete, \$600,000.
14	Fort Peck, Mont.: Fort Peck Dam on the Missouri River for stabilizing flow for navigation below Sioux City.	16,297,000	Project under construction. Cost given is for first 2 years. Additional needed to complete, \$2,922,000.
28	Helena, Mont.: Water mains.....	379,000	
20	Lewiston, Mont.: Water mains.....	238,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
13	Bainville, Mont.: Supplemental supplies from Little Muddy and Shot Gun Creeks for irrigation.....	\$254,000	Plans nearing completion.
28	Townsend, Mont.: Broadwater-Missouri Dam and reservoir for irrigation.....	250,000	Plans not completed. Cost given is for first 2 years. Additional needed to complete, \$370,000.
10	Daniels County, Mont.: Storage reservoir for irrigation on East Fork Poplar River.....	205,000	Requires clearance of rights from Fort Peck Indian Reservation. Plans nearing completion.
9	Richland, Mont.: Storage reservoir for irrigation purposes on West Fork Poplar River.....	359,000	Do.
11	Plentywood, Mont.: Reservoir on Upper Big Muddy for irrigation.....	476,000	
33	Beaverhead County, Mont.: Dam on Red Rock Creek to provide supplemental water supply for irrigation.	860,000	
29	Jefferson County, Mont.: Diversion project water to be stored at Beaverhead Rock Dam for irrigation of Pipestone Benchlands.	200,000	Plans incomplete.
2	Havre, Mont.: Beaver Creek storage for irrigation.....	184,000	Do.
12	Medicine Lake, Mont.: Migratory waterfowl refuge; additional water development.....	15,000	Should not conflict with principal uses of water.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
30	Beaverhead County, Mont.: Big Hole Dam and reservoir for irrigation, power development, and flow regulation.	\$3,500,000	Part of a general plan for irrigation of upper part of basin. Plans are incomplete.
20	Lewiston, Mont.: Big Spring Creek storage dam for late summer irrigation.....	32,000	Plans are incomplete.
2	Blaine County, Mont.: For flood irrigation on Clear Creek south of Chinook.....	213,000	Do.
21	Petroleum County, Mont.: Storage on Flatwillow Creek for irrigation.....	400,000	Do.
31	Dillon, Mont.: Storage on Grasshopper Creek for irrigation.....	200,000	Do.
34	Beaverhead County, Mont.: Development of Medicine Lodge Creek for irrigation.....	69,000	Do.
23	Musselshell County, Mont.: Development of South Willow Creek for irrigation and water supply, partly from artesian wells.	63,000	Do.
16	Research study of erosion and stream flow and the role of forests on the east slope of the Continental Divide in Montana.	395,000	Study similar to that in Columbia Basin.

2. YELLOWSTONE

The principal demand for water in the Yellowstone River Basin, as in other western basins, is for irrigation. The supply in parts of this basin, however, is larger in relation to the demand than in many other western areas. Problems involved in other types of water use are, in general, not acute. Municipal supplies are adequate for present and future needs, power development is adequate for the demand, and flood control is a problem in only a few local areas.

General Description

The Yellowstone River Basin includes parts of Wyoming, Montana, and North Dakota. The river rises near the crest of the Continental Divide and joins the Missouri River near the western boundary of North Dakota. The basin has an area of 70,400 square miles, slightly larger than the State of Missouri. The main river rises in Yellowstone National Park and flows north and east across southern Montana. The Yellowstone Basin is primarily an agricultural area. Crops are irrigated where water can be obtained. Stock is grazed on large areas without adequate water supplies and in localities where the topography is too rough for cultivation. The soils vary in quality, with fertile areas in the valleys.

The population of the basin is small, about 190,000 in 1930. The average population density is less than 3 per square mile. Billings, Mont., the largest city, had a population of 16,380 in 1930. It is the center of 300,000 acres of irrigated land.

Temperatures range from more than 100° in summer to 40° below zero in winter, but the growing season is sufficient for sugar beets in all the major irrigation areas. Some of the higher valleys are limited, however, by short seasons, to production of cereals and forage. The area of good dry farming land is comparatively small. Precipitation varies from 6 to 15 inches in the lower valleys, but the mountain ranges receive more. The average run-off of the basin is about 11,000,000 acre-feet, of which nearly 3,000,000 come from the Yellowstone River above Livingston, about 1,000,000 from the Clark Fork, approximately 3,500,000 from the Big Horn, and the remainder from other tributaries.

Water power is not extensively developed. There are plants on the Shoshone and Riverton Federal irrigation projects utilizing the fall developed in the irrigation systems. Other water-power developments are small. Present power markets are adequately supplied.

Natural gas is available in the lower Yellowstone Valley at costs which limit the installation of competing water-power plants.

Irrigation systems have been constructed for those lands which can be reached by canals at reasonable costs. Shortages for canals diverting from the Yellowstone River have seldom occurred and storage has not been constructed. On the Clark Fork, additional late summer water is needed and some storage is being constructed. On the Shoshone, a principal tributary of the Big Horn, storage serves the Shoshone project of the Bureau of Reclamation. On the Tongue and Powder Rivers present development results in late summer shortages.

Industrial activity, now limited, may be expected to grow as irrigation develops. There is some mining. Recreational use of Yellowstone Park and adjacent areas is growing in importance.

Congress has authorized an interstate compact commission to adjust rights on the Yellowstone River between Wyoming and Montana. At present there is no acute conflict, although increased use of the Big Horn in Wyoming may cause shortages in the supply in Montana for diversions from this stream. Negotiations of such a compact have begun but have not proceeded far enough to enable its terms to be forecast.

Recommended Plan

The future needs of the basin center largely in *irrigation*. Any increase in the population of this area will be dependent principally upon extension of irrigated areas. The projects proposed are those in which the use of water will not conflict with future comprehensive plans for irrigation development in this region.

Projects planned along the Yellowstone River are chiefly for separate pumping plants, which, due to low cost of commercial power, offer a more economical method of development than by use of long gravity canals.

On the Wind River the largest projects are those of the Indian Service and the Riverton project of the Bureau of Reclamation. Both are incomplete and their completion is recommended.

Since construction was begun on Shoshone River by the Bureau of Reclamation, its plans have largely controlled the selection of areas on this stream. Three divisions of the Shoshone project are now operating, one, the Heart Mountain division, is under construction,

and the areas to be served by any future extensions have been selected. No extensions of the present divisions are planned. Construction on the Heart Mountain unit began in 1935. Future plans for the Shoshone project include the Oregon Basin division and possible supplemental service to the Greybull division.

While the Big Horn Basin has been extensively developed, particularly in Wyoming, many additional projects are proposed. The Big Horn drains areas of high elevation with well sustained run-off and many storage sites are available. Increased use in Wyoming has caused some shortages on the Big Horn in Montana. To remedy this condition a large reservoir has been proposed in Big Horn Canyon.

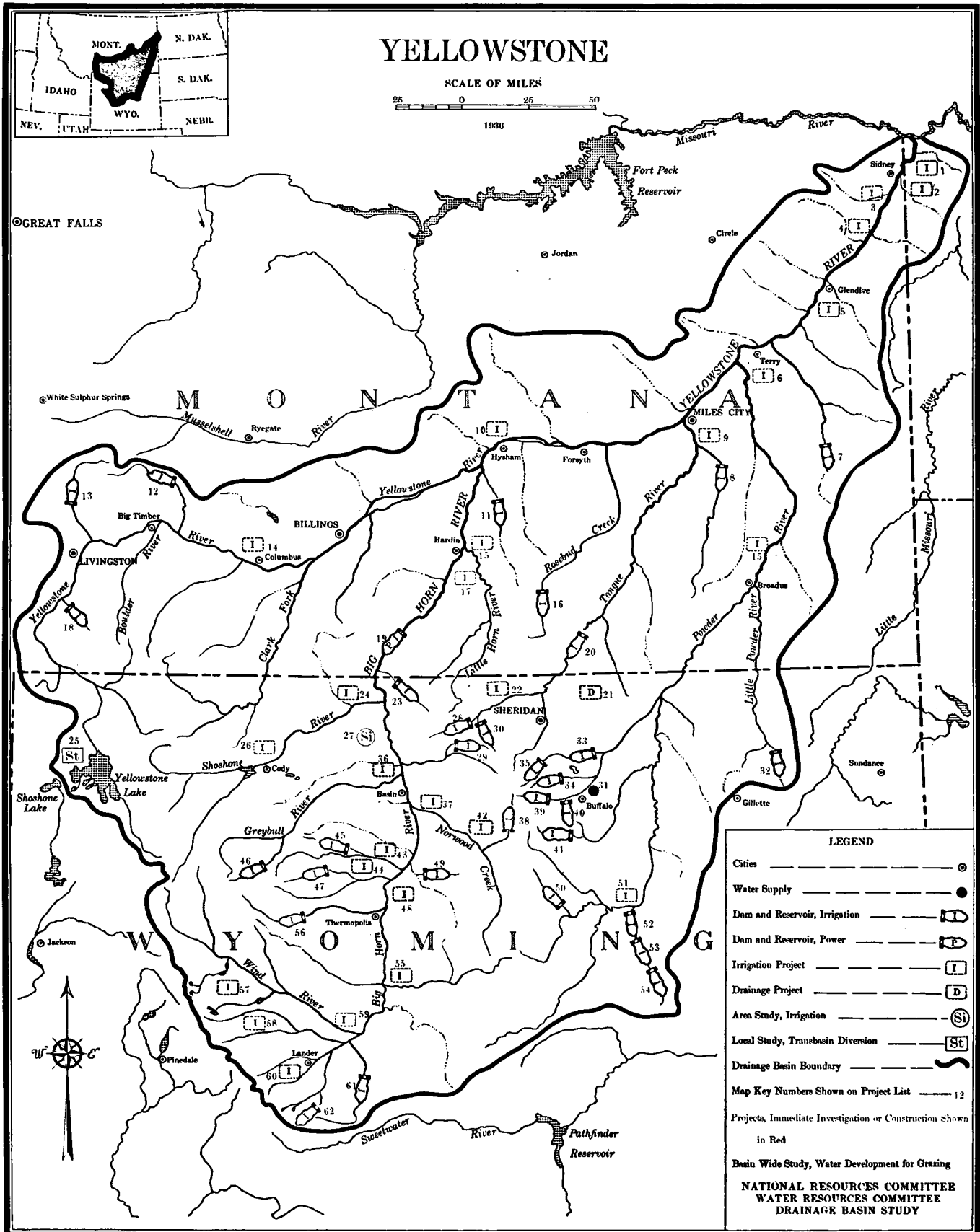
Tongue River and its upper tributaries are the sources of supply for several well-developed areas in the

vicinity of Sheridan, Wyo. Some additional projects are proposed in this area. A project is proposed near the Wyoming line with service to the different canals along the river.

The Powder River drains an area that lacks high mountains and the run-off is much less per square mile than that of other Yellowstone River tributaries. Irrigation from Powder River consists mainly of small areas along the upper tributaries and along the main streams. Several additional irrigation projects are proposed.

Other projects include soil-erosion control, water-supply development for grazing, and the construction of a large number of small reservoirs.

A proposal has been made to divert water from the Upper Yellowstone to Madison River and thence to the north fork of the Snake River.



Yellowstone Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
47	Grass Creek Reservoir, Wyo.: Supplemental storage for irrigation.....	\$100,000	
62	Louis Lake Reservoir, Wyo.: Supplemental storage for irrigation.....	31,000	
38	Tensleep Meadows Reservoir, Wyo.: Storage for irrigation.....	48,000	
20	Tongue River, Mont.: Storage for irrigation.....	820,000	Plans in progress.
15	Big Horn and Powder River Basins, Mont.: Small reservoirs.....	200,000	Plans can be quickly completed.
26	Heart Mountain division, Shoshone project, Wyoming: Irrigation.....	4,500,000	Sum necessary to complete.
25	Yellowstone-Missouri-Snake diversion investigation project for irrigation.....	150,000	
27	Big Horn River Basin, Mont. and Wyo.: Plan of irrigation development.....	50,000	
56	Owl Creek, Wyo.: Irrigation district; supplemental supply.....	325,000	
29	Shell irrigation project, Wyoming: Additional storage.....	55,000	
59	Riverton irrigation project, Wyoming.....	750,000	Cost given is for first 2 years. Additional needed to complete, \$3,100,000.
17	Crow Indian Reservation, Mont.: Irrigation systems.....	300,000	Cost given is for first 2 years. Additional needed to complete, \$200,000.
	Entire Basin: General water development for grazing.....	250,000	
45	Gooseberry Reservoir, Wyo.: Storage for irrigation.....	197,000	
3	Sidney, Mont.: Pumping project for irrigation.....	85,000	Plans nearly completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
58	Wind River Indian Reservation, Wyo.: Storage for irrigation.....	100,000	Cost given is for first 2 years. Additional needed to complete, \$1,205,000.
21	Drainage on irrigation projects in Yellowstone and Clarks Forks Valleys.....	\$350,000	To be planned as required.
(1)	Buffalo Rapids Project, Custer County, Mont., (5, 6, and 9).....	1,000,000	Cost given is for first 2 years. Additional needed to complete, \$5,100,000.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
12	Sweetgrass Creek, Mont.: Storage for irrigation.....	\$282,000	Plans incomplete.
4	Savags, Mont.: Pumping project for irrigation.....	39,000	Do.
1	Cartwright, N. Dak.: Two pumping units.....	250,000	Requires further investigation.
50	Red Fork Reservoir, Wyo.: Supplemental storage for irrigation.....	600,000	Needs further investigation.
60	Lander Valley, Wyo.: Irrigation.....	110,000	Investigation incomplete.
22	Parkman irrigation district, Wyoming.....	200,000	Plans can be quickly completed.
13	Shields River, Mont.: Storage for irrigation.....	1,145,000	Investigations incomplete.
11	Tulock, Mont.: Storage for irrigation.....	31,000	Plans incomplete.
14	Columbus district, Montana: Irrigation.....	55,000	Do.
16	Rosebud River south of Forsyth, Mont.: Storage for irrigation.....	135,000	Do.
35	Cloud Peak Reservoir, Wyo.: Storage for irrigation.....	65,000	Requires further investigation.
19	Big Horn Canyon Dam, Mont.: Reservoir to control Big Horn River for irrigation and power.....	15,000,000	Surveys authorized.
8	Lower Pumpkin Creek, Mont.: Storage for irrigation.....	234,000	Plans incomplete.
18	Mill Creek, Mont.: Storage for irrigation.....	177,000	Plans can be quickly completed.
10	North Sanders, Mont.: Pumping project for irrigation.....	53,000	Plans incomplete.
7	Red Butte Creek, Mont.: Storage for irrigation.....	30,000	Do.
61	Beaver Creek Reservoir, Wyo.: Storage for irrigation.....	38,000	Further investigation needed.
43	Buffalo Basin, Wyo.: Irrigation.....	1,890,000	Do.
53	Coal Draw Reservoir, Wyo.: Storage for irrigation.....	46,000	Plans incomplete.
57	Fremont Canal district, Wyoming: Irrigation.....	1,773,000	Do.
49	Fruitland Reservoir, Wyo.: Storage for irrigation.....	65,000	Do.
44	Gooseberry Farmers Canal, Wyo.: Storage reservoir for irrigation.....	1,094,000	Do.
36	Greybull Valley, Wyo.: Supplemental supply for irrigation.....	2,240,000	Do.
48	Hanover, Wyo.: Pumping project for irrigation.....	825,000	Do.
40	Henry Reservoir, Wyo.: Storage for irrigation.....	200,000	Do.
41	Keays Reservoir, Wyo.: Storage for irrigation.....	60,500	Do.
52	Lewis Reservoir, Wyo.: Storage for irrigation.....	101,000	Do.
32	Little Powder River, Wyo.: Storage for irrigation.....	350,000	Do.
24	Lovell irrigation project, Wyoming.....	31,000	Do.
54	Midwest Reservoir, Wyo.: Storage for irrigation.....	60,000	Do.
28	North Fork Reservoir, Wyo.: Storage for irrigation.....	1,053,000	Do.
37	Paint Rock irrigation project, Wyoming: Storage for irrigation.....	484,000	Do.
33	Piney Reservoir, Wyo.: Storage for irrigation.....	156,000	Do.
23	Porcupine Creek Reservoir, Wyo.: Storage for irrigation.....	100,000	Do.
39	Seven Brothers Reservoir, Wyo.: Storage for irrigation.....	100,000	Investigation incomplete.
30	South Fork irrigation district, Wyoming: Irrigation.....	1,673,000	Plans incomplete.
51	Sussex irrigation project, Wyoming: Storage for irrigation.....	658,000	Do.
42	Tensleep—Bonanza project, Wyoming: Storage for irrigation.....	694,000	Do.
55	Fremont Canal, Wyoming: Pumping for irrigation.....	850,000	Do.
34	Triangle Reservoir, Wyo.: Storage for irrigation.....	134,000	Do.
46	Upper Sunshine Reservoir, Wyo.: Storage for irrigation.....	710,000	Do.
31	Sheridan, Wyo.: Reservoir for municipal use.....	27,000	Plans deferred.
2	McKenzie County, N. Dak.: Benne Pierre Creek irrigation.....	100,000	Plans incomplete.

1 Map key numbers shown following project description.

3. UPPER MISSOURI: WESTERN TRIBUTARIES

No single use of water predominates in the basin of the upper Missouri and its western tributaries, and the waters of the Missouri River are used only to a very limited extent. The run-off of the local tributaries is small and erratic. Only occasional small areas have been irrigated. Hydroelectric power opportunities are limited and undeveloped. Flood control is a problem only in a few isolated areas. Water is used for domestic, municipal, and stock purposes, and such uses have not required the construction of large projects. There are no conflicting uses within the basin.

The water received from the Missouri River headwaters and the Yellowstone flows practically unused through this basin and is much in excess of any probable future demands. There is no plan for making the Missouri River navigable here. Each tributary is self-contained, and no intertributary diversions are planned. There is a severe general water problem arising out of the lack of adequate local supplies.

The preparation of a water-development program for this basin requires determination of the type of agriculture to be followed. If this area is to revert to stock raising and associated small-scale farming it will require only sufficient water for stock, domestic use, and subsistence crops. If an additional farming population is to be supported, additional water will be needed and all feasible irrigation opportunities should be utilized. Full use of all available water supplies will not support a dense population. Irrigation, at most, can be provided for only 1 or 2 percent of the area even with liberal cost limits.

General Description

This basin includes the western tributaries of the Missouri River drainage area from the mouth of the Yellowstone River to the mouth of the Cheyenne River. Neither the basin of the Cheyenne nor that of the Yellowstone is included, however. The principal tributary streams of the area are the Little Missouri, Knife, Heart, Cannonball, Grand, and Moreau. The area receives an average annual inflow from the Missouri River of about 7,500,000 acre-feet and from the Yellowstone River of about 11,000,000 acre-feet. Its surface is made up of plains and prairie which receive an average annual rainfall of from 14 to 18 inches and have a general run-off of from 35 to 50 acre-feet per square mile per year. The Missouri River flows through a narrow valley, diversion of water from its channel, except to limited areas of bottom land, would

be exceedingly expensive. Practically all areas in the basin therefore are dependent on limited local supplies.

Agriculture and stock raising are the only important industries of the area. Transcontinental railroads cross it. Mining, other than the mining of lignite coal, is not important. The largest city is Bismarck with a population of 11,090.

Large areas have at times been devoted to grain production. Past profits from this type of agriculture are attested by substantial improvements on many farms. Rainfall in recent years, however, has been insufficient for crop production. All of this district was within the drouth area of 1934 and 1936. Much land has reverted to grazing and severe problems of relief and population adjustment have arisen.

Recommended Plan

Water supply for domestic and municipal use is obtained principally from wells. These are generally shallow although such wells are subject to fluctuation and many have gone dry during recent years. Artesian wells are used only in the deep valleys of the Missouri and Little Missouri Rivers. The quality of the water from the shallow wells is generally better than that from greater depths.

There are some general questions that should be considered in carrying out any program for municipal projects. One is the future population trend. If this area is to revert to grazing, population decreases in the towns will result. In general, active growth is not to be anticipated since these towns appear to have as large populations as the local resources will support. Caution should be used against overbuilding. However, a number of the towns have immediate need for new or expanded systems, which are recommended for construction.

Pollution problems arise because lack of sustained flow in the streams makes sewage-treatment plants essential. In addition to consideration of population trends, the economic cost limits for sewer systems should be taken into account. The required treatment results in high per capita costs for the towns of 500 to 1,000 population in this area. Some projects, recommended by State authorities, have been included for construction.

Irrigation is practiced only to a small extent in this basin. Even along the Missouri River, where there are many patches of bottom lands 25 to 30 feet above the

river, pumping for irrigation is practiced for only a few individual farms and no canal systems are in use.

The transition occurs in this basin from the arid West, where the advantages of irrigation are unquestioned, to the semi-humid areas farther east, where irrigation has not been considered necessary or advisable. Future irrigation development will be limited probably to not more than 1 percent of the area if the per-acre cost is kept within practicable limits. When distributed over the area, such irrigation would not dominate the agriculture.

If the area is to be used primarily for stock raising, the water can best be put to use through construction of many small stock-water reservoirs together with irrigation facilities for such small areas as the remaining water supply will serve. In a few localities some flood irrigation of hay crops can be practiced. The primary purpose of a water program for this basin should be the stabilization of the present development. Local streams will not supply units of more than 10,000 to 15,000 acres even at excessive costs, so irrigation possibilities are not large in any event.

Potential irrigation developments fall into two types; those on tributary streams and those to be supplied from the main Missouri River. Similar economic conditions will govern the limitation of costs for either type but the conditions surrounding their water supplies will differ materially.

All projects on the tributaries will require storage. Any attempted use of a large proportion of the mean annual run-off of these streams will require carry-over storage, for the run-off in dry years is only a small fraction of the mean. This adds to costs. In general, the larger projects proposed for the tributaries are not attractive. The Corps of Engineers is investigating the Heart Butte and Bowman projects.

Several areas of a few thousand acres each along the Missouri River can be reached by pumping water 25 or 30 feet. Few of these are now irrigated, since the area was not interested generally in irrigation until the recent droughts. The permanence of the present interest is open to question. Channel shifting in the river has made diversions by pumping difficult. Regulation of the stream by the Fort Peck Dam will tend to stabilize the channel. Several projects for use of water directly from the Missouri River have been proposed. The water supply and soil are generally favorable. The projects should be rated on a cost basis. Among the proposals, the revival of the old Buford-Trenton and Williston projects of the Bureau of Reclamation is most strongly urged by local interests. These projects were undertaken at the time the reclamation law required that accretions to the reclamation fund be spent in the State from which they came. This provision of the law was soon found impractical and was

repealed. These two projects were operated a few years and then abandoned. Conditions for their operation are now somewhat more favorable but it is doubtful if water can be delivered at the high lifts at a price that the landowners can or will pay.

Revival of these projects should be deferred until a workable plan is found and other proposed projects on the Missouri River should await completion of the general investigation recommended. If limited to low lifts, at least some of these units should be able to furnish irrigation at costs which the landowners can meet. The need is present for some irrigation development along the river to maintain agricultural production whether these projects are operated as an adjunct to the livestock industry or for independent crops. An essential factor in the feasibility of these projects is the willingness of the landowners to pay for them.

Flood damage occurs occasionally from overflow of towns along the streams. This has occurred at Wibaux and Marmarth on the Little Missouri. Levee projects for these two towns have been authorized by the Congress. Ice jams in the Missouri River cause Heart River to overflow parts of Mandan; a levee recently constructed has remedied this in part.

Navigation will not be an important feature of this area in the future. The costs of improvement of the Missouri River would be excessive, and all reports on navigation projects have been adverse. Even with the regulation resulting from Fort Peck Dam, commercial navigation in this part of the river will not be justified.

Small reservoirs are needed in large numbers. Stock water may control the ability to use range feed. The distance stock can travel to water is limited and such reservoirs need to be closely spaced. In periods of drought, shallow wells may go dry and water may have to be hauled from surface storage for domestic use. Incidental benefits from small reservoirs result also from increasing recreational opportunities. Some reservoirs have been built exclusively for the benefit of wildlife and more are needed for that purpose.

Many small reservoirs have been constructed in this area since 1933 by various Government agencies, largely on a relief labor basis without cost to the user. The drought of 1936 has further stimulated such work. However, this program naturally is adjusted to relief needs, which are not necessarily spread in conformity with the need for stock-water ponds. It will be necessary, probably, to fill in blank spots by a construction program extending over several years.

The States have proposed lists of sites for these small reservoirs. Selection of individual reservoirs for construction should be left to agencies supervising this work as it progresses. The list of such projects presented by North Dakota includes estimates of their

capacity. These indicate costs varying generally from \$35 to \$65 per acre-foot, which is relatively high for storage. However, the cost is not out of line in such small units. The total amount of storage that would be obtained from such a construction program is relatively small. Run-off available for storage represents about 5 percent of the rainfall on these plains areas.

Many reservoirs of this type built by stockmen have failed for lack of proper spillways. Adequate spillways may cost as much as the remainder of the dam. Such spillways are required for permanence, and this program should be based on permanent construction standards.

The reservoirs should be deep enough and have a sufficient drainage area so that they will not go dry in

drought periods if they are to be effective. This requires adoption of general standards of minimum drainage area and storage depth. The standards set up by the North Dakota State planning board form a good basis for such construction.

A factor frequently urged in favor of small reservoirs is that the ground water will be replenished by percolation from the ponds. Percolation is opposed to the purpose of these small reservoirs. The supply during the summer depends on the inflow during the early season. If the reservoir site is not tight there will be no late fall stock water. While retardation of run-off to increase percolation to the ground water is desirable in itself, it is a separate undertaking from storage of stock water for late summer use.

Upper (Missouri) Western Tributaries

Map key no.	Project	Estimated cost	Remarks
GROUP A--FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Investigation of small scale projects in Great Plains area.....	\$150,000	May apply in part to the following basins: Missouri Headwaters, Yellowstone, Cheyenne, White-Niobrara, and Platte.
82	Carter County, Mont.: Little Missouri River storage and irrigation canals.....	778,000	Ready for contract.
(1)	Ashley (71), Bowman (63), Glen Ullin (43), Max (15), Napoleon (53), New Salem (44), Ray (3), Richardson (42), Strasburg (61), Turtle Lake (21), Wild Rose (2), Wishek (59), and 22 other towns in North Dakota, and Java, S. Dak.: Water supply systems and/or wells.	480,000	Plans can be completed quickly for all projects. Plans ready for Java.
(1)	Ashley (71), Beach (39), Beifield (38), Beulah (24), Bowman (63), Golva (41), Dickinson (37), Elgin (56), Glen Ullin (43), Hazen (25), Hebron (36), Hettinger (68), Killdeer (23), Linton (58), Marmath (64), Max (15), Mott (57), Napoleon (53), New England (50), New Salem (44), Ray (3), Richardson (42), Stanley (6), Strasburg (61), Turtle Lake (21), Watford City (18), Wild Rose (2), Wilton (34), and Wishek (59), N. Dak.: Municipal sewer systems.	1,045,000	Plans can be completed quickly for all projects except Hettinger.
(1)	Arkaska (79), Glenham (77), S. Dak.; Goodrich (27), Grenora (1), Hazelton (52), N. Dak.; Herreid (72), Hoven (84), Lebanon (85), S. Dak.; Lehr (60), Linton (58), Parshall (12), N. Dak.; Pollock (73), S. Dak.; Ryder (14), Sanish (11), Stanley (6), Tioga (4), Underwood (22), Washburn (26), Wilton (34), and Zealand (70), N. Dak.: Municipal water supply systems.	525,000	Plans can be prepared quickly for projects in North Dakota. Plans ready for Herreid, S. Dak. No plans for other projects.
(1)	Gettysburg (86), Glenham (77), Herreid (72), Java (78), and McIntosh (74), S. Dak.; and New Leipzig (56), N. Dak.: Municipal sewer systems.	141,000	Plans ready for Java. Plans incomplete for New Leipzig. No plans for other projects.
80	Carter County, Mont.: Irrigation storage on Box Elder Creek.....	67,000	Plans ready.
45	Mandan, N. Dak.: Water treatment plant.....	115,000	Plans can be completed quickly.
56	New Leipzig, N. Dak.: Water distribution system and treatment plant.....	30,000	Plans incomplete.
(1)	Grenora (1), Goodrich (27), Hazelton (52), Lehr (60), Marshall (12), Plaza (13), Ryder (14), Sanish (11), Tioga (4), Underwood (22) and Zealand (70), N. Dak.: Sewer systems.	375,000	Plans can be completed quickly.
48	Steele, N. Dak.: Long Lake bird refuge.....	66,000	Plans completed.
GROUP B--FOR DEFERRED CONSTRUCTION			
(1)	Montana, North Dakota, South Dakota: Small reservoirs for stock water and irrigation on Knife River, Heart River, Cannonball River, Grand and Moreau Rivers and minor tributaries of Missouri River (29, 35, 49, 62, 75, 76, 83).	\$250,000	Plans can be prepared quickly. Cost given is for first 2 years. Additional needed to complete, \$750,000.
GROUP C--TIME OF CONSTRUCTION INDETERMINATE			
(1)	Bulford (10) Trenton (9), and Williston (8), N. Dak.: Pumping project from Missouri River.....	\$783,000	Plans incomplete.
81	Marshall, N. Dak.: Flood irrigation dam.....	30,000	Survey required.
81	Carter County, Mont.: Storage on Big Panne Creek.....	44,000	Reconnaissance.
16	McLean County, N. Dak.: Reservoir at Deepwater Creek.....	40,000	Plans incomplete.
19	McLean County, N. Dak.: Pumping project on Fort Berhold Agency Flats.....	150,000	Do.
20	McLean County, N. Dak.: Pumping project at Fort Stevenson Flats.....	600,000	Do.
7	Williams County, N. Dak.: Pumping project in Nesson Valley.....	495,000	
26	McLean County, N. Dak.: Pumping project near Washburn.....	300,000	
17	McLean County, N. Dak.: Pumping project on Shell Creek.....	555,000	
46	Burleigh County, N. Dak.: Pumping project near Bismarck.....	300,000	
40	Wibaux, Mont.: Big Bear Reservoir for flood protection.....	125,000	Do.
55	Fallon County, Mont.: Little Beaver Reservoir for flood protection at Marmath, N. Dak.....	200,000	Do.
66	Bowman County, N. Dak.: Storage for flood protection at Marmath, N. Dak.....	1,500,000	Do.
82	Marshall, N. Dak.: Bronco Reservoir for flood protection.....	250,000	Requires survey.
54	Sioux, N. Dak.: Dam near Solen for irrigation.....	500,000	Plans incomplete.
67	Adams County, N. Dak.: Lightning Creek Reservoir for irrigation.....	50,000	Do.
1)	Emmons, McLean, Morton, and Mountrail Counties, N. Dak.: Irrigation projects.....	452,000	Do.
47	Burleigh County, N. Dak.: Apple Creek Flats pumping project.....	365,000	Do.
51	Emmons County, N. Dak.: Livona pumping project.....	124,000	Do.
28	McLean County, N. Dak.: Painted Woods irrigation.....	168,000	Do.
33	Oliver County, N. Dak.: Square Butte Creek Reservoir for irrigation.....	144,000	Do.
5	Mountrail County, N. Dak.: White Earth River irrigation.....	108,000	Do.
69	Emmons County, N. Dak.: Winona Flats pumping project.....	150,000	Do.
64	Marmarth, N. Dak.: 2 miles of levees.....	61,000	Sketch plans completed. Includes 39,000 estimated land cost.
30	Wibaux, Mont.: 1.7 miles of levees.....	105,000	Sketch plans completed. Includes \$63,000 estimated land cost.

1 Map key number shown following community names.

2 Map key numbers shown following project description.

3 Map key number shown following county name.

4. UPPER MISSOURI: EASTERN TRIBUTARIES

The water problems in this area are relatively simple and the projects small but numerous. They comprise: water supply systems for many small communities, sewer systems and sewage-treatment plants for a considerable number of towns, and water conservation involving multiple-purpose reservoirs which may be used for stock watering, recreation, wildfowl refuges, or perhaps for occasional draft in emergencies.

General Description

This area has a length of 500 miles extending north and northwest from the mouth of the Platte River. Its greatest width is 150 miles, and the average about 90 miles. It covers 44,500 square miles lying mainly in the Dakotas and Iowa, with small sections in Minnesota and Nebraska. The western half of the area is drained by the James River, the eastern half by a number of small streams. The entire surface is open rolling prairie with low stream gradients.

The population exceeds 600,000. Omaha is the largest city, with 214,000 people. Council Bluffs and Sioux City, Iowa, aggregate 121,000. Probably about a quarter of the population can be classed as rural.

The climate is on the border between semiarid and subhumid. The annual rainfall is from 18 to 29 inches, increasing from west to east. The discharge of the James River at its mouth is about 8 acre-feet per square mile, or an annual average flow of 253 cubic feet per

second. Some streams in the eastern portion of the area have an annual run-off of 800 acre-feet per square mile. The James River drainage area is an extensive artesian basin. Flowing wells are obtained from the Dakota sandstones at depths of 900 to 1,600 feet.

Recommended Plan

More efficient use of the water resources is to be sought chiefly in the construction or improvement of *municipal water systems*, and of *sewer systems* and sewage-treatment plants. There is no large project of either kind in the area, but many small communities are in need of one or more of these facilities.

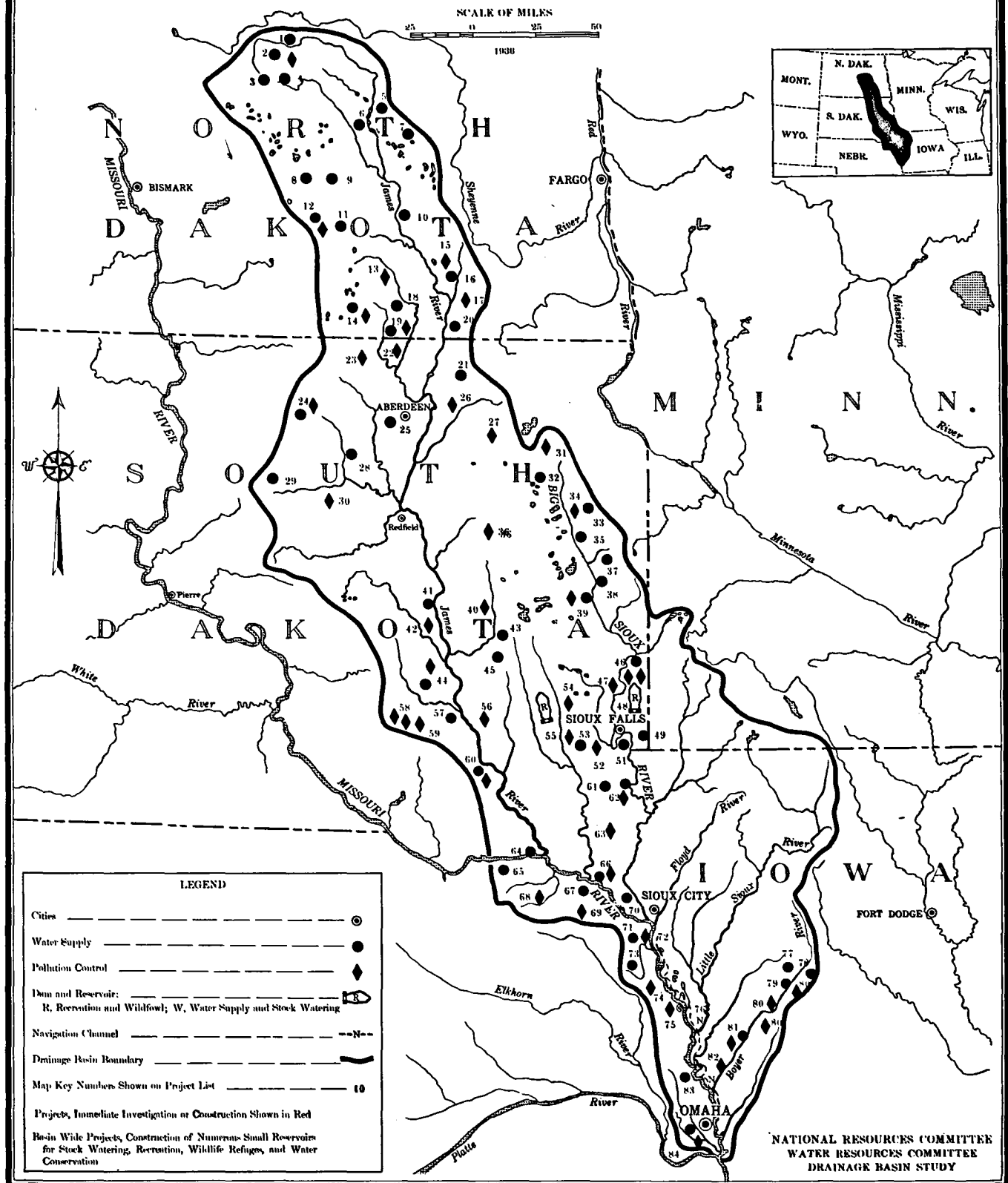
Next in importance to these municipal utilities is the need for a large number of small reservoirs, well distributed throughout the area, principally for increasing stock-watering facilities. Many of these will serve incidentally as recreation centers or as feeding places for wild fowl. They have been grouped in the project list.

Irrigation is not practiced in the basin and there seems to be no sentiment in its favor.

The only *navigable* stream in the area is the Missouri River. Work toward its improvement has been in progress for years and will be continued by the Corps of Engineers as funds are made available.

Flood control is not a major problem. Flood damage is local and not extensive. The improvement of the Big Sioux River channel is listed.

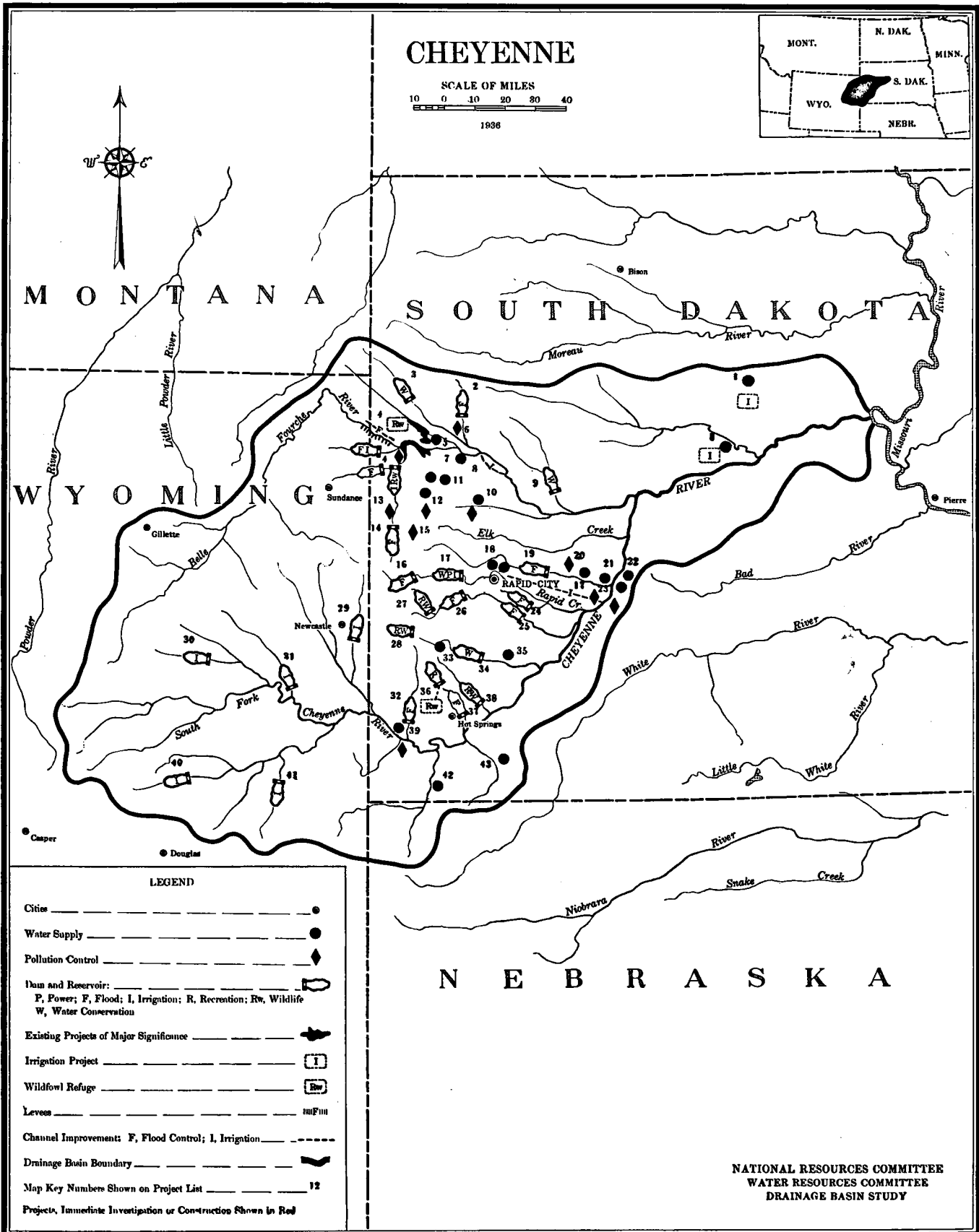
UPPER MISSOURI EASTERN TRIBUTARIES



Upper (Missouri) Eastern Tributaries Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Blair (83), Nebr.; Brandt (37), S. Dak.; Canton (62), S. Dak.; Deloit (79), Iowa; Huron (41), S. Dak.; Jackson (71), Nebr.; Jefferson (70), S. Dak.; Kiron (77), Iowa; Knox County (65), Nebr.; Kulm (14), N. Dak.; Lennox (61), S. Dak.; Maskell (67), Nebr.; Mitchell (52), S. Dak.; Omaha (84), Nebr.; Streeter (12), N. Dak.; Thurston County (73), Nebr.; Tripp (60); Valley Springs (49), and Vermillion (56), S. Dak.; Wall Lake (78) and Woodbine (81), Iowa; Yankton (63), S. Dak.: Water supply systems, construction, improvement or treatment.	\$632,000	Nearly all plans made. Iowa plans incomplete. All estimated costs very approximate; many on per capita basis.
(1)	Decatur (75), Nebr.; Denison (89), Iowa; Dixon County (69), Nebr.; Dow City (80) and Dunlap (80), Iowa; Edgely (13) and Ellendale (19), N. Dak.; Faulkton (36), S. Dak.; Fessenden (2), N. Dak.; Hartington (68), Nebr.; Kulm (14) and La Moure (15), N. Dak.; Missouri Valley (82), Iowa; Montrose (54), S. Dak.; Oaks (17), N. Dak.; Omaha (84), Nebr.; Plankinton (58); S. Dak.; South Sioux City (72), Nebr.; Streeter (12), N. Dak.; Walthill (74), Nebr.; Watertown (34), S. Dak.; Woodbine (81), Iowa; Sewer systems and/or sewage treatment plants.	3,238,000	Plans available for South Dakota projects. Plans for North Dakota projects can be completed soon. Iowa and Nebraska plans incomplete. Iowa costs are rough estimates on per capita basis.
	19 small reservoirs in James River drainage, North Dakota: For stock watering, water fowl, recreation and conservation.	196,000	Plans can be completed quickly.
	4 small reservoirs in South Dakota: Construction or repairs.	15,000	Plans ready.
	James River Dam, water conservation.	484,000	\$384,000 of this amount for land purchases.
76	Navigation, Missouri River, Omaha, Nebr., to Sioux City, Iowa: Completion of present 6-foot channel project.	23,000,000	Authorized by Congress.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Aberdeen, Northern Normal School (25), Brandt (37), Bruce (38), Carthage (43), Castlewood (35), Clifton School district no. 4 (-), Cresbard (28), Flandreau Industrial School (46), Florence (32), Goodwin (33), Humboldt (51), Langford (21), Letcher (44), Roscoe (24), Roswell (45), Seneca (29), Unnamed Place (-), and Volga (39), S. Dak.: Water-supply systems.	215,000	Plans available for Florence, Castlewood, Bruce, and Flandreau Industrial School. No plans for others.
(1)	Bowden (3), Cathay (4), Cleveland (9), Courtenay (7), Ellendale (19), Fessenden (2), Gackle (11), Hamberg (1), Kensal (15), Kulm (14), Ludden (20), Medina (8), Montpelier (10), Monango (18), Pingree (6), Streeter (12), and Verona (16), N. Dak.: Wells for municipal water supply.	22,000	Plans can be completed quickly.
(1)	Alexandria (56), Alpena (42), Beresford (63), Bristol (27), Canton (62), Dell Rapids (47), Flandreau (46), Flandreau Industrial School (46), Frederick (22), Groton (26), Hartford (52), Humboldt (51), Iroquois (40), Leola (23), Mount Vernon (-), Plankinton (58), Roscoe (24), school district no. 3 (59), Tripp (60), Vermillion (66), Volga (39), Waubay (31), Willow Lakes (36), and Woonsocket (44), S. Dak.: Sewer systems and/or sewage-treatment plants.	561,000	Plans available for Flandreau. No plans for other places.
51	Sioux Falls, S. Dak.: Addition to filtration plant.	300,000	Plans available for 18 of these projects. No plans for others. Cost given is for first 2 years. Additional needed to complete, \$681,000.
	54 reservoirs for water conservation at various places in South Dakota.	500,000	
	6 recreational lakes in Big Sioux and Vermillion Basins, S. Dak.	54,000	Plans available for 2. No plans for others.
55	McCook County, S. Dak.: Ramsey Lake recreation project, in Vermillion River drainage.	154,000	Plans prepared.
50	Sioux River channel improvement from Elmwood Park to Brandon, Minnehaha County, S. Dak.	240,000	Plans ready.
	Small headwater reservoirs for water conservation in Nebraska.	200,000	Plans incomplete.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
48	2 dams on Split Rock Creek, in Big Sioux River drainage, Minnehaha County, S. Dak.	\$400,000	Plans are available.

¹ Map key number shown following community name.



5. CHEYENNE

The most important water problem of the basin of the Cheyenne River is that of supplying sufficient water at reasonable cost for municipalities, for irrigation, and for stock. The basin is not well watered. The flow in the streams is highly variable and storage is required to provide reliable water supplies. Flood control is a problem in a few towns, contamination is not serious, and hydroelectric power is limited. Most of the proposed projects are small.

General Description

The Cheyenne Basin, which includes northeastern Wyoming and southwestern South Dakota, has an area of 25,500 square miles. The Black Hills, which lie near the center of the basin, are the most prominent physical features. The Cheyenne River drains the southern part of the basin, flowing around the south side of the Black Hills, and thence easterly to the Missouri River. The Belle Fourche River drains the area farther north, rising near the Cheyenne River and flowing around the north side of the Black Hills to join the Cheyenne east of Rapid City.

The industries of the basin are well diversified. Stock raising is extensive, dry farming is practiced, and land is irrigated where water is available. Mining is active in parts of the Black Hills and lumbering is a well-established industry. Recreational use of parts of the Black Hills area has been well developed. There are no large cities. Rapid City, with a population of 11,346, is the largest town.

The average annual run-off for the basin is slightly more than 1,000,000 acre-feet, of which about half is from the Belle Fourche River. The average annual precipitation varies from 10 to 25 inches. The grow-

ing season is sufficiently long for general crops, including sugar beets. A large part of the run-off of the Cheyenne Basin is still unused; much will probably remain unused due to its erratic occurrence and the expense of its regulation. There is only one large irrigation project within the basin. It is the Belle Fourche Federal reclamation project, now about 30 years old.

The ground water supply in the basin is limited and the plains are semi-arid. The sandstones in the Black Hills absorb a part of the surface run-off in the streams crossing these outcrops and become a source of replenishment for artesian strata in eastern South Dakota. Except in the Black Hills, springs are rare and the water from shallow wells has been found to be unsatisfactory in both quantity and quality.

Recommended Plan

Municipal water supplies have been developed as needed. At present the most important need of the Cheyenne Basin is improvement and development of several existing waterworks systems. While the available sources of supply have generally been adequate to meet the demands, some shortages have occurred in recent years of deficient rainfall. Other needs include small reservoirs for supplemental water storage, general conservation, and stock watering.

Additional *sewage-treatment* plants are needed in the basin as the stream flow is not sufficient to provide dilution for sewage discharged into the streams.

Several desirable projects for small reservoirs for *irrigation* are proposed in Wyoming. There are opportunities for power development for local use in connection with storage for irrigation.

Cheyenne Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Deadwood (12), Edgemont (39), Nisland (5), Sanator (33), South Dakota State School of Mines (18), Vale (7), Wall (22), and Whitewood (11), S. Dak.: Improvements to water supply systems.	\$191,000	Preliminary plans completed.
(2)	Niobrara (41) and Weston (31) Counties, Wyo.: Constructing 4 dams and reservoirs to provide storage of water for irrigation purposes.	25,000	Plans nearing completion.
1	Indian reservations, South Dakota: Improvements to water systems for domestic use, stock, and irrigation purposes.	50,000	Cost given is for first 2 years. Additional needed to complete, \$50,000.
36	Wind Cave National Park, S. Dak.: Diversion dam and pipe line to fill dry lake bed for recreational purposes and to supply water for game refuge.	30,000	Preliminary plans made.
18	Rapid City, S. Dak.: Improvements to water supply system.....	125,000	Plans completed.
10	Sturgis, S. Dak.: Sewage disposal plant.....	136,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Ardmore (42), Fairburn (35), Oelrichs (43), Owanka (20), Quinn (44), Rapid City (18), Sturgis (10), Wall (22), Wasta (21), and Whitewood (11), S. Dak.: Improvements and extensions to the water supply systems.	\$300,000	Preliminary plans only.
(1)	Belle Fourche (4), Deadwood (12), Edgemont (39), Lead (15), Newell (6), Spearfish (13), Wall (22), and Wasta (21), S. Dak.: Sewage treatment plants and sewer systems.	129,000	
4 8	Belle Fourche, S. Dak.: Supplemental storage for Belle Fourche irrigation project.....	100,000	Investigations under way. Plans not complete. Cost given is for first 2 years. Additional needed to complete, \$300,000.
(2)	Butte (3), Custer (34), and Meade (9) Counties, S. Dak.: Small reservoirs, wells, and tanks for watering stock.	150,000	Preliminary plans only. Cost given is for first 2 years. Additional needed to complete, \$150,000.
17	Rapid City, S. Dak.: Dam and reservoir for storage and power on Pactola project and to supplement irrigation water below Rapid City.	100,000	Preliminary plans only. Cost given is for first 2 years. Additional needed to complete, \$2,900,000.
(1)	Belle Fourche (4), Hermosa (25), Hot Springs (37), Keystone (26), New Underwood (19), Rapid City (16), and Spearfish (14), S. Dak.: Small reservoirs and improvements for flood control.	29,000	Partial plans only.
(2)	Custer (28), and Pennington (27) Counties, S. Dak.: 13 reservoirs for storage of water and recreational purposes. All small except Beaver Creek (38), \$100,000.	179,000	Plans completed.
4	Belle Fourche, S. Dak.: Water control structures and fencing of Belle Fourche Migratory Waterfowl Refuge.	22,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
4	Belle Fourche, S. Dak.: Channel improvement and levees for flood control.....	\$46,000	Plans completed. Includes \$22,000 estimated land cost.
4	Belle Fourche, S. Dak.: Dam and reservoir on Chicken Creek for irrigation and wildlife refuge.....	500,000	Plans not completed.
(2)	Campbell (30), Converse (40), and Weston (29) Counties, Wyo.: 9 small dams and reservoirs or enlargements for irrigation purposes.	186,000	Rough preliminary plans only.
(2)	Butte (2), Fall River (32), and Pennington (24) Counties, S. Dak.: 17 small reservoirs for flood control and water conservation purposes.	350,000	No plans available.

¹ Map key number shown following community name.

² Map key number shown following county name.

6. WHITE-NIOBRARA

The principal projects in the White-Niobrara Basin are municipal water supply and sewer systems, and the development of supplies for stock watering. Irrigation, flood control, and navigation are of minor importance. General studies of soil erosion and of recreation and wildlife possibilities are needed as guides for future development.

General Description

The White-Niobrara Basin includes the Missouri River drainage from the mouth of the Cheyenne River to the mouth of the James. In addition to the area along the river it includes the drainage of the Bad, White, and Niobrara Rivers on the west. This basin is a sparsely populated prairie, lying mainly in South Dakota and Nebraska, but also extending into eastern Wyoming.

The White River rises in the northwest corner of Nebraska, at an altitude of about 5,000 feet, and flows northeast 230 miles to its junction with the Missouri, at an altitude of 1,300 feet. The drainage area is 10,200 square miles. The source of the Niobrara is in eastern Wyoming, at an altitude of 5,230 feet. Its basin is 355 miles long, with an area of 13,000 square miles. For half its length, the stream runs through a sand-hill region.

Water projects have not been a major factor in the development of this area, although the character of the rainfall has controlled the agriculture. In the west, irrigation is practiced, but the irrigated area is sharply limited by the available water. Farther east, where increased stream flow would permit more irrigation, profitable crops can be raised in some years with rainfall alone and the difficulty of maintaining canals for part-time use has curtailed this type of development. Irrigation works built during the 1890's have been abandoned.

Dry farming and stock raising have been the main agricultural pursuits. Aside from a tendency to shift from dry farming to stock raising, little change in the

agriculture of the region is to be expected. There are few other industries.

The Missouri is considered navigable through this area, but there is no navigation.

Precipitation varies from 16 to 20 inches a year. The average run-off in a year from the White River is equal to about two-thirds of an inch of water over its drainage area; that of the Niobrara is equal to about one and one-half inches; the average annual run-off for a 3-year period was 362,000 acre-feet at Oacoma, S. Dak., in the White River Basin; the average of a 4-year period at Spencer, Nebr., in the Niobrara River Basin, was 992,000 acre-feet.

Recommended Plan

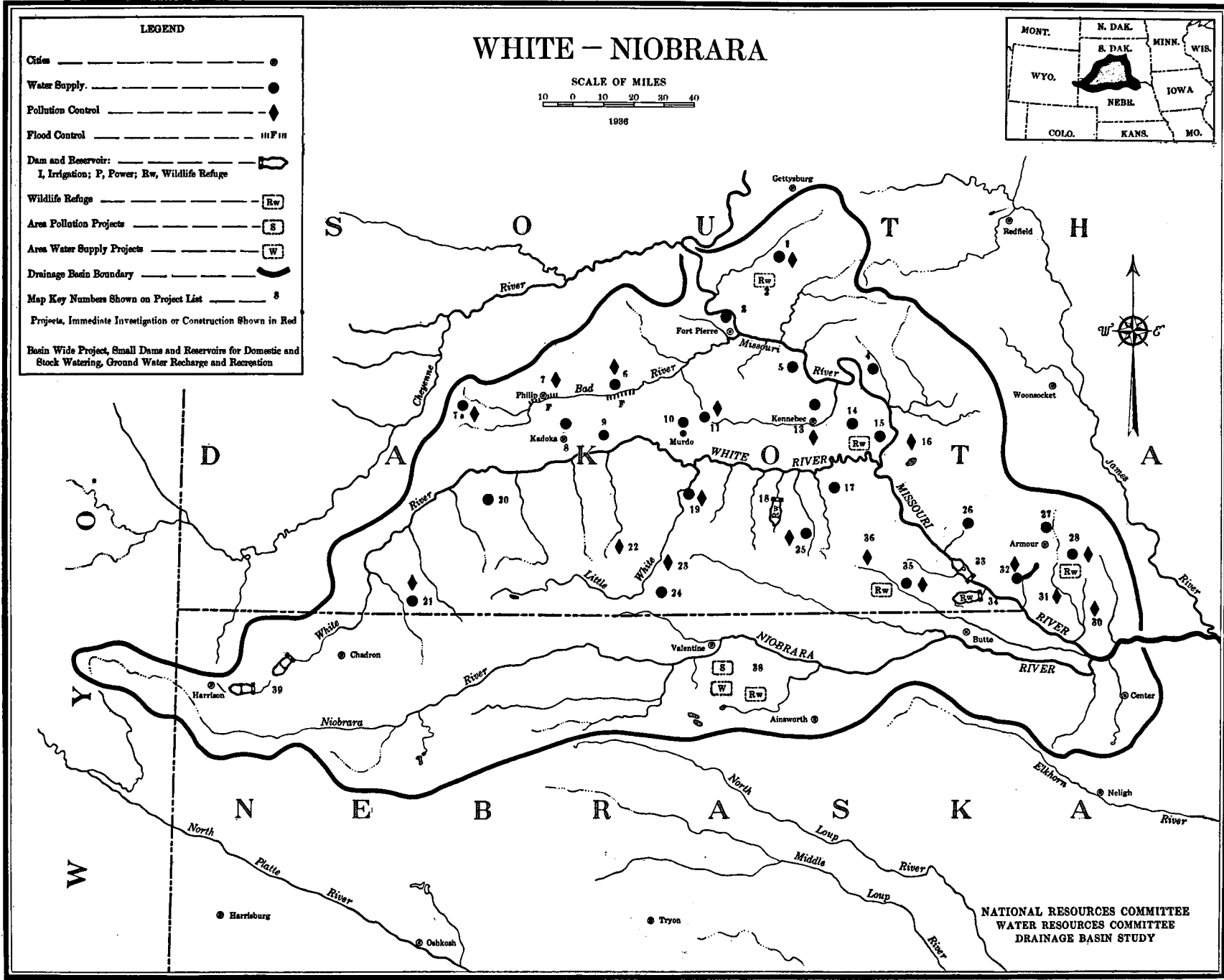
Municipal water supply and sanitation projects for several communities and Indian reservations make up most of the work for immediate construction.

Hydroelectric power.—One large project, the Mule Head Power Dam on the Missouri near the southern boundary of South Dakota, has been proposed, but the Corps of Engineers comment unfavorably on hydroelectric projects here because of expensive construction, poor foundation conditions, low heads, and irregular flow of the river. Additional power is not needed immediately in this area.

The operation of the Fort Peck Dam on the upper Missouri is planned to regulate the Missouri River below Sioux City, some distance downstream from the mouth of the Niobrara. It will also have a stabilizing effect on the river above Sioux City, although the unregulated river inflicts no serious damage in this section.

Special study projects are needed to develop plans for soil erosion control in Nebraska, for recreational projects in South Dakota, and for recreational and wildlife projects at various points in Nebraska.

There are no interstate water problems and no prospective conflicts regarding water use. No extensive planning is needed; each stream and project can proceed on its own merits.



White-Niobrara Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A.—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Armour (27), Belvidere (9), Fort Pierre (3), Hammill (17), Kadoka (8), Kennebec (13), Lake Andes (32), Midland (6), Oacoma (15), Onida (1), Pine Ridge Agency (21), Platte (26), Reliance (14), White River (19), and Winner (25), S. Dak.: Water supply for municipal distribution systems.	\$368,000	Further investigation of all projects necessary
38	Water supply for municipal developments for each of several communities in Nebraska.	377,000	Plans can be completed quickly.
(1)	Burke (35), Midland (6), New He-Dog School (22), Philip (7), Pine Ridge Agency (21), Pukwana (16), and Wagner (31), S. Dak.: Sewer systems.	167,000	
38	Sewer systems and sewage treatment plants for each of several communities in Nebraska.	275,000	Do.
(2)	Crow Creek (4), Lower Brule (5), Pine Ridge (20), and Rosebud (24): Water supply projects for domestic and stock use on these Indian reservations in South Dakota.	50,000	
39	Whitney Irrigation District, Nebr.: Reservoirs for supplemental storage.	81,000	Plans are ready.
GROUP B.—FOR DEFERRED CONSTRUCTION			
(1)	Midland (6), and Philip (7), S. Dak.: Small flood control projects.	\$20,000	
39	Stock watering dams for each of 39 individual projects in South Dakota.	150,000	
(1)	Small reservoirs for water conservation in various locations in Nebraska.	125,000	Plans can be completed quickly.
(1)	Burke (35), Delmont (28), Draper (11), Murdo (10), and Pierre (3), S. Dak.: Municipal water supplies.	152,000	Further study of these projects necessary.
(1)	Avon (30), Delmont (28), Draper (11), Gregory (36), Kennebec (13), Lake Andes (32), Onida (1), Pukwana (16), Quinn, Rosebud (23), White River (19), and Winner (25), S. Dak.: Sewer systems or sewage treatment plants.	105,000	Each of these projects should be investigated before funds are allocated to them.
12	Conservation projects for the combined purpose of recreation and increased percolation to ground water for domestic and stock water use in 38 localities in South Dakota.	400,000	
(1)	Bonesteel (dam) (34); Delmont (city lake) (28), Lake Burke (spillway) (35), Oacoma (ditch) (15), Sully County (diversion to fill dry lake) (2), Sully Lake (2), and Witten (dam) (18), S. Dak.: Recreational projects in these 7 locations.	61,000	
38	Recreational and wildlife refuge projects in various localities in Nebraska.	150,000	Some projects are ready for immediate construction.

1 Map key number shown following community name.
 2 Map key number shown following reservation name.
 3 Map key number shown following location name.

7. PLATTE

The predominant demand for water in the Platte River Basin is for irrigation. The demand is large compared with the supply and in this unequal relation most of the water problems of the area are rooted. Conflicts between Colorado, Wyoming, and Nebraska—parts of which are drained by the Platte system—have grown out of the deficiency in supply, as have controversies between localities within these States.

Uncertainties regarding the outcome of pending litigation prevent the completion of a definite plan of development for the stream as a whole and limit the projects which can be recommended for immediate construction to those units which are not dependent on the various settlements that may eventually result.

Importation of additional water into the South Platte Basin is the major problem of this important and highly developed tributary.

Problems involved in other uses of water in general are not acute. Municipal supplies are generally adequate; available power sites exceed the present needs; flood control is not a major problem; and the river is not navigable.

The available records in the Platte River Basin are in general adequate for planning purposes, but an indeterminate factor has been introduced by serious rainfall and run-off deficiencies in recent years.

General Description

The Platte River Basin includes the most extensively developed portions of Colorado, Wyoming, and Nebraska. It extends from the crest of the Continental Divide in Wyoming and Colorado to the eastern boundary of Nebraska, and contains 90,200 square miles, of which 37,400 are drained by the North Platte, and 24,000 by the South Platte.

The North Platte, the South Platte, and the main Platte each has different characteristics and problems. The North Platte River rises in northern Colorado and flows north into Wyoming and east into Nebraska. The Sweetwater and Laramie Rivers are its main tributaries. The South Platte rises in the high Rockies of central Colorado, collects the run-off of several tributaries draining the eastern slope and joins the North Platte at the town of North Platte, Nebraska, to form the Platte River. The Platte flows east to join the Missouri River at Plattsmouth. Its principal tributary is the Loup River, which drains a large area in northern Nebraska.

The average annual discharge of the North Platte at its mouth is 2,087,000 acre-feet; of the South Platte, 350,200, and of the Loup, 2,152,000.

The climate varies from arid in the western portion through semi-arid to nearly humid in the eastern portion. The growing season is adequate for staple crops in all irrigated areas. Sugar beets, beans, and potatoes are extensively grown by irrigation. A large proportion of the annual rainfall occurs during the growing season.

The total population of the basin in 1930 was 1,277,670, of which 695,200 was rural. The average population density for the basin was 14.2 per square mile. Denver, with a population of 287,640 in 1930, is the largest city. Other cities are mainly local distributing points.

The development of the Platte Basin is predominantly agricultural. Its industries are mainly those utilizing agricultural products. Mining is of importance in Wyoming and Colorado. Transportation by rail, highway, and air is well distributed and adequate.

While irrigation is not essential to adequate crop production in the eastern portion of the basin, it is the basis on which the major portion of the agriculture rests. Water for irrigation is the most important natural resource of the entire basin.

Irrigation has been extensively developed throughout both the North and South Platte Valleys and has extended eastward along the main Platte River. In 1929, 2,315,000 acres were irrigated in the basin, or 12 percent of the total irrigated area in the United States.

Both the North and the South Platte Rivers provide outstanding examples of the extent to which return flow may be used as a form of stream regulation and to increase the area that can be irrigated. The soil formations are such that much of the water diverted drains back to the stream. This increases the low flow and reduces the amount of surface storage required. The alkali content of the soil is very low and the return flow is of good quality.

Underground water is generally available for domestic use. In some areas it is used for irrigation by pumping. Such pumping has been increasing in the South Platte Valley in recent years. If it continues to increase it may have an important effect on the return flow and require readjustments in water use. There are also many pumping plants for irrigation near Grand Island, Nebr.

The principal water-power development on the North Platte has been that of the Bureau of Reclamation at Guernsey and Lingle.

Recommended Plan

The type of plan which should be followed in the development of the Platte Basin can be determined now, but its details and the individual projects best adapted to it must await additional study and adjustment of controversies. The basin should be developed primarily for irrigation. Municipal water demands are not large in relation to the total supply. Only at Denver, which is situated near the headwaters of a tributary, will municipal demands be large by comparison with the water resources locally available. In common with most western streams, more land is available for irrigation along the Platte system than can be supplied by its waters. The comprehensive plan should give maximum benefits from the limited supply. Fortunately, there are enough feasible reservoir sites available along the main streams to provide almost complete flow regulation.

Problems of navigation, flood control, drainage, recreation, wildlife, and pollution are either absent or are relatively minor items in a comprehensive plan for this basin. Water-power development is an optional source of power supply which can be made to assist in financing irrigation but which should not be carried to a point where water will be used and lost in the

The plan for the Platte River Basin can be divided into that for the North Platte and that for the South Platte. While there is opportunity to use the Platte River below the junction of the North and the South Platte, the South Platte has already been developed independently of the main Platte River and now makes only a limited contribution of water to the Platte River.

The first prerequisite to the preparation of a comprehensive plan for the North Platte River is an apportionment of the available water supply between the three States within which its basin lies.

The first project in the plan for this basin should be one for defining the rights of the States. This may be left to court definition, but private and public interests might best be served by negotiation and adjustment between the States. All present studies by each of these states necessarily are planned in relation to the pending suit and do not give full consideration to all points of view. The Federal Government has a major interest in the situation because of its unrepaid expenditures on the North Platte project, the current expenditures on the Casper-Alcova project, and its grants and loans for construction of the "Sutherland", "Columbus", and "Tri-County" power and irrigation

projects in central Nebraska. No major new development should be undertaken on the North Platte River until uncertainties have been adjusted.

An essential part of any plan for the full utilization of the North Platte River is extensive carry-over storage. Recent years have emphasized this need. Any plan for ultimate development should be based on providing adequate storage at the controlling points along the stream. On the upper river, storage on the river channel is essential in order to control the full flow; on the lower river, the flow is better regulated by the return flow. However, in order to obtain adequate carry-over capacity for full development a reservoir in the lower river basin will eventually be required.

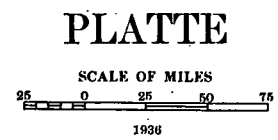
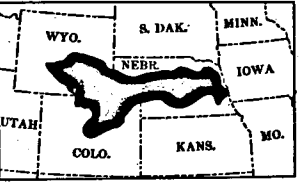
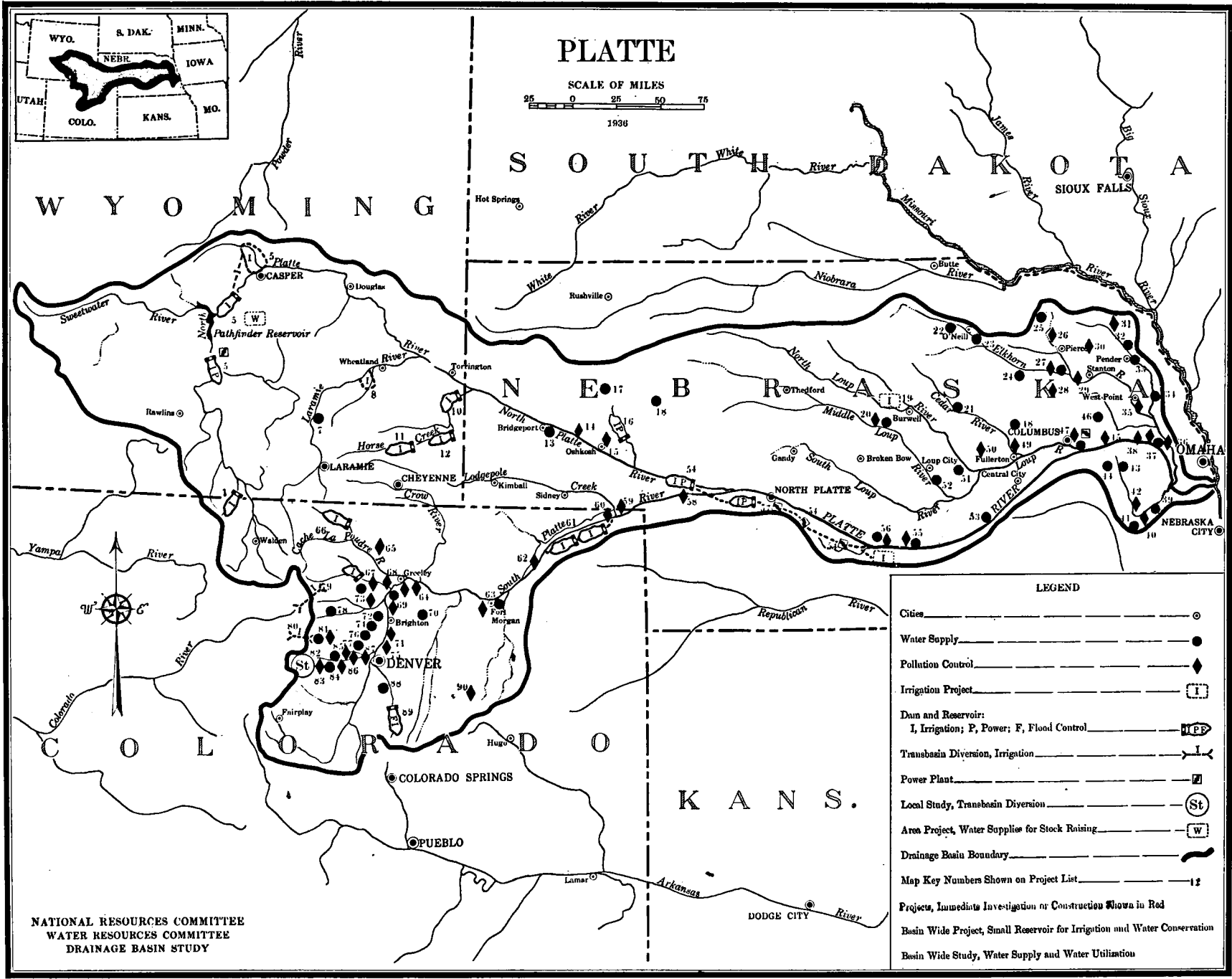
The South Platte River, as previously noted, contributes little flow to the Platte River. Colorado and Nebraska have entered into a compact covering the stream.

The South Platte Valley in Colorado is one of the more highly developed irrigated areas in the West. The available stream flow is very largely used. The run-off above Denver is principally controlled for use by the city. Below Denver several tributaries serve areas along their courses and in the valley. Return flow is used by the lower canals. Many storage reservoirs have been built to conserve surplus water.

There are few proposed projects based on additional use of this stream. Some storage sites are available but remaining unused flow is so small that projects for its control would be costly in comparison to their water yields. Supplemental water is badly needed in the valley. The amount of additional water needed per acre and the high state of development in this area justify relatively high prices for supplemental supplies.

Transmountain diversion from adjacent drainage areas represents the only feasible source of new supplies. Several such diversions are now in operation from the Laramie and Colorado River drainage areas. Larger projects are needed to meet the existing deficiencies for lands now developed. Shortages in late summer months limit the area on which crops of the higher values can be grown and reduce yields obtained.

Many irrigation systems built to divert from the main Platte and the Loup Rivers prior to 1895 lapsed into disuse in the succeeding years of more plentiful rainfall. A considerable number of canals have been maintained, however, and in recent years many plants for pumping from wells have been installed. Deficient rainfall in recent years has led to a revival in interest in irrigation in central Nebraska. Future planning for this portion of the basin must take into consideration irrigation, at least as a supplementary practice, although the permanence of the demand for continu-



LEGEND

- Cities
- Water Supply
- Pollution Control
- Irrigation Project
- Dam and Reservoir: I, Irrigation; P, Power; F, Flood Control
- Transbasin Diversion, Irrigation
- Power Plant
- Local Study, Transbasin Diversion
- Area Project, Water Supplies for Stock Raising
- Drainage Basin Boundary
- Map Key Numbers Shown on Project List
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Project, Small Reservoir for Irrigation and Water Conservation
- Basin Wide Study, Water Supply and Water Utilization

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

ous service in the more eastern portions of the area remains to be demonstrated.

Adequate sources for *municipal water supply* are generally available within the Platte Basin. Both surface and underground waters are used. Denver has the largest consumption, however, and until recently its supply barely met its needs. By acquirement of rights on the upper South Platte, construction of additional storage and the diversion of water from the Colorado River drainage area through the Moffat Tunnel, placed in operation in 1936, Denver has secured a supply sufficient for its present needs. An additional project to divert water from the Williams Fork of the Colorado to provide water for dilution of its sewage effluent is now under construction. Lincoln pumps water from wells adjacent to the Platte River.

In general, *pollution* is a minor factor on the Platte River. Disposal of industrial waste has not been an important problem. Recently constructed sewage-treatment plants for several cities in the South Platte Valley have improved conditions. Some water is released from Pathfinder Reservoir during the nonirrigation season to provide sewage dilution at Casper, on the North Platte.

Irrigation.—The diversion of 100,000 acre-feet from the North Platte Basin in Colorado to the Cache la Poudre has been proposed by Colorado. There is an actual shortage in the Cache la Poudre and South Platte Valleys. No detailed surveys or cost estimates are available for such a diversion. The amount of water available for the proposed diversion cannot be determined until the rights of the three States have been defined.

The major construction now under way on the North Platte River in Wyoming is the Casper-Alcova project of the Bureau of Reclamation. This consists of a reservoir to store 1,000,000 acre-feet of water at Seminoe; a power plant; a diversion dam at Alcova; and canals to serve 35,000 acres near Casper.

Physically, this project can be divided into two parts; the Seminoe dam and power plant, and the Casper-Alcova irrigation system. While the irrigation project requires the storage project, the storage and power could be independent of the irrigation project. The estimated cost of the storage and power features is \$8,246,000 and of irrigation features, \$11,700,000. The lands have contracted to repay \$80 per acre. Sale of power is expected to repay a large portion of the cost of the project.

Seminoe Reservoir is needed for carry-over storage on the North Platte whether or not the water made available is used on the Casper-Alcova lands. The power that can be generated at Seminoe Dam can, probably, be marketed within a reasonable time.

There are other prospective irrigation projects on the North Platte River in Wyoming. Above Seminoe, the Saratoga project, at an altitude of 6,500 feet, is estimated to cost about \$100 an acre. There are opportunities for several pumping projects below Casper, all of which are relatively high in first cost or in operation charges. The Goshen Park Canal, above the present Fort Laramie Canal, has been considered but the costs are also relatively high. Storage under the Fort Laramie Canal similar to that in Lake Minatare on the north side would be very helpful in the regulation of the operation of this system and would furnish some supplemental water. The Horse Creek site could be used for this purpose and could probably be built without conflicting with other rights in Nebraska.

The Laramie River has been apportioned between Colorado and Wyoming. The largest project in Wyoming is the Wheatland project of the Wyoming Development Co. Supplemental storage is now under construction for this project. Additional storage is needed, but its provision must await outcome of litigation.

Public Works Administration allotments are financing five projects in central Nebraska. The Loup River public power district will complete its Columbus project on the Loup River in 1937. The Sutherland project of the Platte Valley public power and irrigation district also is nearly complete. The central Nebraska public power and irrigation district is constructing the "Tri-County" project. Certain modifications and adjustments in the last project have been made necessary by recent court decisions restricting its irrigation to the Platte River Basin. Allocations of Public Works Administration funds for irrigation projects on the Middle and North Loup Rivers have been made recently.

The only feasible source of additional water in the South Platte Valley is by transmountain diversion from adjacent drainage areas, and the Colorado-Big Thompson project has been proposed to fill the need for supplemental water. It proposes storage on the North Fork of the Colorado near Granby; pumping into Grand Lake, and a 13-mile tunnel to the Big Thompson River. About 275,000 acre-feet per year could be obtained at a total cost of about \$25,000,000. With the earnings from power which could be developed in connection with this project, it is estimated that water might be sold for \$2.15 per acre-foot. This price is less than the price frequently paid for stored water in this area. Since the tunnel for this project would be within the Rocky Mountain National Park, much opposition to it has arisen from the fear that it would injure the scenic features of the park. Provisions for such a project are contained in the act creating this park.

An investigation of the diversion of waters of the Blue River to the South Platte is now being made by the Bureau of Reclamation.

Recreation and wildlife.—Use of Platte River water for these purposes has been incidental to other uses. All storage projects will furnish additional recreational facilities. The water supply available for essential uses is too limited in all except the eastern end of the

basin to use water for recreation or wildlife where it would directly conflict with other uses.

Small reservoirs.—The Division of Grazing has proposed water development on public lands. The conditions and needs with respect to storage in small reservoirs are similar throughout the western part of the basin and a general item for such work has been recommended.

Platte Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
82	Blue River Diversion, Summit County, Colo.: Study of economic feasibility of diverting water from Colorado Basin to Missouri Basin.	\$25,000	Sum indicated is needed to complete.
(1)	Study of water supply and use in Colorado, Wyoming, and Nebraska	100,000	Needed as basis for selection of projects.
(1)	Erie (74) and Lafayette (76), Colo.: Municipal water supplies	142,000	
(1)	Albion (48), Alliance (17), Alvo (39), Bridgeport (13), Bruno (44), Clarks (53), Columbus (47), Craig (34), Elba (51), Ericson (21), Fremont (37), Hickman (41), Hyannis (18), Kearney (55), Madison (46), Norfolk (27), O'Neill (22), Overton (56), Page (23), Pender (33), Prague (43), Rockville (52), Sargent (20), and Tilden (24); and Knox (25) and Thurston (32) Counties, Nebr.: Waterworks extensions.	632,000	
(1)	Arlington (36), Broadwater (14), Columbus (47), Fremont (37), Fullerton (49), Kearney (55), Lincoln (42), Meadow Grove (28), Norfolk (27), North Bend (38), Ogallala (58), Oshkosh (15), Osmond (26), Overton (56), Sargent (20), Schuyler (45), Stanton (29), Wayne (30), West Point (35), and Wolback (50); and Dixon (31) and Lancaster (40) Counties, Nebr.: Sewer systems and/or sewage treatment.	905,000	
47	Loup River public power district (Columbus): Power project on Loup River, Platte County, Nebr.	5,200,000	Under construction. Certain construction pertaining to transmission lines is restrained temporarily pending court hearing. Sum given is rough estimate of additional amount necessary to complete. Total cost estimated at \$16,200,000.
(1)	Brighton (75), Fort Lupton (71), and Fort Morgan (63), Colo.: Sewer systems	64,000	Plans can be completed quickly.
42	Lincoln, Nebr.: Sewage channel to Platte River	200,000	
57	Platte Valley public power and irrigation district (Sutherland): Power and irrigation project on North Platte River in Lincoln County, Nebr.	465,000	Nearly completed. Sum given is rough estimate of additional amount necessary to complete. This sum already allotted subject to compliance with certain conditions. Total cost estimated at \$10,165,000.
5	Casper-Alcova project, Wyo.: For irrigation and power	2,000,000	Cost given is for next 2 years. Additional needed to complete, \$4,800,000.
11	Goshen County, Wyo.: Ray Reservoir on Horse Creek to furnish supplemental water supply for 10,640 acres.	315,000	
5	Development of wells, springs, and storage facilities for stock watering on the public range in several counties in Platte Basin in Wyoming.	75,000	
7	Albany County, Wyo.: Near Pole Mountain, reconstruction of water system	16,000	
54	Central Nebraska public power and irrigation district (tri-county) project on Platte River in central Nebraska.	3,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$17,000,000. Certain construction pertaining to power is restrained temporarily pending court hearing. Adjustments to irrigation plans may be necessary because of recent court decisions.
80	Intercepting ditches on Ranch Creek and St. Louis Creek in Grand and Boulder Counties, Colo., to provide additional water for diversion through Moffat Tunnel.	2,250,000	Surveys in progress.
(1)	Castle Rock (88), Central City (81), Frederick (72), Fort Morgan (63), Golden (85), Idaho Springs (84), Keensburg (70), La Salle (69), Louisville (77), Loveland (67), and Nederland (78), Colo.: Municipal water supplies.	251,000	Plans incomplete.
GROUP B—FOR DEFERRED CONSTRUCTION			
79	Colorado-Big Thompson transmountain diversion of water from Colorado Basin to Missouri Basin for supplemental irrigation supply.	\$3,000,000	Feasible and badly needed, to supply water for lands now under cultivation. Estimate includes a definite provision for compensating reservoirs fully sufficient to protect the rights of water users on the Western Slope. Cost given is for first 2 years. Additional needed to complete, \$22,000,000.
(1)	Arvada (87), Central City (81), Deer Trail (90), Fort Collins (65), Georgetown (83), Golden (85), Idaho Springs (84), Johnstown (68), Julesburg (59), Kersey (64), La Salle (69), Longmont (73), Loveland (67), Merino (62), Mountain View (86), Ovid (60), and Platteville (69), Colo.: Sewage-treatment plants.	274,000	Plans incomplete.
16	8 small storage projects for irrigation in Wyoming	72,000	Plans can be completed quickly.
12	Garden County, Nebr.: Blue Creek public power and irrigation district project	400,000	Plans incomplete.
12	Frances March McDonald Reservoir on Horse Creek, in Goshen County, Wyo.: For supplemental irrigation supply.	450,000	Further study needed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
8	Wheatland irrigation project in Platte County, Wyo.: Additional storage and canals	1,105,000	Plans incomplete.
66	Cache la Poudre River, Larimer County, Colo.: Enlargement of Halligan Reservoir	345,000	Plans completed.
39	Rebuilding Castlewood Dam, in Cherry Creek, Elbert County, Colo.	450,000	Plans incomplete.
	Small headwater reservoirs for water conservation in Loup River drainage in Nebraska	1,113,000	Do.
	Small headwater reservoirs for water conservation on tributaries of the Platte in Nebraska, other than the Loup.	1,000,000	Do.
67	Arkins Reservoir on Big Thompson River, in South Platte drainage, in Larimer County, Colo.	2,005,000	Do.
61	Sedgwick storage project, consisting of feeder canal and 2 reservoirs in South Platte drainage, in Sedgwick County, Colo., for irrigation of lands in Nebraska.	1,971,000	Do.
19	Almeria public power and irrigation district, on North Loup River, in Loup County, Nebr.: Rehabilitation of old canal.	9,000	Do.
1	Casteel Reservoir, in North Platte drainage, in Carbon County, Wyo.	250,000	This is an alternative site for Big Creek Reservoir of Encampment project. Plans incomplete.
10	Horse Creek Reservoir, in North Platte drainage, in Goshen County, Wyo.	900,000	Plans can be completed quickly.

¹ Map key number shown following community name.

8. KANSAS RIVER

Flood control for the area at and near Kansas City, Mo., and Kansas City, Kans., is the outstanding water problem of the Kansas River Basin. Improvement of municipal water supplies and elimination of stream pollution rank next in importance. Water conservation on some of the tributaries and the construction of farm reservoirs are desirable if well planned. Recreation lakes and parks are needed in the area. Extensive studies of water use in this basin are already under way.

General Description

The Kansas River is the most southerly of the plains tributaries of the Missouri. Its basin lies in the Great Plains and central lowlands areas and unlike the Platte to the north and the Arkansas to the south, it includes no mountain area. The principal tributaries, the Republican and Smoky Hill Rivers, rise at an altitude of about 5,500 feet above sea level on the eastern slopes of the high plains of central eastern Colorado.

The length of the Kansas River Basin from the headwaters of the Republican River to the Missouri River almost due east is approximately 480 miles. The greatest breadth of the basin is about 140 miles. Its total area is 61,441 square miles, of which about 40 percent is in the basin of the Republican, 33 percent in that of the Smoky Hill River.

The topography is remarkably regular although there is more rolling country in the eastern portion than in the west. The plains slope downward at approximately 12 feet per mile to the central portion of the basin, and then at a rate of about 5 feet per mile to an altitude of 720 feet at the mouth of the river.

The valley of the Kansas averages 2 miles in width and reaches a maximum width of 5 miles. The lower valleys of its principal tributaries, the Republican, Smoky Hill, and Big Blue Rivers, are from 1 to 2 miles wide.

The eastern part of the basin is moderately wooded, but farther west there are few trees and these are confined to narrow strips along the streams.

The total population of the basin in 1930 was 1,103,000 including Kansas City, Kans., with 122,000; Topeka, with 64,000; and Salina, Kans., with 20,000. Kansas City, Mo., with a population of 393,000 lies just outside the drainage area at the mouth of the Kansas River. About half of the inhabitants of the basin are engaged in farming.

Mineral resources of the basin include oil, coal, gypsum, salt, and volcanic ash. The production of oil and coal is relatively small.

Numerous industries are concentrated in the eastern portion of the area, particularly at Kansas City. Transportation facilities are excellent. Several transcontinental railroads run east and west along the Kansas River and its principal tributaries.

Hydroelectric plants have only 13,500 kilowatts out of a total installation of 203,000 kilowatts in the basin.

Soils of glacial origin consisting of sandy, gravelly, and stoney loams are confined chiefly to the hills and higher country of the northeastern portion of the basin; yellow clay and loam soils cover the extensive tablelands between the stream courses of the northern and western portions of the basin; alluvial soils are found in all of the principal valleys; residual soils are found in scattered areas throughout the basin. Farms of the basin are, in general, productive of the usual Midwest crops.

The average annual precipitation increases from about 15 inches in the western to 36 inches in the eastern part of the basin. In the eastern portion approximately 75 percent of the rain falls between April 1 and September 30 and about 55 percent during the four principal crop months. The average annual temperature is about 51° and the range from 121° above zero to 38° below. The length of the growing season increases from 149 days in the west to 201 days in the east. The average annual snowfall is about 25 inches and is generally sufficient to protect winter crops.

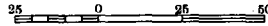
In the eastern part of the basin, storms are often both heavy and prolonged. Storms of the cloudburst type occur throughout the area, a notable example being the storm that caused the Republican River flood of 1935.

Destructive floods have occurred on many of the lower tributaries and on the main river. The Republican River flood of 1935 showed that flood dangers exist throughout the entire length of the principal tributaries as well as on the lower reaches and on the main river.

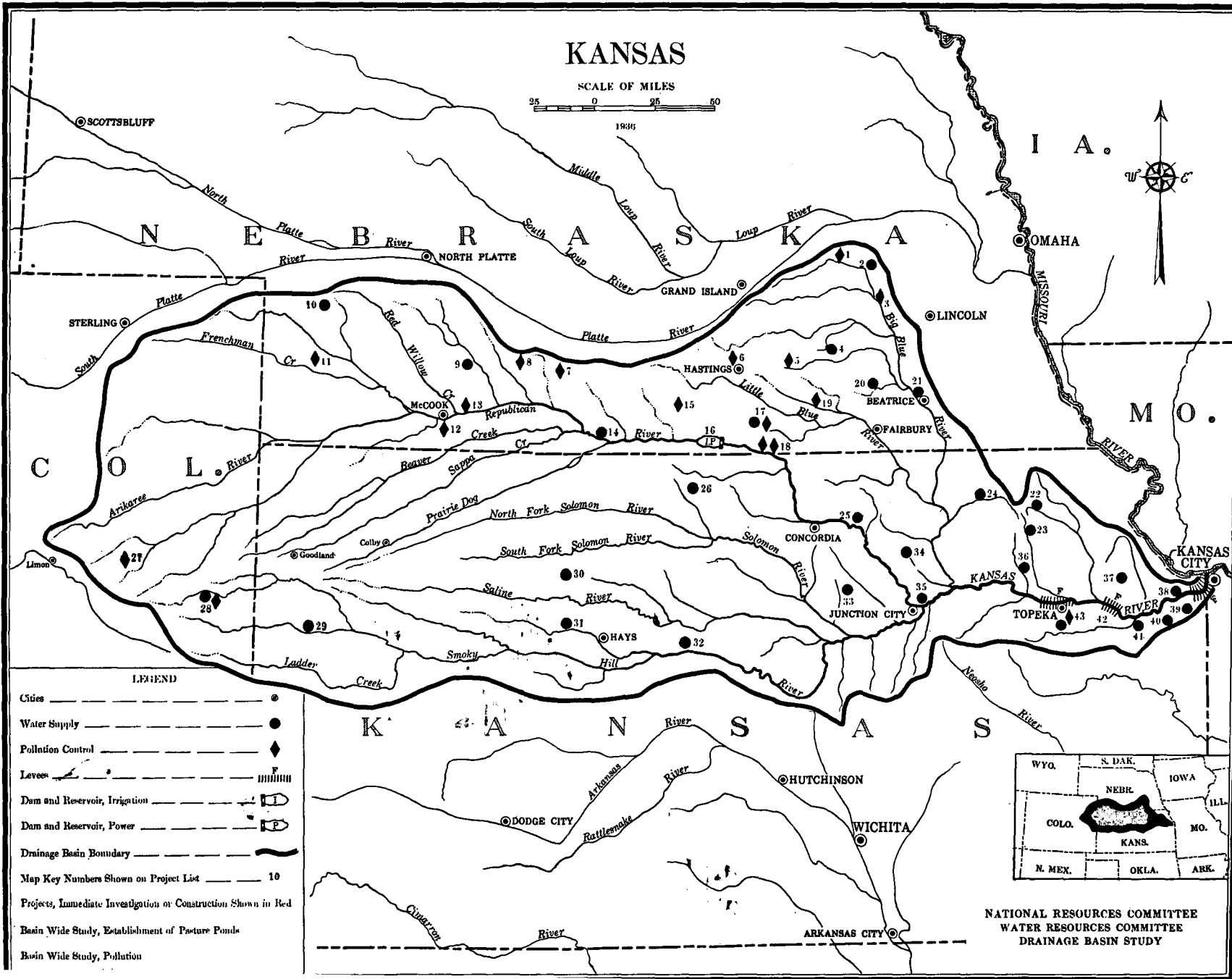
The flow of the Kansas and its tributaries is erratic, with infrequent high flood peaks and long periods of low flow. Recorded discharges for the Kansas River near its mouth have varied from a minimum of 100 cubic feet per second to a maximum of 260,000 cubic feet per second. The recorded run-off for a period of

KANSAS

SCALE OF MILES



1986



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Levees ———— [|||||]
- Dam and Reservoir, Irrigation ———— [D]
- Dam and Reservoir, Power ———— [P]
- Drainage Basin Boundary ———— [thick line]
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Establishment of Pasture Ponds
- Basin Wide Study, Pollution



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DRAINAGE BASIN STUDY

13 years varies from a maximum of 7,300,000 to a minimum of 1,680,000 with a mean of 3,890,000 acre-feet annually, equivalent to a depth of 1.19 inches on the drainage area.

Throughout the basin underground water in varying amounts and of varying qualities may be obtained from bedrocks and from alluvial fill and unconsolidated surface materials. The alluvial valley fills are in general the most reliable source of water supply. Within a given valley, good wells are often found near poor ones. Sandstones and limestones yield supplies of ground water adequate in many places not only for farms but for small towns. This water is of varying quality, however.

Recommended Plan

Flood protection for the railroad and manufacturing center at Kansas City, Mo., and Kansas City, Kans., is of outstanding importance. This is one of the most important railroad centers in the country, and the manufacturing district one of the most important in the west. Most of the area is in the flood plain of the Missouri and Kansas Rivers and although it is protected in part against minor floods, it is unprotected from maximum floods. Fourteen railroads utilize the bottom lands for main lines, yards, and terminals and the assessed valuation of railroads, industrial plants, and other properties within the proposed flood project exceeds \$116,000,000 of which about 70 percent is along the Kansas River and the remaining 30 percent along the Missouri. The greatest flood of record was in 1844, prior to the present railroad and industrial development. The flood of 1903, almost as great as that of 1844, resulted in tangible damages of \$20,000,000. A similar flood today would cause a much greater loss. Studies have outlined a high levee plan to give protection, and an item of \$10,000,000 for construction and \$8,000,000 for rights-of-way and damages was included in the Omnibus Flood Control Act of 1936.

The Army Engineers are now preparing a modification of the earlier plan for high levees with permanent bridges at high levels. They now are considering retaining the high levees but arranging all the low-level railway bridges on hydraulic jacks, so that they may be raised during extreme floods to provide a free floodway. At such times the gaps in the levees at the ends of the bridges would be closed by sandbags or shut off by flood gates, and rail traffic within the protected area re-routed by way of one or possibly two high-line bridges, one of which is now constructed. All highway bridges would be raised permanently above the levee grade. The cost of the modified project is estimated at \$17,200,000.

Another plan contemplating the reduction of Kansas River floods by a series of reservoirs on its main

tributaries has been under study since October 1934. No final decision should be made as to the type of protection for the Kansas City area until this is completed.

Flood levee projects for the protection of portions of Topeka and Lawrence, Kans., should also be considered and final decision reached only after the reservoir studies have been completed.

Water-supply improvements are recommended for Topeka and for Olathe, Kans.; Cheyenne Wells, Colo.; and eight communities in Nebraska. Water-supply systems are also recommended for 16 communities in Kansas.

Pollution in the Kansas basin becomes progressively more important toward the lower reaches of the stream. In the Smoky Hill Basin, nine towns discharge untreated sewage into the stream, while six more use primary treatment only. It is doubtful whether contamination from these sources reaches downstream far enough to affect the supply of any town dependent on the river for water.

In the Republican Basin 17 Kansas towns have sewer systems, 9 with secondary treatment and 3 with primary treatment; 5 discharge without treatment into the river. Of the last group, all on the lower section of the stream, four are relatively small and the fifth, Junction City, affects only the Kansas River.

On the Kansas River proper the necessity for pollution abatement is more pressing. In 1920 and 1921, the cities of Lawrence and Topeka abandoned groundwater supplies and installed treatment plants to purify river water for domestic use. In 1922, on account of this change, a survey was made of sanitary conditions along the Kansas River and along its principal tributaries in the eastern half of the State. In certain sections pollution was found to be excessive. The most serious pollution created by discharge of raw sewage at Topeka has since been abated by new construction.

Untreated sewage is still being discharged into the Kansas River at Junction City, Fort Riley, Ogden, Manhattan, Wamego, St. Marys, Lawrence, Bonner Springs, and Kansas City, Kans. Negotiations have been under way for the abatement of pollution at Fort Riley, Manhattan, and St. Marys. With the extension of sewer systems and consequent increased volume of sewage reaching the Kansas River, the safety of dependence upon dilution is open to question. Sewer extensions and improvements at Topeka, sewer systems for eight Nebraska communities, and disposal plants for four others, as well as sewer systems and sewage treatment plants for two communities in Colorado, are recommended for construction. Storm sewers are also recommended for Superior and Nelson, Nebr.

Irrigation has not been extensively developed in this basin, and under present conditions it does not appear

to be economically feasible if dependent on storage works on the main streams. One project, however, is included in the list for deferred construction. It contemplates direct diversions from the Republican River and storage and diversion from reservoirs on two of its northern tributaries. A compact is under consideration between Colorado, Nebraska, and Kansas for division of the waters of the Republican River, and construction of irrigation projects on the stream should await its adoption.

Farm ponds have been constructed in large numbers under a Kansas statute which permits the remission of a certain part of the taxes on lands where such ponds are built in accordance with standards set by

the State. A study project is set up for a general survey and determination of such additional construction programs as may be justified.

Navigation is no longer of importance on the Kansas. It is effectively stopped by bridges constructed at low levels near the mouth of the stream.

Water power has been developed at plants of small or moderate size, but the remaining power possibilities are unattractive and no power developments have been considered in this report.

A more extensive list of studies would be recommended were not additional investigations by the Army Engineers and the Bureau of Reclamation already under way.

Kansas Project List

Map key no.	Project	Estimated Cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of pasture ponds throughout basin.....	\$10,000	
	Study of pollution throughout basin.....	20,000	
38	Kansas City, Kans.: Waterworks improvement.....	200,000	Plans completed.
43	Topeka, Kans.: Waterworks improvement.....	219,000	Do.
(1)	Clifton (25), Delia (36), Dorrance (32), Ellis (31), Eudora (41), Fort Riley (35), Lebanon (26), Leonardville (34), Longford (33), McLouth (37), Palco (30), Shawnee (39), Soldier (23), Vermillion (24), Wallace (29), and Wetmore (22), Kans.: Municipal water supplies.	689,000	Do.
(1)	Alma (14) and Beatrice (21), Nebr.; Cheyenne Wells (28), Colo.; Dwight (2), Exeter (4), Grajinton (10), and Nelson (17), Nebr.; Olathe (40), Kans.; Stockville (9), and Swanton (20), Nebr.: Waterworks improvements.	318,000	Do.
43	Topeka, Kans.: Sewer extensions and improvements.....	307,000	Do.
(1)	Campbell (15), Davenport (19), Hastings (6), Imperial (11), Indianola (13), Osceola (1), Seward (3), and Sutton (5), Nebr.: Sewer systems.	344,000	Do.
(1)	Bertrand (7), Elwood (8), McCook (12), and Superior (18), Nebr.: Sewage treatment plants.....	161,000	Do.
(1)	Cheyenne Wells (28) and Flagler (27), Colo.: Sewer systems and sewage treatment plants.....	49,000	Do.
(1)	Nelson (17) and Superior (18), Nebr.: Storm sewers.....	43,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
38	Kansas City, Mo., and Kansas City, Kans.: Flood levees.....	\$17,200,000	Authorized by Congress. Includes \$8,000,000 estimated cost of lands and damages to be supplied by local interests.
43	Topeka, Kans.: Flood levees.....	1,652,000	Authorized by Congress. Includes \$807,000 estimated cost of lands and damages to be supplied by local interests.
42	Lawrence, Kans.: Flood levees.....	281,000	Authorized by Congress. Includes \$118,000 estimated cost of lands and damages to be supplied by local interests.
16	Nuckols and Webster Counties, Nebr.: Bostick Reservoir on the Republican River and canal for irrigation and power.	1,500,000	

¹ Map key number shown following community name.

9. LOWER MISSOURI

The outstanding water problem on the main stem of the lower Missouri River is flood protection for Kansas City, Mo., and Kansas City, Kans., a subject discussed at length in the report on the Kansas River Basin. Flood protection for agricultural areas along the stream, channel stabilization, and regulation of low water flow for navigation are also needed. Pollution abatement, wildlife conservation, and recreation should be studied.

General Description

This drainage area comprises the alluvial valley of the Missouri River from the mouth of the Platte in Nebraska to the mouth of the Missouri, and includes in addition the Platte of Missouri and Iowa, and the Nodaway, Tarkio, Nishanabotna, Lamine, Moreau, and other minor drainage basins. The major tributaries are considered elsewhere. Of the total of 115,620 square miles in the Missouri River Basin below the mouth of the Platte, an area of 24,420 square miles is included in the lower Missouri River Basin as it is considered here.

The western part of the basin, extending from the mouth of the Platte down to Booneville, is characterized by nearly level topography in the uplands, rolling hills near the main stream, and a broad alluvial valley along the river; the prairie country drops off sharply to the river valley. The eastern part, from Booneville, Mo., to the mouth of the river, is hilly and cut by the deep valleys of the tributaries. The flood plain in this section averages some 2 miles in width and is bordered by high bluffs.

The land elevations vary from 400 to 1,100 feet above sea level. The channel slope of the river throughout this section is nearly uniform at 0.9 foot per mile.

Alluvial soils in the valley flood plain vary from fine sandy loams to heavy clays. In general, the Missouri River alluvial bottoms contain the most productive soil in the basin. They are, however, closely approached by the deep, dark prairie soils in the western portion of the area.

The population of this area in 1935 was estimated at 1,371,000, with 525,000 in the twin Kansas Citys and 81,000 in St. Joseph. There are 300 incorporated towns in the basin; nearly all are growing.

The St. Louis metropolitan area, containing a population of about 1,000,000, joins the basin on the east.

Railroads and State highways adequately serve the entire basin. A barge service is operated seasonally

between St. Louis and Kansas City. The more important items of manufacture in the basin are meat products, chemicals, clay products, glass, and clothing.

About 260,000 people are engaged in agriculture in the basin. The alluvial valley of the Missouri includes an old, stable, and highly developed agricultural area. Because of the deep fertile soils and nearby markets, conditions appear to favor expansion of a more intensive and specialized type of farming. Corn Belt agriculture, stock raising and feeding, orchards, truck gardening, and specialty crops are at present leading types of farming. In the Missouri River bottoms, corn, wheat, clover, and alfalfa are important crops. A small portion of the Missouri River bottom has been drained by ditching and tiling.

The average annual precipitation varies from about 32 inches in the west to 40 inches in the east. A large part of the precipitation falls during the growing season, which in this section of the valley is about 200 days long.

Formerly the river did great damage to adjacent farm lands but revetments, dikes, and other controls, built since 1912, have stabilized the channel to a large extent. The river transports much silt. Its discharge varies between wide limits. At St. Joseph, the estimated maximum discharge is 425,000 cubic feet per second, the minimum 3,730, with an average of about 36,000 cubic feet per second.

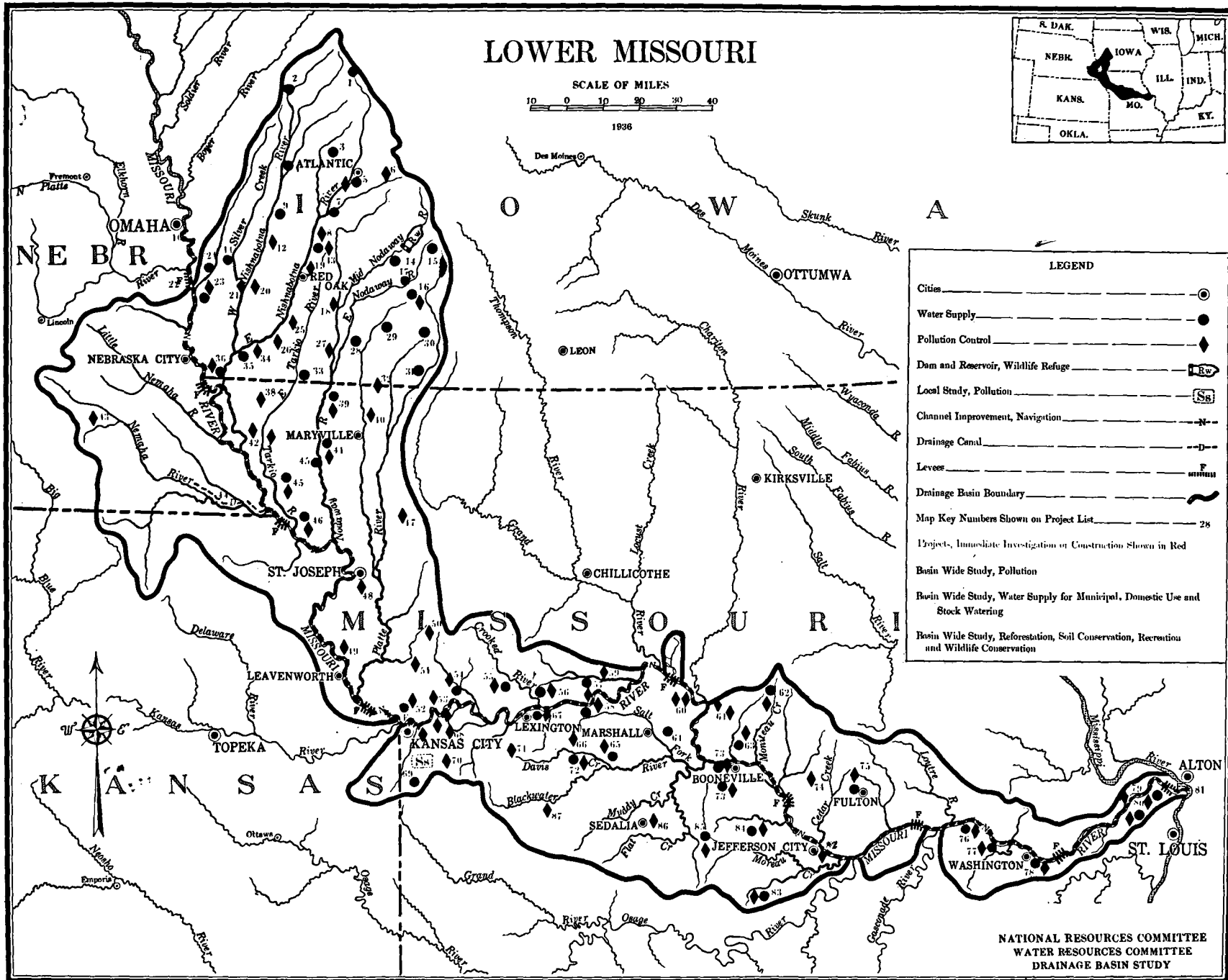
Large supplies of underground water are available in the alluvial deposits of the flood plain of the Missouri River and its major tributaries. Farm and domestic supplies are also obtained by boring wells into the glacial drift, especially in the northern part of the basin where the drift is often from 150 to 350 feet thick in the upland areas. The yield from such wells varies, depending upon the nature and size of the sand or gravel beds, many of which are lenses or pockets in the clay. There are, moreover, marked regional variations in the chemical content of the underground water. Deep wells in St. Charles and St. Louis Counties in Missouri and in almost all of the western half of the basin yield rather highly mineralized water.

Duck hunting and fishing are important recreational activities. A few small cut-off and artificial lakes have been developed as regional State parks.

Recommended Plan

Flood protection at Kansas City, Mo., and Kansas City, Kans., by far the most important problem in the

LOWER MISSOURI



LEGEND

- Cities _____ ●
- Water Supply _____ ●
- Pollution Control _____ ◆
- Dam and Reservoir, Wildlife Refuge _____ [Rw]
- Local Study, Pollution _____ [Ss]
- Channel Improvement, Navigation _____ -N-
- Drainage Canal _____ -D-
- Levees _____ F
- Drainage Basin Boundary _____ [thick line]
- Map Key Numbers Shown on Project List _____ 28
- Project, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution
- Basin Wide Study, Water Supply for Municipal, Domestic Use and Stock Watering
- Basin Wide Study, Reforestation, Soil Conservation, Recreation and Wildlife Conservation

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basin, is covered in detail in the report on the Kansas River Basin.

Flood damages averaging approximately \$2,000,000 annually occur in the agricultural portions of the basin along the Missouri River. More than 80 drainage districts have spent a total of \$10,000,000 in efforts to protect 400,000 acres of farm and city lands, with varying degrees of success. Further protection must be largely by means of levees. Preliminary studies, however, have shown that general protection is not economically justifiable.

Lower Missouri flood protection by several alternative systems of reservoirs has been studied in great detail, but even the most advantageous combination

was found to cost more than the estimated benefits under existing conditions.

Water supplies should be installed, extended, or improved in a number of the municipalities.

Pollution should be abated before it becomes more serious. Several treatment plants are recommended for immediate construction, and a study of the situation at the twin Kansas Cities is immediately desirable.

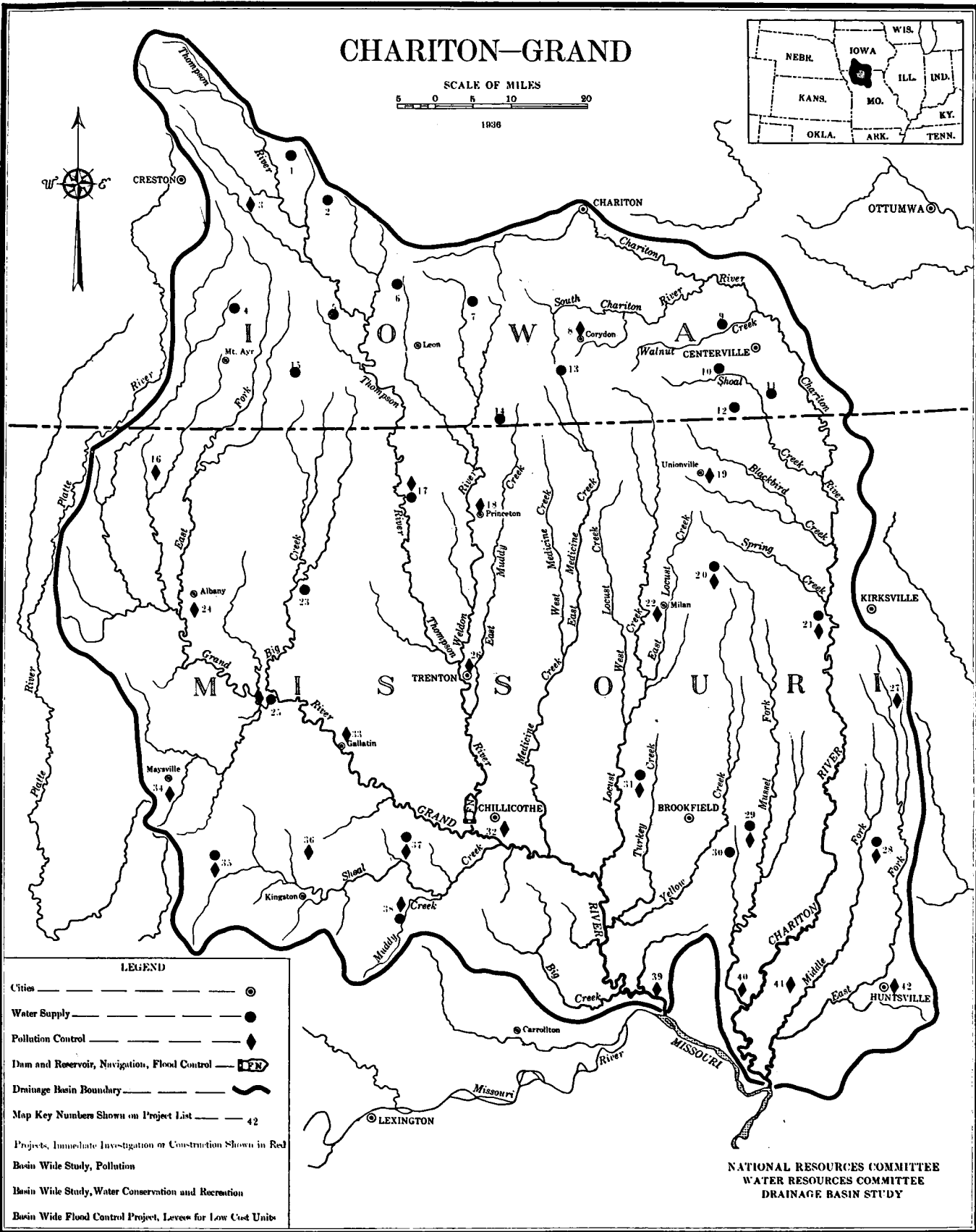
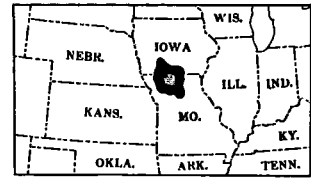
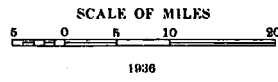
Navigation will be amply served by completion of the 6-foot channel now authorized for the Missouri River. To complete the present program from the mouth of the river to Kansas City will require \$3,600,000, and \$5,600,000 will be needed to complete the work between Kansas City and Omaha.

Lower Missouri Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of stream pollution throughout basin.....	\$10,000	
	Study of water supply for municipal, domestic, and stock watering throughout basin.....	10,000	
	Study of recreation, reforestation, soil conservation, and wildlife facilities of basin.....	50,000	
52	Kansas City, Mo.: Improvements to waterworks system.....	527,000	
(1)	Belton (69), Boonville (73), Burlington Junction (39), California (84), and Concordia (72), Mo.; Corning (17), Iowa; Eldon (83), Excelsior Springs (54), Fulton (75), and Hermann (76), Mo.; Lenox (16), Iowa; Lexington (67), Maitland (45), Marshall (64), Mound City (45), New Franklin (63), New Haven (77), Norborne (57), North Kansas City (52), Oregon (46), Richmond (55), Skidmore (41), Sweet Springs (65), Tipton (85), and Washington (78), Mo.: Water-treatment plants.	627,000	
(1)	Atlantic (5), Avoca (4), Defiance (2), Elk Horn (3), Elliott (13), Glenwood (23), Hamburg (36), Hastings (20), Lewis (7), Oakland (9), and Pacific Junction (24), Iowa; Pilot Grove (73), Mo.; Riverton (35), Silver City (11), and Templeton (1), Iowa: Waterworks systems and improvements.	288,000	
(1)	Adams (43), Nebr.: Anita (6) and Atlantic (5), Iowa; Boonville (73), Burlington Junction (39), California (84), and Carrollton (59), Mo.; Carson (12) and Clarinda (27), Iowa; Columbia (74), Concordia (72), Eldon (83), Mo.; Elliott (13) and Essex (25), Iowa; Excelsior Springs (54) and Fairfax (42), Mo.; Farragut (34), Iowa; Fayette (61), Fulton (75), Gilliam (60), and Glasgow (61), Mo.; Glenwood (23), Griswold (8), and Hamburg Iowa; Herman (76), Higginsville (66), Hopkins (32), Independence (68), Jefferson City (82), and King City (47), Mo.; Lenox (16), Iowa; Lees Summit (70), Lexington (67), Liberty (53), and Maryville (40), Mo.; Melvern (21), Iowa; Mound City (45), Mount Washington (68), New Franklin (63), New Haven (77), Norborne (57), North Kansas City (52), Odessa (71), Oregon (46), Pilot Grove (73), Plattsburg (50), Mo.; Red Oak (19), Iowa; Richmond (55), Rockport (42), and Sedalia (86), Mo.; Shenandoah (26), Iowa; Skidmore (41), Slater (60), Smithville (51), St. Charles (79), St. Joseph (48), Sugar Creek (53), Sweet Springs (65), Tarkio (38), and Tipton (85), Mo.; Villisca (19), Iowa; Warrensburg (87), Washington (78), and Weston (49), Mo.: Sewage treatment plants.	3,278,000	
52	Study of sewage treatment, Kansas City, Kans., and Kansas City, Mo.....	20,000	
48	St. Joseph, Mo.: Sewer system.....	930,000	
10-81	Omaha, Nebr., to mouth of Missouri River: Construction of navigation channel of 6-foot depth.....	9,200,000	Sum needed to complete present project.
44	Richardson County, Nebr.: Channel enlargement, Big Nemaha River, for drainage improvement..	253,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Blockton (31), Clearfield (30), College Springs (33), and Gravity (29), Iowa; Hardin (56), and Higbee (62), Mo.; New Market (28), and Orient (15), Iowa; Overland (80), Mo.; Prescott (14), Iowa; St. Ferdinand (80), and Waverly (58), Mo.: Municipal water supply systems.	\$494,000	
(1)	Hardin (56), Higbee (62), Overland (80), St. Ferdinand (80), and Waverly (58), Mo.: Sewage-treatment plants.	202,000	
52	Kansas City, Mo.: Sewage-treatment plant.....	3,000,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Kansas cities: Flood levees.....	See remarks	Cost of levees shown in "Kansas River Basin" project list.
22-81	Lower Missouri River below mouth of Platte River: Levees for flood control.....	\$1,000,000	
14	Adams County, Iowa: Lake for recreation and wildlife (Crabhill Lake).....	175,000	

1 Map key number shown following community name.

CHARITON-GRAND



NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

10. CHARITON-GRAND

The chief problems on the Chariton and Grand Rivers involve stream pollution, water supply, and flood control. Soil erosion has an important bearing on the quality of the stream water and on the permanence of both agriculture and surface storage. Reservoirs in this area have been investigated as a part of a general plan for controlling floods on the Missouri River.

General Description

The two rivers rise in the rolling plain of southern Iowa and flow south through Missouri to the Missouri River. The combined area of their basins is about 10,860 square miles, about one-quarter of which is in Iowa. Glacial deposits in this area formed a mantle of clay, sand, and some gravel in a wide, smooth plain that has since been cut by the river systems. The main valleys of the Grand and Chariton vary from $\frac{1}{4}$ mile to 5 miles in width. They are bordered by hills from 50 to 200 feet high. The streams meander through the valley floors, but in the upper part of the Grand River basin many of the bows have been eliminated by artificial channels to carry away the flood waters.

The soils formed by weathering from the glacial drifts and from deposits of wind-borne dust are generally fertile unless depleted by sheet erosion, and agriculture is practiced all through the basin, the principal crops being corn, livestock, small grains, and grasses.

The total population of the area decreased steadily from 1900 to 1930. About 275,000 people in the 2 basins are engaged in agriculture; the rest live in small towns and cities dependent on the rural areas. Manufacturing is relatively unimportant.

The basin is generally well served with railways and highways, but a good secondary road system is needed. Power is generated by steam and oil engines or transmitted from plants outside the basin. Suitable sites for hydroelectric plants are lacking.

Temperatures range from 30° below zero to 112° above, with an average of about 52°. Precipitation is about 36 inches, two-thirds of which falls in the growing season, with May and June particularly wet.

The run-off is rapid but the total is only about 20 percent of the rainfall. Only the larger streams flow throughout the year.

Underground water from deep wells is too highly mineralized for drinking purposes, but good water is obtained from shallow wells in the mantle of drift. These wells, however, are liable to fail in time of

drought. The river water is muddy throughout the year and is little used for water supplies. Ponds for livestock watering are numerous, but when they receive drainage from cultivated land they fill up rapidly and new ones have to be built every 2 or 3 years.

Recommended Plan

Sewage-treatment plants have been installed by most towns that discharge sewage into the streams, but in some cases insufficient treatment results in pollution. Several towns, tourist camps, and creameries discharge untreated sewage and wastes into the waters. Recommended projects include new or improved treatment facilities for a number of towns, some form of regulation of pollution from tourist camps, and a general survey of pollution conditions as a basis for future plans.

Water supplies have been provided in 31 towns in the area. Forty-five others have no public water or sewer systems. Urban water supplies from wells, with treatment for softening and iron removal, are proposed for several towns in the area, and a surface reservoir for one other community. There has been some investigation of the ancient pre-glacial channels, now buried in drift, which can be expected to furnish dependable supplies. The investigation should be extended.

Flood protection is now provided to 142,600 acres in the Grand River Basin, and partial protection to 338,500 acres. There are 45 incorporated drainage districts and 10 not incorporated. The effect of the protective work in this area has been to increase floods downstream in the central lower part of the basin to such an extent that large areas of fertile land have been removed from use. The Corps of Engineers have prepared plans for protecting some of this land, but the average cost of a general system would be nearly \$100 per acre. On the Chariton a complete system of flood protection against usual high water has already been installed.

Storage in future may be developed at the Chilli-cothe Reservoir site. The possibilities of this storage have been studied by the Corps of Engineers in connection with a system consisting of the Arlington, Topeka, and Fort Peck Reservoirs, for the alleviation of floods in the Missouri Basin. These reservoirs, supplemented by the Richland, Osceola, South Grand, and Pomme de Terre also have been studied for the primary purpose of alleviating flood conditions on the Lower Mississippi. Of these reservoirs, only Fort Peck has been started.

Soil erosion has ruined many thousand acres in the Grand and Chariton Basins. Preliminary studies by the Soil Conservation Service indicate that most of the area has lost half its topsoil. All the reservoirs and farm ponds of the area depend for their continued usefulness on a program of erosion control for the tributary watershed.

Recreational uses of the streams are limited by the fact that they are muddy and irregular in their flow. There are some sites available for artificial lakes, which

could be combined with reforestation and soil-erosion control. A national forest purchase unit has been established in southern Iowa, and all lands purchased or controlled are to be set aside as game refuges.

Two migratory waterfowl flyways cross these basins, but many of the shallow lakes and lagoons that once served as stopping places have been drained. The areas that have been abandoned because of flood conditions possibly might be used as a refuge for wild game.

Chariton-Grand Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of stream pollution throughout basin.....	\$10,000	
	Study of water conservation and recreation.....	20,000	
(1)	Afton (3), Iowa; Albany (24), Bevier (28), Breckenridge (37), Brunswick (39), Bucklin (29), Cainsville (17), Cameron (35), and Chillicothe (32), Mo.; Corydon (8), Iowa; Gallatin (33), Grant City (16), Green City (20), Hamilton (36), Huntsville (42), Keytesville (40), La Plata (27), Linneus (31), Maysville (34), Milan (22), Novinger (21), Pattonsburg (25), Princeton (18), Salisbury (41), Trenton (26), and Unionville (19), Mo.: Sewage treatment plants.	767,000	Preliminary plans completed.
38	Braymer, Mo.: Sewer system and sewage treatment plant.....	49,000	Plans ready.
(1)	Bevier (28), Braymer (38), Breckenridge (37), Bucklin (29), Cainsville (17), Green City (20), Linneus (31), Novinger (21), and Pattonsburg (25), Mo.: Municipal water supplies.	348,000	
(1)	Allerton (13) and Murray (2), Iowa: Municipal water supplies.....	133,000	
(1)	Bethany (23), Cameron (35), and Marceline (30), Mo.: Improvement of water supplies.....	215,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
	Flood levees for such land units as may be protected at relatively low cost.....	\$225,000	
(1)	Cincinnati (12), and Mystic (9), Iowa: Water supply systems.....	220,000	
(1)	Exline (11), Garden Grove (7), Grand River (5), Kellerton (15), Lineville (14), Lorimer (1), Numa (10), Tingley (4), and Van Wert (6), Iowa: Water supply systems.	377,000	Improvement to supplies.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
33	Chillicothe Reservoir: Flood control and navigation.....	\$31,700,000	Preliminary plans and surveys completed.

¹ Map key number shown following community name.

Osage Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of water supply for municipal, domestic, and stock watering in western section of basin.....	\$20,000	
	Study of stream pollution throughout basin.....	10,000	
(1)	Drexel (10), Mo.; Eskridge (1), Kans.; Fair Play (43), Garden City (8), Huma (27), and Liberal (46), Mo.; Louisburg (11), Kans.; New Linn Creek (31), Mo.; Pomona (2) and Quenemo (14), and Scranton (3), Kans.; Sheldon (44), Mo.; Spring Hill (5), Kans.; Tuscumbia (21) and Westphalia (20), Mo.; Water supply systems.	310,000	Final plans needed.
(1)	Harrisonville (3), Mo.; Melvern (15), Kans.; Morrisville (50a) and Pleasant Hill (8), Mo.: Additions to water supply systems.	329,000	
(1)	Appleton City (24), Ash Grove (50), Bolivar (42), Buffalo (41), Camdenton (33), Clinton (17), Cole Camp (18), Drexel (10), Eldorado Springs (36), Greenfield (49), Harrisonville (9), Humansville (35), Iberia (32), Liberal (45), Lockwood (48), Marshfield (51), Nevada (37), New Linn Creek (31), Osceola (30), Pleasant Hill (6), Rich Hill (28), Sheldon (44), Stockton (40), Versailles (19), Warsaw (22), Westphalia (20), and Windsor (7), Mo.: Sewage treatment plants.	923,000	Do.
47	Mulberry, Kans.: Sewer system and sewage treatment plant.....	70,000	Do.
(1)	Arcadia (46), Eskridge (1), Gardner (4), Louisburg (11), Moran (26), Mound City (25), Pomona (2), Quenemo (14), Scranton (3) and Waverly (16), Kans.: Sewer systems and sewage treatment plants.	314,000	Do.
12	Osawatomie, Kans.: Sewage treatment plant.....	65,000	Do.
39	Nevada, Mo.: Waterfowl refuge.....	96,000	Plans being prepared.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
29	Osceola Reservoir, St. Clair County, Mo.: For flood control, navigation and power.....	\$24,663,000	Final plans needed.
(2)	Fort Scott (38), Osawatomie (12), and Ottawa (13), Kans.: Flood protection levees.....	1,439,000	Final plans ready, but construction deferred pending completion of reservoir studies now in progress.
(2)	South Grand River Reservoir (23), Warsaw, and Pomme de Terre River Reservoir (34), near Hermitage, Mo.: For flood control, navigation, and power.	14,792,000	Further study needed.

¹ Map key number shown following community name.

² Map key number shown following reservoir name.

11. OSAGE

In the Osage Basin the more pressing needs are improvement of municipal water supply, elimination of stream pollution by raw sewage, and flood protection for three cities and for agricultural lands in the upper headwaters region.

General Description

The Osage River, known in Kansas as "Marais des Cygnes", rises in the rolling prairies of east-central Kansas. It flows first southeastward into Missouri through wide swampy bottom lands and then northeastward to its junction with the Missouri River near Jefferson City. At the headwaters the altitude is about 1,250 and at its mouth about 500 feet. The area of the basin is 15,300 square miles, one-third in Kansas and the rest in Missouri. It is about 250 miles long and 100 wide. Channel slopes in the main stream and in its principal tributaries are irregular, the river consisting at low water of a series of pools, often 3 or 4 miles long, formed by gravel shoals, and without perceptible current.

In the central part of the basin the rolling prairies, characteristic of the western or headwaters region, merge into more hilly country, which still farther east changes in turn to the most broken topography of the basin, especially among the Ozark tributaries entering from the south.

The headwaters valley is broad and shallow and the stream meanders in wide loops. The central basin is nearly flat and more or less marshy with a rank growth of grass and open groves of pin oaks; in the eastern portion, where the stream traverses the hill country, the valley is generally less than a mile wide.

The basin has three main types of soil: that of the limestone uplands, fertile but stony; the prairie soils in the western portion, excellent for staple crops; and the river flood plains, rich but subject to overflow and in need of artificial drainage.

Forests originally covered most of the basin. Almost all of the commercial timber has been cut. What remains is scattered through the drainage area of the smaller tributaries in the Ozark foothills.

Railroad facilities in the western portion of the Osage basin are good, but in the eastern part large areas along the river have no rail service. Highway systems are well developed and are being extended and improved.

The population of the basin in 1930 was 350,000, of which 306,000 were on farms. The western part of the

area lies directly south of Kansas City, and the eastern section is tributary to Springfield and St. Louis. There are no large cities within the basin. Numerous small communities serve as local trading centers for surrounding agricultural territory. With improvements in transportation, the larger towns are growing at the expense of the smaller.

Agriculture is the leading activity. Stock raising in connection with farming is important, particularly in Missouri. Farm lands comprise 54 percent of the basin. The holdings are in general small and the production diversified.

Oil, natural gas, and coal are produced.

Temperatures range from a maximum of 121° to a minimum of 40° below zero, with an average annual of about 56°.

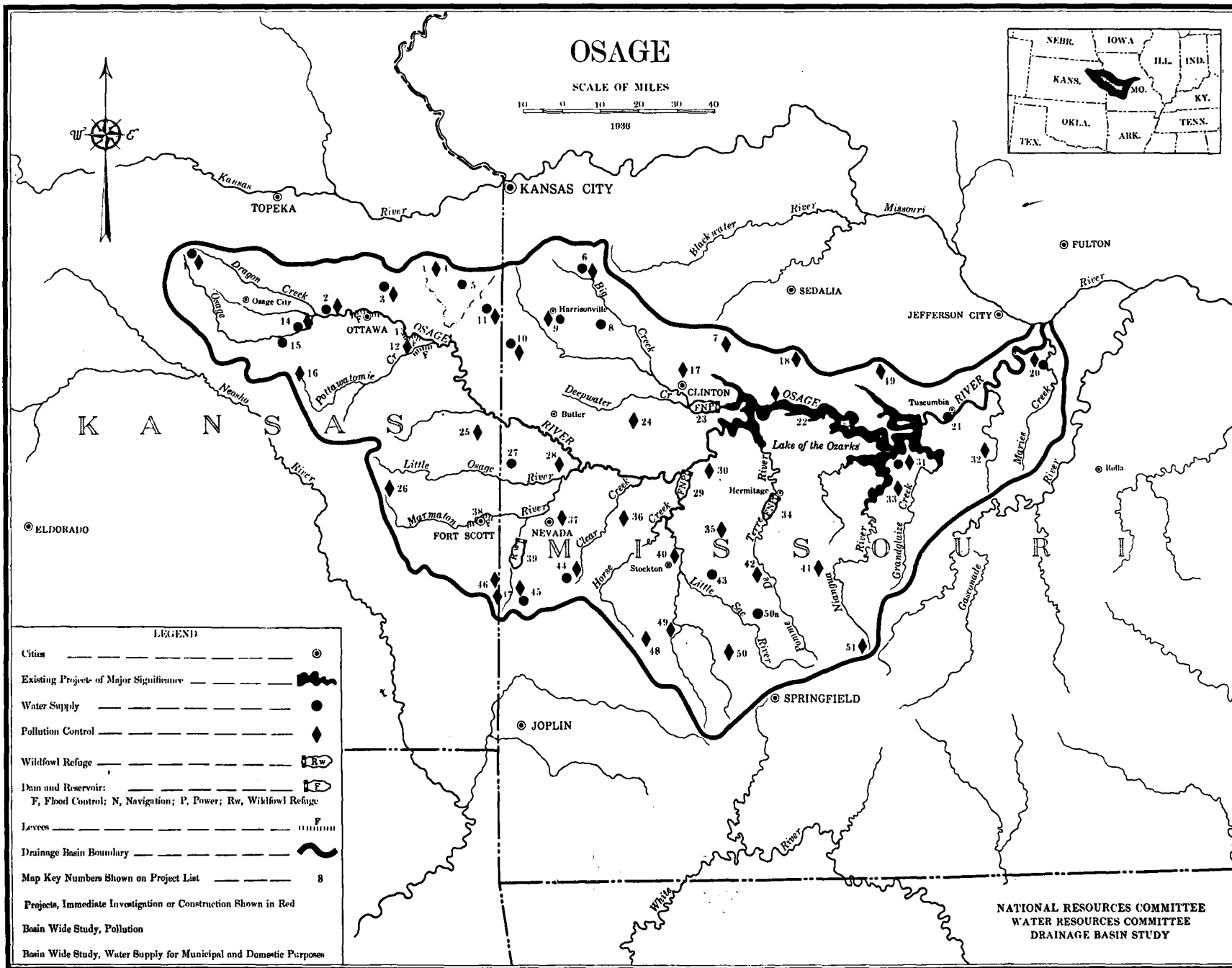
Precipitation averages 36 inches in the prairie headwaters, increasing to 42 inches in the Ozarks. About 65 percent of the moisture is received during the growing season, extending from April 1 to September 30, with most of this in the 4 months, May to August. While rainfall is usually adequate, both in amount and seasonal distribution, droughts of 3 to 6 weeks in the important crop months, July and August, are not infrequent.

Violent storms with excessive rainfall occur frequently in the headwaters basin and along the foothills of the Ozarks, with a maximum of 10.3 inches in a single day. Only a few floods, however, have been so general as to affect the main stream and all its tributaries.

Run-off varies even more widely than rainfall in different parts of the basin—the upper headwaters yielding a normal run-off less than 5 inches, while during the same period the Niangua River, a southern tributary heading in the Ozarks, averaged nearly 20 inches.

A 14-year record at the Bagnell gaging station which commands nine-tenths of the drainage area showed a maximum of 17,900,000 and a minimum of 912,000 acre-feet. The average of 7,090,000 acre-feet was equivalent to an average depth of 9.5 inches on the drainage area above Bagnell.

Underground water is obtainable throughout the basin. In the western part of the basin this water shows a relatively high mineral content, which increases with depth until the water is no longer fit for human consumption. Wells in the Ozark region usually furnish an abundant supply of good water. In Kansas the underground water is within 200 feet of



the surface but is too scanty for municipal supplies. Shallow farm wells except in river bottoms are likely to fail during dry periods.

Recommended Plan

Water supplies are needed for a number of municipalities in both States. Additional supplies are required by some towns now partially provided.

Pollution of streams is not yet critical, but is recognized, particularly by Missouri authorities, as a problem of immediate importance. A factor in the pollution problem is the increase in the number and population of recreational centers, particularly in the Ozark region. Only 40 out of 275 camps in Missouri have sufficiently high standards to receive the approval of the State board of health. Sewer systems and sewage-treatment plants are proposed for a number of municipalities which now discharge raw sewage into the streams.

Recreation in Missouri centers at the Lake of the Ozarks, formed by the Bagnell Power Dam which was completed in 1932. This lake has an area of 61,000 acres, and a shore line of nearly 1,300 miles. It has become the outstanding recreation center of the State. The National Park Service has acquired and is developing 25,000 acres of land on the Grand Glaize arm of the lake. Similar recreation facilities in other sections are greatly needed.

In Kansas, three recreation projects are now nearing completion. One at Farlington consists of a lake of 150 acres and 300 acres of park land; one at Garnett has a lake of 48 acres and park land of 100 acres; the third near Gardner consists of a lake of 130 acres, with 200 acres of park land.

Flood damage is confined largely to the upper section of the stream, west of Warsaw, Mo. Below that

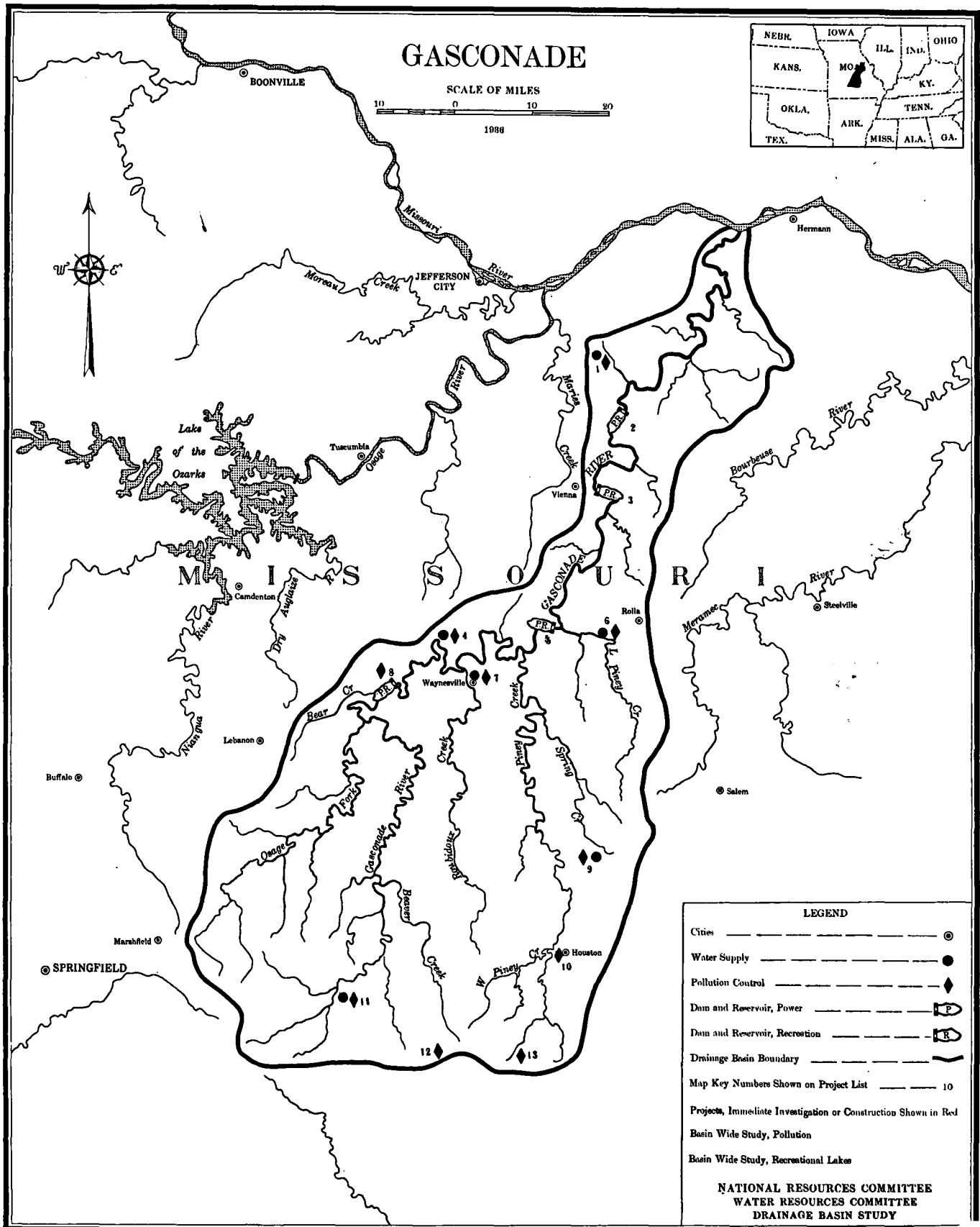
point the Bagnell Dam now normally serves to eliminate flood damage. Overflows in the upper basin affect about 290,000 acres of agricultural land, 112,000 acres of which are now protected, at least in part, by works constructed by drainage districts.

A study of proposed protection works for one area of 57,000 acres showed that costs of construction would be out of proportion to the benefits obtained there.

Studies have shown that protective levees are clearly justified for Fort Scott and Ottawa and on the border line of economic justification for Osawatomie, Kans. Construction of four reservoirs, on which detailed studies are now being made, has been suggested as a means of providing flood protection. Construction of the three levee projects should be deferred, pending the outcome of the reservoir studies.

Power is supplied by 25 fuel plants with a combined capacity of 32,000 kilowatts, and 4 hydroelectric plants, the largest at Bagnell, Mo., with a combined capacity of 158,000 kilowatts. The output of the existing plants provides a surplus for transmission to markets outside the basin. Additional units can be installed at Bagnell and no new power projects are recommended.

Storage, of large capacity, may be obtained at the Osceola, South Grand, and Pomme de Terre reservoir sites. Possibilities of their utilization for control of floods and for navigation on the Missouri and Mississippi to Cairo, either operating as a group or in conjunction with the Bagnell Reservoir, have been studied by the Corps of Engineers. They have also been considered together with the Richmond, Arlington, Chilli-cothe, and Garfield Reservoirs for the primary purpose of alleviating flood conditions on the Lower Mississippi River.



12. GASCONADE

The Gasconade Basin has a small population, but is becoming increasingly important as a recreational area. Its towns should improve their water supplies and provide sewage-treatment plants. Stream pollution abatement and prevention will be of growing importance due to increased summer occupancy. Hydroelectric power opportunities exist, but there is little demand for power in the basin itself.

General Description

The Gasconade River rises in the northern Ozark foothills and flows northeastward to its confluence with the Missouri 107 miles above the mouth of the latter at the town of Gasconade. The basin is about 130 miles long. It has an area of 3,600 square miles.

Extending from the rough, broken country of the extreme headwaters down to the vicinity of Arlington, is a rolling plateau into which the streams have cut deep and narrow valleys. These are bordered by bluffs that rise from 100 to 150 feet above alluvial bottoms that average a few hundred feet in width. Downstream from Arlington the terrain becomes progressively more hilly and broken. The river bottoms from Arlington to within 30 miles of the mouth are generally less than three-quarters of a mile wide. In the last 30 miles the valley gradually widens until it is one and one-half miles wide at the mouth.

The uplands are about 850 to 1,500 feet above sea level. The stream's altitudes range from 1,200 feet at the headwaters to 492 feet at its mouth. Even in the headwaters the slope of the stream is only 6 feet per mile; near the mouth it is 1.2.

Throughout its course the river meanders from bluff to bluff in ox-bow bends, and erosion has produced U-shaped valleys. The channel bed is gravel, with occasional rock ledges. Deep pools and eddies separated by shoals or riffles are typical of the streams in the Ozarks.

Originally well forested, only about 30 percent of the basin is now timbered, and much of this is in scrub oak. The soils of the uplands, generally thin and gravelly, are not well fitted for agriculture except for production of grapes and small fruit. The alluvial valleys contain fertile soils.

Mountain Grove, with about 2,000 people, is the largest community in the basin. The small towns are along the boundary ridges rather than along the river itself.

Of the total population of 75,000, the rural population is 45,000. The only important population trend is a growing influx of summer visitors. The rugged and picturesque landscape, the fine water, and the well developed camps make this area popular with vacationists.

While the 1925 Census of Agriculture classified 70 percent of the area of the basin as farms, it reported only 20 percent cropped in 1924. The chief crops in order of importance are corn, wheat, hay, and forage. Dairy products and poultry are sent to the metropolitan district of St. Louis, about 100 miles distant.

Lumbering, formerly the most important industry, now is confined principally to the production of railroad ties.

Clay deposits constitute the only mineral resource of present importance.

Three railroads cross the narrow part of the basin north of Waynesville, but the southern portion is without railroad facilities save for a single line which skirts the southwestern boundary for 80 miles. State highways cross the narrow northern portion of the basin, but in the southern portion they are not well distributed.

The mean annual temperature is about 55°, with an extreme range from 34° below zero to 110° above, and an ordinary range from 22° above zero to about 90°.

The normal annual precipitation varies in different parts of the basin from 36 to 44 inches, of which 60 percent falls during the growing season of 180 days. The average annual run-off is about 14 inches. Many storms are of high intensity and long duration, the majority coming in the spring and early summer months, although severe storms and floods have been recorded in every month of the year.

The combined flow of many springs maintains an unusually high discharge in low-water seasons. The annual run-off recorded at Rich Fountain has ranged from a maximum of 4,740,000 to a minimum of 1,270,000 acre-feet. A 16-year mean was equivalent to 13 inches depth, as great or greater than that for any other tributary in the Missouri River system.

Bank erosion on the Gasconade River is not severe and the suspended sediment carried by the river is small when compared with that of other major streams of the Missouri system.

Recommended Plan

Stream pollution in the Gasconade Basin is not yet serious, but growing recreational use of the basin by a large transient summer population warrants especial care in the prevention or reduction of contamination. Benefits derived by people of the basin from the recreational activities should encourage them to provide their communities with better water supplies and sewer and sewage-treatment systems. Projects of this type are recommended for construction. Of the 21 incorporated towns within the basin only 2 have public sewer systems. Most of the smaller towns and some of the larger communities discharge raw sewage directly into the streams without any type of treatment, as do also nearly all the many tourist camps.

The only industrial waste of troublesome proportions is that of the numerous creameries and cheese factories scattered throughout the basin. These wastes cause local nuisances and increase the acidity of the water to an extent detrimental to fish life.

Water power is the most important resource but the scant population of the basin and its lack of industries have retarded development. The four power plants, now operating, are small and none is driven by water power. The power requirements are supplied almost

entirely by transmission lines from plants located outside the watershed.

The most promising power market is in the St. Louis district about 100 miles east of the northern end of the basin. The St. Francois lead-mining region, Jefferson City, and the various towns nearby afford other markets.

Four dam sites on the main river near Richland, Arlington, Vienna, and Rich Fountain offer opportunities for water-power development. They command 303 feet out of a total of 347 feet gross head in this stretch of the river. About 85,000 kilowatts could be produced at these four sites. As a single project the suggested Arlington development with an installed capacity of 30,000 kilowatts was found to be the cheapest and any progressive future development should start there. Its cost was estimated at \$5,836,800.

Floods in the basin itself are unimportant. Short and flashy peaks occasionally flood small areas of unimproved bottom land but no material flood damage has been reported. Flood-control operation of the Arlington Reservoir on the Gasconade to reduce floods on the Mississippi River and on the lower Missouri River was studied. It was found that the effects would be inappreciable on the Mississippi and very small on the Missouri.

Gasconade Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of stream pollution conditions throughout basin.....	\$5,000	
	Study for extension of recreational facilities of basin.....	5,000	
(1)	Cabool (13), Houston (10), Mountain Grove (12), and Richland (8), Mo.: Sewage treatment plants.	255,000	Final plans required.
(1)	Crocker (4), Hartville (11), Lane (1), Licking (9), Newburg (6), and Waynesville (7), Mo.: Municipal water supply systems and sewage treatment plants.	155,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
5	Arlington, Mo.: Hydroelectric and recreation reservoir and power plant.....	\$5,500,000	Final plans required.
(1)	Rich Fountain (2), Richland (8), and Vienna (3), Mo. Hydroelectric and recreation reservoirs, and power plants.	13,700,000	Do.

¹ Map key number shown following community name.

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1. UPPER ARKANSAS

The water plan for the upper Arkansas River Basin is primarily concerned with the production of a more reliable water supply for irrigation. This can be achieved in part by additional storage of flood water, but the recent record, including the drought years, would appear to indicate the ultimate importance of an additional supply from outside the valley. Water now diverted from the western slope of the Rocky Mountains, or about to be diverted, will not be sufficient, and studies should be made of the possibility and desirability of diverting additional water.

The water plan includes the correction of damaging flood flows on certain of the tributaries in the southeastern part of the State and on Fountain and Monument Creeks, but definite proposals should await the result of further investigation.

The plan may include, as a result of further study, a program of small reservoirs in the southeastern part of the basin for local water supply, stock watering, and minor irrigation, but such development will be limited in part by existing water rights. Development of small reservoirs of this type is definitely indicated for parts of the basin in Kansas.

Municipal water supply is generally adequate, but there is an extensive need for treatment of municipal sewage. The abatement of industrial pollution is important on some minor streams.

General Description

The upper Arkansas River Basin, as here considered, is the area drained by the Arkansas River and its tributaries above Hutchinson, Kans., plus the area lying south of the watershed of the Smoky Hill River and north of the watershed of the Cimarron River which has no exterior drainage.

This basin contains 39,250 square miles of which about 25,250 are in Colorado and 14,000 are in Kansas. About one-eighth of the basin lies in the Rocky Mountains, and the rest in the Great Plains. The Arkansas River rises in the Saguache, Sangre de Cristo, Culebra, Mosquito, and Colorado ranges which have many peaks higher than 14,000 feet above sea level. The mountain section of the river is about 130 miles long, and falls to 5,320 at which altitude it debouches through the Royal Gorge into the foothills and plains at Canon City, Colo. From Canon City it falls 3,805 feet in 500 miles to Hutchinson. The basin is bounded on the north by the Republican Basin and on the south by the Cimarron.

The Rocky Mountain section is composed of great masses of igneous intrusions which have been stripped of over-lying sedimentary formations by severe stream and glacial erosion. The slopes are steep with exposures of bare rock in many places, and a thin mantle of rocky soils in others. The section includes the southern part of the "Golden Crescent", a richly mineralized region of Colorado, containing many deposits of gold, silver, and lead. Between a dry lower limit at 6,000 feet and a cold upper limit at 10,000 feet coniferous forests thrive.

The Arkansas River has eroded a trough which is 300 or 400 feet deep across the high plains to near Dodge City, Kans. Tributaries have cut both sides of the trough into a broken belt. Eastward from the high plains escarpment at Dodge City the river flows across the western part of the rolling prairies. The plains section is underlain generally by sedimentary strata which contain extensive salt and gypsum deposits. In the Raton district there are rich coal beds.

The total population of the basin in 1930 was about 400,000; 282,000 in Colorado and 118,000 in Kansas. About 40 percent is urban. The mining population trends point to a decline. Irrigation farming populations are stabilized at the present level due to nearly complete use of present water resources. The wheat and stock ranch population is approaching stabilization with a slow growth. Most of the cities, therefore, are stabilized as to their population.

The temperatures in the mountain district range from cool to cold depending largely on altitude. The precipitation increases with altitude up to about 9,000 feet, from 20 to 45 inches. The snow accumulates deeply in the forests and high valleys, and some of the snowfields are perennial. The rains and melting snows provide the basic flow of the Arkansas. A triangular tongue of plains and foothills with Canon City at the apex is hemmed in by mountains. Here mountain and valley winds are localized. Heated air from the plains, rising toward higher elevations, encounters cold air, causing any moisture to precipitate rapidly and resulting in torrential rain. These rains cause sharp-crested floods at Pueblo and points downstream. The Fountain Creek Basin in the vicinity of Pikes Peak, the canyon of the Purgatoire River, and, to a lesser extent, the canyon of Timpas Creek also are areas where "cloudburst" storms are common. The erratic flood flows resulting from these storms make up practically all of the water originating in the basin which is not utilized for irrigation.

The plains were once covered with a luxuriant growth of grass. Because of overgrazing, the importance of cattle ranching has steadily declined in recent years. Wheat raising by dry-farming methods flourished and declined along the eastern border, which is within the zone of occasional wet seasons. The central Kansas plains are well developed with wheat and stock ranches.

The substantial economic development of the basin has been in irrigated agriculture. Many places have developed crop specialties, such as vegetables, melons, and sugar beets.

The climate of the plains is semiarid. The mean annual temperature is about 50°, with extremes from 30° below zero to 110° above. The average annual precipitation decreases from 27 inches at Hutchinson to 12 inches at Pueblo. Precipitation varies from year to year from as low as 6 inches to as much as 33 inches over wide areas. Most precipitation of the plains comes as summer thunderstorms, frequently of great violence.

Decreased flow of the river in the plains section, due to evaporation, absorption, and irrigation, has resulted in the building up of the stream channel by deposits of sediment which the stream can carry no further. This is especially noticeable in the Kansas section where periods of zero flow are common. The river bed is unstable and wide and the channel shifts frequently.

From the Kansas-Colorado line to Larned, Kans., a distance of about 200 miles, the river receives no tributary flow. This accounts in part for the rapid reduction in flood peaks in this section. Several streams in this part of Kansas, notably Wildwoman and Bear Creeks, have well-developed drainages for a considerable distance and then disappear in the quick mantle of unconsolidated material which overlies much of the area.

Recommended Plan

Irrigation.—Water from the Arkansas River and its tributaries is used in Colorado and Kansas for irrigation of more than 600,000 acres. About 405,000 acres are irrigated in the plains section below Pueblo of which about 340,000 are in Colorado and 65,000 in Kansas. It is estimated that prior to 1930 there was an average annual water shortage in excess of 200,000 acre-feet in the Colorado section alone. In Kansas recurring shortages have resulted in the abandonment of about 200,000 acres which were irrigated at one time.

A dam at Caddoa on the main stream 18 miles above Lamar would catch the greater part of the flood water and hold it for beneficial use. Estimates indicated that a 680,000 acre-foot reservoir at Caddoa, with 400,000 acre-feet reserved for irrigation and 280,000 for flood control, would make available approximately

170,000 acre-feet of supplemental water per year. The dam and reservoir with the necessary appurtenances would cost approximately \$10,000,000. This reservoir would eliminate practically all flood damage in the valley as far as Larned, and would make appreciable reductions in flood damages as far as Hutchinson.

At a site on the Purgatoire River, a reservoir of 145,000 acre-feet capacity would make 48,500 acre-feet of supplemental water available each year. The cost of the project would be about \$1,600,000.

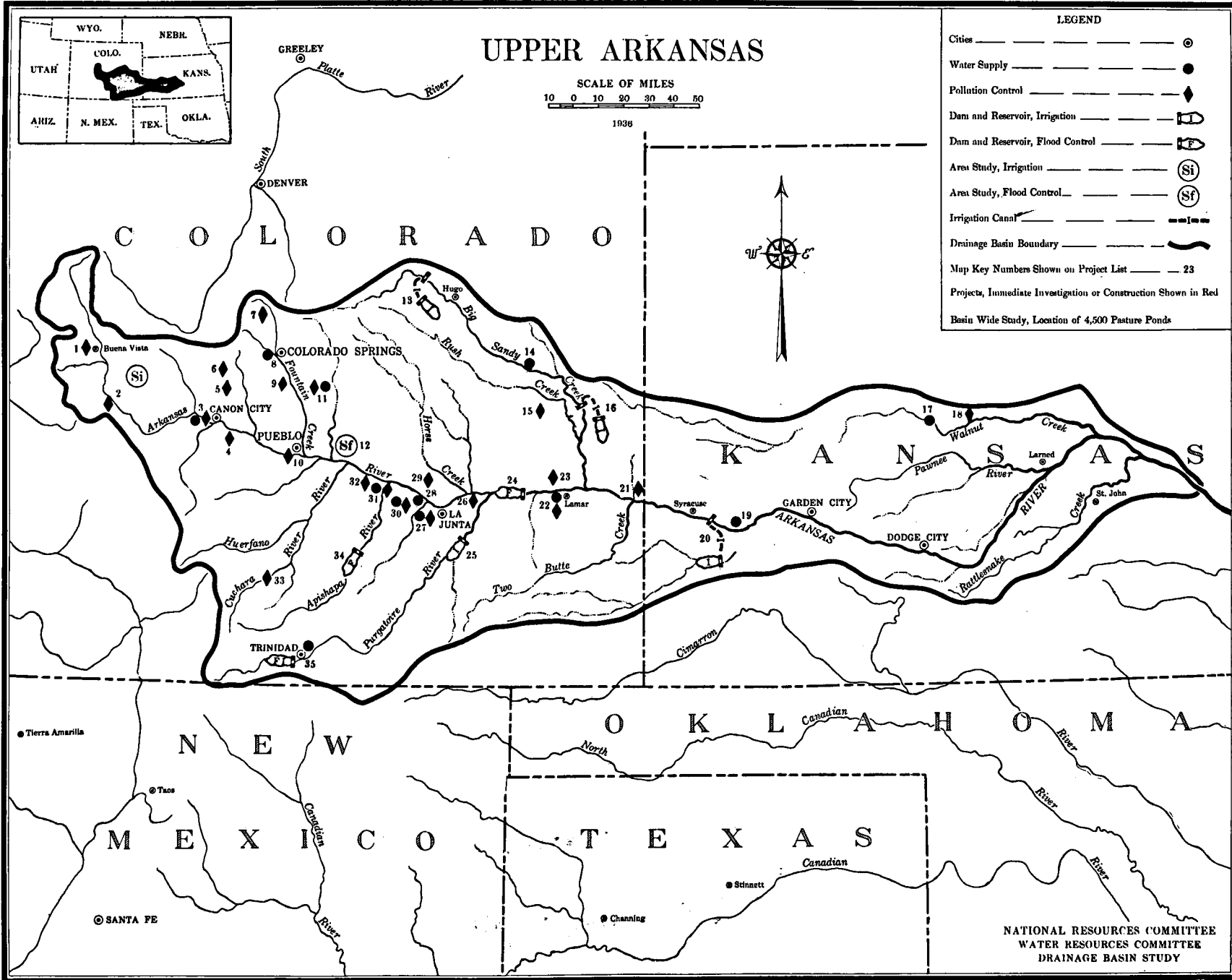
Another reservoir site is available—the Bear Creek reservoir in western Kansas. This is an off-channel reservoir which would be supplied by a canal about 15 miles long from a diversion dam across the Arkansas River above Hartland, Kans., estimated to cost \$700,000. The capacity of the reservoir would be about 60,000 acre-feet and it is estimated that it would provide 40,000 acre-feet of supplemental water per year for use in the vicinity of Garden City, Kans.

Development of these projects has been deterred not only because of the high cost but because of the litigation between Colorado and Kansas over water rights. A stipulation has recently been entered which says in effect that if the Caddoa Reservoir is built, water uses below the site shall continue substantially as in the past except for flood flows made usable by the reservoir which shall be divided equally between the two States. This action should help to clear the way for construction of the Caddoa project.

Supplemental water may be supplied by two other methods; transmountain diversions and pumping from underground sources. Both methods are now used to some extent and both should be studied further. The Twin Lakes Reservoir & Canal Co. is now engaged in the construction of a transmountain diversion to bring water from the Colorado River basin at a cost of \$2,200,000. About 50,000 acre-feet will be supplied by the diversion for use on an area of 50,000 acres. To stabilize present irrigation development in the Arkansas River basin, other importations as well as construction of additional storage on the east slope, have been proposed. Because of the shortage of water for the lands now irrigated, no proposals for the irrigation of new areas should be considered.

Flood control.—Although not a major problem in most of the area, floods are damaging in a few localities, especially on Fountain Creek near Pueblo and Colorado Springs, and near Trinidad where the Purgatoire River frequently leaves its banks. The Caddoa project would eliminate flood damage for some distance below the dam, and studies are now being made of the flood problems on the other streams by the Bureau of Reclamation and the Soil Conservation Service.

Underground water is used extensively for irrigation and municipal water supply. The Dakota Sand-



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stone, which furnishes an abundant supply, at places from flowing wells, is the principal deep-well source. Some of the wells in the Dakota formation in Kansas produce mineralized water which contains objectionable quantities of fluorine.

Shallow wells ordinarily yield supplies which are fair to good in both quantity and quality in most of the plains area. More than 3,000 acres are irrigated from shallow wells in Scott County, Kans., with no appreciable lowering of the water table. Shallow wells in the valley of the Arkansas River and in dry creek beds usually yield good supplies which are extensively used for supplemental irrigation.

A fall in the water table in the vicinity of La Junta, Colo., indicates that the draft there exceeds the supply. The underground water resources of the basin deserve careful study to assist in preventing their overdevelopment and depletion.

Drainage of large areas of irrigated land in the valley has resulted in the return of considerable water to the stream. Such drainage will probably be applied on the rest of the irrigated area in the valley of the Arkansas as the land requires.

Urban water supply is not a serious problem. Most of the towns have adequate systems. A few of the smaller towns which now have no water systems, could probably support municipal works, and some of the

larger towns need improved plants. In a few small areas in Kansas where fluorides are present in the water, a serious problem exists.

In some rural districts in Kansas, the stock-water problem has become serious in the past few years. The State has adopted the policy of reducing tax assessments by \$40 per acre-foot of water storage capacity on the farms where small ponds are built.

Pollution is not generally serious in the basin. Most of the towns have sewer systems and a few have sewage-treatment plants; some for primary treatment, others for complete treatment. Two towns with urgent pollution problems are Pueblo and Walsenburg, Colo., both of which need complete treatment plants. In some of the mountain streams, tailings from ore mills are fouling the water and damaging fish life.

The debris load of the Arkansas River and its tributaries in this region is large. Erosion is severe in parts of the mountainous section and throughout the mesa land. Methods of reducing erosion are being studied by the Soil Conservation Service and the Forest Service, and efforts are being made to conserve what soil remains in these badly eroded areas. Additional studies and more work are necessary.

There are a few small hydroelectric plants in the mountain section but steam and internal combustion engines furnish the bulk of the electric power.

Upper Arkansas Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
2	Colorado River-Arkansas River diversion: Study to determine the practicability and desirability of diverting the headwaters of the Gunnison and Frying Pan Rivers to the Arkansas River Basin and the feasibility of Tennessee Pass Tunnel for irrigation.	\$215,000	Study has begun.
12	Study to determine measures for flood control on the Apishapa, Cuchara, Huerfano, and Purgatoire Rivers in Colorado.	100,000	Authorized by Congress. In addition to studies now being made by Bureau of Reclamation.
24	Taylorville, Colo.: Earth dam and reservoir at the Caddoa site on the Arkansas River for flood control and to supplement water supply for irrigation.	10,000,000	Plans near completion. Authorized by Congress.
10	Pueblo, Colo.: Complete sewage treatment plant.	500,000	Plans completed.
33	Walsenburg, Colo.: Complete sewage treatment plant.	50,000	Do.
(1)	Bazine (18), Kans.; Buena Vista (1), Camp Martin (11), Canon City (3), Cripple Creek (6), Eads (15), Florence (4), Fowler (32), Fountain (9), Holly (21), La Junta (27), Lamar (22), Las Animas (26), Manzanola (31), Monument (7), Rocky Ford (30), Salida (2), Sugar City (28), Victor (5), and Wiley (23), Colo.: Sewage treatment plants for partial or complete treatment.	396,000	Do.
(1)	Camp Martin (11), and Kit Carson (14), Colo.: Water supply systems.	40,000	Plans completed. Camp Martin project authorized by Congress.
(1)	Canon City (3), Colorado Springs (8), and La Junta (27), Colo.; Lakin (19), Kans.; Lamar (22), and Manzanola (31), Colo.; Ness City (17), Kans.; Rocky Ford (30), Swink (28), and Trinidad (35), Colo.: Improvements and repairs to water supply system.	190,000	Preliminary plans made.
34	Las Animas, Colo.: Rehabilitation of Apishapa public irrigation district by replacement of dam which failed in flood.	300,000	Plans completed. Appurtenant works completed.
13	Hugo, Colo.: Diversion dam on Big Sandy Creek, reservoir and canals for the Hugo public irrigation district.	180,000	Preliminary plans only.
16	Chivington, Colo.: Completion and rehabilitation of the Chivington public irrigation district.	86,000	Plans completed.
	Colorado and Kansas: Approximately 4,500 small farm ponds throughout the basin.	655,000	Rough preliminary plans only; further study to disclose location and type.
GROUP B—FOR DEFERRED CONSTRUCTION			
35	Trinidad, Colo.: Construction of 5 reservoirs and intake canal for flood control and irrigation.	\$652,000	Plans nearing completion.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
25	Bent County, Colo.: Dam no. 2 and reservoir on Purgatoire River below Higbee to supplement Caddoa Reservoir.	\$1,600,000	This may be necessary to supplement capacity of the Caddoa Reservoir reduced by silting. See Group A.
20	Hartland, Kans.: Off channel reservoir to store water from Arkansas River to supplement irrigation water from Caddoa Reservoir.	700,000	

¹ Map key number shown following community name.

2. CIMARRON

In the upper reaches of the Cimarron Basin, water conservation for irrigation is needed, and near its mouth there is a pollution problem of growing importance. The most pressing need, however, is for small reservoirs on tributaries for stock watering and local subsistence.

General Description

The Cimarron River rises in northeastern New Mexico and flows east, crossing and recrossing the Kansas-Oklahoma boundary, to its junction with the Arkansas River in eastern Oklahoma. The basin is about 600 miles long. It has an average width of about 30 miles. Its area is 18,000 square miles, of which 1,100 are in New Mexico, 2,000 in Colorado, 6,100 in Kansas and the remainder in Oklahoma.

The river's headwaters drain mountains and plateaus in New Mexico with maximum altitudes of 8,000 feet. The altitude at the New Mexico-Oklahoma line is 4,600 feet. The river flows in New Mexico in a narrow canyon eroded in the sandstones, but in places wider valleys appear, affording some tillable land. About 9,900 acres are now under irrigation and about 8,600 additional acres are irrigable. Pinon and scrub oak grow on the mesas, cottonwood and willow along the river, but there are no forests.

Shortly after the river enters Oklahoma the canyon widens into a valley about 2 miles in width. This valley is about 60 miles long. At its lower end the river channel narrows to that of a small dry creek, with no indication that flood conditions ever obtain. It retains that form for another 60 miles, after which springs appear and the river takes on new life. This dry stretch marks the division between the upper and lower rivers. Little water passes this reach, except in periods of extreme flood flows. In all but one respect the upper and lower sections are different rivers; the continuous channel alone argues that they be considered as one.

In the lower 250 miles of the river the stream bed is sandy and broad, in places a mile or more in width. The topography is varied. For more than 50 miles sand hills covered with scrub oak flank the stream. At certain points deep ravines have been cut in the red beds. The best farming land in the basin lies in the lower 200 miles, where there are about 150,000 acres adapted to production of cotton, corn, and small grains.

Most of the tributaries of the Cimarron are dry creeks except during torrential rains. With two ex-

ceptions they are short and drain small areas. The North Fork, 130 miles long, is the largest. It has a drainage area of 2,000 square miles. Rising in southeastern Colorado, the North Fork joins the main river in Kansas. Entering from the north, Crooked Creek, 99 miles long, has a drainage area of 1,200 square miles, almost entirely in Kansas. No other tributary drains more than 700 square miles.

The eastern part of the Cimarron Basin contains an extensive oil and natural gas field. An important natural gas field occupies the southern part of the Kansas section of the basin. Agriculture, however, is the basic and dominant industry.

The population of the basin is about 217,000, of which not to exceed 1,800 live in New Mexico, approximately 39,000 in Kansas, and 177,000 in Oklahoma.

Precipitation is about 18.5 inches annually throughout the New Mexico, western Oklahoma and Kansas areas. In the lower 300 miles the rainfall increases gradually to 36 inches at the mouth of the river. This section has sufficient moisture for successful farming without irrigation.

Recommended Plan

The valleys in the western part of the basin are adapted to growing subsistence and forage crops by irrigation. A system of small reservoirs on the tributaries would improve living conditions for a considerable dispersed population in the so-called "dust bowl" country.

Small reservoirs.—Outside of the main valley of the Cimarron, the urgent need is for a widespread development of small reservoirs for local water supply to support grazing and such dry farming as may persist. Between rains the stream beds are dry. A system of small reservoirs at intervals of a few miles might appreciably improve the economic condition of this section.

Irrigation is the important problem in the Cimarron Valley in New Mexico and western Oklahoma. The average annual precipitation here is insufficient for successful farming, even though three-fourths of it occurs in the period April to September, inclusive. Reservoirs are needed to conserve the winter run-off and the excess flow from torrential storms for seasonal irrigation.

Four reservoir sites have been proposed, known respectively, in descending order on the stream, as

Morrow, Honey, Baker, and Kenton. The first three are in New Mexico, the last in Oklahoma. The Morrow site has only 45 square miles of tributary drainage area, and the Honey site not to exceed 100 square miles. These reservoirs are too near the headwaters to control adequate run-off.

The Baker site is about 25 miles west of the New Mexico-Oklahoma border. An estimated 10,000 acres of irrigable land lie below it in New Mexico. It has been proposed that this reservoir have a capacity of 21,000 acre-feet, about 50 percent in excess of the probable average annual supply available for storage. Its estimated cost is \$734,000. The Corps of Engineers has reported that the project is not justified on a basis of direct returns. A reservoir of smaller capacity, allowing some part of the run-off to reach the Kenton site, might be considered.

The Kenton site is some 20 miles below Kenton, Okla., and about 50 miles below the Baker site. It would impound 125,000 acre-feet at an estimated cost of \$3,250,000. The proposed capacity is nearly three times the annual supply which may reasonably be anticipated, even if no storage is constructed above. There is more than enough irrigable land below this site to utilize all the water that might be stored. The Corps of Engineers has reported adversely on the Kenton project, but additional study is needed to determine whether agriculture and stock raising in the upper Cimarron Valley cannot be substantially improved, possibly by including construction at Baker and Kenton as a single project, at a cost which will not be excessive.

In the Kansas portion of the basin, irrigation is of relatively little importance. Small areas of bottomland are irrigated by diversions direct from the streams. The broken terrain affords very little land which could be irrigated even if the water supply were ample.

Irrigation is not practiced nor is it necessary in the Cimarron Valley in eastern Oklahoma.

Flood control is not an important problem on the upper Cimarron, partly because of the infrequent occurrence of major floods and partly due to the small amount of valuable property within their reach. A flood in 1908 practically destroyed the town of Folsom, killing 17. No other major flood has been reported. The town, with 400 inhabitants, is built in a canyon directly in the path of any flood which may occur. The cheapest form of flood protection for Folsom would be to move the town to higher ground. The Corps of Engineers estimated at \$14,300 the average annual flood loss preventable by the Kenton reservoir.

There are no serious flood problems in the Cimarron basin in Kansas. Occasional high stages of the river inundate small areas but do no damage except to an occasional highway bridge.

The Corps of Engineers has studied all reservoirs proposed for flood control on the lower river, reporting adversely on all except the Mannford site on which judgment is suspended. This site is so near the mouth of the river that its benefits would accrue in any case to the Arkansas or Mississippi Valleys.

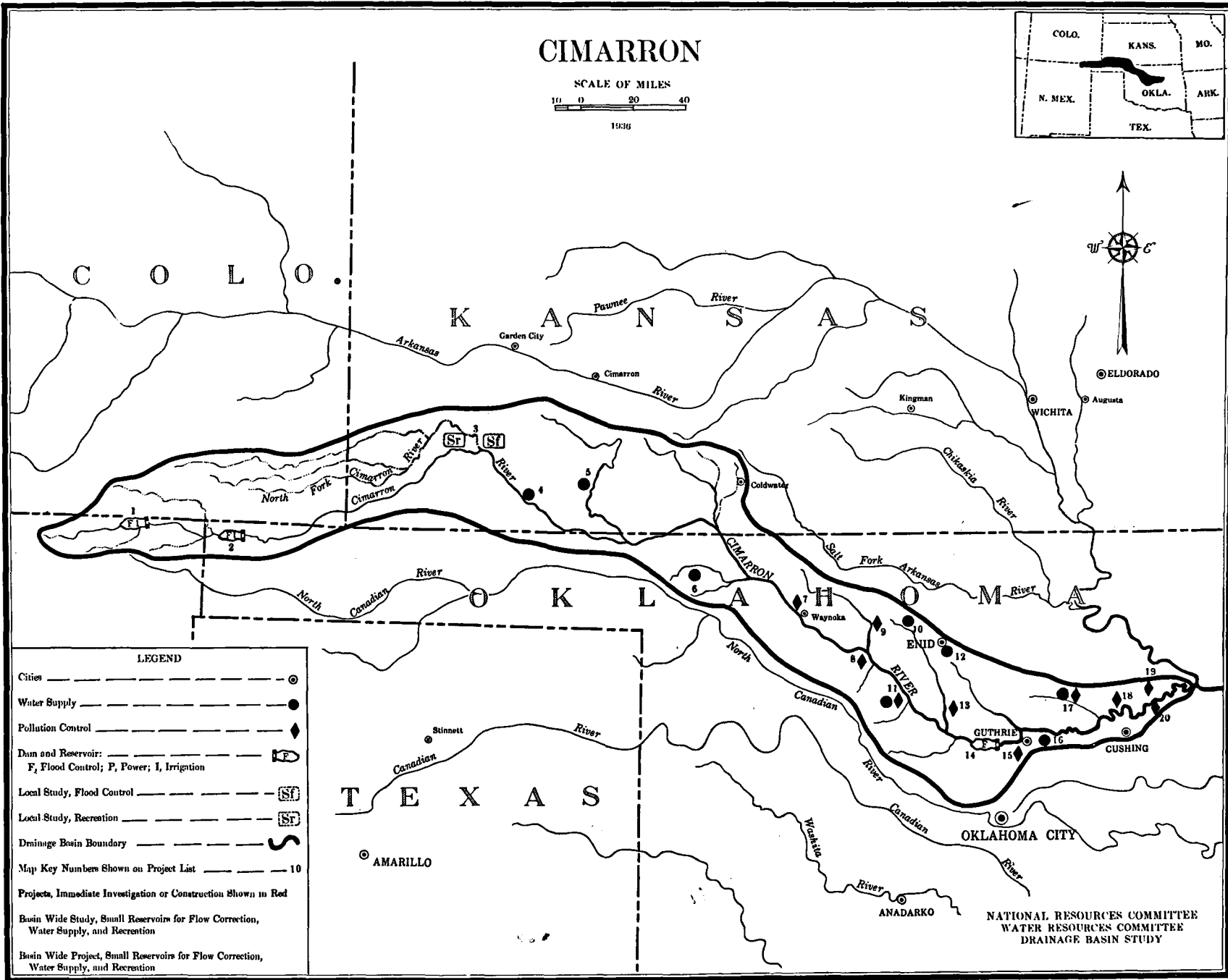
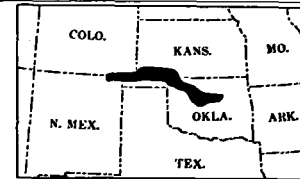
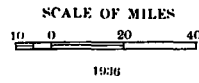
Construction of a lake for recreational purposes has been proposed at the junction of the North Fork and the Cimarron in Grant County, Kans. Further study of costs and possible benefits appear warranted. It may have incidental value for flood control.

Water supply is not an acute problem in the Cimarron drainage area. The cities as a rule have satisfactory supplies, most of them obtained from underground sources. In two counties in Oklahoma the water is soft and the quantity adequate. In a part of the Kansas area the water is quite hard but otherwise satisfactory. Waterworks are proposed for one small town.

Stream pollution is serious in the eastern end of the basin. Very little sewage is discharged into the Cimarron River above Fairview, which is 200 miles from the mouth of the river. Guthrie, with a population of 9,600, is the only relatively large community where untreated sewage is discharged. It is 120 miles from the river mouth. At periods of low flow the discharge of untreated or partially treated sewage creates objectionable conditions. These are aggravated by wastes from oil refineries.

Nine cities and towns, aggregating 27,000 people, are in need of improvements in sewerage facilities. While betterment will result from more nearly complete treatment of municipal wastes, wholly satisfactory conditions can be brought about only by increasing the low water flow through regulation of the river. The most suitable reservoir for this purpose appears to be one at the Crescent site, about 10 miles above Guthrie. This was investigated by the Corps of Engineers for flood control. The estimated cost of construction is \$1,200,000, including land and damages. The reservoir would have a capacity of 200,000 acre-feet. The Corps of Engineers estimated its value for flood control purposes at \$690,000. A re-investigation should be made of this and other possible sites in Oklahoma for storage for sanitary improvement and flood control, jointly.

CIMARRON



LEGEND

- Cities ———— ⊙
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir: ———— [P]
 - F, Flood Control; P, Power; I, Irrigation
- Local Study, Flood Control ———— [SF]
- Local Study, Recreation ———— [SR]
- Drainage Basin Boundary ———— S
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Small Reservoirs for Flow Correction, Water Supply, and Recreation
- Basin Wide Project, Small Reservoirs for Flow Correction, Water Supply, and Recreation

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Cimarron Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Study of possible sites for small reservoirs for flow correction, water supply and recreation.....	\$10,000	Preliminary plans made.
	Buffalo (6), Enid (12), Golby (10), Okla.; Kismet (4), Kans.; Langston (16), Okla.; Meade (5), Kans.; O'Keene (11), and Stillwater (17), Okla.: Water supply systems or improvements.	616,000	
15	Guthrie, Okla.: Sewage treatment plant.....	150,000	
(1)	Carmen (9), Fairview (8), Hennessey (13), Jennings (19), Oilton (20), O'Keene (11), Stillwater (17), Waynoka (7), and Yale (18), Okla.: Sewer system improvements and/or sewage treatment plants.	109,000	
3	Study of lake in Grant County, Kans., to determine its usefulness in flood correction in connection with its primarily intended use for recreation and wild life conservation.	5,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
14	Logan County, Okla.: Dam and reservoir at Crescent site for storage for increasing low flows..... Construction of small reservoirs for flow correction, water supply, and recreation throughout the basin.	\$1,280,000 500,000	Subject to further study. Exact locations and details to be determined by study project.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
2	Cimarron County, Okla.: Dam and reservoir at Kenton site for flood control and for irrigation of 17,000 acres between Garrett and Boise City.	\$2,423,000	Subject to conclusions drawn from study project.
1	Los Animas County, Colo., and Union County, N. Mex.: Dam and reservoir at Baker site for flood control and irrigation.	784,000	Do.

¹ Map key number shown following community name.

3. CANADIAN

The basin of the Canadian River is made up of the basins of the twin streams, the North and South Canadian Rivers. These streams are erratic and storage for regulation of their flow is the most important problem in the basin. Such storage would provide water for irrigation, alleviate flood conditions, and improve sanitation.

General Description

The basin of the Canadian River includes the northeastern corner of New Mexico, the northern part of the Texas Panhandle, most of the Oklahoma Panhandle, and a strip through the middle of Oklahoma nearly to the eastern boundary. The area is 47,500 square miles, of which 16,066 are in New Mexico, 13,372 in Texas, and 18,062 in Oklahoma.

The basin is drained by two streams, the North Canadian and South Canadian Rivers. For 100 miles they are separated by a distance of only 10 to 20 miles. They join 40 miles above the junction of the Canadian and Arkansas Rivers.

The South Canadian basin is larger and hydrologically more important, though perhaps less populous than its neighbor. No important tributaries enter the South Canadian east of Major Long's Creek, which joins it about 40 miles east of the New Mexico-Texas line, until Little River is reached. This enters the main stream 110 miles from its mouth. The drainage area of the South Canadian is 30,650 square miles, with 15,200 in New Mexico, 8,800 in Texas, and 6,650 in Oklahoma. The total length of the river is 900 miles.

The basin of the North Canadian is about 460 miles long. In the Oklahoma panhandle, it is approximately 60 miles wide. A narrow tongue extends 50 miles into New Mexico. From the Texas-Oklahoma line the basin narrows rapidly from 50 miles to 12 or 15, a width it maintains for 100 miles before expanding into a crude oval, approximately 60 by 100 miles, near its end. About 30 miles east of the Texas line Wolf Creek joins the main stream. Deep Fork, the most important tributary, draining 2,540 square miles, joins about 15 miles above the mouth. The North Canadian drains 16,850 square miles, of which 866 are in New Mexico, 5,472 in Texas, and 11,412 in Oklahoma.

The South Canadian originates in a network of snow-fed streams rising high upon the eastern slope of the Sangre de Cristo Range. Parts of the drainage area rise above 12,000 feet altitude. The tributary

streams fall rapidly until the plains area is reached, but thereafter the gradient is less. At the mouth, the altitude is 450 feet.

Most of the river channel in eastern New Mexico and across Texas lies in a broad canyon from 300 to 600 feet below the level of the "llano estacado." This region contributes practically nothing to the flow of the stream. Throughout Oklahoma, the river occupies a wide meandering channel.

The North Canadian rises in the plateau region of northeastern New Mexico at an altitude of about 6,500 feet. It falls rapidly for 65 miles to 4,600 feet at the New Mexico-Oklahoma line. The fall is comparatively rapid for the next 165 miles. The river flows the entire length of the Oklahoma panhandle. In that distance it receives no important tributaries from the north. Coldwater Creek with a drainage area of 1,870 square miles, Paloduro Creek with 1,660, and Wolf Creek with 1,660, enter from the south. Throughout the eastern section, the river flows very near to the north edge of its basin, the channel being, in places, not more than 3 or 4 miles from the divide which separates the North Canadian from that of the Cimarron River. The channel of the North Canadian is some 200 feet higher than that of the Cimarron, and from 50 to 100 feet above that of the South Canadian. From Oklahoma City to Shawnee, about 80 miles, the basin is rolling and the greater part of it is in cultivation.

The population of the Canadian Basin is 982,000, of which nearly 800,000 are in Oklahoma, a little more than 100,000 in Texas, and 82,000 in New Mexico. The urban population is 48.5 percent of the total in Oklahoma, about 50 percent in Texas, and in New Mexico, about 26.6 percent.

In Oklahoma the percentage of land in farms increases from 77 in the eastern part of the basin to 96 in the panhandle. The cropped area, however, is greatest in the vicinity of Oklahoma City, where it is 50 percent of the total, as compared with 22 percent in the extreme east and 27 percent in the western end of the panhandle.

In the New Mexico area there were 69,811 acres under irrigation in 1931, and a much larger acreage in dry farming.

The industrial activities of the Canadian basin are those connected with the production of oil, coal, and natural gas. Coal is produced near the eastern end of the basin in Oklahoma, and at Dawson, N. Mex.,

in the extreme northwest corner. The Amarillo gas field in Texas is one of the more important in the United States. Petroleum and natural gas are produced in central and eastern Oklahoma.

The average annual precipitation is about 26 inches in the mountains at the west. It decreases toward the east to a minimum of about 15 inches at Taylor Springs, N. Mex., some 85 miles west of the New Mexico-Texas line. It then increases at a fairly uniform rate to 42 inches at the mouth of the river. Throughout the basin more than 60 percent of the rainfall occurs in the five months May to September, though it tends to be more evenly distributed in eastern Oklahoma.

Stream flow in the upper basin is erratic. At Logan, N. Mex., which commands 64 percent of the total drainage area in that State, the average annual discharge of the South Canadian River is about 325,000 acre-feet. The maximum was 685,628 in 1914 and of this 313,568 were discharged in the month of August. The minimum was 134,307 in 1926 when two-thirds of the total came in May and June. Although 1910 was the year of minimum precipitation, the discharge of the river was 391,890 acre-feet, 20 percent more than the average. In the record period of 168 months there were 5 months in which there was no discharge whatever at Logan, Okla. At Calvin, Okla., 105 miles from the mouth of the river and 565 miles below Logan, there are discharge records for only four years, 1906 and 1928-30. The drainage area above this station is 2.56 times that above Logan. The average annual discharge of the South Canadian at this point is about 1,540,000 acre-feet, nearly five times the average at Logan. The maximum, 1929, is 15 percent above the average, and the minimum, 1928, is 20 percent below. So far as may be concluded from so short a record the annual average is less variable at Calvin than at Logan. The distribution through the year, however, is as irregular and uncertain.

The lower river is likely to require some storage regulation in addition to whatever may be provided above Logan.

The description of precipitation distribution applies as well to the North Canadian, but since its basin does not extend into the high mountain areas, it does not profit from the greater rainfall of the high altitudes.

The greatest flood of record on the North Canadian was in October 1923. The maximum discharge at Woodward, Okla., was estimated at 90,000 cubic feet per second on October 12. At El Reno, Okla., the maximum was 80,000 cubic feet per second on October 15.

Minimum flows are of only slightly less importance than flood discharges, particularly where the streams are relied upon to carry off sewage effluents and indus-

trial wastes. Both the South Canadian and the North Canadian Rivers have gone virtually dry. In 1930 the discharge of the South Canadian at Calvin was only 45 cubic feet per second for 12 consecutive days in April, and was zero for several periods of a week or more in July, August, September, and October. On the North Canadian at Woodward, the minimum was 5 cubic feet per second in August and 2 in September of 1929. In 1930 it dropped to 1 cubic foot per second in August. At Wetunka, less than 100 miles above the mouth of the river, the discharge dropped to 67 cubic feet per second in September and October 1929.

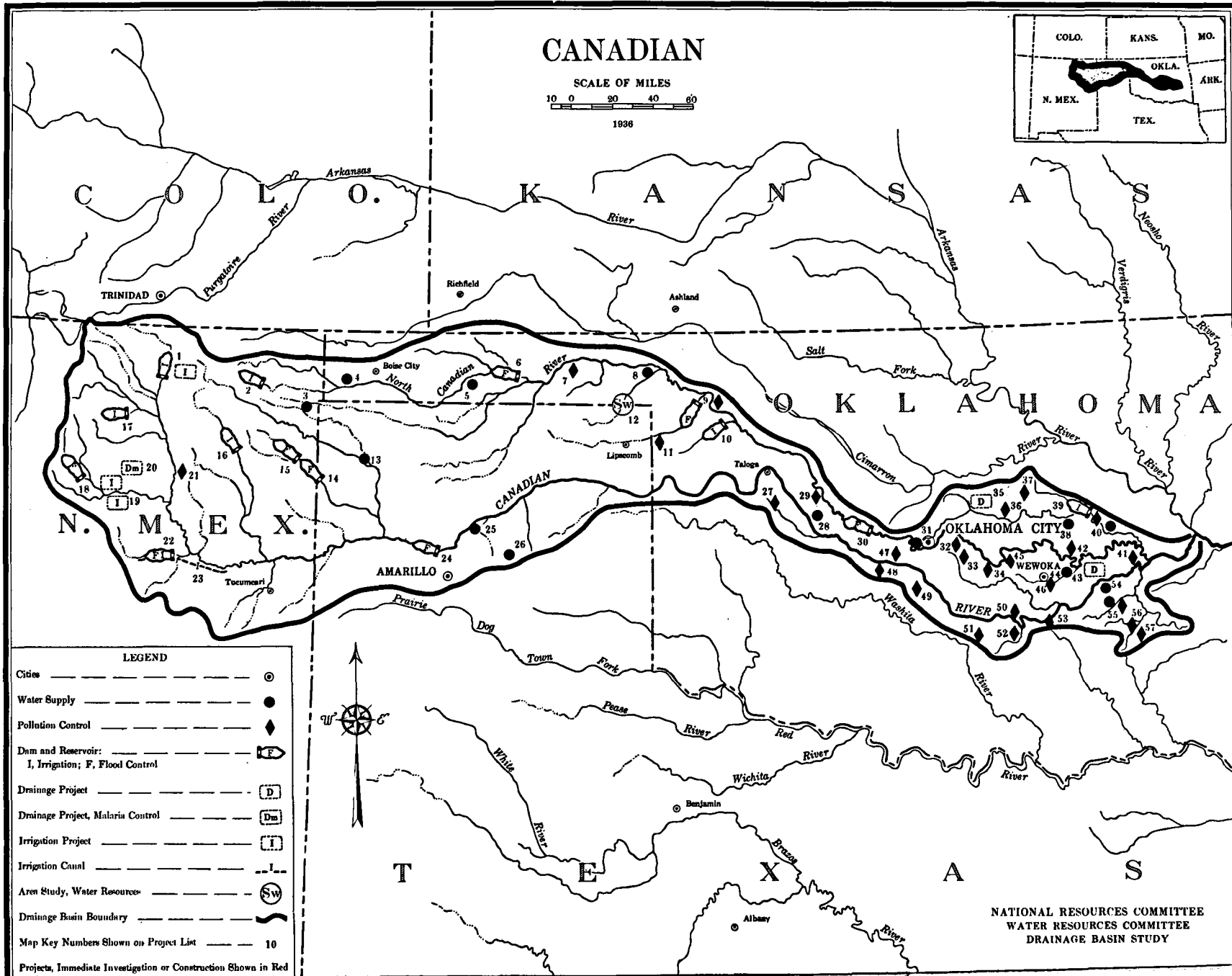
Recommended Plan

Irrigation is the subject of first importance in the New Mexico and western Oklahoma portions of this basin. A number of existing systems in New Mexico are in need of improvements or extensions. The Conchas Reservoir on the South Canadian is under construction. It is expected to provide a water supply adequate for the irrigation of 65,000 acres. Detailed plans for a canal and distribution system to serve these lands have not been made. About 10,000 acres in Texas and Beaver Counties, Okla., can be irrigated with water to be stored in the Optima Reservoir, and about 20,000 acres in Woodward County can be served from the Fort Supply Reservoir. Construction of the reservoirs has been authorized by the Congress. A study should be made of the necessary distribution system.

Flood control is of undoubted importance on the streams of this basin, particularly on the lower reaches. Many suggested reservoir sites have been studied by the Corps of Engineers, which concluded that the preventable damage would not justify the cost of construction. Some of these reservoirs, however, may be made to serve more than one purpose.

The Conchas Reservoir, mentioned above, will control the run-off from nearly one-quarter of the South Canadian drainage area and will no doubt go far toward mitigating the severity of the floods on the lower river. If future experience shows that this reservoir is not alone sufficient, the Amarillo Reservoir may become desirable. Its site is 200 miles downstream from Conchas. It would control an additional 8,000 square miles. These two reservoirs would afford full control of all the water from the upper half of the South Canadian drainage area.

In the North Canadian the Optima Reservoir in Texas County, Okla., and the Fort Supply Reservoir on Wolf Creek would serve both for flood control and for irrigation, as well as to maintain a suitable dry season flow for sanitation in the river. Both have been authorized by the Congress. The Optima Reservoir



would have a capacity of 77,500 acre-feet and command 2,560 square miles of drainage on the main stream. The Fort Supply Reservoir is planned for a capacity of 150,000 acre-feet. It would have a tributary drainage of 1,600 square miles on Wolf Creek, the most productive tributary of the upper river. It is 130 miles downstream from the Optima.

A third reservoir in this system will be necessary in order to maintain an adequate dry season flow on the lower river and to insure a sufficient domestic water supply to Oklahoma City. It was originally proposed to construct this unit a short distance above El Reno, but some opposition has arisen and the Corps of Engineers is studying other possibilities.

The Deep Fork will require flood protection by works entirely independent of those on the main river. This stream has a drainage area of 2,640 square miles lying in a region where the precipitation averages 36 inches annually. The Corps of Engineers has studied the Okmulgee Reservoir. This would command 2,146 square miles, have a capacity of 400,000 acre-feet, and protect an area of 42,850 acres. The cost per acre-foot of storage would be high.

The Eufaula Reservoir, which has been proposed for flood control, would be formed by a dam below the mouth of the North Canadian and would control the entire drainage area of both rivers. Although situated in the Canadian Basin, its benefits would accrue only to the lower Arkansas and to the Mississippi.

Stream pollution is of first importance in the lower end of the basin. Few towns have complete treatment for municipal wastes, and oil refineries discharge wastes into the stream. A number of sewage-treatment plants are needed. However, proper sanitary conditions can be brought about only by increasing the dry-season stream flow so that effluents may be suitably diluted.

Water supplies are known to be inadequate in many towns and cities, but detailed information is not available. The largest and most important water-supply problem is that of Oklahoma City. In order to insure adequate supply for the future, the city desires to obtain reserve storage of 100,000 acre-feet. Small reservoirs, chiefly to supply stock water, are a desirable improvement in the western part of the basin, but no specific projects have been listed.

Canadian River Project List

Map key No.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
34 (1)	Shawnee, Okla.: Sewage treatment plant.....	\$250,000	No treatment facilities at present.
	Allen (53), Beaver (7), Blanchard (48), Depew (37), Eufaula (41), Haileyville (56), Hartshorne (57), Konawa (50), McAlester (55), McLoud (33), Morris (40), Norman (47), and Puroell (49), Okla.; Roy (21), N. Mex.: Seminole (45), Sbatuck (11), Stratford (51), Thomas (27), Watonga (29), Weleetka (42), Wewoka (46), and Woodward (9), Okla.: Improvements to sewer systems and sewage treatment plants.	448,000	
26 (1)	Whitdeer, Tex.: Water supply system.....	9,000	Preliminary plans made.
	Ada (52), Chandler (36), and Jones City (32), Okla.: Improvements to sewer systems and sewage treatment plants.	210,000	
54	McAlester, Okla.: Water supply improvements.....	193,000	Do.
22	Tucumcari, N. Mex.: Conchas Dam and reservoir for flood control, irrigation, and water supply....	6,500,000	Under construction. Estimated cost is amount necessary to complete project.
12	Study of possibilities of irrigation systems corollary to Optima, and Fort Supply Reservoirs in Tex.; Beaver and Woodward Counties, Okla.	50,000	
6	Texas County, Okla.: Optima Reservoir on Beaver River for flood protection and storage.....	1,530,000	Authorized by Congress.
9	Woodward County, Okla.: Fort Supply Reservoir on Wolf Creek for flood protection and storage...	2,585,000	Do.
18	La Cueva, N. Mex.: Earth fill dam on the Mora River for retention of flood waters for irrigation	91,000	Plans completed; core drillings have been made.
19	Mora County, N. Mex.: Improvement of Colmar irrigation system.....	23,000	Plans completed.
1	Colfax County, N. Mex.: Dam and reservoir at Maxwell site for storage of waste water and for irriga- tion purposes.	23,000	Do.
17	Colfax County, N. Mex.: Completion of Miami Dam to insure cultivation of about 6,500 acres of fertile farm land.	60,000	Preliminary plans and surveys made. Approxi- mately \$50,000 already spent by farmers' develop- ment company.
20	Mora County, N. Mex.: Eradication of malaria mosquito breeding areas by fill and drainage.....	32,000	
35	Lincoln County, Okla.: Drainage for farm lands.....	72,000	
43	Hughes County, Okla.: Drainage for farm lands.....	84,000	
31	Oklahoma City, Okla.: Improvements to supplement present water supply.....	1,000,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Greenfield (28), Indianola (54), Morris (40), Okfuskee (38), and Wetumka (44), Okla.: Water supply improvements.	\$251,000	
(1)	Borger (25) and Dalhart (13), Tex.: Water supply.....	915,000	
3	Clayton, N. Mex.: Storage reservoir to augment urban water supply.....	150,000	Preliminary plans only.
23	Clay and San Miguel Counties, N. Mex.: Canal and lateral system on Conchas irrigation project, to irrigate 35,000 acres in vicinity of Tucumcari.	1,000,000	Reconnaissance surveys have been made. Cost given is for first 2 years. Additional needed to complete, \$2,980,000.
(1)	Cimarron, Harper, and Texas Counties, Okla.: Wells, near Boise City (4), Guyman (5), and La- verne (8) for irrigation purposes.	50,000	
10	Woodward County, Okla.: Reservoir and water mains for irrigating nurseries and for fire protection at Bureau of Plant Industry field station.	50,000	Present water supply inadequate. Sketch plans have been completed.
1	Colfax County, N. Mex.: Improvement to Colfax irrigation district.....	75,000	Preliminary plans made.
9	Mora County, N. Mex.: Structures for the Watrous irrigation system to irrigate about 10,000 acres in Mora River Valley.	400,000	Do.
30	Canadian County, Okla.: Reservoir on North Canadian River for flood control and storage of water...	6,032,000	Cost estimate is approximate. Report on selection of exact site in preparation by Corps of Engineers.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
39	Okmulgee County, Okla.: Flood protection reservoir on Deep Fork River.....	\$5,260,000	Further study necessary.
24	Potter County, Tex.: Flood protection reservoir at Amarillo site on Canadian River.....	4,325,000	Contingent upon whether warranted on account of possible future flood damages after construction of Conchas Dam.
16	Union County, N. Mex.: Water control of Ute Creek for flood control and water conservation.....	200,000	Plans in preparation.
15	Union County, N. Mex.: Earth-fill dam at Clapham site for flood protection and irrigation; also 5 miles of canal.	100,000	Preliminary plans prepared.
2	Union County, N. Mex.: Dam and storage reservoir at Greenville for flood protection.....	100,000	Do.
14	Union County, N. Mex.: Dam at Trampas site for flood protection and storage.....	300,000	Plans in preparation.

¹ Map key number shown following community name.² Map key number shown following county name.

4. CENTRAL ARKANSAS

The two principal water problems of the central Arkansas River Basin result from the frequent extremes of flood and drought which characterize the area. These problems are flood control and intensification of pollution of both underground and surface waters during periods of low flow in the streams.

General Description

The central Arkansas River Basin includes the drainage of the main stem of the Arkansas River and its tributaries from Hutchinson, Kans., to Tulsa, Okla. It includes some 17,000 square miles, of which 11,500 are in Kansas and 5,500 in Oklahoma. The altitude of the river at Hutchinson is 1,515 feet and at Tulsa 655 feet, giving a fall of 860 feet in distance by river of 260 miles. The principal tributaries are the Walnut, Salt Fork, Ninnescah, and Little Arkansas Rivers.

The Arkansas River meanders through a broad shallow valley. The Walnut River and the southern part of the main stem drain the steep, rocky limestone Flint Hills. The headwaters of Salt Fork drain the rugged "Red Beds." The central plains are underlain chiefly by shales and sandstones at varying depths. The soil in the northern portion is more pervious than that in the southern. Salt is mined extensively at Hutchinson and Lyons, Kans. There are extensive "salt flats" in the vicinity of Cherokee, Okla. Gypsum beds are widespread. There are oil pools in both Kansas and Oklahoma. Large refineries are situated at Wichita, El Dorado, and Hutchinson, Kans., and at Ponca City, Blackwell, Kaw City, Shidler, and Cleveland, Okla.

The mean annual temperature is about 57° with extremes of 15° below zero and 115° above. Precipitation ranges from about 36 inches on the east to 23 inches on the west. About 65 percent of the rainfall occurs in the summer in severe thunderstorms. The native vegetation ranges from the famous "blue stem" grasses in the east to bunch grass in the west.

The central plain, with its fertile alluvial soils, is devoted to agriculture, with wheat dominating in the west and corn in the east. There is a trend toward diversification and stock farming. Near the cities dairying is important. On the hilly, poor soils of the eastern and western margins stock grazing dominates.

The total population is about 575,000 of which 428,500 are in Kansas and 146,500 are in Oklahoma. In the grazing areas the population density is as low as 6 per square mile. The principal cities are: Wichita,

111,000, Hutchinson, 27,000, Arkansas City, 14,000, El Dorado, 10,000, and Winfield, 9,000 in Kansas, and Ponca City, 16,000, and Blackwell, 9,500, in Oklahoma. These cities are connected by railways, highways, airways, pipe lines, gas lines, and power lines.

Although the agricultural industry has reached economic maturity, the oil fields are still in the exploration stage and new pools may replace old ones in production for a few decades to come. When they are exhausted it is probable that increasing demands on agricultural production will make it possible for the area as a whole to maintain and slowly increase its population.

The rainfall of the area, while not abundant, is sufficient to permit growth of crops except in years when the precipitation falls far below normal. The run-off varies in different portions of the area, but is generally low.

The Arkansas River does not bring damaging flood flows into this area from the reaches above Hutchinson. The floods in the central Arkansas River Basin are produced locally, and are the result of brief but intense precipitation on the tributaries. The frequency of floods varies. Approximately 350,000 acres are in flood plains of this area, of which about 130,000 acres are along the main stem of the Arkansas. Wichita, Hutchinson, Winfield, and Arkansas City lie on the flood plain. Recent floods in Kansas have inundated 175 miles of railway, 53 miles of State highway, and 375 miles of county and township roads.

Along the northern edge of the basin there is excellent underground water at shallow depths, and underground water is generally plentiful throughout. The alluvial fill of the main valley, which is in general pervious, carries a large amount of water which moves down the valley almost as an underflow. At low stages of the streams, much of the water sinks into the alluvial fill. Below Wichita the underground water becomes salty, partly from contact with natural saline deposits and partly from the salt brine of oil wells, and at some places this water is not suitable for human consumption.

Recommended Plan

The pollution problem throughout this area is serious, particularly along the main stem of the Arkansas River. Until recently many towns discharged sewage untreated into the streams. The State health departments of both Kansas and Oklahoma are insisting that

the towns install treatment plants. However, neither Hutchinson nor Wichita have adequate sewage-treatment plants, and they contribute heavily to the polluted condition of the Arkansas River as it enters Oklahoma. There is also some pollution of the Walnut River, and subsequently of the Arkansas River, by waste oil from pumping operations, which can be controlled by better production methods. An even more serious problem is the extensive pollution of groundwater under and adjacent to oil fields by brine from oil wells. Kansas authorities, in cooperation with the United States Bureau of Mines, are investigating methods of disposing of oil well brines. The correction of such pollution is necessary to improvement of the southern portion of this area.

Sheet erosion is serious in much of the agricultural portion of the area. The methods used in production of wheat have contributed largely to this condition. Silting of many streams has resulted, and fish are now relatively scarce. The Soil Conservation Service is introducing, through demonstration projects and advice to farmers, such corrective measures as contour farming, terracing, cover for fallow land, and discontinuance of the cultivation of the stream banks.

Water supply.—None of the towns in this area in Kansas and very few of those in Oklahoma, obtain their water supply from the streams, which, as noted above, are frequently contaminated with salt and sewage. Most of the urban water systems depend for supply on underground water which is obtained at shallow depth. A few towns, especially in the southern portion, have impounded supplies, and the trend of improvement is in this direction. One of the uses of the Braman Reservoir now under construction on the Chikaskia River is to furnish an impounded water supply for Blackwell, Okla. Rural water supplies are obtained in most places from shallow wells, commonly less than 100 feet deep.

Small reservoirs.—A more extensive use of stock ponds has been proposed. These would appear to be feasible only in the southern portion of the area where the impervious shale is near the surface, and even there high losses from evaporation must be expected.

Recreation.—Water recreational facilities are at present limited. In view of the density of urban population they merit expansion. Kansas has a State fish hatchery on the south fork of the Ninnescah, and a state park in Butler County with a 230-acre lake. The dam now under construction in the Kingman State Park near Kingman, Kans., will create a lake of approximately 1,000 acres, with storage of 7,000 acre-feet. This lake will be used primarily for recreational purposes. Additional small lakes are proposed on Otter Creek and Clear Creek, both in Kansas. Several towns

in Kansas and Oklahoma have developed or expect to develop small lakes for recreational use.

There are two localities in the area which afford unusual opportunities for the development of *wildlife* refuges. Both have been studied by the Bureau of Biological Survey. One is Cheyenne Bottoms, an area of approximately 32,000 acres in central Kansas, 20 to 25 feet lower than the surrounding country, and occasionally covered with water. Diversion of water from the Arkansas River into this depression and the maintenance of a regulated level in the shallow pond thus created has been proposed. Another project with large attendant flood control value is the proposed 28,000-acre Great Salt Plains Reservoir with a capacity of 332,000 acre-feet on the middle course of the Salt Fork River. Of this area 21,577 acres are now in a wildlife refuge under the control of the Bureau of Biological Survey, which is experimenting with various means of providing shallow pondage for growing feed for migratory birds. If this reservoir were created, it would control the maximum expected floods on the upper Salt Fork River, and would also permit a reasonable amount of water to be retained for use as feeding grounds for birds. This reservoir has been authorized by the Congress.

Two types of major *flood-control* improvements have been proposed in this area. They are floodways at Hutchinson and Wichita, Kans., with levees below Wichita on the main stem of the Arkansas River, and retention reservoirs on several of the tributaries. The works proposed at Hutchinson and Wichita, which have been authorized by the Congress, would provide local protection, but under certain conditions might increase the rate of flow downstream. The plan of the Corps of Engineers for Hutchinson provides a spillway to carry floods on Cow Creek around Hutchinson and to empty the flow into the Arkansas River several miles below the city. This would increase the peak flow below Hutchinson from a present maximum of about 13,000 cubic feet per second to possibly 50,000 cubic feet per second due to reduction of natural storage in the flood plain above Hutchinson. If the further investigation of Cow Creek, which is now authorized, indicates that any considerable portion of its flood flow could be stored in a reservoir above Hutchinson, the amount of this increase might be reduced by construction of a dam.

Under the present plan the increased flow below Hutchinson would necessitate diverting that water around Wichita, which now has inadequate protection against flood flows from Little Arkansas River and Chisholm Creek. The plan provides for diverting all these excess waters above Wichita and carrying them through a floodway following Big Slough, finally re-

turning them to the present channel several miles below. The present authorization also provides for levees on one side of the Arkansas River from Wichita to the mouth of the Ninescah River and also up the Ninescah for several miles. This protection of Hutchinson, Wichita, and vicinity would result in increasing the flood flow at Arkansas City and below.

The Corps of Engineers also considered the possible influence of a system of large retention reservoirs, located on important tributaries of the Arkansas River, upon flood flow in the lower Arkansas and upon the flood situation in the lower Mississippi River. The flood flow on the main stem of the Arkansas River would be materially reduced by the operation of this system of reservoirs. However, flood flows would still greatly exceed channel capacities. Such a system of retention reservoirs on tributaries offers values justifying further consideration from two important standpoints: possible protection of the valleys of the tributaries below the dams and of the main stem of the

Arkansas River in the area below the Ninescah River, from minor and moderate floods, or possibly against all except infrequent major floods; and the release of a portion of the water stored to maintain a reasonable dry-weather flow in the respective tributaries and in the main stem of the Arkansas River. This latter operation would aid materially in correcting present serious unsanitary conditions caused by pollution as discussed above. The prospective values of retention reservoirs for stream stabilization justify a further investigation with special reference to this feature. The study of the Corps of Engineers indicated the desirability of levees to protect Winfield and Augusta, Kans., and Blackwell and Kaw, Okla.

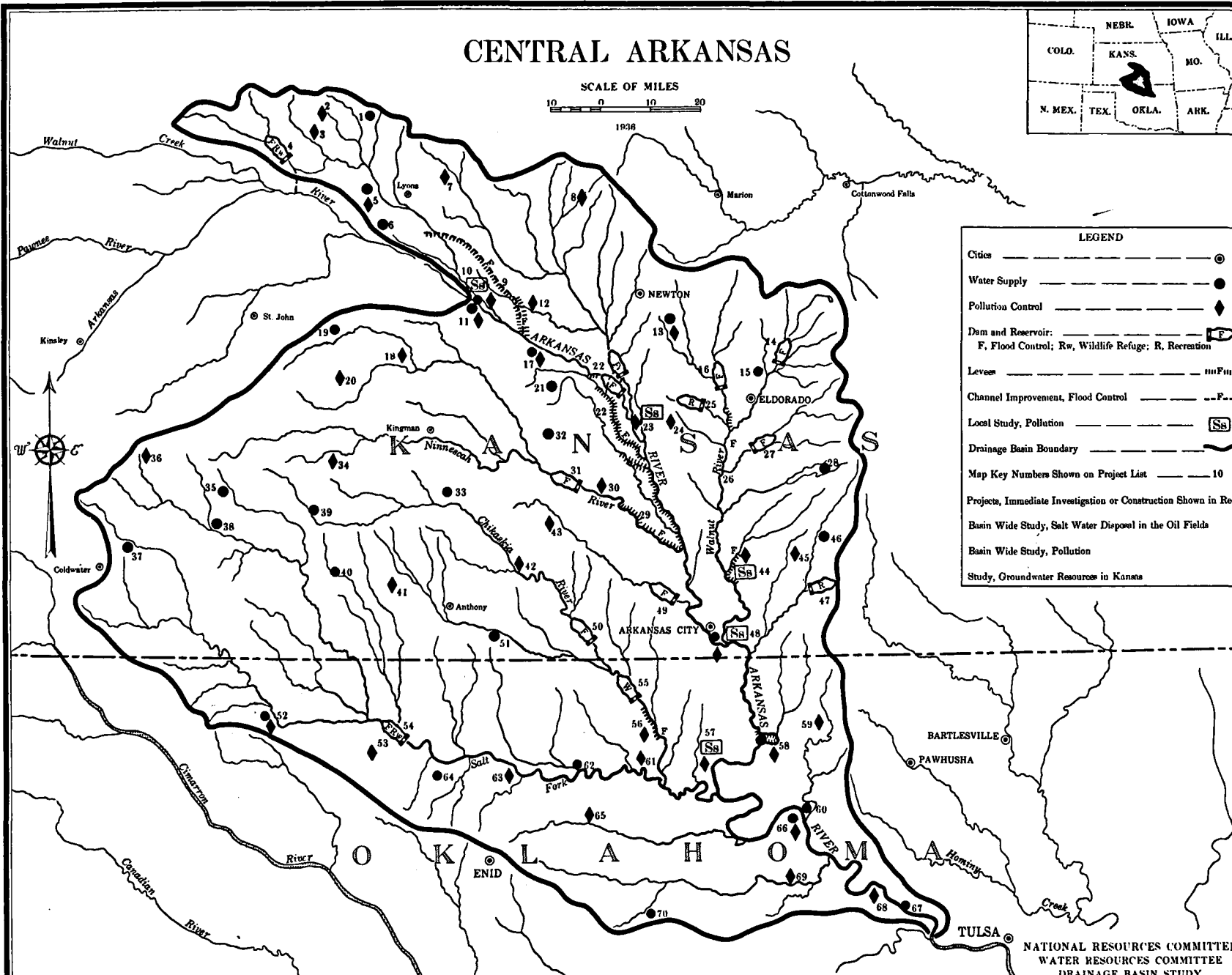
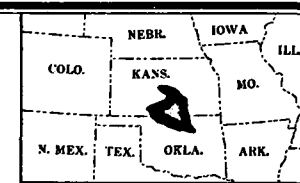
Even with such improvement in low-flow as would result from the operation of retention reservoirs, the towns along the tributaries and those along the main stem of the Arkansas River should install sewage-treatment plants as rapidly as practicable.

CENTRAL ARKANSAS

SCALE OF MILES



1936



LEGEND

- Cities ———— ⊙
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir: ———— [F]
- F, Flood Control; R, Wildlife Refuge; R, Recreation
- Levees ———— [F] [R]
- Channel Improvement, Flood Control ———— [F]
- Local Study, Pollution ———— [Sb]
- Drainage Basin Boundary ———— [thick line]
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Salt Water Disposal in the Oil Fields
- Basin Wide Study, Pollution
- Study, Groundwater Resources in Kansas

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Central Arkansas Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of salt-water disposal in the oil fields in Kansas and Oklahoma.....	\$25,000	
	Study of stream pollution in Kansas and Oklahoma.....	20,000	
(1)	Study of ground-water resources in Kansas and effects of oil brines.....	10,000	
	Arkansas City (48) and Hutchinson (10), Kans.; Ponca City (57), Okla.; Wichita (23) and Winfield (44), Kans.: Study and preparation of plans for sewage treatment plants.	25,000	
48	Arkansas City, Kans.: Development of new water supply.....	751,000	Preliminary plans made.
15	Eldorado, Kans.: Improvements to waterworks system.....	144,000	Do.
10	Hutchinson, Kans.: Improvements to waterworks system.....	1,422,000	Do.
(1)	Isabel (39), Kans.; Kaw City (58), Okla.; Lorraine (1), Mount Hope (17), and Norwich (33), Kans.; Osage (67), Okla.; Sharon (40) and Silvia (19), Kans.: Waterworks system or improvements to existing systems.	360,000	Do.
70	Perry, Okla.: Improvements to existing waterworks system.....	210,000	Do.
(1)	Attica (41), Burrton (12), Galvo (8), Mount Hope (17), Kans., and Pawnee (69), Okla.: Sewer systems and/or sewage treatment plants.	234,000	Do.
10	Hutchinson, Kans.: Extensions to sewer system.....	120,000	Do.
55	Braman, Okla.: Dam and storage reservoir for water supply of Blackwell, Okla.....	50,000	Sum needed for completion of a project already under way.
54	Alfalfa County, Okla.: Great Salt Plains Reservoir on Salt Fork River for flood control and wildlife refuge.	1,233,000	Authorized by Congress.
(1)	Fairfax (60) and Ralston (66), Okla.: Improvements to existing waterworks systems.....	115,000	
10	Hutchinson, Kans.: Complete sewage treatment plant.....	400,000	Depends on study project.
23	Wichita, Kans.: Secondary sewage treatment plant.....	1,000,000	Do.
(1)	Arkansas City (48), Kans.; Ponca City (57), Okla.; and Winfield (44), Kans.: Complete sewage treatment plants.	550,000	Do.
(1)	Alva (52), Cherokee (53), Cleveland (68), Shidler (59), and Tonkawa (61), Okla.: Complete sewage treatment plants.	180,000	
(1)	Billings (65), Blackwell (56), Kaw City (58), Pond Creek (63), and Ralston (66), Okla.: Improvements to existing sewage treatment plants.	61,000	
(1)	Alva (52), Lamont (62), and Nash (64), Okla.: Waterworks or waterworks improvements.....	55,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Argonia (42), Arlington (18), Burden (45), Chase (5), Claflin (3), Clearwater (30), Conway Springs (43), Cunningham (34), Haviland (36), Holyrood (2), Leon (24), Little River (7), South Hutchinson (11), Turon (20), and White Water (13), Kans.: Sewage treatment plants.	\$455,000	
(1)	Alden (6), Andale (21), Bluff City (51), Cambridge (46), Chase (5), Coats (35), Garden Plain (32), Latham (28), South Hutchinson (11), Sun City (38), White Water (13), and Wilmore (37), Kans.: Waterworks or waterworks improvements.	225,000	
9	Hutchinson, Kans.: Diversion of Cow Creek around Hutchinson for flood control.....	1,400,000	Authorized by Congress.
22	Wichita, Kans.: Big Slough Floodway; Chisholm Creek improvement and diversion; Little Arkansas and Arkansas Rivers diversion for flood control.	4,200,000	Do.
29	Belle Plaine, Kans.: Levees along the Ninnescah River for protection of agricultural lands.....	1,882,000	Do.
(1)	Cowley (47) and Sedgwick (35) Counties, Kans.: 2 small lakes on Otter and Clear Creeks for recreational development.	480,000	Preliminary plans made.
(1)	Augusta (26), Kans.; Blackwell (56) and Kaw (58), Okla.; Winfield (44), Kans.: Levees to protect property.	319,000	Authorized by Congress. Plans in preparation.
(1)	Chickaskia River (50), Cole Creek (14), Little Walnut River (27), Ninnescah River (31), State Creek (49), and Whitewater River (16), Kans.: Construction of 6 reservoirs on the above streams.	14,000,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
4	Hoisington, Kans.: Cheyenne Bottoms Reservoir for waterfowl refuge and flood control.....	\$667,000	Project in abeyance pending development of new oil projects in the vicinity.

¹ Map key number shown following community name.
² Map key number shown following county name.
³ Map key number shown following stream name.

5. NEOSHO-VERDIGRIS

In this portion of the Arkansas River Basin there is an important interstate consideration with regard to floods and other problems which indicates the desirability of very close cooperation between the sections of Kansas and Oklahoma through which the streams flow, and also between these sections and the lower sections of the Arkansas Basin in Oklahoma and Arkansas.

The principal streams of this area, the Verdigris, the Neosho (Grand), and the Illinois Rivers, are characterized by heavy flood flows followed by very low dry-weather flows. Regulation of stream flow will be the major feature of the comprehensive plan in this region. Amelioration of floods and improvement in the quality of urban water supplies would result. Pollution would be abated and water power could be generated at one or more sites.

General Description

The total area drained by the Neosho, Verdigris, and Illinois Rivers is 22,430 square miles, of which 10,590 are in Kansas, 7,740 in Oklahoma, 2,950 in Missouri, and 1,150 in Arkansas. The three rivers join the Arkansas River independently but within a short distance downstream from Tulsa, Okla. The headwaters of the Verdigris spread northwestward, and it drains 8,150 square miles; the Neosho extends northward and drains 12,660 square miles; and the Illinois northeastward, draining 1,620 square miles. The name Neosho covers both Grand River in Oklahoma and Neosho River in Kansas. They are portions of the same stream.

The Neosho River is 458 miles in length; the Verdigris, 340; and the Illinois, 145. The western headwaters of the Neosho, including its principal tributary, the Cottonwood River, and the Verdigris River rise on the eastern flanks of the Flint Hills of Kansas and Oklahoma at an altitude of about 1,400 feet. The eastern headwaters of the Neosho and the Spring, Shoal, and Elk Rivers, its tributaries, and of the Illinois River, rise on the western flank of the Ozark highlands at altitudes ranging from 1,400 to 1,750 feet. The northern headwaters of the Neosho and Spring Rivers rise on the smooth gently undulating Springfield Plateau as it merges with the Osage and Cherokee Plains of eastern Kansas. The Shoal and Elk Rivers have deeply eroded the southern border of the Springfield Plateau in southwest Missouri and northwest Arkansas. The Illinois River has maturely dissected the western flanks of the Boston Mountains of northwestern Arkansas.

The Neosho and Verdigris Rivers flow in shallow broad easily flooded valleys in the Cherokee Plains, the central part of the area. The region has in general poor soils. Only the valley floors are fertile.

Coal, oil, zinc, and clays used in the manufacture of brick and tile are produced in the area.

The mean annual temperature ranges from 54° in the northern part to 60° in the south. The mean annual precipitation ranges from 44 inches in the south to 30 in the northwest. The maximum rainfall occurs in the summer. Thunder storms cause sudden floods.

The native vegetation consists of a hardwood forest in the eastern part and prairie grasses in the central and western parts. There are numerous sawmills.

Some cotton, wheat, and much hay are grown. The grazing and feeding of livestock is a major activity. In the Spring River district the soils are better and farming is more productive, as at Mount Vernon, Mo., where there is a milk-condensing plant. The Ozark hills are devoted to apples and small fruits including strawberries and grapes. Rogers and Bentonville, Ark., are important fruit-shipping points. There are cotton gins, grain elevators, canneries, and vinegar factories.

Joplin, Aurora, and Webb City in Missouri, Galena in Kansas, and Pitcher and Miami in Oklahoma are zinc-mining centers. Pittsburg, Kans., is the outstanding coal-mining center. Due to the proximity and cheapness of oil and natural gas, coal mining has been retarded. The Oklahoma oil fields were discovered at Bartlesville and prospecting extended the production north and south the length of the central plains from Eureka to Tulsa. Cheap gas has attracted zinc smelting to Cherryvale, Kans.

The total population of the basins is about 800,000, about 430,000 being rural. There are 33 cities with more than 2,500 population. The principal cities are Joplin, with a population of 33,000; Pittsburg, 18,000; Coffeyville, 16,000; Emporia, 14,000; Bartlesville, 14,000; Independence, 12,000; and Chanute, 10,000. Tulsa is within a few miles of the southern border.

For the streams of this area, the rate of run-off is comparatively rapid and produces high flood flows in the crooked channels. The Neosho River system has a flood plain of approximately 343,000 acres, of which approximately 260,000 are on the main stem of the upper and middle reaches.

The Verdigris River system has a flood plain of 375,000 acres, of which approximately 197,000 acres are on the main stem. Major floods occur on both the

Neosho and the Verdigris in about 1 year in 10, moderate floods 1 year in 4, and minor floods each year. The Illinois River valley has no flood problem of economic importance.

These three rivers are important contributors to floods in the lower Arkansas. During the 1927 flood their combined flows represented 45 percent of the discharge of the Arkansas at Fort Smith and 32 percent of its discharge at Little Rock.

Recommended Plan

Flood control in this area is important not only locally but also to sections of the Arkansas River basin and ultimately to the lower Mississippi Valley. Protective works operated for the benefit of downstream areas might not give protection to the local areas. They might even aggravate local floods. On the other hand, protective works operated for local benefits might be of little value downstream. These streams are interstate, and all of their water problems should receive joint attention from the States involved.

Water supply.—The towns in the Ozark section generally utilize deep wells or springs for their water supply, and distribute the water without treatment. Along the main valleys of both the Verdigris and Neosho Rivers the towns generally depend upon the rivers for their water supply, although several of the smaller communities use underground water. As the gross pumpage along the streams represents 10 to 15 times the dry-weather flow, the water is used repeatedly. Municipal water systems and water-treatment plants are needed at many points.

Pollution.—The main stems of both the Verdigris and Neosho Rivers are seriously polluted with sewage and industrial wastes, and only a few of the towns now have adequate sewage treatment. A bad situation results during periods of very low flow. Pollution from oil-well brine is an increasing menace, especially on the lower Verdigris. The problem of handling oil-well brine is being investigated actively, especially in Kansas, where the studies have indicated the best method is pumping the brine underground into a stratum which will absorb it and at the same time will not contaminate fresh water strata. In some instances the brine has been ponded and released when rivers are at flood stage. Sewage-treatment plants are needed at many cities and towns.

Stream regulation, needed to correct problems discussed in each of the three preceding paragraphs, has been the subject of several reconnaissance investigations.

Although no sites for headwater reservoirs have been selected, the studies have indicated the general locality where they would be feasible. On the Neosho River the most promising project is a 48,000-acre-foot reser-

voir near Council Grove, Kans. Other reservoirs have been proposed on the Cottonwood River in Marion County and Chase County. In the Verdigris Basin the most promising project is a reservoir near Fall River, Kans., on the Fall River. Kansas authorities have suggested a capacity of 107,000 acre-feet for this reservoir, but a smaller reservoir might be preferable if other reservoirs on headwater streams are developed. Another site has been proposed near Madison, Kans. A detailed study of the flow requirements and of available sites is needed in order that the present serious conditions may be corrected.

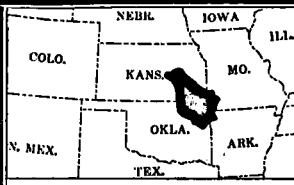
Major reservoir projects for relief of floods on the lower Arkansas River have been proposed for streams in this area. Such projects should be considered from the standpoint of local benefits and damages as well as benefits to the major downstream basin. A project which appears justified is a reservoir on the upper Caney River at Hulah, Okla. This reservoir would also have value for low-flow control. Another proposal which would be primarily for flood control but would also have conservation value is a 190,000 acre-foot reservoir on the main stem of the Verdigris at Neodesha, Kans. A major project which has been proposed primarily for the purpose of flood control on the lower Arkansas would require a 615,000 acre-foot lake at Oologah, Okla., on the Verdigris River. A reservoir of this size does not appear to be in the best interest of this sub-basin, but a smaller reservoir at this site should receive further consideration.

On the Neosho River a retention reservoir above Burlington, Kans., has been proposed but as a railroad line now lies at the edge of the flood plain at this point the project might be unduly expensive. The Pensacola Dam project on the Neosho River, the development of which would be primarily for power, might be designed and operated so that the proposed capacity of more than 2,000,000 acre-feet would provide considerable protection to the lower Arkansas River through retention of flood flow.

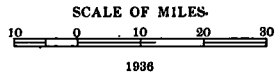
Further studies should be made promptly of the possible effects of each unit of this system of reservoirs in protecting areas now subject to flood in Kansas and Oklahoma. The overall contribution of reservoirs at these sites to flood protection in the lower Arkansas Valley should also be considered.

Another flood-control reservoir has been proposed for Tenkiller Ferry in Oklahoma on the Illinois River. As this project would be of benefit to only the lower Arkansas, its development probably should be delayed until comprehensive studies of the main stems of the Verdigris and the Neosho have been completed.

There have been proposals for a large number of local levees along the Neosho and Verdigris Rivers. The original suggestions for these levees did not con-

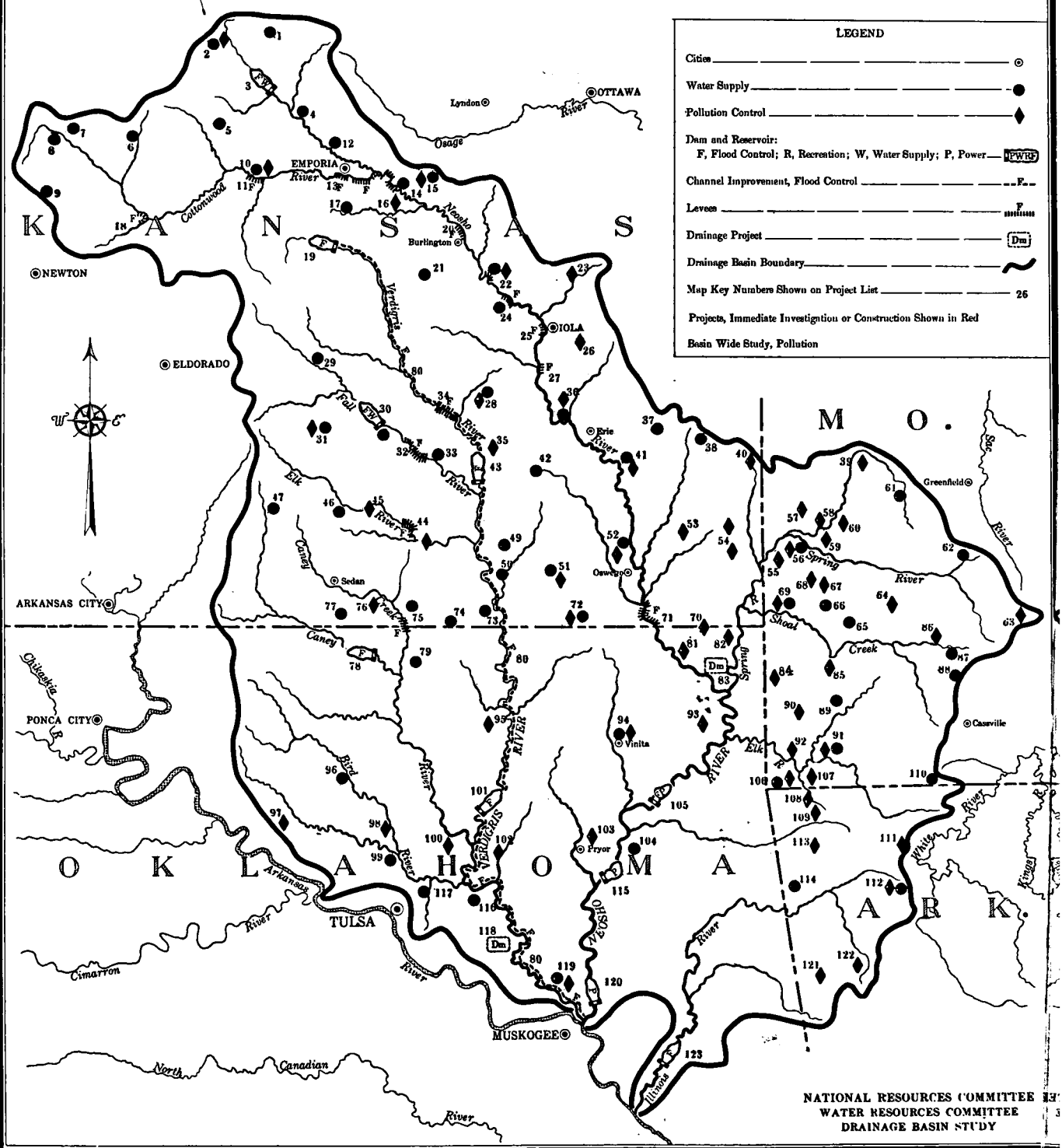


NEOSHO-VERDIGRIS



LEGEND

- Cities _____ ○
- Water Supply _____ ●
- Pollution Control _____ ◆
- Dam and Reservoir:
F, Flood Control; R, Recreation; W, Water Supply; P, Power — **PWRP**
- Channel Improvement, Flood Control _____ F- - -
- Levees _____ F
- Drainage Project _____ Dm
- Drainage Basin Boundary _____
- Map Key Numbers Shown on Project List _____ 26
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution



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DRAINAGE BASIN STUDY

sider flow reduction which might result from upstream reservoirs. These levees should be investigated in connection with the study of the possible influence of the proposed flood-control reservoirs.

Underground water.—Except in the hilly sections, the available underground waters are chiefly those held in the valley-filled material. This supply is usually adequate for rural and small-town use, except during extended droughts. There has been no survey of the underground-water resources, but it appears likely that the supply will be inadequate for extensive urban or industrial purposes.

Water power.—There are at present a few small hydroelectric installations, primarily for local supply. The one outstanding site for large hydroelectric development is at Pensacola, Okla., on the Neosho River below the mouth of the Spring River, where there is a steep canyonlike valley. A 125-foot dam has been proposed, and a plant with an installation of 57,600 kilowatt capacity to be followed possibly by construction

of low dams downstream at Markhams Ferry and Fort Gibson. The development of these three sites would utilize practically the entire fall of the lower reaches of the river.

Recreation.—The Illinois River Basin, portions of the Spring and Elk Rivers in the Ozark highlands, and the vicinity of Lake Spavinaw are attractive recreational areas. The Oklahoma Fish and Game Commission is sponsoring the construction of a large number of low dams in the tributaries of the Illinois and Neosho Rivers for the propagation of fish. Growing local interest in outdoor life may be expected to foster a further development of parks and resorts.

The plan also contemplates the early retirement from cultivation of submarginal land, and the return of such areas to a cover of either grass or forest. Such change in land use will usually have a beneficial effect in reducing the rate of run-off and thereby contributing to some extent to the control of flood flow in the streams.

Neosho-Verdigris Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study and survey of sources and extent of stream pollution in Kansas, Oklahoma, and Missouri.....	\$20,000	Quantitative knowledge of pollution is seriously lacking.
(1)	Barnsdall (36) and Catoosa (116), Okla.; Cherryvale (49), Kans.; Golden City (61) and Joplin (69), Mo.; LeRoy (22), Kans.; Monett (87), Mo.; Mound Valley (51), Kans.; Oronogo (56) and Pineville (91), Mo.; Salina (104), Okla.; Severy (31), Kans.; Southwest City (108), Mo.; Springdale (112), Ark.; Strong (10), Kans.; Vinita (94) and Wagoner (119), Okla.; Walnut (37) and White City (2), Kans.: Waterworks, improvements, extensions, or construction to secure additional supply.	733,000	
(1)	Chanute (36), Eureka (39), and Fredonia (33), Kans.: Filtration or treatment plants.....	216,000	
(1)	Chanute (36), Kans.; Joplin (69) and Lamar (39), Mo.; LeRoy (22), Kans.; Lincoln (121), Prairie Grove (122), and Sulphur Springs (108), Ark.; Vinita (94), Okla.: Sewage treatment plants.	636,000	
(1)	St. Paul (41), Kans., and Springdale (112), Ark.: Waterworks and sewer system for the former; extensions to sewer system for the latter.	81,000	
3	Morris County, Kans.: Dam and reservoir near Council Grove on Neosho River for stream flow stabilization, for improvement of municipal water supplies.	1,330,000	Preliminary studies made. Additional survey needed to determine size of reservoir.
30	Greenwood County, Kans.: Dam and reservoir near town of Fall River on Fall River for stream flow stabilization, for improvement of municipal water supplies.	1,276,000	Preliminary studies made. Additional study necessary to determine size of reservoir.
(1)	Afton (93), Okla.; Alba (59), Mo.; Altamont (52) and Altoona (35), Kans.; Anderson (90), Mo.; Arma (40) and Buffalo (28), Kans.; Carl Junction (55) and Cartersville (67), Mo.; Cherokee (54), Kans.; Claremore (102) and Collinsville (100), Okla.; Colony (23), Kans.; Commerce (81), Okla.; Decatur (113), Ark.; Edna (72) and Elk City (44), Kans.; Gravette (109), Ark.; Hartford (16), Kans.; Hominy (97), Okla.; Jasper (60), Mo.; La Harpe (26), Kans.; Lanagan (92), Mo.; Lebo (15) and Longton (45), Kans.; Marionville (63), Mo.; McCune (53) and Mound Valley (51), Kans.; Neck City (57), Neosho (85), and Noel (107), Mo.; Nowata (95), Okla.; Oronogo (56), Mo.; Peru (76), Kans.; Picher (82), Okla.; Pierce City (56), and Pineville (91), Mo.; Pryor (103), Okla.; Purcell (58), Mo.; Rogers (111), Ark.; Sarcoux (61), Mo.; Scammon (54), Kans.; Seneca (84), Mo.; Severy (31), Kans.; Skiatook (98), Okla.; Southwest City (106), Mo.; Strong (10) and Trece (70), Kans.; Wagoner (119), Okla.; Webb City (68), Mo., and White City (2), Kans.: Sewer systems and/or primary, secondary or complete treatment plants or reconditioning of existing systems.	1,138,000	Rough estimated cost, with allowance for possibility that some of the projects may not be constructed.
(1)	Altamont (52), Americus (12), Buffalo (28) and Chautauqua (77), Kans.; Copan (79) and Dawson (117), Okla.; Dearing (73), Kans.; Diamond (65) and Duenweg (66), Mo.; Dunlap (4), Durham (8), Dwight (1), Edna (72), Elk Falls (46) and Fall River (30), Kans.; Goodman (89), Mo.; Grenola (47), Gridley (21), Havana (75), Hepler (38), Lebo (15), Lehigh (9), Liberty (50), and Lincolnville (6), Kans.; Miller (62), Mo.; Neosho Falls (24), Neosho Rapids (14), and Olpe (17), Kans.; Purdy (88), and Seligman (110), Mo.; Siloam Springs (114), Ark.; Sperry (99), Okla.; Tampa (7), Thayer (42), Tyro (74), and Wilsey (5), Kans.: Complete water supply system or extensions.	458,000	Do.
78	Osage County, Okla.: Dam and reservoir at Hulah site on Caney River for flood control and stream flow stabilization.	2,343,000	Authorized by Congress.
	Ottawa (83), Tulsa (118), and Wagoner (118) Counties, Okla.: Malaria control.....	689,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
105	Delaware County, Okla.: Dam and reservoir near Pensacola on Neosho River for partial control of floods on the Arkansas River, stream-flow regulation and ultimate development of water power.	\$9,000,000	Study authorized by Congress. Oklahoma has created the Grand River Dam Authority to sponsor this project. There is no present market for the power. Cost estimate is reduced from that of the Corps of Engineers to provide for reduced scope as contemplated by the water plan.
123	Cherokee County, Okla.: Dam and reservoir at Tenkillers Ferry on Illinois River, for flood control..	9,692,000	Study authorized by Congress.
80	Oklahoma and Kansas: Channel clearance on Verdigris River from its mouth to Madison, Kans., for flood relief.	232,000	Authorized by Congress.
(1)	Benedict (34), Kans.; Chataqua County (75), Kans.; Cherokee (71), Elk City (44), and Fredonia (32), Kans.; Lyon (13) and Montgomery (75) Counties, Kans.; Washington (75) County, Okla.; and Wilson (32) County, Kans.: Levee system to protect agricultural lands along Caney Creek and the Elk, Fall, Neosho, and Verdigris Rivers.	1,246,000	Authorized by Congress.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Burlington (20), Chetopa (71), Cottonwood Falls (11), Emporia (13), Florence (18), Hartford (16), Humboldt (27), Iola (25), LeRoy (22), Neosho Falls (24), and Neosho Rapids (14), Kans.: Levees for flood protection.	\$267,000	Authorized by Congress.
101	Rogers County, Okla.: Dam and reservoir at Oologah site on Verdigris River for stream-flow stabilization.	5,142,000	Contingent upon study authorized by Congress.
43	Wilson County, Kans.: Dam and reservoir near Neodesha on Verdigris River for flood control.....	\$2,750,000	Preliminary estimates made.
19	Greenwood County, Kans.: Dam and reservoir near Madison on Verdigris River for stream-flow stabilization.	1,336,000	Do.
115	Mayes County, Okla.: Dam and reservoir near Markham on Neosho River for power.....	4,712,000	Study authorized by Congress. No present market for power.
120	Cherokee and Wagoner Counties, Okla.: Dam and reservoir near Fort Gibson on Neosho River for power.	6,511,000	Do.

1 Map key number shown following community name.

6. LOWER ARKANSAS

Pollution and flood control are the major problems of the lower Arkansas River Basin. Large quantities of waste and brine are contributed by oil fields of Kansas and Oklahoma.

Cities face difficult water supply problems, underground waters being frequently polluted, and surface supplies generally unsatisfactory. Prolonged periods of low-water flow are frequently followed by floods of damaging magnitude which affect a large portion of the major agricultural areas of the lower Arkansas and its tributaries. Flow correction is the primary objective of any water plan for this area. This may be attained by reservoir developments which should give primary consideration both to augmenting dry-weather flows and to reducing the frequency of over-bank flows.

A study is recommended to determine what benefits to the Lower Arkansas could be expected from the flow correction projects suggested in reports on Arkansas tributaries. These projects are intended to be developed principally for the benefits they may provide in their respective sub-basins.

General Description

The lower Arkansas River Basin includes the area drained by the main stem and tributaries of the Arkansas River between Tulsa, Okla., and Little Rock, Ark., some 13,600 square miles, of which about 4,900 are in Oklahoma, and 8,700 in Arkansas. Excluded and discussed in other sections are the Verdigris, Neosho, Illinois, and Canadian Rivers. The altitude at Tulsa is about 656 feet, and at Little Rock, 222 feet, giving a fall of 434 feet in a river distance of 392 miles. The principal right bank tributaries discussed in this report are the Poteau, Maumelle, Fourche La Fave, Petit Jean, and Hurricane Rivers; the left bank streams are the Piney, Mulberry, Illinois Bayou, Point Remove, and Cadron Rivers.

There are five distinct physiographic types in the lower Arkansas area: the southern flanks of the Boston Mountains, altitude about 2,500 feet; the northern flanks of the Ouachita Mountains, about 2,000 feet; the intervening Arkansas Valley penplain, altitude about 800 feet; the Cherokee Plains, about 750 feet; and the Arkansas River flood plain, from 240 to 700 feet above the sea. The Cherokee Plains structures yield oil and gas. Tulsa, Sapulpa, and Muskogee, Okla., are important oil cities. The Cherokee Plains also contain coal beds mined chiefly in the vicinity of Fort Smith.

The mean annual temperature is about 60°, with a January mean of 32° and an August mean of 92°. The mean annual precipitation ranges from 50 to 55 inches on the Boston and Ouachita Mountains to 40 to 45 inches in the Arkansas flood plain and Cherokee plains. The rugged land, which comprises a major part of the area, has a cover of hardwood forests containing much oak, hickory, and walnut. Where the forests have been cleared serious soil erosion is occurring.

The extensive fertile flood plain areas are cultivated, cotton being the principal crop. Agricultural activities have been stabilized. Hardwood lumbering is carried on locally in the mountains and there are many small sawmill towns.

The total population of the lower Arkansas River Basin is about 712,000, divided about equally between Oklahoma and Arkansas. In Oklahoma, about 60 percent is urban, while in Arkansas, about 60 percent is rural. The principal cities are Tulsa, 140,000; Muskogee, 32,000; and Sapulpa, 10,500 in Oklahoma; and Little Rock-North Little Rock, 100,000; and Fort Smith, 31,000, in Arkansas.

Recommended Plan

Flood control.—General storms of high intensity often produce damaging floods on the tributaries of the Arkansas River. On the Poteau, it is estimated that moderate floods occur once in 5 years and major floods about once in 25 years, but overbank flows occur about three times a year and the average acreage overflowed annually is 44,600. The Petit Jean, with major floods about once in 14 years, moderate floods once every 5 years, and minor overflows several times a year, inundates on the average about 24,700 acres annually. The other important tributary, the Fourche La Fave, overflows about 65,100 acres. These three flashy mountain streams are also major contributors to floods on the lower Arkansas, being exceeded by only two other tributaries—the Neosho and the Verdigris Rivers, which are discussed separately.

Complete protection from floods on the lower Arkansas was considered in 1933 by the Corps of Engineers, which concluded that “with the exception of possibly a few minor items no projects for the control of floods in this basin are economically justified at this time.”

It may be found feasible, however, to provide flood-correction facilities to reduce the frequency of over-bank flow, particularly in the stretch of the lower river

between the mouth of the Verdigris and Little Rock. A degree of regulation under which overflow between Fort Smith and Little Rock, Ark., would not occur more often than once in 5 years would permit of a more stable agricultural economy. It might properly be supplemented by levee protection of the more valuable areas.

Storage reservoirs on the central and upper reaches of the Arkansas, and on its large tributaries, have been discussed in other sections. Many of these in their operation would, if built, tend to alleviate flood conditions in this basin.

The flashy tributaries of the lower river afford excellent opportunities for flood-flow reduction with the principal benefits accruing to the lower Arkansas. The Wister Reservoir on the Poteau and possibly the Brazil Creek project could also be operated to provide some local flood protection. In addition, they would augment low flows in the Arkansas. These developments, along with the Blue Mountain project on the Petit Jean and the Nimrod on the Fourche La Fave, are included in a comprehensive reservoir plan suggested by the Corps of Engineers.

Reservoirs of the capacities reported upon by the Corps, even though giving only partial protection to the lands immediately below, were found very much too expensive. Some lesser capacity for each might provide sufficient augmentation of low flows and a degree of partial local protection, which, when coupled with benefits accruing on the main stream, might justify the projects.

Low flows which have reached minimum values of from 175 cubic feet per second at Tulsa to 1,100 cubic feet per second at Little Rock should be augmented throughout the basin and particularly below the oil fields.

Reservoir studies should give serious consideration to the fact that the basin is in the malarious section of the United States.

It is recommended that some rational, attainable reduction in frequency of overbank flow on the lower Arkansas, coupled with the largest possible increase in dry-weather flows, be set as an objective for the near future. To effect this, a study project is recommended to ascertain: (1) if such results can be expected from proposals as set-up in other sub-basin reports on major tributaries of the Arkansas; (2) if supplemental reservoirs are necessary in this area and if so whether they are warranted; and (3) what levee construction would become warrantable if a considerable reduction in frequency of overbank flow can be achieved.

Pollution.—The oil fields in Kansas and northern Oklahoma add salt brines to the Arkansas River, making it unfit for municipal or industrial use throughout

the lower basin. Further pollutorial load is added to the river by domestic and industrial wastes of the cities. All municipalities discharge untreated wastes, except one city in Oklahoma and several Arkansas communities. Some acid mine wastes find their way into the Poteau River and thence to the Arkansas. The flows of the Arkansas and its tributaries at low stages are insufficient to furnish adequate dilution.

Water conservation projects to supplement dry-weather flows, complete treatment of municipal wastes, and control of brine wastes at the source are the methods to be used to minimize pollution. Many treatment plants are needed.

Water supplies.—In Oklahoma practically all municipalities obtain their water from surface sources, but in Arkansas 6 of the 16 cities rely on wells. Surface supplies obtained from the Arkansas River and within its backwater limits are unsatisfactory due to the high salt content and sewage pollution. On the tributaries impounded stream flow would furnish adequate supplies.

In Arkansas, good underground water can be obtained in adequate quantities from either shallow or deep wells throughout the overflow plains of the main stream. Elsewhere it is more limited, but is generally adequate except in the Fourche La Fave Basin and in some other highland areas. In Oklahoma, underground supplies are adequate but frequently very hard and in the vicinity of the oil fields they are extensively polluted by brines. Urban water supply problems require elimination of pollution of the waters of the Arkansas River and of the underground waters in the oil fields region and the development of storage reservoirs for municipal supplies in the mountainous sections. Several projects are recommended.

Rural water supplies are derived principally from shallow wells, springs, and small ponds. In the hilly country serious shortages have occurred where reliance was placed on wells. Small reservoirs seem to be indicated as the solution there. Elsewhere pollution difficulties similar to those noted for urban supplies are encountered.

Recreation and wildlife.—Large portions of the Ozark and Ouachita National Forests with their mountains, forests, spring-fed streams, trails and roads lie within the basin. The 100,000-acre project in Logan and Yell Counties, Ark., and the 55,000-acre Boston Mountains project, both being developed by the Resettlement Administration, will add further recreational and wildlife facilities. These are all finding increased usage, but they lack small recreational lakes.

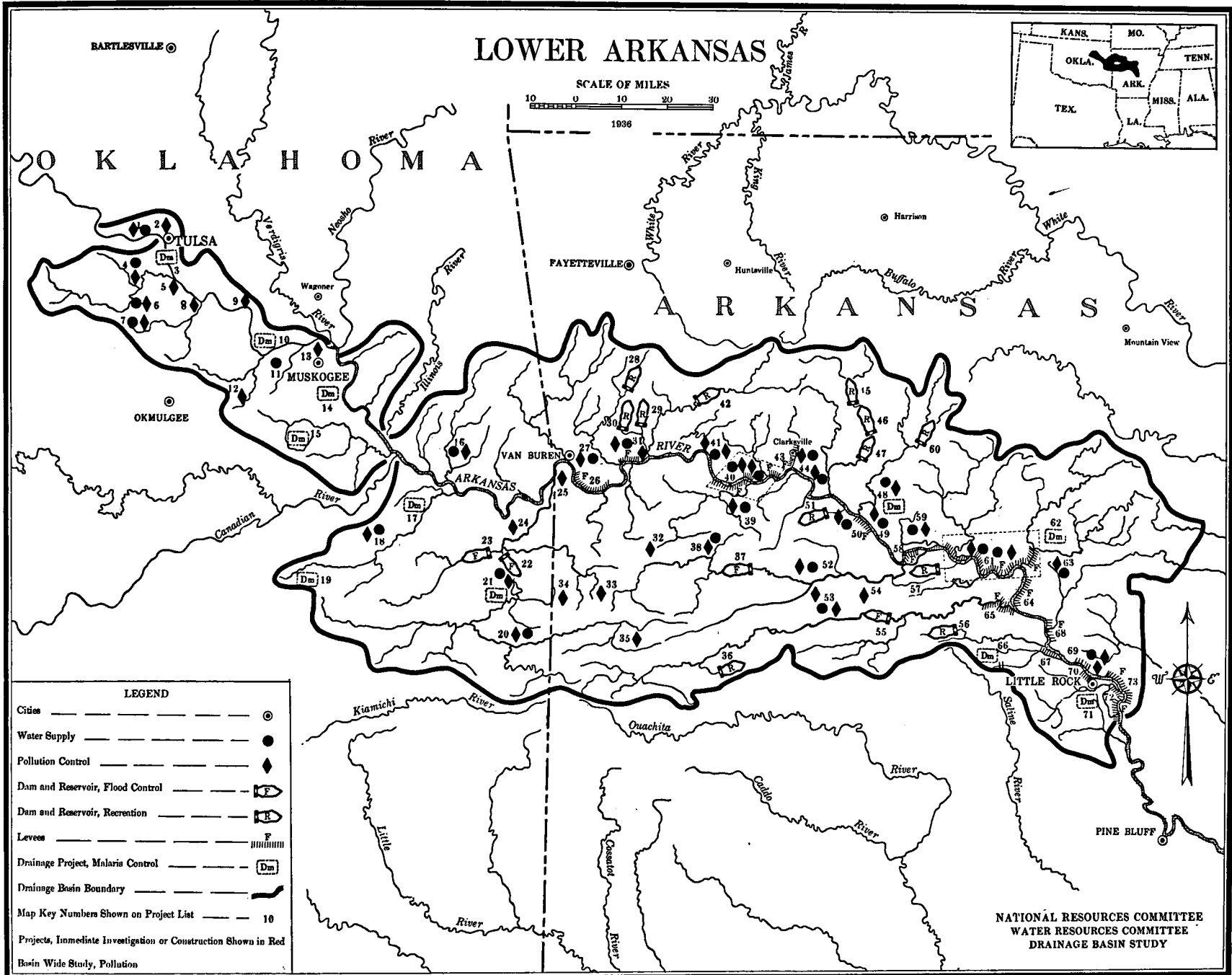
Silting and soil erosion.—Soil erosion is not a serious problem in the Oklahoma section, but in Arkansas a great portion of the basin is affected. Many of the

smaller streams show evidence of silting in their lower reaches and, in at least one instance, an impounded water supply has been greatly reduced due to rapid silting.

The Forest Service estimates that about 88 percent of the Petit Jean and Fourche La Pave area and about 70 percent of the entire lower Arkansas Basin should be in forest.

Land drainage and levees.—About 9,000 acres of land in Tulsa County are in 3 drainage projects and some 15,000 acres additional are in need of drainage, but the tight soils and almost flat terrain make successful drainage difficult.

In Arkansas there are 34 levee and drainage districts with a total acreage of about 178,000 in the valley of the main stream between Little Rock and Fort Smith. With the exception of those in Pulaski County, they have not been successful, principally because of inadequate levees. In the 1935 flood most of the levees above Pulaski County failed. If some or all of the flood-correction projects set up in the water plans for this and the other subbasins are constructed, sufficient decrease in flood stages may result to warrant less expensive and more substantial levees in certain localities. Rehabilitation of drainage structures and ditches within the districts should also be undertaken.



Lower Arkansas Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Studies: (1) In the Cimarron and Canadian sub-basins to determine reservoir developments to achieve the best flow regulation for irrigation, augmentation of low flows, reduction in frequency of overbank flows and water supplies; (2) of the Central Arkansas, Verdigris, Neosho (Grand), and Illinois Rivers with special emphasis on multiple use reservoirs for flow regulation, water supply, water power, or recreation; (3) to determine what changes could be made in the design or operation of flow regulation projects in other sub-basins to increase benefits to the Lower Arkansas without materially lessening the local benefits; a determination of the benefits primarily to the main stem of possible reservoir projects on the Poteau, Petit Jean, and Fourche La Fave Rivers; a determination of levee projects which might supplement the reservoirs.	\$825,000	All these studies are to determine what combination of projects and operation will attain a considerable increase in low flows and a material reduction in frequency of overbank flows. All studies of tributary reservoirs should include consideration of any incidental benefits to the lower Arkansas.
	Study of stream pollution to ascertain its extent and character and to make recommendations which will lead to its ultimate abatement.	15,000	
2	Tulsa, Okla.: Sewage treatment plant.	971,000	Preliminary plans made.
63	North Little Rock, Ark.: Intercepting sewers.	269,000	Do.
(1)	Danville (53), Fort Smith (25) (intercepting sewer), Hartford (34), Mansfield (33), Mulberry (31), and Waldron (35), Ark.: Sewer systems and/or sewage treatment plants.	200,000	Do.
(1)	Camp Pike (69), Dover (48), and Plumerville (61), Ark.; Stigler (18), and Taft (11), Okla.: Water-supply systems and/or extensions.	139,000	Preliminary or complete plans available.
70	Little Rock, Ark.: 2 miles of levees on Arkansas River for flood protection.	111,000	Authorized by Congress. Detailed plans in preparation.
69	North Little Rock, Ark.: 4.3 miles of levees and walls on Arkansas River for flood protection.	401,000	Do.
43	Clarksville, Ark.: Flood protection levees on Spadra Creek.	70,000	
(1)	Faulkner County (62), Ark.; Haskell (17), LeFlore (21), McIntosh (15), Muskogee (14), and Pittsburg (19) Counties, Okla.; Pope (48), Pulaski (71), and Saline (60) Counties, Ark.; Tulsa (3) and Wagoner (10) Counties, Okla.: Malaria control.	1,665,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Dardanelle (50); Faulkner County Levee District No. 1 (64); Gillett to North Little Rock (73) and Morrilton (61), Ark.: Flood protection levees on Arkansas River.	\$1,763,000	Authorized by Congress. Detailed plans in preparation. Estimate includes \$884,000 for part of the Little Rock-Gillett levee system, the rest of which is in the lower Mississippi list.
(1)	Altus (41), Atkins (59), Belleville (52), Clarksville (44), Coal Hill (40), Conway (63), Dardanelle (50), Dyer (31), and Hartman (40), Ark.; Heavener (20) and Kiefer (6), Okla.; Lamar (44), Magazine (38), and Morrilton (61), Ark.; Mounds (7), Okla.; Paris (39) and Plainview (53), Ark.; Poteau (22), Okla.; Russellville (49), Ark.; Sand Springs (1), Sapulpa (4), and Sallisaw (16), Okla.; and Van Buren (27), Ark.: Water supply systems and/or improvements.	683,000	
(1)	Altus (41), Atkins (59), and Belleville (52), Ark.; Bixby (8), Okla.; Booneville (32), Ark.; Boynton (12), Okla.; Clarksville (44), Coal Hill (40), and Conway (63), Ark.; Coweta (9), Okla.; Dardanelle (50), Dover (48), Dyer (31), and Hartman (40), Ark.; Heavener (20), Jenks (5), and Kiefer (6), Okla.; Lamar (44), Levy (69), Magazine (38), and Morrilton (64), Ark.; Mounds (7) and Muskogee (13), Okla.; Ola (54), Ozark (41), Paris (39), Plainview (53) and Plumerville (61), Ark.; Poteau (22), Okla.; Russellville (49), Ark.; Sand Springs (1), Sapulpa (4), Stigler (18), Spiro (24), and Sallisaw (16), Okla.; and Van Buren (27), Ark.: Sewer systems and/or sewage treatment.	829,000	
(1)	Big Piney (46), Cass (42), Cedar Creek (36), Gaylor (28), Hurricane Fork (29), Maumelle (56), Middle Fork (60), Rough Hollow (47), Shores Lake (30), and Trace Creek (45), Ark.: Dams to develop recreational reservoirs in Ozark and Ouachita National Forests	1,745,000	Cedar Creek reservoir. Partly completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	LeFlore County, Okla.: Wister Reservoir (23) near Howe and Brazil Reservoir (22), near Panama: For high and low water regulation on Poteau River, Brazil Creek, and Arkansas River.	\$1,800,000	Subject to findings of special study. Cost is less than that of Corps of Engineers due to necessary reduction in capacity. Surveys authorized by Congress.
55	Nimrod, Ark.: Nimrod Reservoir, for high and low water regulation on Fourche La Fave and Arkansas Rivers.	700,000	Subject to findings of special study. Cost is less than that of Corps of Engineers due to necessary reduction in capacity.
37	Logan County, Ark.: Blue Mountain Reservoir for high and low water regulation on Petit Jean and Arkansas Rivers.	1,000,000	Subject to findings of special study. Cost is less than that of Corps of Engineers due to necessary reduction in capacity. Survey of Petit Jean authorized by Congress.
57	Logan County, Ark.: Petit Jean State Park, reservoir and recreation improvements.	238,000	Plans completed.
51	Yell County, Ark.: Mount Nebo State Park, reservoir and recreational improvements.	157,000	Do.
(1)	Arkansas: Levees for flood control as follows:		Authorized by Congress.
	Arkansas River, Conway County (61)	589,000	
	Arkansas River, Frog Bayou to Mulberry Creek, Crawford County (31)	1,280,000	
	Arkansas River, Crawford County (26)	1,712,000	
	Arkansas River, Johnson County (40)	479,000	
	Arkansas River below Little Rock (72)	708,000	
	Arkansas River, Logan County (40)	516,000	
	Arkansas River, Yell County (58)	302,000	
	Cadron Creek, Conway and Faulkner Counties (61)	864,000	
	Fourche La Fave River near Bigelow (65)	1,275,000	
	Little Maumelle River, Pulaski County (67)	179,000	
	Palarn Bayou, Pulaski County (68)	91,000	

1 Map key number shown following community name.
 2 May key number shown following county name.

7. UPPER WHITE, BLACK, AND ST. FRANCIS

The Ozark Mountain region, drained by the White, Black, St. Francis, and other streams, is an area of swift, clear mountain rivers, many springs and forests, lying within easy reach of large cities, among them Kansas City, St. Louis, Memphis, and Tulsa. A long-range plan for this section should consider recreational developments first, but should not omit studies preparatory to utilizing the large amount of potential water power afforded in the streams. A number of communities of the area need improved water supplies and sewage facilities. In view of the increasing use of the region by summer tourists, these improvements should be made soon.

General Description

The Ozark highland area considered here covers 25,090 square miles in Missouri and Arkansas.

The White River extends 390 miles in the Ozarks, falling 1,565 feet from an altitude of 1,800 feet at its headwaters to 235 feet at the point where it flows from the highlands into the Mississippi River lowlands near Batesville, Ark. The Black River has a length of 80 miles in the Ozarks and falls from 600 feet to 325 feet near Menigo, Ark. It joins the White River in the lowlands. The St. Francis River rises in the St. Francois Mountains of the Ozarks at 1,800 feet, and falls in 150 miles to an elevation of about 325 feet at Wappapello, Mo.

The Clark and Gardner National Forests lie almost entirely in the area, and about 20 percent of the Ozark National Forest is included. The Ozark highlands range from moderately hilly to very rugged topography. The major portion of the area is underlain by massive beds of limestone and dolomite which are honeycombed with caves. Over most of the area a large proportion of the precipitation enters underground reservoirs, reappearing in large springs. The poor quality of the soils, combined with the rugged topography, renders the land generally unsuitable for agriculture. A high percentage of the area has an oak-pine forest cover.

A thick bed of St. Peter Sandstone at Crystal City, Mo., is the basis of large-scale manufacture of glass. There are large deposits of high-grade glass sand from Batesville to Fayetteville, Ark., along the Boston Escarpment. Cement is manufactured from limestone at St. Genevieve and Cape Girardeau, Mo. Iron ore deposits of the limonite type are widespread in both the Missouri and the Arkansas sections. Most of the deposits are small. Phosphates are found in northern

Arkansas but are of too low a grade to compete in the present markets. There are many small deposits of lead and zinc scattered throughout the area. Extensive deposits of manganese are found in northern Arkansas but they are of low market value.

The forests are a source of railroad ties, cordwood, tool handles, and barrel staves. Lumbering is generally carried on by the farmers in winter, or by portable sawmill outfits. A few villages are dependent on sawmill operations.

In a few places, there are excellent soils, as at Farmington, Mo. The loess soils along the Mississippi River are farmed where the slopes are not too steep. Most of the flood plain lands are used for corn and hay. The uplands are devoted to wheat and hay in spite of low yields. In the western headwaters apples, grapes, and tomatoes are grown on the hills with considerable success, as at Fayetteville, Ark.

The forests are interspersed with farm clearings and small towns based on timber and mineral resources. There are about 590,000 inhabitants in the region. The rural areas are sparsely populated, and the extension of public forest reserves will eventually result in a decline of rural population. Stock ranching probably will displace most of the other types of agriculture. A few places, as at Lake Taneycomo, will profit by recreational facilities.

The area is poorly provided in general with transportation facilities. There are railroads along the eastern and western borders and two cross from northwest to southeast. A few paved and many gravel highways have been constructed recently.

Temperatures range from an annual average of 63° in the south to 58° in the north. The summer maximums average about 88°. The winters are cool. Snowfall is light, the most being at Springfield, Mo., which receives about 8 inches. The average annual precipitation ranges from 46 inches in the south to 44 inches in the northwest, and 38 inches in the north. It is well distributed over the growing season and is usually adequate. Storms in winter cover wide areas, but the summer rains commonly are severe local thunderstorms. The annual run-off is about 16 inches. The streams are swift, and flow in deep narrow valleys; the fall averages 3 to 4 feet per mile. The flow is "flashy." Frequent floods of short duration occur, but little damage results in the narrow valleys. The St. Francis River at Patterson, Mo., with a drainage area of 956 square miles, has discharged as much as 82 cubic feet per second per square mile, but at times its flow is

practically zero. The other streams, however, have relatively high minimum flows because of contributions from numerous springs. In general the crests from the headwater streams do not synchronize with the crests in the lowlands outside the Ozark area because the storms are local. Any development in the hill country which flattens the irregularities of the flows will be of distinct value in the lowlands outside the area.

There is extensive underground water of good quality. Most of the municipalities depend upon wells or springs for their water supplies. Rural supplies are generally obtained from shallow wells or springs. These sources are not altogether reliable, however, and some are affected in drought periods.

An important characteristic is the great number of springs, both large and small. There are seven in Missouri with gross flows of more than 100,000,000 gallons daily. Big Springs, the flow of which exceeds 800,000,000 gallons daily, is the second largest in the United States. The springs are frequently subject to minor pollution from farms. State parks, forest preserves, and fish hatcheries have been developed in connection with several of the larger springs.

Recommended Plan

Water supply, sewer systems, and sewage-treatment plants are of primary importance in the long-range water plan for the Ozark region. The small financial resources of the rural communities have curtailed their ability to install sanitary facilities. Throughout the Ozark area there is pollution from the small towns, resorts, and camps located near streams. Pollution already menaces the Lake Taneycomo area, and strict supervision in the future will be required to prevent its spread in other valuable recreational zones. There is also industrial pollution by small creameries and canneries.

In many places, although present underground water is available in adequate quantities only in deep wells and expensive pumping is required, increased interest can be expected in surface supplies for both urban and rural use. The irregular topography, with many deep ravines, affords opportunities for constructing small lakes or ponds at reasonable cost and adequate for local needs.

Recreational activities may be expected to grow rapidly. Both the Federal and State Governments

have sponsored extensive public forest developments with attendant improvements. It is anticipated that submarginal farm land will be retired from cultivation in the not distant future, and used for either grazing or forest cover. A number of tentative sites have been selected for the erection of dams to create small, regulated lakes for recreational purposes and *wildlife* refuges, of which one is included in the project list.

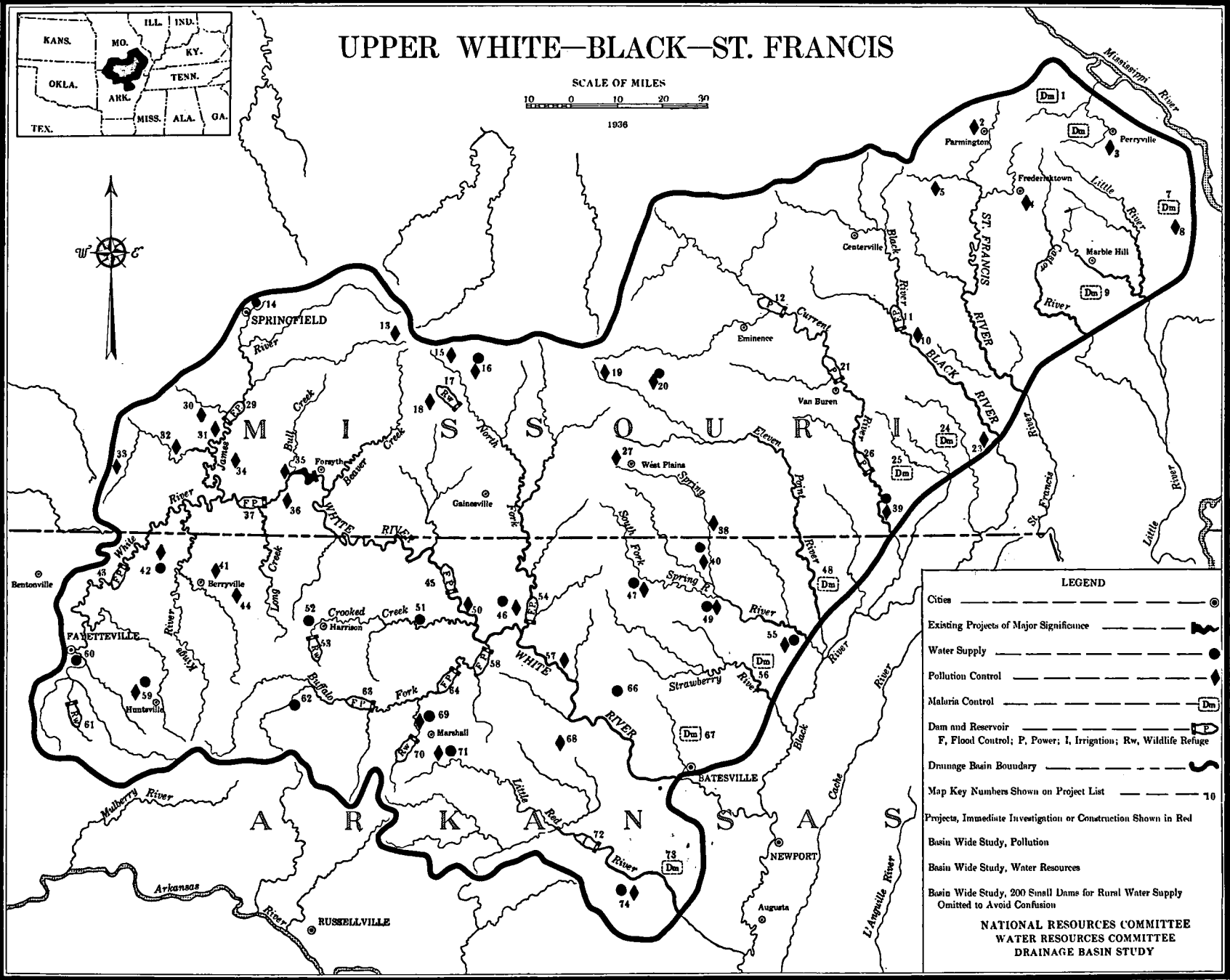
Water power.—Studies of the power markets in and adjacent to the region should be made, with a view to developing the extensive hydroelectric-power resources as rapidly as is economically justified. A number of sites have been studied by the Corps of Engineers; proposed installations range from 10,000 to 100,000 kilowatts and the potential capacity of all sites in the region is approximately 450,000 kilowatts. Although present power consumption in the vicinity would not justify any of the larger projects as base-load plants, in the future such projects as Table Rock, Wild Cat Shoals, and Hargus Eddy, each with capacities in excess of 50,000 kilowatts, may be needed for operation as peak-load auxiliaries to the large steam generating installations at St. Louis and Kansas City. Meanwhile no expensive improvements should be made in the areas which would be flooded by the power dams.

Various projects have been suggested which would not be of material benefit to the Ozark region itself but which would improve downstream areas outside the mountain region. One such project worthy of further study is a large impounding dam at Greers Ferry to provide water for irrigating extensive rice fields in the Arkansas River Basin. This dam might also be used in flood control. Proposals have been made for the erection of flood-control dams in the mountains to obtain better stream regulation in the lowland reaches of the streams. Available sites include Clearwater on the White River and Wappapello on the St. Francis River.

Although the Ozark region is mountainous, several lowland communities on the edge of the region, such as Poplar Bluff, Mo., will be benefited by levees which have been authorized by the Congress.

Additional basic information on water conditions in the region is needed to aid in future planning. Pollution and underground water studies and a study of the relative values of recreation and power developments are needed.

UPPER WHITE—BLACK—ST. FRANCIS



SCALE OF MILES
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 1936

LEGEND

- Cities ———— ○
- Existing Projects of Major Significance ————
- Water Supply ———— ●
- Pollution Control ———— ◆
- Malaria Control ———— Dm
- Dam and Reservoir ———— P
- F, Flood Control; P, Power; I, Irrigation; Rw, Wildlife Refuge
- Drainage Basin Boundary ————
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Pollution
- Basin Wide Study, Water Resources
- Basin Wide Study, 200 Small Dams for Rural Water Supply Omitted to Avoid Confusion

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Upper White-Black-St. Francis Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Study to determine the extent and source of stream pollution throughout the basin..... Study to determine the relative values of water resources for power or recreation throughout the basin. Doniphan (39), Mo.; Eureka Springs (42), Huntsville (59), Imboden (55), Jasper (52), Leslie (71), Mammoth Springs (40), Marshall (69), Melbourne (66), and Mountain Home (46), Ark.; Mountain View (20), Mo.; Fangburn (74), Ark.; Springfield (14), Mo.; and Yellville (51), Ark.: Waterworks or improvements.	\$25,000 15,000 578,000	Plans completed.
(1)	Huntsville (59), Leslie (71), Marshall (69), and Mountain View (68), Ark.: Sewer systems.	178,000	Do.
(1)	Berryville (41), Ark.; Cassville (33), Mo.; Green Forest (44), and Hardy (49), Ark.; Ironton (5), Mo.; Fangburn (74), Ark.; Ferryville (3), Piedmont (10), and Thayer (38), Mo.: Sewer systems and sewage treatment plants.	441,000	Do.
(4)	Doniphan (39), Mo.; Eureka Springs (42), Ark.; Poplar Bluff (23), West Plains (27), and Willow Springs (19), Mo.: Sewage treatment plants.	192,000	Preliminary plans made.
(1)	Bolinger (9), Butler (24), and Cape Girardeau (7) Counties, Mo.; Independence (67) and Lawrence (56) Counties, Ark.; Perry (3) County, Mo.; Randolph (48) County, Ark.; Ripley (25) and St. Genevieve (1) Counties, Mo.; and White (73) County, Ark.: Malaria control.	439,000	
17	Ava, Mo.: Lake for recreational purposes..... Arkansas and Missouri: 200 small dams to augment adjacent water supplies.....	50,000 1,000,000	Plans not completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Ava (18) and Branson (35), Mo.; Calico Rock (57) and Cotter (50), Ark., and Crane (30), Mo.: Sewer systems and sewage treatment plants.	\$184,000	Preliminary plans made.
(1)	Fayetteville (60), Harrison (52), and Salem (47), Ark.: Water supply and/or waterworks systems or improvements.	205,000	Do.
(1)	Farmington (2), Fredericktown (4), and Jackson (8), Mo.: Sewage treatment plants.....	87,000	Do.
37	Taney County, Mo.: Table Rock Dam and Reservoir on White River near Branson for power and flood control.	15,206,000	Do.
45	Baxter and Marion Counties, Ark.: Wild Cat Shoals Dam and Reservoir on White River near Cotter for power and flood control.	25,712,000	Do.
26	Ripley County, Mo.: Hargas Eddy Dam and Reservoir on Current River near Doniphan for power..	7,141,000	Do.
21	Carter County, Mo.: Mill Creek Dam on Current River near Van Buren for power.....	5,075,000	Do.
12	Shannon County, Mo.: Blair Creek Dam on Current River below Eminence for power.....	6,728,000	Do.
72	Cleburne County, Ark.: Greers Ferry Dam on Little Red River near Heber Springs to impound water for irrigation of rice in Grand Prairie region.	2,050,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Hardy (49), Ark.; Jenkins (32), Norwood (16), and Read Springs (34), Mo.: Water supply and waterworks systems or improvements.	\$55,000	Preliminary plans prepared.
(1)	Galena (31) and Hollister (36), Mo.; Imboden (55), Ark.; Jenkins (32), Mo.; Mammoth Springs (40), Ark.; Mansfield (15), Mo.; Mountain Home (46), Ark.; Mountain View (20), Mo.; Norwood (16), and Reeds Springs (34), Mo.; Salem (47), Ark.; and Seymour (13), Mo.: Sewer systems and sewage treatment plants.	417,000	
(1)	Bone and Searey Counties, Ark.: 2 dams and reservoirs, one on Bear Creek near Marshall (70) and the other near Harrison (53), Ark., for recreational purposes.	16,000	
61	Washington County, Ark.: Dam, reservoir, and improvements for game refuge.....	10,000	
	Dams and reservoirs for power development and with some benefit to flood control, as follows.....	65,350,000	Do.
11	Clearwater Dam, Black River, Mo. (\$6,700,000).....		
43	Beaver Dam, White River, Ark. (\$8,540,000).....		
29	Galena Dam, James River, Mo. (\$9,660,000).....		
58	Lone Rock Dam, Buffalo Fork, White River, Ark. (\$3,180,000).....		
63	Mill Creek Dam, Buffalo Fork, White River, Ark. (\$9,330,000).....		
54	Norfolk Dam, North Fork, White River, Ark. (\$21,700,000).....		
64	Rush Creek Dam, Buffalo Fork, White River, Ark. (\$6,240,000).....		

* Map key number shown following community name.

8. UPPER RED

A long-range water plan for the basin of the Red River above Denison, Tex., will have as its principal purpose the conservation of water for the improvement of agriculture, for urban supply, and for regulation of stream flow. Reservoirs will be needed on the principal tributaries. The plan will provide for the conservation of underground water in the high-plains section. A solution is needed for the problem created by the fluoride content of underground water. The plan includes the necessary sanitary improvement of the region by the installation of sewage-treatment works, improved recreational opportunities, and continuation and further development of soil conservation work, now in the demonstration stage.

General Description

The upper Red River Basin contains about 30,500 square miles, of which 21,700 are in Texas, 8,750 in Oklahoma, and 50 in New Mexico. The basin extends from the mouth of the Washita River to the headwaters at the Texas-New Mexico boundary line. The principal tributaries are the Wichita, Pease, Prairie Dog, Salt, North Fork, and Cache Rivers.

The Red River headwaters rise in the high plains section of the Texas Panhandle at an altitude of about 4,000 feet. The plains slope gently and smoothly eastward about 10 feet per mile to an abrupt escarpment several hundred feet high. The escarpment is a belt of "bad lands." Underneath the plains, Tertiary formations, 400 feet thick, are the source of underground water for local rural and urban water supply, and for irrigation. About 7,000 acres are irrigated from shallow wells and are intensively cultivated. The precipitation on the high plains averages 10 to 15 inches and the growing season is about 180 days long. Large acreages have been dry-farmed and much land is used for grazing. Wheat, oats, barley, grain sorghums, alfalfa, vegetables, livestock, dairy products, poultry, and eggs are produced. Pampa, with 10,470 population, is the largest city in this section. It is largely supported by oil- and gas-field business.

The remainder of the upper Red Basin, east of the escarpment, is in the rolling plains section of Texas and Oklahoma. Many streams have cut deep valleys with nearly flat bottoms here. The interstream uplands have been eroded into rounded hills. The precipitation ranges from 30 inches in the east to 20 inches in the west. This section has a fertile, brown soil. Great varieties of crops are produced in the eastern

part. Specialization in cotton, wheat, or alfalfa and cattle is general in the west. Oil, gas, asphalt, gypsum, lime, and glass sand are mineral resources utilized in various localities. Cotton-oil mills, flour mills, oil refineries, clay products, cement and plaster manufactures are important. There are consumer goods factories in the larger cities, chiefly in Wichita Falls, which has 43,700 population. Other cities are trade and railroad centers. They include Vernon, 9,200, Electra, 6,700, Quanah, 4,500, and Childress, 7,100, in Texas; and Lawton, 12,000, Altus, 8,400, Duncan, 8,300, Elk City, 5,600, and Hobart, 4,900, in Oklahoma.

The Wichita Mountains along the northern divide are rugged, rising from 500 to 1,500 feet above the surrounding plains. They are wooded and provide an excellent setting for wildlife conservation and recreation.

The total population of the upper Red Basin is about 640,000, of which about 50,000 are in the high plains. Of the 590,000 in the rolling plains, 315,000 are in Texas and 275,000 are in Oklahoma. The agricultural and mineral resources of the basin have not been fully utilized. The future development of the basin can be greatly facilitated by increasing the reliable water supply for rural, urban, and industrial uses.

Records of precipitation are reasonably adequate in this area, but there are no satisfactory records of stream flow. Records of stream flow for 7 and 8 years exist at three points and for shorter periods at a few other stations. The only valuable record for the whole basin has been made at Denison, Tex. It covers a period of 11 years and indicates an average annual runoff of 3,538,000 acre-feet.

Underground water is found in the Tertiary sands of the high plains in relatively large quantities at depths of from 50 to 400 feet. It is now subjected to heavy withdrawals both for municipal water supply and for irrigation. The effect on the water table should be studied in the immediate future. In certain parts of this area storage of surface water for underground water recharge may be feasible. Over a large part of this section underground water contains a considerable amount of fluoride which makes it undesirable as a drinking water supply for children.

A high gypsum content commonly makes underground water below the escarpment unsatisfactory for municipal supply. In this area, therefore, a development of the surface water resources is particularly important.

Recommended Plan

Water supply.—In the high plains section there appears to be ample underground water for urban use, but the high fluoride content in many places renders it unsatisfactory as a permanent supply unless means can be found for fluoride removal. Further study of this problem is needed. In the central section of the basin both underground and surface waters require softening to be thoroughly satisfactory for home and industrial use. The high cost of operation of softening plants has kept most of the smaller towns from installing them. Many municipal supplies are taken from surface water. Stream beds in this area are frequently dry in summer and many municipal supplies have been very low during the recent years of drought. The cities of Crowell and Electra, in Texas, have been forced to import water by rail for a considerable period of time. Several of the large cities have developed reliable surface supplies through storage. The development of stored water for the supply of other cities is needed and in certain instances this may be worked out as part of a combined water development program involving irrigation, some measure of flood flow correction, and improvement of low water flows for sanitary purposes.

Pollution.—Because of the low summer flow in the streams, sewage wastes in this area should be treated. On the Texas side of the basin 83 percent of the urban population above Denison is served by some form of treatment, and works for complete treatment of sewage serve about 70 percent. On the Oklahoma side the proportions are about the same. However, a number of the cities use only primary settling.

The discharge of raw sewage by certain of the cities, inadequate preliminary treatment only of the sewage of others, and apparently a failure to operate some of the better plants to best advantage, combine to create a serious sanitary problem which is critically aggravated in periods of extremely low flow. Because many cities depend upon surface run-off for urban water supply, correction of this situation needs attention. Complete treatment of the sewage of most of the cities will be required, and the low flow on most of the tributaries will have to be augmented. In some instances this may be worked out to advantage in connection with the storage of water for other purposes.

There is also some pollution from oil-field wastes, particularly from brine, but the condition is not so critical as in other drainage basins in Oklahoma and Kansas.

Flood control.—An extensive study of flood flow in the streams of the Red River has been made by the Corps of Engineers. Studies were directed primarily to correction of floods in the Red River below Denison, and to reduction of the effect of Red River flood

peaks on Mississippi River floods. However, this study contained an analysis of flood flows and flood damages on the Red River above Denison and on certain of the tributaries, with a finding that the expense involved in flood protection, either by levees or by levees and detention reservoirs, was greatly in excess of apparent benefits. Protection from moderate floods may be warranted when the lands in the overflow areas are more highly developed. A restudy is required of flood characteristics of the whole upper Red River Basin, including the possibilities of introducing a reasonable measure of protection into multiple-purpose projects.

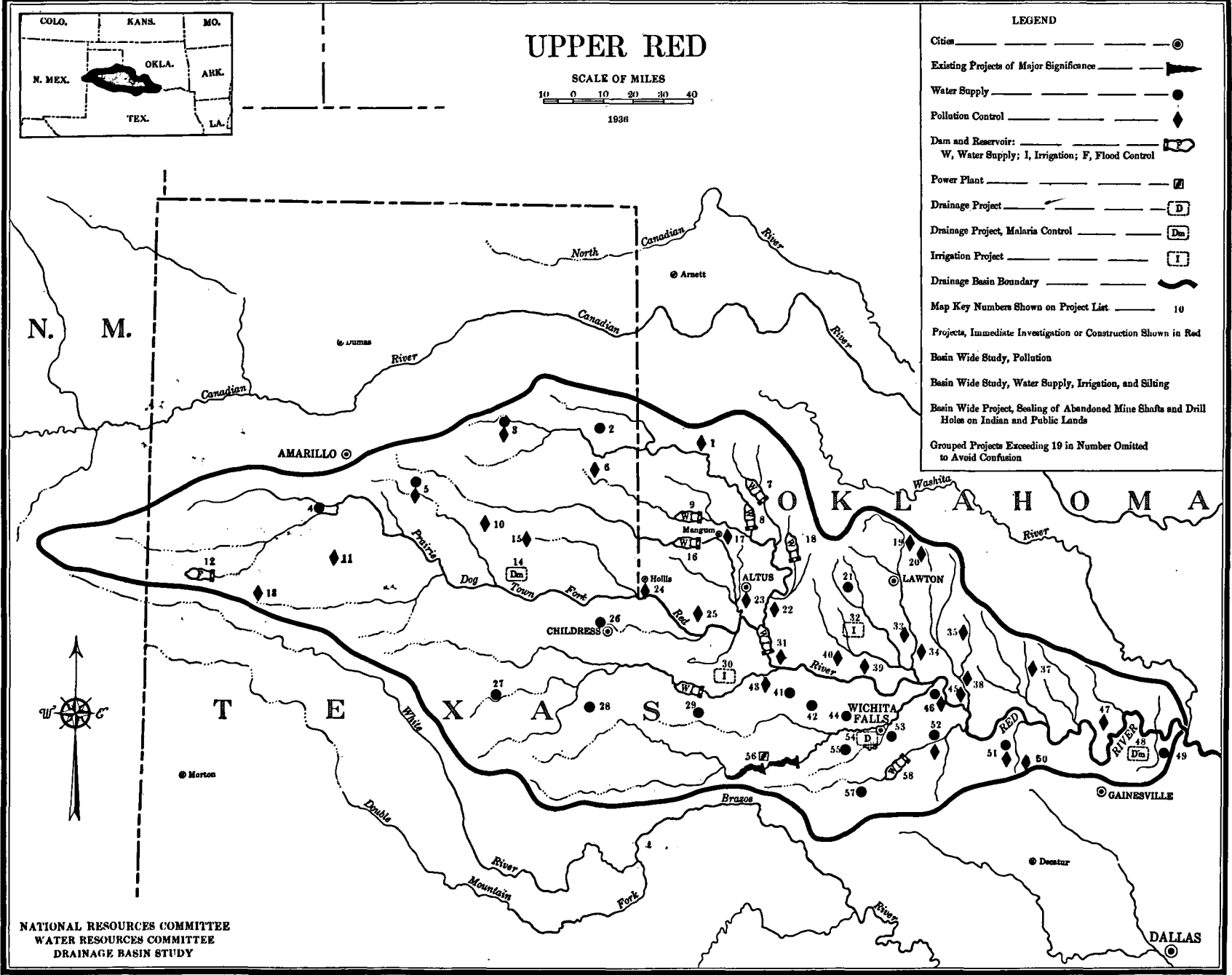
Irrigation of a supplemental type is needed by a large acreage of fertile agricultural land. Experience with small operations, and on the Wichita project, where supplemental water has been applied during July and August, has shown that the increase in crop values is very large. About 1½ feet of water per acre is required. About 35,000 acres are now being irrigated in the Wichita Basin and it is possible that this acreage can be doubled.

Studies have been made of similar developments on the Pease River in Texas with a reservoir at Crowell to serve 75,000 acres below that point, and of a proposal on the North and Salt Forks in Oklahoma involving interconnected reservoirs which would supply supplemental water for 160,000 acres. These proposals should be restudied as multiple-purpose projects.

Water power.—There do not appear to be any hydroelectric power possibilities of importance in this basin, but the development of some power may ultimately be justified in connection with multiple-purpose projects. The Corps of Engineers is restudying a proposed development at Denison for which hydroelectric power is one of the important items. A project for the development of hydroelectric power at Lake Kemp on the Wichita River seems feasible in the event that the water supply is not needed for irrigation of additional land, but the project requires further study.

Soil conservation.—The streams in the eastern and central part of this basin have a high silt content and soil erosion is serious over a considerable part of the area below the High Plains escarpment. There is need for better soil conservation practice in this part of the basin and, wherever new reservoir projects are constructed, this need will be greatly increased, as a measure to prolong their usefulness.

Recreation and wildlife.—There are a few satisfactory recreational facilities in the area, resulting largely from the use of existing reservoir lakes such as Lake Lawtonka, Lake Altus and Lake Kemp. The Resettlement Administration is sponsoring a project for the construction of a dam which possibly would create a 9,800-acre lake in Lake Murray State Park in Carter and Love Counties, Okla.



Upper Red Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study and survey of stream pollution in Texas and Oklahoma. Chemical and biological analyses of surface water to determine extent and seriousness of pollution. Should include fluoride analyses.	* \$25,000	Texas \$15,000 per year; Oklahoma \$10,000 per year.
	Study of reservoirs throughout the subbasin in Oklahoma and Texas to determine the most warrantable system for water supply, irrigation, and flow regulation, including a study of methods to minimize silting in reservoirs.	175,000	This study may indicate the desirability of altering the proposed Denison project. Elm Fork, North Fork, and Pease projects in C group are also subject to this study.
53	Wichita Falls, Tex.: Water supply, 5 miles of 42-inch pipe line and treatment plant to improve quality of water.	1,500,000	Preliminary plans made.
(1)	Indianola, (21), Okla.; Iowa Park (44) and Wheeler (2), Tex.: Water supply or improvements.....	162,000	
(1)	Claude (5), Lefors (3), Nacona (51), and Petrolia (46) Tex.: Water supply and sewer systems.....	238,000	
54	Wichita Falls, Tex.: Drainage of irrigated land.....	345,000	Preliminary plans made.
	Indian and public lands: Sealing of abandoned mine shafts and drill holes.....	10,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Altus (23), Apache (19), Comanche (35), Davidson (31), Devol (39), Eldorado (25), Fletcher (20), Grandfield (40), Okla.; Hedley (15), Tex.; Hollis (24), Mangum (17), Marietta (47), Ringling (37), Ryan (45), Sayre (1), Temple (34), Tipton (22), Walters (38), and Waurika (38), Okla.: Construction of sewage treatment plants or improvements to existing plants.	\$243,000	
(1)	Canyon, Harrold (41), Matador (27), and Pottsboro (49), Tex.: Water supply systems or improvements.	216,000	
56	Baylor County, Tex.: Lake Kemp power plant. Installation of 1,400 KW generating capacity to make use of water now wasted.	170,000	Project dependent on agreement of water users not to expand acreage under irrigation and on analysis of flow during recent dry years.
12	Farmer County, Tex.: Dam on Friona Draw for flood control and flow regulation for benefit of town of Friona and Paloduro Canyon Park.	40,000	
(1)	Archer City (57), Childress (26), Crowell (29), Electra (42), Henrietta (52), and Holliday (55), Tex.: Water treatment plants.	200,000	All towns have surface supplies which are unsatisfactorily treated.
(1)	Clarendon (10), Dimmitt (13), Happy (11), Henrietta (52), St. Joseph (50), Shamrock (8), and Vernon (43), Tex.: Sewage treatment plants.	204,000	Additional treatment needed.
(1)	Grayson (48) and Hall (14) counties, Tex.: Malaria control.....	117,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
7	Elk Creek at Sentinel, Okla.: Dam and reservoir for urban water supply, irrigation, flow regulation.	\$416,000	Construction should follow findings of study recommended in group A.
9	Elm Fork at Mangum, Okla.: Dam and reservoir for urban water supply, irrigation, flow regulation.	623,000	
58	Little Wichita at Scotland, Tex.: Dam and reservoir for urban water supply, irrigation, flow regulation.	478,000	
8	North Fork at Lugert, Okla.: Dam and reservoir for urban water supply, irrigation, flow regulation.	1,260,000	
18	Ottar Creek at Mountain Park, Okla.: Dam and reservoir for urban water supply, irrigation, flow regulation.	432,000	Reservoir construction program on North Fork and Salt Fork Rivers must include soil-conservation program on watershed to prevent loss of capacity through silting.
29	Pease River at Crowell, Tex.: Dam and reservoir for urban water supply, irrigation, flow regulation.	4,059,000	
31	Red River at Davidson, Okla.: Dam and reservoir for urban water supply, irrigation, flow regulation.	3,835,000	Approximately 200,000 acres available for irrigation.
16	Salt Fork at Mangum, Okla.: Dam and reservoir for urban water supply, irrigation, flow regulation.	1,081,000	
	Oklahoma and Texas: Irrigation of lands in upper basin in connection with construction of dams and reservoirs recommended elsewhere.	10,000,000	
28	Paducah, Tex.: Water supply from wells and 30 miles of 10-inch pipe line.....	309,000	Both ground and surface waters in this section generally hard.
	Water-softening plants for 40 towns in Oklahoma to serve a population of 70,000.....	350,000	

¹ Map key number shown following community name.
² Per year.

9. WASHITA

The Washita Basin is in the zone of transition between humid and arid climates. It is alternately drenched by "cloudburst" storms and dried by severe droughts. High temperature and low precipitation of July and August result in low stream flow. Therefore, a coordinated long-range plan of water development should center on the construction of a series of reservoirs on the tributaries of the Washita River to control floods, to store water for irrigation and drought relief, to increase the low flow for dilution of wastes, and generally to provide a more reliable water supply. This basic program should be supplemented by complete treatment of urban and industrial wastes and by improvement of the quality of water supplies. Incidental benefits would accrue to water power development and through provision of better facilities for recreation and wildlife conservation. Preliminary studies have indicated the desirability of such a project, its probable feasibility, and general justification, but they should be followed by further and more detailed investigations.

General Description

The Washita Basin contains 7,800 square miles, of which 7,336 are in Oklahoma and 464 in Texas. It is bounded on the north by the Canadian, on the east by the lower Red, and on the southwest by the upper Red River Basins. The Washita River is 658 miles long and has a total fall of 2,163 feet from headwaters 2,700 feet above sea level to its confluence with the Red River near Denison, Tex. In the lower 250 miles of its course the fall averages $2\frac{1}{2}$ feet per mile. Its tributaries are mostly short creeks.

The Washita Basin includes a small portion of the Coastal Plains and the Arbuckle Mountains, Anadarko Basin, and Sand Hills of the Great Plains area. In the Coastal Plains the Washita River has cut a broad shallow flood plain. The Arbuckle Mountains comprise a triangular area about 30 miles on a side. The granite core rises about 1,400 feet above the adjacent plains, and has been eroded by minor streams into a deeply cut fringe of gulches and ravines. The Anadarko Basin is in the central Washita Basin. The Wichita Mountains border a part of the basin rim on the south. Gypsum beds in the "Red Beds" of the basin render much of the ground water in wells and springs unpalatable and unfit for washing. In other areas the ground water supply is satisfactory as to quality, but is generally inadequate in quantity. There are extensive gas fields in the basin, and oil

fields south of the Arbuckle Mountains. The Sand Hills region has been formed by erosion of the headwaters area of the Washita River in the edge of the high plains.

The soils of the Arbuckle Mountains are generally thin and rocky and of low fertility. When the native vegetal cover is cleared, the soils tend to wash and gully badly. The central and upper parts of the basin are fertile prairie soils which tend to erode when the grass cover is plowed under. The Washita and its principal tributaries have eroded broad troughs some 200 feet deep. There are 432,000 acres of bottomland of which about half is subject to overflow. The native vegetation of the eastern third of the basin is typically post and blackjack oak on the mountain ridges, with some hardwoods on the bottom lands. In the western third grasses prevail and most streams are tree-lined.

The 1930 population of the Washita Basin was about 250,000 of which 65 percent was rural. There are 8 cities of 2,500 or more inhabitants. The average population per square mile is 21.6. In cattle ranch and waste land areas it is as low as 5, and in the central part it is as much as 50.

Farming and stock ranching about equally divide the Washita Basin. Wheat, corn, cotton, and grain sorghums are the chief crops in the western part. Cotton is dominant, with some wheat and alfalfa in the central and eastern parts. Pecan and peanut production are increasing in the eastern part.

Some 200 cotton gins, compresses, and oil mills are operating in the basin. Oil refineries are located along the south-central border. Gypsum, limestone, asphalt, granite, and clay deposits are exploited. Few factories are situated in the basin. The basin is well provided with gas and electric facilities.

The average annual temperature is 61.5° , with an average of 59.5° in the upper and 63.4° in the lower end of the basin. Temperatures range from 116° above zero to 17° below. The growing season is 209 days long in the upper part, and 244 days long in the lower part. The average precipitation is 29.6 inches per annum, ranging from 27 inches in the upper to 38 inches in the lower basin. Storms of the "cloudburst" type are frequent, and cause damaging floods. It is not unusual for crops to be injured by both floods and drought in the same year. The average annual run-off for the entire basin is 2.8 inches, but at the western end in some years it may be as low as 0.9 inch.

Coincidence of low rainfall and very hot weather in July and August often gives rise to severe drought conditions. At Hammon, Okla., toward the headwaters of the basin, the average precipitation for each of these two months is about 2.2 inches, but in recent years it has often been much less.

The discharge of the Washita River at Durwood, Okla., near the mouth, averaged 1,470 cubic feet per second for the years 1929–35, inclusive. The greatest average annual discharge was 2,140 cubic feet per second in 1935, and the smallest, 842, in 1934. The greatest discharge of record at Durwood was 35,400 second-feet on May 19, 1935.

Recommended Plan

A coordinated, long-range plan of water development for the Washita Basin should have for its purpose the solution of the four major problems, flood control, drought relief, pollution abatement, and improvement of water supplies. For a number of years a comprehensive plan of tributary reservoirs has been advocated to attain these objectives. The present plan includes 25 reservoirs, all but one of which are on the tributaries of the Washita River. Part of the capacity of each reservoir would be used to store water for *irrigation* and part would be reserved for *flood control*.

As proposed by the Oklahoma water resources committee these reservoirs would have a combined storage for irrigation of 472,000 acre-feet with 348,000 acre-feet for flood control. The irrigation storage would equal the estimated average annual run-off, which varies from 1.2 inches of depth on the drainage area at the western end of the basin to 4 inches at the eastern end. The space reserved below the spillway level for flood storage would be equivalent to 2 inches depth on the watershed, but some further storage, assumed to extend 5 feet above spillway level, could be used in reducing floods. The cost of the combined project is estimated at \$10,767,600. The cost of individual reservoirs would range from \$6 to nearly \$48 per acre-foot of capacity below the spillway level.

Data bearing on the practicability of this project have been collected by the Oklahoma water resources committee. A preliminary study of some of the hydrological phases has been made by the water consultants. The sites of the basins have been surveyed, their capacities computed, and the costs of the dams estimated. Run-off records, as far as available, have been collected, and rainfall and evaporation records have been assembled. A small amount of data has been collected on the frequency of floods. The studies made have shown that the proposed development is badly needed, and that it would be of great benefit to the basin.

The release of water into the stream channel for irrigation would bring benefits in diluting sewage and other wastes and in improving the quality of water for public water supplies drawn from the river. Some benefits would accrue in providing recreational facilities and in the conservation of wildlife. The increased flow of the river might bring a small incidental benefit to water power.

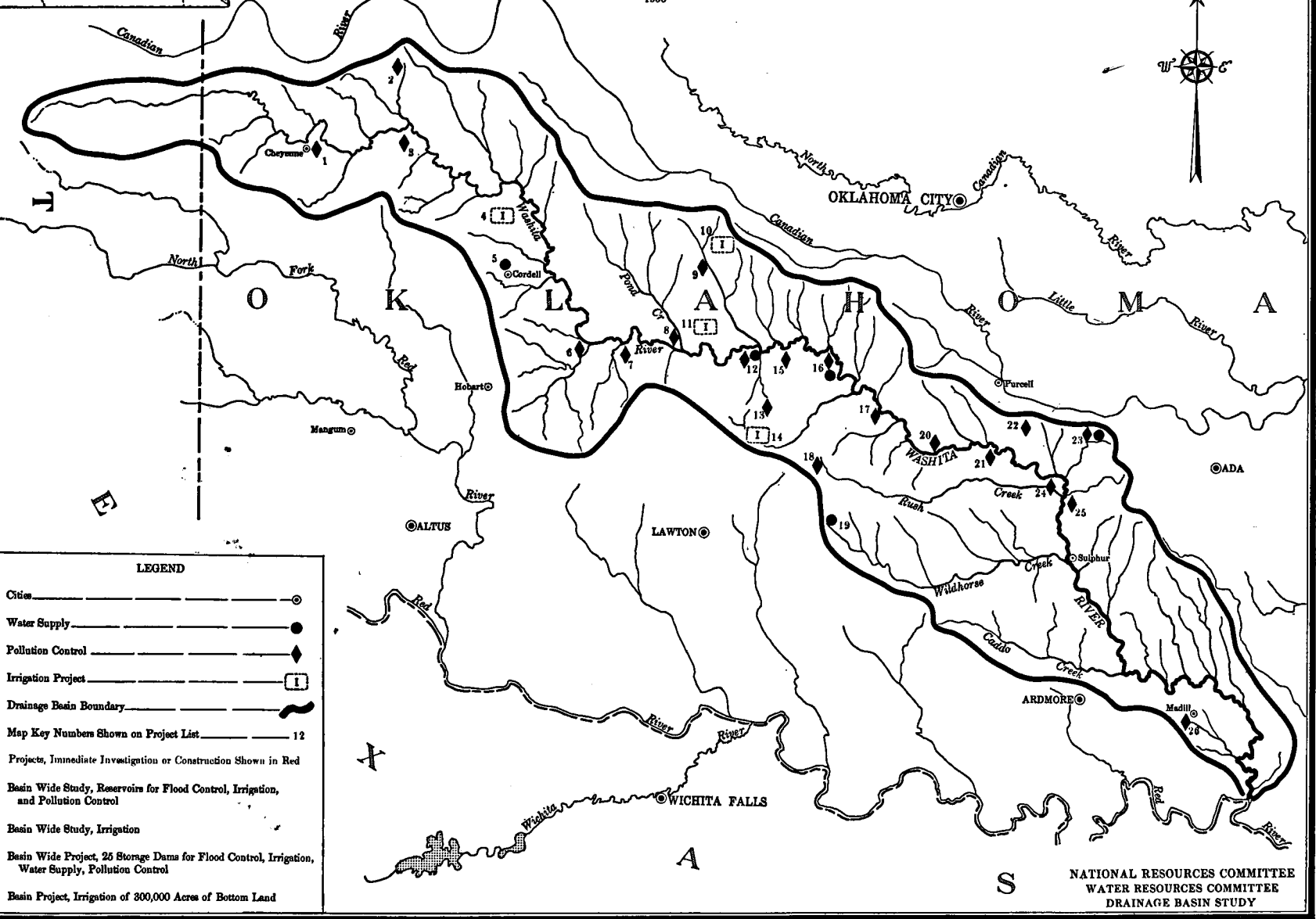
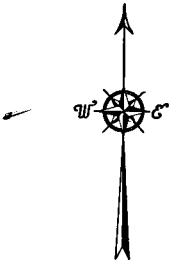
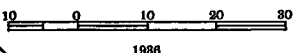
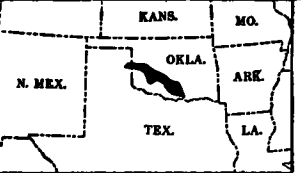
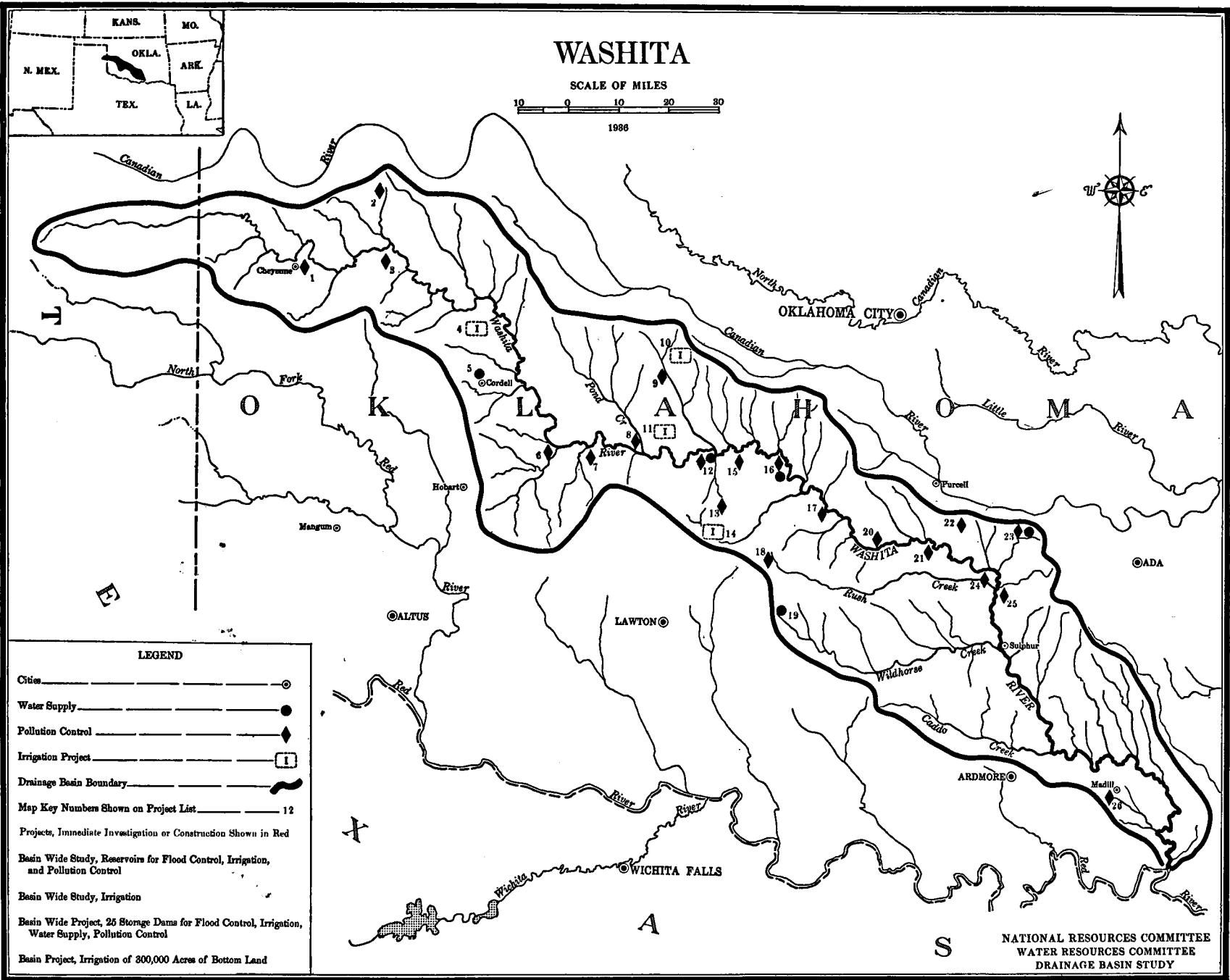
Perhaps the greatest uncertainty is with regard to the irrigation phases, since irrigation heretofore has not been practiced in the valley. Because farms are small, irrigation to be successful must be carried on by united effort through some sort of organization, with a system of ditches, and perhaps pumps for raising the water. The cost of constructing and operating such a system must be known before it can be established that the water will be used for irrigation even if the storage is provided. The more easterly of the storage reservoirs are in a region where the rainfall is usually adequate and the necessity for irrigation is not evident. Here the expense must be shown to be warranted for flood protection and sanitation.

Some of the storage projects in the plan appear much more expensive than others, but the data are insufficient to establish either the necessity for the more expensive ones, or the advisability of abandoning them. More data are desirable on the available water supply from the tributaries in dry years, and on the frequency and magnitudes of floods.

A study of the valley for possibilities of flood control, navigation, irrigation, and water power was made by the Corps of Engineers. The report did not consider any work in the basin economically justified. However, not all phases of water conservation were considered.

Much of the flood damage occurs where the tributaries of the Washita cross the valley of the main stream in poorly defined channels. Storms covering more than a few of the tributaries at a time are rare, and the peaks of the most severe floods flatten quickly in the main river. Available data indicate that floods occur annually on the tributaries in the upper portion of the basin, about every other year in the middle portion, and about once in 4 or 5 years in the lower portion.

Pollution.—The Washita and many of its principal tributaries are badly polluted. Two of the larger towns in the valley, Anadarko and Pauls Valley, Okla., discharge their sewage directly into the river without treatment. Some pollution is caused by salt water from oil wells. All but 2 of the 24 urban centers have some form of sewage disposal, but only 6 have adequate treatment facilities. Complete treatment of all urban and industrial wastes should be included in the plan.



Water supplies drawn from the river at Anadarko and Chickasha, Okla., are polluted by sewage from the upstream towns. Several other towns in the basin need additional water-treatment facilities. All of the 35 towns, however, have public water supplies, 27 of which are drawn from wells.

Improvements should be made in the quality of rural and urban water supplies. With rising standards, softening and demineralization will probably be introduced, especially in those areas where the waters have a disagreeable gypsum content.

Better facilities for recreation and wildlife conservation should be provided in the basin. The construc-

tion of flood correction works would permit the development of park sites along the river now undeveloped because of frequent flooding.

Any development of the Washita Basin should be coordinated with improvements on the Red River at Denison, Tex. If flood storage is provided in the Washita Basin less will be necessary at Denison, and the development of warranted projects, similar to that of the Washita, in several sub-basins of the upper Red River would call for fundamental changes in the Denison project, or might lead to its abandonment. The Denison project is now being studied thoroughly by the Corps of Engineers.

Washita Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of proposed plan to construct 25 reservoirs on tributaries of Washita River for flood control, irrigation, water supply, and maintenance of adequate dry-season flow for dilution of sewage and other wastes, in the Washita Basin, Okla. The study shall include the determination of the value of such reservoirs and the collection of all necessary data for the preliminary plans for the proposed reservoirs and their use.	\$180,000	
	Study of practicability of irrigation in the basin in Oklahoma and Texas.....	50,000	
(1)	Anadarko (12), and Paul's Valley (24), Okla.: Complete sewage-treatment plants.....	65,000	
(1)	Alex (17), Binger (9), Carnegie (7), Cement (13), Chickasha (16), Davis (25), Fort Cobb (8), Hammon (3), Leedey (2), Lindsay (20), Madill (26), Maysville (21), Mountain View (6), Rush Springs (18), and Verden (15), Okla.: Secondary sewage-treatment plants.....	107,000	
(1)	Anadarko (12), Byars (23), Chickasha (16), Cordell (5), and Marlow (19), Okla.: Water supply....	174,000	
23	Byars, Okla.: Sewage-treatment plant.....	31,000	
22	Wayne, Okla.: Sanitary sewers.....	20,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
	Oklahoma: 25 reservoirs for flood control, irrigation, flow equalization, and water supply.....	\$1,500,000	Subject to confirmation or modification after completion of study project. Cost given is for first 2 years. Additional needed to complete, \$9,268,000.
1	Cheyenne, Okla.: Sewer system and sewage-treatment plant.....	100,000	Do.
	Washita River Basin, Okla.: Irrigation of 300,000 acres of bottom land.....	7,500,000	
	Caddo (11), Canadian (10), Comanche (14), and Washita (4) Counties, Okla.: Small irrigation projects for Arapaho, Cheyenne, and Kiowa Indian Reservations: Water supply from wells and Washita River.....	57,000	

¹ Map key number shown following community name.

10. LOWER RED

Floods in the lower Red River Basin inundate at frequent intervals valuable agricultural land. To provide complete protection probably is not warranted, but protection from minor overflows would enhance the value of these lands and might be provided by a system of retention reservoirs which also would contribute other benefits.

General Description

The lower Red River Basin includes the drainage of the Red River from the mouth of the Washita, just upstream from Denison, Tex., to the edge of the Mississippi River lowlands in the vicinity of Alexandria, La., a stream distance of 638 miles. The basin includes some 27,500 square miles, of which 4,500 are in Arkansas, 8,150 in Oklahoma, 9,450 in Texas, and 5,400 in Louisiana.

The tributaries entering from the north, the Blue, Boggy, Kiamichi, and Little Rivers, rise in the Arbuckle and Ouachita Mountains. The upper and middle parts of their courses have steep gradients. Their lower courses are in the border of the Coastal Plain where they have developed broad fertile flood plains. Their basins include 12,400 square miles, much of which is rugged, with rocky, poor soils, and is generally forested. In the northwest coal is mined from extensive reserves. Some oil and gas have been produced in the upper Blue Basin. Granite and marble are quarried at several places.

The Sulphur, Cypress, and Dorcheat Rivers are tributaries in the lower or southern part of the basin. They lie in the Gulf Coastal Plains. Their headwater altitudes are about 500 feet and the altitudes of their mouths about 150 feet. They have meandering channels and sluggish flow. The topography of their basins is gently rolling. The soils of the valleys are fine-textured and very fertile, but this bottom land is subject to frequent flooding. Adequate protection from floods would greatly enhance its value and productivity. The bottom lands are generally wooded with cypress and gum trees. In the extreme southern parts of the Red River Basin below Shreveport, much of the bottom is swampy, although some land has been reclaimed by levees. The interstream uplands are generally farmed where rich, black, waxy soils prevail, and are in pine forests where the soils are sandy. Cotton, fruits, nuts, and vegetables are raised on a commercial scale.

The mean annual temperature is about 63°. The January mean is 50° and the July mean is 77°. The

growing season ranges from 250 days in the southeast to 230 days in the northwest. The basin is humid. The poorly drained valleys afford widespread breeding places for mosquitoes.

The total population of the basin is about 1,081,500 of which about 474,500 are in Texas, 313,900 in Louisiana, 156,600 in Oklahoma, and 136,500 in Arkansas. In the coastal plains there are several important cities, including Shreveport with 76,600 population, Alexandria, 23,000, and Natchitoches, 4,500, in Louisiana; Texarkana, 27,300, in Arkansas and Texas; Marshall, 16,000, Sherman, 15,700, Paris, 15,600, and Denison, 13,800, in Texas; Hope, 6,000, in Arkansas; and Durant, 7,400, and Hugo, 5,300, in Oklahoma.

Throughout this section the main stream traverses a rather wide overflow plain having a sandy channel of from 1,000 to 1,500 feet in width. The slope of the stream averages about 1 foot per mile in the upper part of this reach and less than 6 inches per mile in the lower portion. Low-water flows range from 300 cubic feet per second at Denison to more than 1,000 below Fulton. Flood-flows below Denison have exceeded 150,000 cubic feet per second and at Shreveport 250,000 cubic feet per second.

Recommended Plan

Flood control.—Possibilities of completely protecting fertile lands from flood damages have been exhaustively studied by the Corps of Engineers. The protection of such lands against maximum expected floods would involve costs far in excess of probable benefits. For this basin, the best plan of flood protection was found to be that of detention reservoirs. A system of reservoirs to protect the lands along the Red River itself was proposed, most of them in the lower reaches of the tributaries. In most of the valleys, satisfactory reservoir sites with more than half the total area tributary to them were found. These were investigated also in combination with channel improvement. This particular investigation involved the warrantability of complete protection of these bottom lands from floods and it was found again that the cost would be considerably in excess of the probable benefits.

In view of the fact that the best plan of flood correction involved the use of reservoirs and that a reservoir scheme can be developed to give any desired degree of protection, and in view also of the apparent need of water storage on certain of the tributaries for other purposes, an additional investigation of flood protection by reservoirs is desirable. A plan might be de-

veloped to reduce the frequency of minor floods, possibly limiting the overflow of good agricultural lands to once in about 5 years.

The State Department of Reclamation of Texas has proposed a plan of channel improvement and floodway development for the Sulphur River which apparently would protect its valley from local floods. This plan should be given serious consideration, but it is possible that increased flood flows at the mouth of the Sulphur would result. This would appreciably increase flood peaks and flood damages on the Red River below.

For the streams flowing out of the Kiamichi Mountains and from the southwestern slope of the Ouachita Mountains, water storage for power may possibly be worked into a multiple-purpose program. Certain projects proposed by the board of State engineers of Louisiana appear to be in accord with the long range plan, and are recommended for study.

Navigation.—Extensive studies by the Corps of Engineers for developing reliable navigation on the Red River indicate a cost for such a project far in excess of the benefits.

Hydroelectric power.—Studies of the power possibilities in this basin also have been made by the Corps of Engineers, which concluded that construction solely for power will not be justified in the near future, either on the main stream or on its tributaries. However, the cost of power production at the Antlers site on the Kiamichi and at the Eagletown and Yashoo sites on the Mountain Fork of the Little River appears to be sufficiently low to justify further consideration, particularly in connection with the storage of water for multiple uses. Such possibilities at the Denison site are now being studied further.

Drainage of agricultural lands in the Oklahoma and Texas sections of the basin is not extensive. In Arkansas and Louisiana, however, most of the land included in levee districts has been drained. In Arkansas 135,000 acres are in drainage districts. Most of the districts have been in financial difficulties and the facilities are commonly in a state of disrepair. Extensive rehabilitation of the drainage structures is needed.

To the extent that fertile lands in Oklahoma are relieved of frequent flooding and their productivity cor-

respondingly increased, further installation of land drainage may be justified.

Water supply.—In the Oklahoma section of this basin 11 of the cities, generally the larger ones, depend on surface water supplies. Nine use underground water. Surface waters are generally soft, but are subject to serious pollution at some places. In Arkansas, Nashville uses surface water, Texarkana surface water in part, and all other towns underground water. The underground water is adequate at present, but probably will not serve any large increase in population. Wider use of surface water supplies is indicated in the future. In the Texas area, in addition to Texarkana, Sulphur Springs is using surface water. The other cities use underground water, which is available at shallow depths. A thorough study of underground water resources for the whole area is needed. Complete information with regard to urban water supply in Louisiana is not available.

Abatement of pollution of certain surface water supplies through improvement of stream flow is needed. Rural water supply has not been a serious problem except that in parts of the Oklahoma area water for stock has been inadequate during dry summers. Construction of small reservoirs for stock watering would help.

Pollution.—All of the Oklahoma cities of sufficient size to have sewer systems have some form of treatment. In many cases, however, this consists of only preliminary settling, and appreciable stream pollution results. In Arkansas, all but three of the cities have sewer systems and some form of treatment, but complete sewage treatment is needed because some streams are dry in summer. In the Texas area, Denison is discharging raw sewage into Red River. Improvement of sewers and sewage treatment is recommended for a number of the smaller cities.

Recreation.—There is a serious lack of water areas for recreational purposes. Caddo Lake, on lower Cypress Creek, with about 50,000 acres, is used for recreational purposes, as are many of the oxbow lakes along the Red River, particularly in Arkansas. The construction of reservoirs for water supply, flood control or power, in the mountainous sections of Oklahoma and Arkansas, would provide recreational opportunities.



Lower Red Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
(1)	Arkansas, Louisiana, Oklahoma, and Texas: Blue River (8), Boggy Creek (11), Kiamichi River (27), Little River (43), Sulphur River (60), Cypress Creek (90), Bayou Bodcan (82), and Bayou Dorcheat (81): Study of reservoirs for partial flood control in connection with water power.	\$200,000	
34	Pollution survey in Arkansas, Louisiana, Oklahoma, and Texas. Study of reservoir possibilities at Denison, Tex., in connection with tributary reservoirs in the basin for power and flood control.	20,000 50,000	Further development of studies now in progress, under authority of Congress.
(7)	Atoka (10), Bryan (32), Choctaw (28), and Coal (6) Counties, Okla., Fannin (36) and Hunt (66) Counties, Tex., Johnston (8), Latimer (3), Le Flore (1), and McCurtain (22) Counties, Okla., Miller (54) County, Ark., Pittsburg (4) and Pushmataha (15) Counties, Okla., and Sevier (20) County, Ark.: Study of small water conservation projects.	25,000	For summer supply in areas lacking adequate ground water.
(7)	Atoka (10), Okla., Bailey (64), Bloomsburg (75), and Commerce (67), Cooper (61), Tex., Dierks (18), Ark., Dodd City (37), Tex., Durant (31), Okla., Ector (35), and Hallsville (89), Tex., Lewisville (77), and Magnolia (80), Ark., Mooringsport (92), La., Mount Pleasant (72), Tex., Ringgold (98), Robeline (101), La., Sherman (33) and Trenton (65), Tex., Valliant (26), Okla., and Waskom (95), Tex.: Water supplies or improvements.	706,000	Preliminary plans made.
(7)	Atlanta (74), Daingerfield (86), Detroit (41), Omaha (73), Pecan Gap (63), Pittsburg (87), and Texarkana (56), Tex.: Water supply and sewer systems or improvements to existing systems.	968,000	Plans made.
(7)	Avery (42), Tex., Barksdale Field (96), La., Blossom (40), Tex., Dierks (18), Ark., Gilmer (88), Tex., Magnolia (80) and Mineral Springs (49), Ark., New Boston (57), Tex., Shreveport (94), La., and Waskom (95), Tex.: Sewer systems and sewage treatment plants or improvements to existing facilities.	407,000 357,000	Preliminary plans made.
(7)	Ashdown (48), Cove (17), DeQueen (44), Foreman (47), Fulton (53), Garland (76), Hope (52), Horatio (45), McNeill (79), Ark., Pittsburg (5), Okla., Stamps (78), Ark., Talihina (2), Okla., and Washington (51), Ark.: Water supply systems and water improvements.	234,000	
(7)	Antlers (13), Okla., Ashdown (48), Ark., Atoka (10), Caddo (30), and Coalgate (6), Okla., Cove (17), DeQueen (44), Foreman (47), Fulton (53), Garland (76), Hope (52), and Horatio (45), Ark., Hugo (29), Okla., Lewisville (77), Locksburg (46), McNeill (79), and Nashville (50), Ark., Pittsburg (5), Okla., Stamps (78), Ark., Talihina (2), Okla., Texarkana (55) and Washington (51), Ark.: Sewer systems and sewage treatment plants.	477,000	
97	Arkansas, Oklahoma, Louisiana, and Texas: Malaria control.	1,000,000	
	Bossier Parish, La.: Bayou Bodcan diversion floodway involving 33.5 miles of levee and 3 miles of ditches to carry waters of Bayou Bodcan and Cypress Bayou to Red River. For protection against headwaters floods.	1,893,000	Authorized by Congress. Detailed plans in preparation.
100	Desoto, Natchitoches, and Red River Parishes, La.: Enlargement of drainage channels through Bayou Pierre and Bayou Pierre Lake from Bayou Wincesy to the north at Grand Ecore for protection against headwaters floods.	300,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
	Small water conservation projects in 14 counties in Arkansas, Oklahoma, and Texas.....	\$500,000	Locations and plans dependent on study project group A.
(1)	Cumby (69), DeKalb (58), Denison (34), Honey Grove (33), Hughes Springs (85), Linden (84), Mount Vernon (71), Sulphur Springs (70), Tex.: Sewage treatment plants.	198,000	Cost estimate approximate.
	Antlers (13), Broken Bow (23), and Isabel (25), Okla.: Sulphur Springs (70), Tex.: Water supply improvements.	95,000	Do.
83	Caddo Parish, La.: Black Bayou Dam and Reservoir.....	125,000	Authorized by Congress.
99	Caddo Parish, La.: Wallace Lake Dam for storage of floodwaters.....	400,000	Do.
81	Bienville Parish, La.: Construction of earth filled dam 7,265 feet long, across Bayou Dorcheat, for restoration of Lake Bistenau for fish and game preserve.	71,000	
GROUP C—TIME OF STARTING INDETERMINATE			
(1)	Antlers (14), Kiamichi River; Bossier (32), Bodcan Bayou; Caddo Lake (93), Cypress Creek; Darden (59), Sulphur River; Eagle Town (21), and Yashoo (16), Mountain Fork River; Idabel (24), Little River; McGee (12), Muddy Boggy Creek; Sandy Creek (9), Blue River; Springhill (81), Dorcheat Bayou; and Tupelo (7), Clear Boggy Creek; Flood control and power reservoirs.	\$20,000,000	To be restudied in connection with study project.
62	Delta County Levee improvement district No. 2, Texas: Levees and channel improvements.....	25,000	Preliminary plans made.
68	Hopkins County Levee improvement district No. 4, Texas: Levees.....	100,000	Do.
39	Lamar County Levee improvement district No. 3, Texas: Levees and channel improvements.....	71,000	Do.
62	Sulphur River, Tex.: Channel improvement.....	1,310,000	Do.
91	Black Bayou and Twelve Mile Bayou in Caddo Parish, La.: Construct 18-mile levee along east bank of Black Bayou and Jefferson Canal: 5-mile levee along east bank of Twelve Mile Bayou, north of Shreveport. Includes drainage structures. To protect against headwater overflows.	1,005,000	Preliminary plans completed.

¹ Map key number shown following stream name.
² Map key number shown following community name.

11. OUACHITA

The plan for the best use of water resources in the Ouachita River Basin should include pollution abatement projects, installation and improvement of water-supply systems, malaria control through land drainage, and stream regulation by the construction of a large dam and reservoir which, by decreasing flood crests and increasing low-water flow, will reduce pollution, improve the quality and safety of water supplies, decrease flood damage and develop electric power.

General Description

The area under consideration is that part of the Ouachita Basin above the Mississippi bottom lands. Although the Ouachita River below Camden, Ark., is excluded, the headwaters flowing into the main stream above that point are included. Three-fourths of the area of 17,600 square miles is in Arkansas, the remainder in Louisiana. Twenty percent of the region lies in the Ouachita Mountains; a series of narrow valleys and long ridges with crest lines varying from 500 to 2,000 feet above sea level. This watershed area is drained by the upper 115 miles of the main stream and by numerous short tributaries forming a trellislike pattern. Stream slopes are steep, averaging 12 feet per mile. After leaving the mountains the Ouachita flows, with a fall of about 3 feet per mile, through the Coastal Plain, which slopes slightly to the south with a gently rolling surface averaging 250 feet in altitude.

Living within the basin are 480,000 persons, one-quarter in cities and towns. There are three cities with more than 10,000 inhabitants each. Rural population is decreasing, and the population of the industrial towns is increasing. In oil and lumber towns wide fluctuations of population occur.

Although lumbering, mining, and oil now dominate the basin's economic life, the early history of the region was entirely agricultural. Cotton plantations were first established on the rich alluvial bottom lands, followed by cultivation of the less fertile mountain valleys as the timber was cleared. Aside from the flood plains the soils of the area are generally poor, particularly in the mountains.

When aluminum assumed commercial importance, the mining of bauxite in Saline County, Ark., was started. Ore reserves in this deposit are estimated at 30,000,000 tons. Large increases in population followed the opening of the Caddo oil field in Louisiana in 1906 and the Smackover field in Arkansas in 1922. Manufacturing in the basin consists chiefly of process-

ing its raw materials. Besides petroleum products, including such derivatives as carbon black and printers' inks, the region produces lumber, furniture, paper, textiles, brick, tile and processed bauxite ore.

The average annual temperature in the basin is 65°, ranging from 43° in January to 83° in July. Average annual rainfall is 50 inches, being heaviest in the winter months. Run-off in the mountainous section is large, and there heavy rainfall, steep slopes and narrow valleys result in frequent floods. During dry weather, on the other hand, stream flow dwindles to small proportions. The result is an unusually large variation between minimum and maximum flows, with a flood peak 4,000 times the smallest recorded discharge. On the coastal plain, the flood waters spread through wider valleys which suffer considerably from floods.

Recommended Plan

Improved public health is the objective upon which are centered present problems and immediate plans for this basin. The objective is approached from several angles: decreased stream pollution, better water supplies, and the reduction of malaria.

Stream pollution in the Ouachita Valley comes from two sources, industrial wastes from oil fields and paper mills, and raw or insufficiently treated urban sewage. Oil-field pollution can be expected to diminish gradually as the fields are depleted, but further growth of the paper industry seems probable, and the result may be a net increase in industrial pollution.

In addition to the Caddo and Smackover oil fields, the paper mills at Hodge and Monroe, La., are sources of pollution. Another paper mill now being built at Crossett, Ark., will soon be adding its contribution to the pollution load.

No definite alleviation project is recommended at this time, because, although many paper-mill wastes are treated, no completely satisfactory treatment has been found for the wastes from the sulphite process used in this region. For the time being the best remedy is dilution by increasing minimum stream flow, but any substantial increase in the number of mills will require more direct methods.

The discharge of raw sewage from municipalities within the basin is an almost universal practice. Hot Springs is the only town of considerable size providing complete treatment. In Arkansas, the cost of needed betterments to existing sewer systems and disposal plants during the next 15 years is estimated at \$466,000,

new construction at \$351,000. Immediate construction of new systems is recommended at four towns. The Arkansas State Planning Board has listed 26 other towns where such construction is advisable, but in most instances plans have not been prepared for these projects.

No corresponding figures are available for Louisiana, where basic data are lacking, but it is known that new sewer systems or extensions are needed at several towns.

Water supplies throughout the Coastal Plain are derived principally from underground sources. Although apparently ample in quantity, these waters are frequently of poor quality. In a number of smaller towns new public systems or extensions are needed. Definite information on quantity and quality of underground water resources is lacking, and it is recommended that a thorough study be made to provide basic data for further utilization of this resource.

In the mountains and in a narrow zone southeast of them only small amounts of underground water are available. Most of the towns along the main river below Malvern, Ark., draw their supplies from it and during low-flow periods suffer from deterioration of quality of supplies. Better regulation through a plan described later is the obvious remedy here.

Malaria control is a matter of considerable importance for this basin. Projects in this classification costing in all about \$75,000 have been approved by the Works Progress Administration. These should be completed, but no definite recommendations for future work can be made until more data become available. A thorough study of this question and the preparation of a definite program are advisable.

Flood control and power possibilities in the Ouachita Basin are limited to a small part of the river's length. Along the greater part of its course frequent floods of

considerable height have retarded or prevented the development of land near the channel, and very little of it has even been cleared. Protection would be expensive and unjustified.

The only major flood-control project which seems feasible is that along the upper part of the Coastal Plain section where the land is fertile and has been partly cleared for cultivation. Construction of a large reservoir at Blakely Mountain, using the upper 12 feet of depth for the storage of flood peaks and the lower section for power generation, would give satisfactory protection to 24,000 acres between Malvern and the mouth of the Caddo River and partial protection to 8,000 additional acres between that point and Arkadelphia. In addition, it would increase low-water stream flow, providing greater dilution for pollution and reducing the deterioration of water supplies. This reservoir and power project is now being considered for immediate construction by the holder of a Federal Power Commission license.

Another flood-control problem which needs further study is at Hot Springs, where floods caused by sudden heavy rains frequently overflow parts of the city.

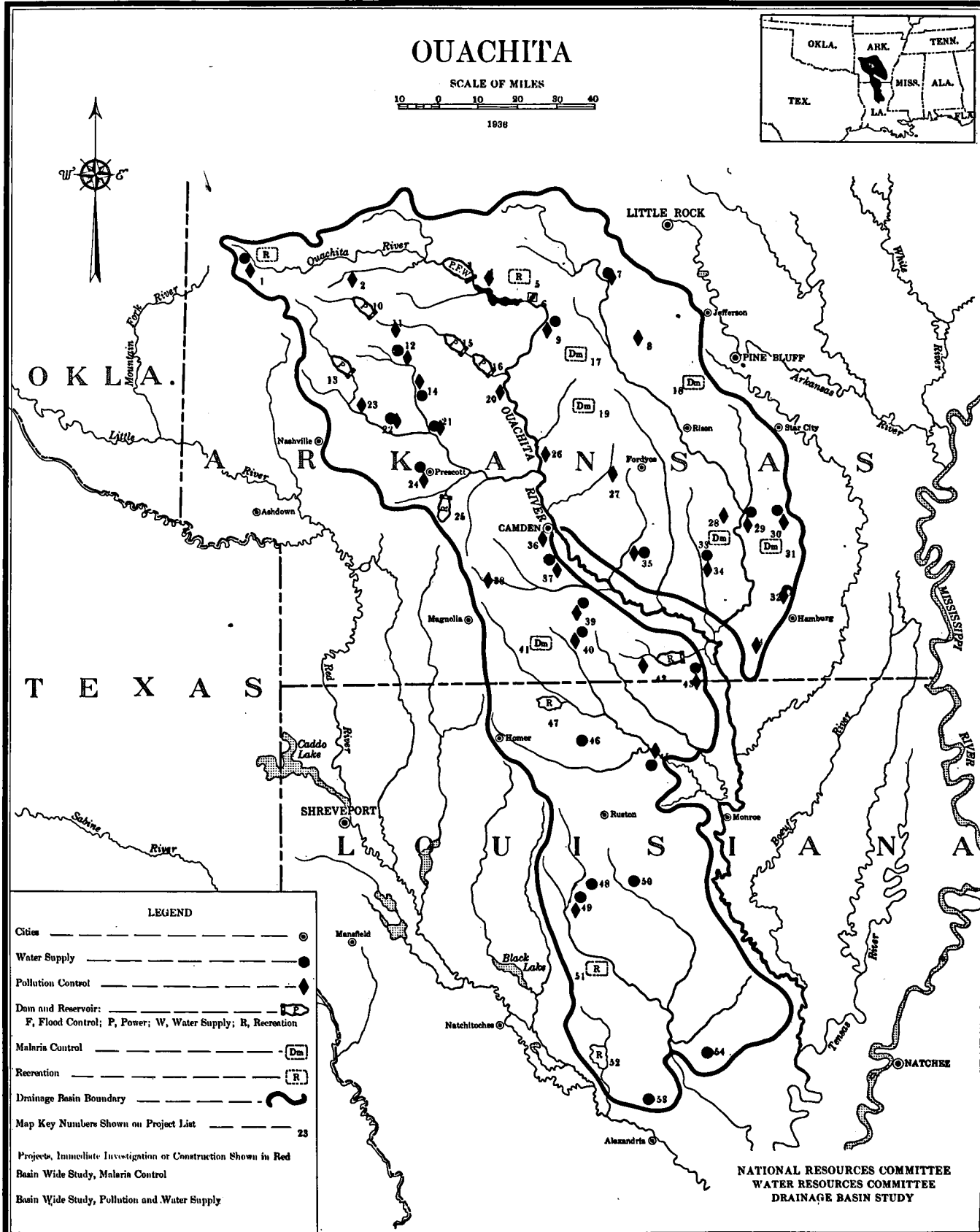
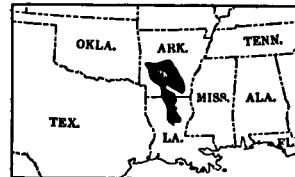
Recreation facilities in the Ouachita Basin consist principally of Hot Springs National Park and the Ouachita National Forest, but additional developments are planned. Projects of the Resettlement Administration in Claibourne and Webster Counties, La., include three lakes for fishing, bathing, boating, and camping. The Louisiana State Park Commission recently acquired three lakes for future development. Arkansas has State parks near Mena, Prescott, and Strong, and an undeveloped tract on Lake Catherine which could readily be developed for recreational use. Further improvement of these areas and the acquisition of others is recommended.

OUACHITA

SCALE OF MILES



1936



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir: ———— [Dm]
- F, Flood Control; P, Power; W, Water Supply; R, Recreation
- Malaria Control ———— [Dm]
- Recreation ———— [R]
- Drainage Basin Boundary ———— [Wavy Line]
- Map Key Numbers Shown on Project List ———— 25

Projects, Immediate Investigation or Construction Shown in Red

Basin Wide Study, Malaria Control

Basin Wide Study, Pollution and Water Supply

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

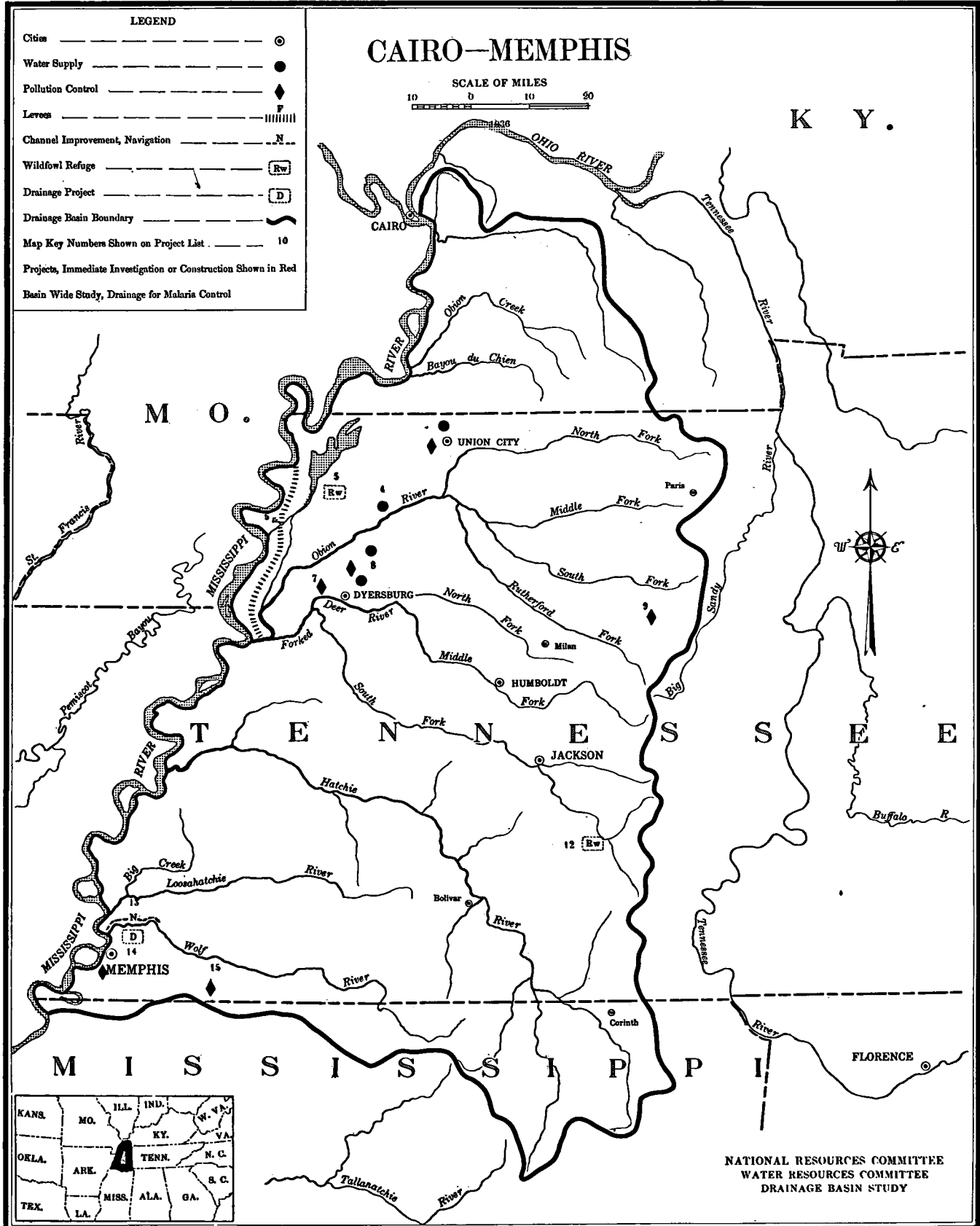
Ouachita Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study to collect and analyze data on water resources to draw up water plan for entire basin, including consideration of sanitation and water supply.	\$80,000	
(1)	Amity (12), Ark.; Farmerville (45), and Jonesboro (49), La.; Murfreesboro (23), Sparkman (26), and Stephens (38), Ark.: Sewer systems and sewage-treatment plants.	234,000	Preliminary plans made.
(1)	Amity (12), and Benton (7), Ark.; Bernice (46) and Chatham (50), La.; Delight (22), Ark.; Farmerville (45), La.; Fountain Hill (32), and Hampton (35), Ark.; Hodge (48), Jena (54), and Jonesboro (49), La.; Okolona (21), Ark; and Pollock (53), La.; Waterworks, water supply systems or improvements.	358,000	Do.
	Malaria control project throughout basin.....	100,000	10-year program.
GROUP B—FOR DEFERRED CONSTRUCTION			
3	Hot Springs, Ark.: Dam at Blakely Mountain for power, flood control, and improvement of downstream water supplies.	\$13,442,000	Preliminary plans made.
6	Malvern, Ark.: Increase of installed capacity of generating plant of Remmel Dam to utilize draw-down from Blakely Mountain Reservoir.	760,000	Do.
(1)	Arkadelphia (20), Benton (7), Camden (36), Crossett (44), El Dorado (40), Huttig (43), Louann (37), Malvern (9), Mena (1), Monticello (30), Norphlet (39), Prescott (24), Sheridan (9), and Warren (28), Ark.: Sewage-treatment plants and/or improvement and extension of sewer systems.	382,000	
	Graysonia (14), Hermitage (34), and Wilmar (29), Ark.: Water supply systems.....	62,000	
(1)	Delight (22), Fountain Hill (32), Graysonia (14), Hampton (35), Hermitage (34), Mount Ida (2), Okolona (21), Rosboro (11), Strong (42), Thornton (27), and Wilmar (29), Ark.: Sewer systems.	228,000	
(1)	Huttig (43), Louann (37), Malvern (9), Mena (1), Monticello (30), Norphlet (39), and Prescott (24), Ark.: Improvement to water supply systems.	104,000	
4	Hot Springs, Ark.: Improvement of storm water sewers for flood control.....	250,000	
(1)	Corney Lake (47) and Dugdama Bayou (57), La.; Hot springs (5), Ark.; Iatt Lake (52), La.; and Mena, (1) Ark.: Park development, improvement of streams and lakes for recreational purposes.	470,000	
(1)	Bradley (33), Dallas (19), Drew (31), Hot Springs (17), Jefferson (18), and Union (41) Counties, Ark.: Malaria control.	96,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
40	El Dorado, Ark.: Water supply system.....	\$275,000	Plans made.
16	Arkadelphia, Ark.: DeGray Dam and Reservoir on Caddo River for development of power.....	2,121,000	Preliminary plans completed.
15	Arkadelphia, Ark.: Lennox Dam and Reservoir on Caddo River for development of power.....	2,326,000	Do.
10	Montgomery County, Ark.: Caddo Gap Dam and Reservoir on Caddo River for development of power.	2,516,000	Do.
13	Murfreesboro, Ark.: Narrows Dam and Reservoir on Little Missouri River for development of power.	2,162,000	Do.
25	Prescott, Ark.: Park, including dam and artificial lake for recreational purposes.....	100,000	
42	Strong, Ark.: Park, including dam and artificial lake for recreational purposes.....	150,000	

1 Map key number shown following community name.

LOWER MISSISSIPPI DRAINAGE BASINS

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1. CAIRO-MEMPHIS

Control of the tributary waters between Cairo, Ill., and Memphis, Tenn., presents two major problems—drainage in the upland area to improve productive lands, correct malarial conditions, and minimize soil erosion; and levee construction to protect lowlands.

General Description

This area is drained by four streams—Mayfield Creek, Obion River, Hatchie River, and Wolf River. Included are the western ends of Kentucky and Tennessee and a small section of northern Mississippi. Topographically, the area is divided into two distinct parts, the upland region on the east and the low alluvial lands along the Mississippi River on the west.

Extensive forest growths originally covered this area, but most of the land has been cleared and is under cultivation except where rendered unfit by erosion. In the uplands the predominant soil is sand-clay toward the east and loess toward the west. Between the bluffs and the river are rich alluvial soils.

The population of the area in 1930 was 829,000, most of which was rural. Memphis, Tenn., with 253,153, is the largest city. Five other cities have populations of more than 6,000.

Agriculture is the principal industry; the most important products are cotton, corn, tobacco, garden truck, hogs, and cattle. Logging operations and the manufacture of wood products are activities of lesser and decreasing importance.

The average annual rainfall is 49 inches. Variations in stream flow are very wide; the maximum flood discharges of the four principal streams are 150 to 430 times the low-water flow. Underground waters are abundant and of good quality. Flowing and nonflowing wells are numerous and are the principal sources of urban and rural water supplies. Memphis obtains its water supply for all uses by pumping from a system of artesian wells.

Recommended Plan

Drainage is a prime necessity in the bottom lands of this area. The problem is presented chiefly in the valley bottoms of the eastern upland region where there are swamps that are not only useless but also promote breeding of mosquitoes and the spread of malaria. Many of these lands, if properly drained, would be productive. Much work was done by drainage districts in Tennessee between 1910 and 1930. Some 440,000 acres of land were included in these districts.

Remedial projects in certain isolated places are recommended for construction, but a successful solution of the drainage problem requires an exhaustive study of the area as a whole. Such investigation should include topography, hydrology, climatic conditions, soil characteristics, migratory waterfowl habitat, and other pertinent factors in order that the benefits accruing to one area may not be nullified by damage to another. Measures to combat soil erosion and malaria should be determined and coordinated at the same time. This survey, a considerable undertaking in itself, is recommended as an essential preliminary to large-scale construction.

Flood protection is of importance in the lowlands bordering the Mississippi River, and, to a lesser degree, along the principal tributaries. The alluvial strip extends northward about 100 miles from the mouth of the Hatchie River, attaining its maximum width of 15 miles opposite Dyersburg, Tenn. South of the Hatchie the bluffs are so near to the bank of the Mississippi that the lowlands are negligible in area and do not justify the cost of protection.

A standard levee extends from Hickman, Ky., along the east bank of the river to a high ridge just above Tiptonville, Tenn., and beyond to a point nearly opposite New Madrid, Mo. This affords protection against direct overflow from the Mississippi, but the major portions of the lowlands are still subject to inundation by backwater through the Reelfoot Lake area. About 110,000 acres can be protected by a levee from Tiptonville south to the Obion River, so located as to guard a maximum amount of valuable land without restricting too much the flood-carrying capacity of the Mississippi. This levee would also protect Tiptonville, Ridgely, and other communities, and would prevent the Mississippi floodwaters from backing up into the Reelfoot Lake area. It would not prevent overflow from floods in the Obion and Forked Deer Rivers, but these are of short duration. The project has been authorized by the Congress and is recommended for construction.

A considerable part of the lowlands is so situated that protection would cost too much and would also undesirably constrict the flood channel. These lands afford a large amount of needed valley storage during extreme high water.

Navigation on the tributary streams is restricted to minor and local traffic, such as logging and the barging of rough forest products, except on the Wolf River at Memphis, where the river serves as a harbor.

Stream pollution is not a general problem in this area. Public and private water supplies are almost exclusively from underground sources. Discharge of industrial wastes and of untreated sewage into creeks and rivers has not yet created a nuisance, except in the Wolf River at Memphis, where objectionable conditions extend throughout the lower part of the harbor. The city has taken initial steps toward abatement of this nuisance.

Sewer-system construction or extension and sewage-treatment plants are recommended for several com-

munities when the plans are completed. Extensions to water systems in some places are included.

The most important *wildlife* area in this region is Reelfoot Lake, in the extreme northwestern corner of Tennessee, owned by the State and supervised jointly by the forestry department and the game and fish department. A migratory waterfowl refuge near Tiptonville, Tenn., is projected by the Bureau of Biological Survey at an estimated cost of \$103,000. Plans are complete and 45 percent of the necessary area has been purchased. The relation of the project to malaria should be considered.

Cairo-Memphis Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study to devise a coordinated plan of upland drainage. Plan provides for malaria control.....	\$100,000	Surveys, investigation, and reports in line with recommendations by the planning commissions of Kentucky and Tennessee, but more comprehensive.
14	Memphis, Tenn.: Nine drainage projects including street drainage.....	1,704,000	
14	Memphis, Tenn.: Nine drainage projects involving levee construction, stream improvement, and drainage ditches for flood protection and malaria control.	414,000	
5	Lake and Obion Counties, Tenn.: Water control structures to create waterfowl refuge at Lake Isom.	103,000	Plans completed. 45 percent of purchase area optioned.
12	Chester and McNairy Counties, Tenn.: Creation of lakes for county fish and game preserves.....	14,000	Plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
6	Dyer, Lake, and Obion Counties, Tenn.: Levee from Tiptonville to mouth of Obion River to protect lowlands east of Mississippi River, including towns of Tiptonville, Ridgley, and other smaller communities.	\$730,000	Authorized by Congress. Construction contingent upon procurement of lands, settlement of damages, and maintenance of structures by local authorities. Negotiations not completed. Detailed plans not completed.
13	Memphis, Tenn.: Completion of dredging 9-foot navigable channel in Wolf River from Memphis harbor to Hindman Ferry Road.	628,000	Authorized by Congress. Construction contingent upon local authorities, furnishing right-of-way. Surveys completed.
7	Dyersburg, Tenn.: Additional water supply, treatment plant, and extension of mains. Extensions of sewer system and partial sewage-treatment plant.	127,000	Plans completed.
8	Newbern, Tenn.: Extension of water supply and sewer systems.....	115,000	Do.
3	Union City, Tenn.: Extension of water supply and sewer system and construction of partial sewage-treatment plant.	75,000	Do.
4	South Fulton, Tenn.: Extension of water-supply system.....	80,000	Preliminary plans completed.
15	Colliersville, Tenn.: Sewer system with partial sewage-treatment plant.....	71,000	Do.
9	Huntingdon, Tenn.: Sewer system.....	45,000	Do.

2. LOWER MISSISSIPPI

The area here discussed comprises the river from St. Louis to the Gulf and the adjacent alluvial lands on the west side of this part of the river.

The plan for the efficient use and control of the waters in this area comprises the completion of the comprehensive system of levees and floodways for protection against Mississippi River floods, as authorized by Congress; the continued improvement of the Mississippi River Channel for navigation and to increase its flood-carrying capacity; and the construction of works to protect certain areas in the lower basins of the St. Francis, White, Black, Arkansas, Ouachita, and Red Rivers against overflow by headwater floods from these tributaries.

Acquisition by the United States of lands in natural and artificial floodways, and also in certain natural backwater areas where protection against all floods is not feasible, may also prove desirable. If acquired, such lands should be reserved for floodwater storage as elements in the flood-control system and should be converted into forest and game preserves.

Investigations are projected to devise coordinated plans for land drainage in the alluvial sections of Arkansas and Missouri, and to determine means for remedying depletion of underground water in the rice fields of Arkansas.

General Description

The area of 104,000 square miles comprised within this subbasin extends along the west bank of the Mississippi River from St. Louis to the mouth, a distance by river of 1,265 miles. It lies between the main stream on the east and the edge of the alluvial valley on the west, and extends for short distances up the valleys of the St. Francis, White, Arkansas, Ouachita, and Red Rivers, important tributaries of the Mississippi. Included in the southwestern part are the drainage areas of the Vermilion and Atchafalaya Rivers discharging into the Gulf of Mexico. The larger portion of the area consists of alluvial lands built up by the Mississippi River and its tributaries. There are a few small ridges, not of alluvial origin, too high to be topped by great floods. In the extreme lower portion most of the lands are true delta lands built out into the Gulf.

The area is bountifully watered, the soil is deep and fertile, and there are many miles of navigable streams. The average annual rainfall ranges from 45 inches in the vicinity of Cairo to nearly 60 inches at New Orleans. In the southern portion the winters are mild

and summer heat rarely exceeds 96°. Extremes of temperature, both high and low, increase in a northward direction.

The drainage area of the Mississippi River system above Cairo is 894,700 square miles or practically 72 percent of the entire Mississippi River watershed. At Vicksburg the flow fluctuates between 100,000 and 2,500,000 cubic feet per second. The Arkansas and White Rivers have been known to discharge as high as 1,300,000 cubic feet per second, at Arkansas City. The Atchafalaya River, which receives run-off from the Red, Ouachita, and Tensas watersheds and also a part of the Mississippi flow, has a discharge capacity of 500,000 cubic feet per second.

Underground waters are generally abundant, easily obtained, and of good quality for domestic use. In Arkansas and Louisiana they are being drawn upon heavily for rice irrigation; in the Arkansas field, signs of depletion are beginning to appear.

Despite its abundant water supplies and its fertile soil, this area does not support as large a population nor as high a standard of living as would be expected. The area is predominantly agricultural; the prevailing tenacious system of farming imposes a basic and severe social handicap, widespread and difficult of eradication. Frequent overflows by floodwaters and heavy assessments for maintaining levee and drainage districts have been further handicaps. The total population is about 1,747,000; St. Louis, Cairo, Memphis, and New Orleans are not included, being just outside the boundaries of the area, although they are gravely concerned in its problems. The principal cities and their populations are Shreveport (76,655), Monroe (26,028), and Alexandria (23,025) in Louisiana and Pine Bluff (20,760) in Arkansas. There are numerous towns with 3,000 to 14,000 inhabitants. The rural population averages about 40 per square mile.

The principal agricultural products are cotton, corn, livestock, dairy products, rice, sugarcane, and truck. Lumbering, for many years one of the major industries, has decreased in importance; only about one-third of the original timber is left; but large tracts of pine, cypress, and hardwoods still remain, and some of the country's larger sawmills are in Louisiana. Lumber cut during 1935 in Louisiana alone was valued at \$26,000,000. Waste forest materials from cut-over lands are being utilized to make paper and wallboard. Tung-oil production on cut-over lands is a new and promising development. Fisheries and fur trapping along the

Gulf coast and inland waters bring an annual income of \$9,000,000.

The mineral resources of the region yield oil, gas, carbon black, salt, and sulphur in large quantities whose annual value now exceeds \$70,000,000; oil and gas alone have materially changed the economic outlook in recent years. The growing importance of these activities is reflected in the rapid increase of waterborne tonnage on the lower Mississippi.

Navigation facilities in this region include a very large mileage of navigable waterways carrying traffic of three kinds: (a) seagoing vessels in coastwise and foreign trade, some of which ascend the Mississippi River as far as Baton Rouge; (b) river barges which are used for long-distance haul, principally on the main river, for such bulk commodities as oil, gasoline, coal, sugar, salt, sulphur, bauxite, lumber, steel, and cotton, and which ascend the Ohio, Missouri, and upper Mississippi Rivers; and (c) miscellaneous small craft on the minor tributaries and bayous.

The navigable depth in the main river is 35 feet from the mouth to Baton Rouge, a distance of 243 miles; 9 feet from Baton Rouge to St. Louis, a total river distance of 1,025 miles which is now being shortened 100 miles by means of cut-offs. The 850 miles of main river below Memphis rarely require dredging to maintain 9-foot depths. Above Memphis dredging is required during low-water seasons, to confine the flow, but no difficulty is experienced except in extraordinarily dry years.

River traffic has been gaining in tonnage as well as in mileage. The old-style stern-wheel packet boat is rapidly being displaced by the modern screw-propelled, 1,000 hp. Diesel-engined towboat. Steel barges are typically of 2,000 tons capacity, and require 9-foot depth. They are assembled in tows of from 6 to 12 barges, moved by a single towboat. It is now common practice to transport in one tow merchandise equivalent to that carried by 8 to 15 freight trains of 50 loaded cars each. In 1931 the Illinois River was opened to navigation with 9-foot depth. In 1935, barge service was extended up the Missouri River as far as Kansas City, 1,660 miles from New Orleans.

Navigation on the tributaries and bayous is comparatively small in volume, except on the Ouachita River, which is used extensively for shipping oil. On many of the smaller waterways, especially in the bayou country, the local population makes extensive use of watercraft of all descriptions.

Recommended Plan

Flood control in the alluvial valley was recognized as a national problem by the Congress in the act of May 15, 1928. Up to that time citizens of the valley had spent an estimated \$292,000,000 of their own funds

to protect their lands. Reclamation by white settlers began about the year 1700 and proceeded for about two centuries through uncoordinated individual and group efforts. Levee building had become extensive by the time of the Louisiana Purchase in 1803. Federal operations on the Mississippi date from 1820, but were restricted chiefly to navigation improvements for nearly a century.

The act of May 15, 1928, provided for flood-control works on a comprehensive scale and marked a turning point in the economic history of the valley. These works have been largely completed. Projects to supplement them at an estimated cost of \$310,000,000 were provided for by the Congress on June 15, 1936. Additional authorization is contained in the act of June 22, 1936.

Work needed to fulfill the immediate objectives of this enormous undertaking, in which so many hundreds of millions have already been invested, consists mainly in the completion of the levee system by enlarging the existing levees at certain places to full prescribed height and dimensions; the completion of improvements to stabilize the main channel for both navigation and flood control; the provision of two new floodways, the Eudora and the Morganza, to receive floodwaters in excess of the capacity of the leveed main channel; and the enlargement of the natural floodway of the Atchafalaya River, including a new outlet from Grand Lake to the Gulf of Mexico.

The Eudora floodway below the mouths of the Arkansas and White Rivers will take the excess waters intended for conveyance in the Boeuf floodway under the earlier plan. The use of the Boeuf floodway will be discontinued by closing off its head with a levee. The Eudora will be fed by spillways spaced at intervals along 100 miles of the right bank of the main river, providing an ultimate discharge capacity of 1,000,000 cubic feet per second. It will extend along the east side of Macon Ridge and empty into the large natural backwater area of the mouths of the Red and Ouachita Rivers, from where the diverted waters will be absorbed into the Atchafalaya system.

The Morganza floodway below latitude 31°00' will relieve the main river of all floodwaters in excess of 1,500,000 cubic feet per second and will discharge into the lower end of what is now the Atchafalaya east floodway. The upper end of the Atchafalaya east floodway consists largely of lands under cultivation, which will be eliminated from the floodway by levees.

The natural floodway of the Atchafalaya River will require more flood-carrying capacity, which will be provided by enlarging its present leveed channel and constructing an additional outlet to the Gulf from Grand Lake.

Stabilization of the channel of the main stream by means of cut-offs and dredging should be continued in order to further lower the flood profile, thus adding to the carrying capacity of the river and the security of the levee system.

In addition to these main works, projects are recommended at various places in the lower tributary valleys to protect lands against either backwaters from the main stream or headwater floods from the tributaries.

Retirement of lowlands.—The foregoing projects provide for complete protection against invasion by Mississippi River waters in this area, except for certain lowlands whose protection is impracticable or undesirable. Consideration should be given to the reservation of these lands for flood overflow, as follows:

(a) Lands within the Eudora, Morganza, and Atchafalaya floodways, which must necessarily remain dedicated to overflow during great floods. These lands are in large part timbered swamps, and many of them are covered with excellent hardwoods. Consideration should be given to their acquisition by the United States under the Weeks law for ultimate conversion into forest and game preserves. Included is a tract of virgin cypress, gum, and other swamp-timber species in the southern part of the Birds Point-New Madrid floodway in Mississippi County, Mo., west of Wolf Island, in the overflowed lands along the Mississippi River. Its location is such as to cause no interference with the safe operation of the Birds Point-New Madrid floodway of the Mississippi River Commission.

(b) Lands within the backwater areas at the mouths of the St. Francis, White, Arkansas, and Red-Ouachita Rivers, which cannot economically be protected against overflow. These areas now serve during high stages of the Mississippi as natural reservoirs for the storage of floodwaters. Their function in this respect, which is highly important, should not be interfered with, lest increases in Mississippi River flood stages result. As only about 25 percent of the lands in these areas are under cultivation and none of them can ever be made permanently safe for human occupancy, consideration should be given to their acquisition by the United States for conversion into forest and game preserves. A large wildlife refuge is now being developed near the mouth of the White River in Arkansas.

Navigation presents no new problems in connection with the nationally important navigable waters in this area, but further improvement of the channel of the Mississippi River is required at a number of points. Completion of existing projects is recommended.

Drainage has gone hand in hand with levee building since the earliest days of settlement in reclaiming the low alluvial lands. The alluvial area is subdivided into drainage or levee districts organized under the laws of

the respective States. These organizations have spent vast sums through the levying of assessments.

In Louisiana the State assists these organizations with engineering advice as well as with funds, and good coordination between adjacent districts and with Federal flood-control work has resulted. Major drainage problems requiring special attention will arise in connection with the new floodways, the construction of which will interfere with some of the existing drainage systems.

Large swamp areas remain where no drainage has been undertaken. These are for the most part timbered and produce cypress and many other varieties of hardwoods. In their undrained condition they contribute materially to the difficulties of mosquito control in this region.

Investigations are recommended to devise coordinated plans for drainage in the alluvial valley counties of Arkansas and Missouri and to indicate the required construction.

Malaria control through the drainage of wet lands has been effected in some degree, but lack of coordination and the fact that the areas of water surface and undrained swamp lands are very large, leave mosquito eradication still an unsolved problem. A program of unusual magnitude has been launched by the State Board of Health of Missouri, with W. P. A. funds, providing for complete drainage of all breeding places of malaria-carrying mosquitoes on 1,300 square miles of lowlands in the nine counties composing the Missouri section of this region at a cost of over \$5,000,000.

Irrigation is practiced in the Grand Prairie region of Arkansas and in southwestern Louisiana for growing rice; water pumped from deep wells is extensively used for this purpose. In the Arkansas fields the annual pumpage exceeds ground-water replenishment and the water table is being lowered at a rate which calls for remedial measures. Storage of surface waters is contemplated in the Grand Prairie region, but the length of the required canals presents a serious problem. As rice cultivation is a growing industry, the situation will become increasingly complex. The necessary supply cannot be pumped from the White River or its tributaries without curtailing the low-water flow and thereby interfering with navigation. Storage of floodwaters appears to be a logical plan and the proposed 400,000 acre-feet Greer's Ferry Reservoir site on Little Red River would be designed for this purpose. A detailed study of the various possibilities is recommended.

Municipal water supplies are practically all taken from deep wells, underground water being plentiful and generally of good quality. In central and southern Louisiana, trouble is experienced with salt water. In Arkansas and Missouri colloidal iron is present in

LOWER MISSISSIPPI

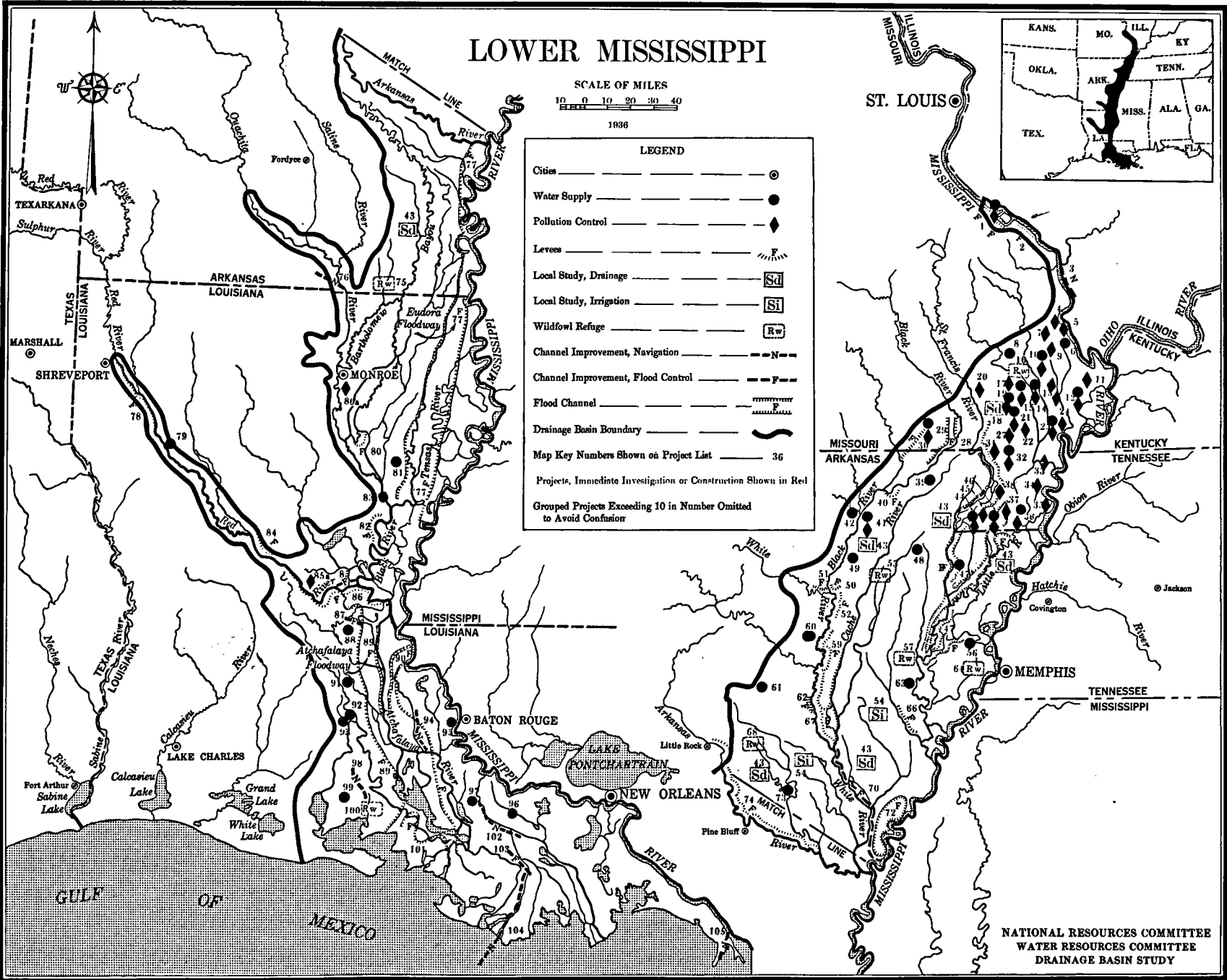
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LEGEND

- Cities ———— ○
- Water Supply ———— ●
- Pollution Control ———— ◆
- Levees ———— F
- Local Study, Drainage ———— [Sd]
- Local Study, Irrigation ———— [Si]
- Wildfowl Refuge ———— [Rw]
- Channel Improvement, Navigation ———— N
- Channel Improvement, Flood Control ———— F
- Flood Channel ———— F
- Drainage Basin Boundary ———— W
- Map Key Numbers Shown on Project List ———— 36

Projects, Immediate Investigation or Construction Shown in Red

Grouped Projects Exceeding 10 in Number Omitted to Avoid Confusion



NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

many ground waters. Because of the generous annual rainfall, water shortages are rarely felt. A number of projects are listed for extensions to existing municipal waterworks systems.

Sewage and stream pollution.—The prevailing practice throughout this area is to waste raw sewage into nearby surface waters. Little trouble has resulted so far, because most domestic water supplies are taken from deep wells and the amount of sewage is usually small compared with the stream-flow. As the population increases, sewage-treatment plants may be needed. Wastes from oil fields and pulp mills are being discharged in harmful quantities in several places. Pollution of coastal waters by oil and sulphur is bringing complaints from the shellfish industry.

New Orleans, population 500,000, now wastes raw sewage into the Mississippi River, and during high river stages pumps its sewage into a bayou draining east through marsh lands into Lake Borgne. This practice may in time reach objectionable proportions and, if so, will require the installation of a sewage-treatment plant. At New Orleans salinity invasion occurred during the summer of 1936 rendering the water supply from the Mississippi River unpalatable for a time. The problem of preventing, if practicable, a recurrence of this condition should be studied. At St. Louis, pollution of the Mississippi River by sewage has not yet reached the nuisance stage, but with increasing population and manufactures it will become an important problem.

Lower Mississippi Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
43	Study to devise a coordinated plan of drainage for alluvial valley counties in Arkansas.....	\$100,000	To be coordinated with a similar study in Missouri.
18	Study to devise a coordinated plan of drainage for 9 alluvial valley counties in Missouri.....	60,000	To be coordinated with a similar study in Arkansas.
54	Study project for water supply for irrigation of rice fields in alluvial valley counties in Arkansas....	75,000	Extension of previous studies.
13	Sikeston, Mo.: Construction of concrete storm sewer and riprapping river bank.....	31,000	Final plans completed.
87	Avoyelles Parish, La.: Bayou des Glaises diversion canal. Excavation of a drainage canal 6 miles long from Bayou des Glaises at Moreauville to a borrow pit of West Atchafalaya levee at Lake Bayou. To reduce overflow and improve drainage.	285,000	Authorized by Congress. Detailed plans in preparation.
	Continuation of flood-control project for Lower Mississippi River as modified in Act of June 15, 1936. The project comprises the following work:	100,000,000	Cost given is for next 2 years; \$210,000,000 additional needed to complete. Authorized by Congress.
89	1. Avoyelles, Iberia, Iberville, Pointe Coupee, St. Martin, and St. Mary Parishes, La. Atchafalaya Basin floodways to relieve Mississippi River floodwaters in excess of its safe carrying capacity. Includes guide levees control works for Morganza floodway, land rights, drainage, clearing, railroad and highway changes.		
89 and 101	2. Atchafalaya River improvements in Louisiana. For flood control and navigation. Includes new outlet from Grand Lake into Gulf of Mexico.		
77	3. Chicot and Desha Counties, Ark.; East and West Carroll, Madison, and Tensas Parishes, La. Eudora floodway and control works. To relieve the Mississippi River of floodwaters in excess of its safe discharge capacity. Includes guide levees, drainage, clearing, railroad and highway changes, land rights and utility changes.		
47	4. St. Francis River flood control works in Arkansas; to protect against headwater floods above the backwater of the Mississippi River. Involves construction of levees and drainage structures.		
72	5. Desha and Phillips Counties, Ark., White River Emergency Reservoir. Levee construction to protect 152,400 acres against all but very great floods. During latter, area is available for flood storage for protection of lower Mississippi Valley.		
	6. Arkabutla, Coffeetown, Coldwater, Enid, Grenada, and Holcomb, Miss.; flood control reservoirs for protection of Yazoo Delta lands against headwater flood. This series of reservoirs is shown on the Yazoo-Black Basin map. Map key numbers, (1), (2), (5), (6), (7), (8).		
	7. Dredging, channel contraction and revetment on main river.		
77 and 90	Field examination, appraisal, and acquisition by the United States of lands in the Eudora and Morganza Floodways in order to withdraw them from human occupancy, and convert them into National Forest and Game Preserves. These are permanently exposed to occasional flood overflows.	17,000,000	Cost estimate roughly approximate. Acquisition to be considered under the provisions of the Weeks Act by establishment of land-purchase units.
80	Columbia, La.: Construction of levees on Ouachita River, including bulkhead and interior drainage works to protect town from flooding by Ouachita and Mississippi Rivers.	395,000	Authorized by Congress. Detailed plans in preparation.
84	Grant and Rapides Parishes, La.: Extension of existing levees along left bank of Red River from Colfax, La., to north bank of Bayou Darro. To protect lands along left bank of Red River from overflow.	71,000	Preliminary plans completed.
59	Jackson and Woodruff Counties, Ark.: Village Creek, White River, and Mayberry district. Construction of 197 miles of levees along east bank of White River. For flood protection.	1,154,000	Authorized by Congress.
74	Jefferson, Lincoln, and Pulaski Counties, Ark.: North Little Rock to Gillette, improvement of existing levees and construction of new levees on north bank of Arkansas River. For flood protection.	1,845,000	Authorized by Congress. Remainder of project, \$894,000 is included in lower Arkansas list.
86	Natchitoches Parish, La.: Construction of 21 miles of levee on right bank of Red River from head of Cave River to and across mouth of Cave River; includes low dam, floodgates, and drainage structures. For protection against headwater floods.	355,000	Authorized by Congress. Detailed plans in preparation.
52	Newport on White River, Ark., in Jackson County: Improvement on 6.2 miles of existing levees and construction of flood wall. For flood protection.	261,000	Authorized by Congress.
2	Perry County drainage and levee districts, nos. 1, 2, and 3, Missouri: Improvement of existing Mississippi River front and back levees.	913,000	Do.
78	Red River Parish, La.: Enlargement and extension of existing levee system on right bank of Red River below Shreveport. For protection against headwater floods.	180,000	Authorized by Congress. Detailed plans in preparation.
40	Skaggs Ferry on Black River east of Pocahontas, Ark., in Randolph County: Construction of 8.2 miles of levee including drainage works for flood protection.	80,000	Authorized by Congress.
102	Assumption and La Fourche Parishes (Bayou La Fourche) near Napoleonville, La.: Dredging channel 6 feet deep and 60 feet wide for improvement of navigation.	351,000	Cost figure needed to complete. Surveys and preliminary plans completed.
3	Mississippi River between the Ohio and Missouri Rivers: Consists of dredging and channel contraction work to provide navigable channel 9 feet deep, 300 feet wide, for a length of 195 miles—part of Lakes to the Gulf Waterway.	2,000,000	Cost given is for first 2 years. Additional needed to complete, \$10,100,000. Surveys completed.
105	Southwest Pass, Mississippi River: Construction of dikes and regulating works to maintain a more stable channel and improve navigation.	300,000	Cost given is for first 2 years. Additional needed to complete, \$420,000. Surveys completed.
100	Avery Island game reserve, Iberia Parish, La.: General improvements urgently needed.....	21,000	Plans completed.
16	Mingo migratory waterfowl refuge in Stoddard County, Mo.: Several miles of dikes to restore swamp status, including structures for water level control.	82,000	Preliminary plans made. Lands optioned and under condemnation.
97	Napoleonville, Assumption Parish, La.: 33 wells, average depth 200 feet to obtain uncontaminated drinking water for communities throughout parish.	12,000	Plans completed.

¹ Approximately.

Lower Mississippi Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
95	Port Allen, La.: Extension of waterworks system and deep well.....	\$21,000	Detailed plans and specifications available.
36	Steele, Mo.: 2 settling basins and water-treatment plant; also necessary appurtenances to existing water systems.....	22,000	Final plans completed.
93	Sunset, La.: New waterworks, including deep well.....	28,000	Detailed plans and specifications available.
96	Thibodaux, La.: Desilting basin and treatment plant for water supply from Mississippi River.....	29,000	Plans completed.
80a	Monroe, La.: Sewer system; extension of water supply system; storm sewers and pumping plant; drainage canal and pumping plant.....	1,068,000	Preliminary plans made.
83	Harrisonburg, La.: Water supply system.....	22,000	
85a	Pineville, La.: Sewers.....	50,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
	Field examination, appraisal, and acquisition by the United States of lands which cannot be economically protected from overflow, with the view to converting them into national forest and game preserves and for use as natural flood storage area. This would include selected areas between the Mississippi River and its Bluffs.....	\$19,800,000	Cost estimate roughly approximate. Acquisition to be considered under the provisions of the Weeks Act by establishment of land-purchase units.
50	Big Bottom, Independence County, Ark.: Construction of 9.8 miles of levee along north bank of White River at mouth of Black River.....	148,000	Authorized by Congress.
28	Butler County, Mo., and Clay County, Ark.: Construction of a leveed floodway to divert flood waters of Black River by building 88 miles of levees.....	2,604,000	Do.
30	Butler and Ripley Counties, Mo., and Clay County, Ark.: Construction of 22.5 miles of levee along little Black River.....	820,000	Do.
66	Lee County, Ark.: Construction of 3.3 miles of levee on Big Creek and L'Anguille River.....	97,000	Authorized by Congress. Preliminary plans complete. Requires further study.
67	Monroe, Prairie, and Woodruff Counties, Ark.: Construct 74 miles of levees on east bank of White River and west bank of Cache River between Augusta and Clarendon, Ark.....	8,100,000	
104	Bayou Grand Caillou and Le Carpe in Terrebonne Parish, near Houma, La.: Dredging channel 5 feet deep and 40 feet wide a distance of 16.3 miles as feeder to Intracoastal Waterway, for improvement of navigation. Local interests to furnish right-of-way.....	56,000	Sum needed to complete. Survey and preliminary plans completed.
94	Bayou Grossetete in Iberville Parish at Maringouin, La.: Widening to full width of 60 feet to a depth of 5 feet to improve navigation.....	101,000	Do.
98	Bayou Teche in Iberia Parish at New Iberia, La.: Widening channel to full project dimensions of 60 feet and 80 feet for a depth of 8 feet to improve navigation.....	141,000	Do.
(*)	Ashley (75), Crittenden (64), Cross (57), Lonoke (68), Monroe, and Woodruff Counties, Ark.: Stream improvements and construction of reservoirs in 8 existing and proposed game refuges. Improvements to fish and game preserves.....	145,000	
(*)	Cape Girardeau (4) and St. Genevieve (1), Mo.: Sewage treatment plants.....	120,000	Preliminary plans completed.
1	St. Genevieve, Mo.: Water treatment plant.....	27,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
18	Drainage for 9 alluvial counties in Missouri: Construct drainage ditches and rebuild or revise existing drainage works as may be needed to establish a coordinated drainage system. Must be coordinated also with similar system planned for alluvial valley counties in Arkansas.....	\$5,000,000	To be preceded by study project needed to devise coordinated system.
43	Drainage for alluvial counties in Arkansas: Construct drainage ditches and rebuild or revise existing drainage works as may be needed to establish a coordinated drainage system. Must be coordinated also with similar system planned for alluvial valley counties in Missouri.....	12,000,000	Do.
54	Water supply for irrigation of rice fields in alluvial counties in Arkansas: Construct reservoirs for impounding flood waters and also ditches for use in irrigating rice fields in Arkansas. This growing industry is now pumping ground water to depletion.....	5,000,000	To be preceded by study as provided in study project.
82	Jonesville, Catahoula Parish, La.: Construction of levees and concrete retaining walls on Ouachita River, with flood gate and drainage works to protect against overflow from Ouachita and Mississippi Rivers.....	443,000	
85	Saline Point cut-off in Avoyelles and Catahoula Parishes, La.: Excavate cut-off across Saline Point on Red River for flood reduction.....	135,000	Authorized by Congress. Detailed plans in preparation.
1	St. Genevieve levee district no. 1, Missouri: Improvement of 4 miles of existing Mississippi River front levee and construction of 1.5 miles of back levee.....	202,000	Authorized by Congress.
76	Navigation canal, Ouachita River to Felsenthal, Ark., in Union County: Construct canal 3,600 feet in length with 7 feet depth for commercial navigation.....	36,000	Preliminary plans completed. Construction is contingent on local interests providing a highway to the canal terminal, furnishing rights-of-way, and providing terminal facilities.
103	Terrebonne Parish near Houma, La.: Enlarge existing canals and construct outlet to divert water from Bayou Black to the Intracoastal Canal. For protection against overflow when Atchafalaya River is high.....	74,000	Plans completed.
(*)	Arnoldville (92), Coushatta (79), Delcambre (99), Plaucheville (88), Port Barre (91), and Wisner (81), La.: Water supply systems.....	183,000	Preliminary plans made.
(*)	Advance (88), Clarkton (32), Dexter (19), East Prairie (12), and Fornfelt (6), Mo.: Water supply systems.....	147,000	Plans completed for Clarkton, Dexter, and Fornfelt. Preliminary plans completed for Advance and East Prairie.
(*)	Black Rock (42), Bradford (60), Caraway (47), Humphrey (73), Knobel (39), Madison (63), McRae (61), Nettleton (48), Swifton (49), and Turrell (56), Ark.: Construct waterworks.....	260,000	
	Biggers, Eudora, Forrest City, Gould, Hamburg, Lake Village, Marvell, Monticello, Tillar, Trumann, and Weiner, Ark.: Extension to waterworks.....	200,000	
	Black Rock, Bradford, Cabot, Caraway, Crawfordville, De Volls Bluff, Gould, Elaine, Gillett, Harrisburg, Hoxie, Hughes, Humphrey, Knobel, Lake City, Leachville, Madison, Manila, Marked Tree, McCrory, McRae, Monette, Nettleton, Newark, Parkin, Pocahontas, Portland, Rector, Swifton, Trumann, Turrell, Tyroneza, Weiner, and Wilmot, Ark.: Sewer systems.....	962,000	
	Augusta, Bald Knob, Biggers, Blytheville, Clarendon, Dermott, Earl, England, Eudora, Forrest City, Jonesboro, Lake Village, Marianna, Marvell, McGehee, Monticello, Newport, Walnut Ridge, and West Helena, Ark.: Extensions to sewer systems.....	472,000	
35	Caruthersville, Mo.: Activated sludge sewage treatment plant.....	85,000	
(*)	Campbell (31), Charleston (11), Fortageville (33), Senath (45), and Sikeston (13), Mo.: Sewage treatment, trickling filter, secondary basins.....	113,000	
(*)	Chaffee (7), Kennett (38), and new Madrid (24), Mo.: Sewage treatment, Imhoff tanks, trickling filter, secondary basins.....	96,000	
(*)	Benton (9), Bloomfield (17), Deering (37), Dexter (19), Hayti (34), Illmo (5), Malden (27), Parma (22), Puxico (20), and Steele (36), Mo.: Complete sewer systems.....	323,000	
(*)	Bernie (21), Cardwell (44), Clarkton (32), East Prairie (12), Essex (15), Hornersville (46), Lilbourn (23), Morehouse (14), Morley (10), and Naylor (29), Mo.: New waterworks and sewage treatment plants.....	331,000	
41	Portia, Lawrence County, Ark.: Sewer system.....	20,000	
41	Portia, Lawrence County, Ark.: Install modern waterworks.....	25,000	

* Map key number shown following community name.

* Map key number shown following name.

Lower Mississippi Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP C--TIME OF CONSTRUCTION INDETERMINATE—Continued			
78	Shreveport, Caddo Parish, La.: Clearing brush from shores of Cross Lake.....	\$56,000	Plans completed.
62	Des Arc, Prairie County, Ark.: Levee along White River 2 miles long. Local interests to furnish right-of-way. Not needed until levee along east bank of White River is built, which would greatly increase high water stages.	42,000	Preliminary plans completed.
70	Clarendon to Laconia Circle on White River in Monroe, Phillips, and Desha Counties, Ark.: Construction of 71.5 miles of levee along east bank of White River from Clarendon to the Mississippi River levee at Laconia Circle. For protection against overflow from Mississippi River and White River.	8,960,000	Authorized by Congress. Sketch plans completed. This project is doubtful and will not be required if Purchase Unit is established in the White River backwater area.

3. YAZOO-BLACK

In this area the chief water problems are the protection of lowlands from headwater floods and a system of drainage for the Yazoo Delta. To accomplish the first objective, a project now under way by the Corps of Engineers should be completed by the construction of reservoirs or by other means. The drainage problem is recommended for special investigation to devise a comprehensive and coordinated plan resolving the dependent or conflicting interests of present drainage districts. The control of soil erosion in the upper valleys should be the subject of another study to devise a rational corrective program. Consideration should be given to the acquisition by the United States of certain lands whose complete protection from floods would be uneconomic, in order that they may be withdrawn from human occupancy and preserved as national forests and wildlife refuges.

General Description

The basins of the Yazoo and Big Black Rivers together form a pear-shaped area in northern Mississippi extending along the Mississippi River from the northern boundary of the State to a point 20 miles south of Vicksburg. The extreme dimensions are 220 miles from north to south and 110 miles from east to west. The total surface is 16,800 square miles.

Topographically the region divides into two distinct parts—the Yazoo Delta to the west, somewhat the smaller, a long narrow oval of low alluvial lands with a maximum width of 65 miles and an area of 6,600 square miles; and the deeply eroded uplands, an irregular belt along the east. Carved into the uplands for its entire length is the narrow valley of Big Black River.

The Delta land was formed in part by alluvial deposits of the Mississippi and in part by sediment washed down from the uplands by the many short eastern tributaries of the Yazoo. Included are some of the more productive lands in the State. Through this low-lying area the Yazoo and its principal tributary, the Sunflower, wind slowly in tortuous channels. Formerly all of the Delta country was subject to overflow by the Mississippi. Today three-quarters of the area is protected from Mississippi floods by continuous levees along the main river. Some 1,700 square miles of swamplands in the lower Delta are still exposed to inundation by backwater through the necessary gap in the levee at the mouth of the Yazoo, and the upper part of the Delta is still overflowed by headwater floods from the uplands.

The uplands along the east form part of the great belt of badly eroded lands extending from the mouth of the Ohio River southward to the latitude of Baton Rouge, La. The country is highly cultivated except where large areas once in crops have been abandoned as worthless because of excessive erosion.

Before 1886 the entire area was densely forested, but not more than 5 percent of the original stand now remains.

The population in 1930 was 880,000, more than 80 percent rural. Vicksburg is the largest town, with a population of 23,000; Clarksdale, Greenwood, and Greenville have over 10,000 each.

Cotton is the predominant crop, with corn in second place. There is a good deal of subsistence farming. The soils of the Delta are very fertile and are capable of producing any crop adapted to a warm temperate climate.

The normal monthly average temperature ranges from 41° to 82°. Winters are mild and summer heat rarely exceeds 96°. Annual precipitation is 50 to 55 inches, more than half of which falls in the period April to October, inclusive. Variations in stream flow are extremely large. The minimum flow in the Yazoo and the Sunflower is from one-fortieth to one-one hundredth of the maximum; in the hill section a minimum of 69 and a maximum of 41,800 cubic feet per second have been recorded on the Coldwater River and similar variations on other streams.

There is an abundance of underground water, much of its artesian, and all of good quality. Most of the municipal water supplies are pumped from deep wells, but Vicksburg has a treatment plant and uses Mississippi River water. In some places the underground supplies are reaching their optimum yield and depletion is likely to follow. Many of the farms in the Delta depend upon shallow wells whose yield is ample but hard.

Recommended Plan

Flood control and drainage are closely associated in this region. The main problems center in the alluvial lowlands of the upper Yazoo Delta where 4,900 square miles have already been protected by levees against invasion by Mississippi floods. This area is in a high state of cultivation, contains many towns, is well served by highways and railroads, yet is not prosperous in proportion to the natural advantages which it enjoys. Ineffective drainage, the prevailing tenant system of farming, lack of crop rotation, and lack of community

interest are in part responsible for the indifferent results obtained and the generally low standard of living. Overflows from headwater floods descending from the uplands are almost annual afflictions in the upper Yazoo Delta, greatly aggravated by inadequate drainage. Uncoordinated management by mutually antagonistic drainage districts has created here a difficult situation.

The Congress in the act of June 15, 1936, authorized the construction of seven reservoirs for the control of tributary floods, at an estimated cost of \$48,000,000. One of these reservoirs on the Little Tallahatchie River near Sardis, Miss., is under construction. Levees, floodways, or auxiliary channels may be substituted for reservoirs in the remainder of the project at the discretion of the Chief of Engineers. Completion of the work is recommended.

The Upper Yazoo Delta faces also an urgent need for a well-designed and unified drainage system. Most of the Delta lands have a fairly good slope; drainage by artificial channels and by straightening the winding courses of the Yazoo and other streams is physically practicable. In order to carry through a comprehensive and economical plan it will be necessary to consolidate the score or more of independent drainage districts under one management. A study to work out a plan for a comprehensive and coordinated drainage system is recommended for immediate action. The control of malaria should also be considered in this connection.

The extreme lower portion of the Yazoo Delta, subject to backwater from the Mississippi, is now partly covered by the Delta purchase unit with a view to converting it into the Delta National Forest. This backwater area operates as an important natural flood-

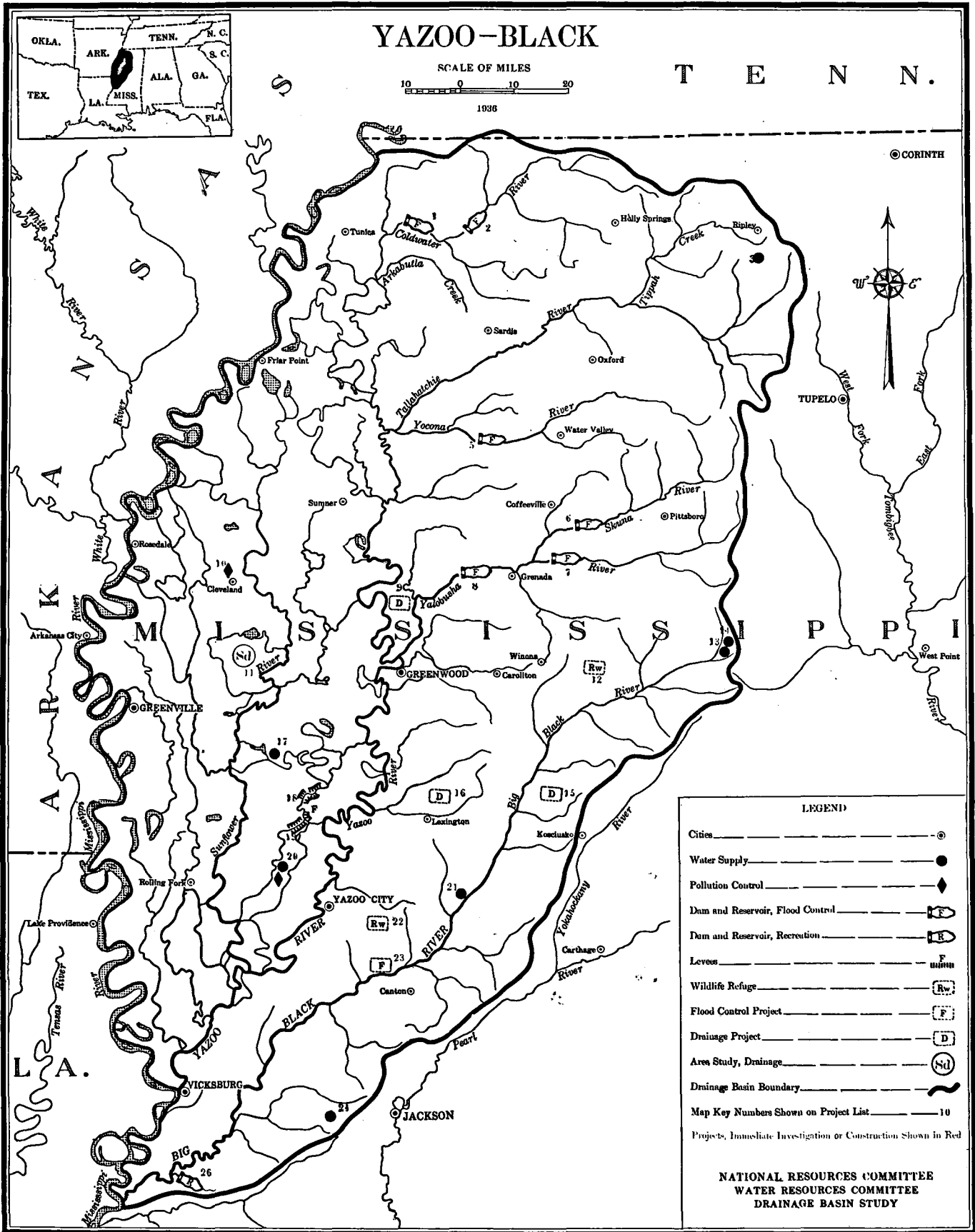
water reservoir in the Mississippi River flood-control system, and its preservation for this purpose is recommended.

Flood control for the valley of Big Black River is an entirely different problem. The valley is so narrow that levees far enough apart to carry flood-waters would protect a relatively small area of bottom lands. Flood storage by reservoirs is not practicable because much of the best land needing protection would lie within the reservoirs. A flood-control program to cost \$850,000 has been authorized by the Congress, but no projects so far examined have been found economically justified.

Soil erosion has reached an advanced stage in the uplands. State and Federal authorities are working to reforest tracts that have been rendered unfit for cultivation and to check erosion by other methods. The upland soils should be stabilized to protect the flood-control reservoirs and drainage channels from silting. The newly created Holly Springs purchase unit covers the headwaters of the Little Tallahatchie River, on which Sardis Dam is now under construction. The upper end of the proposed reservoir will lie within the Holly Springs National Forest.

Water supplies and *sewerage works* are needed by several municipalities in the area. These projects are desirable and should be completed as rapidly as they can be financed. All of the proposed water supplies will be obtained from deep wells. Pollution by sewage is not a problem, because the quantities of sewage are small compared with the volume of stream flow.

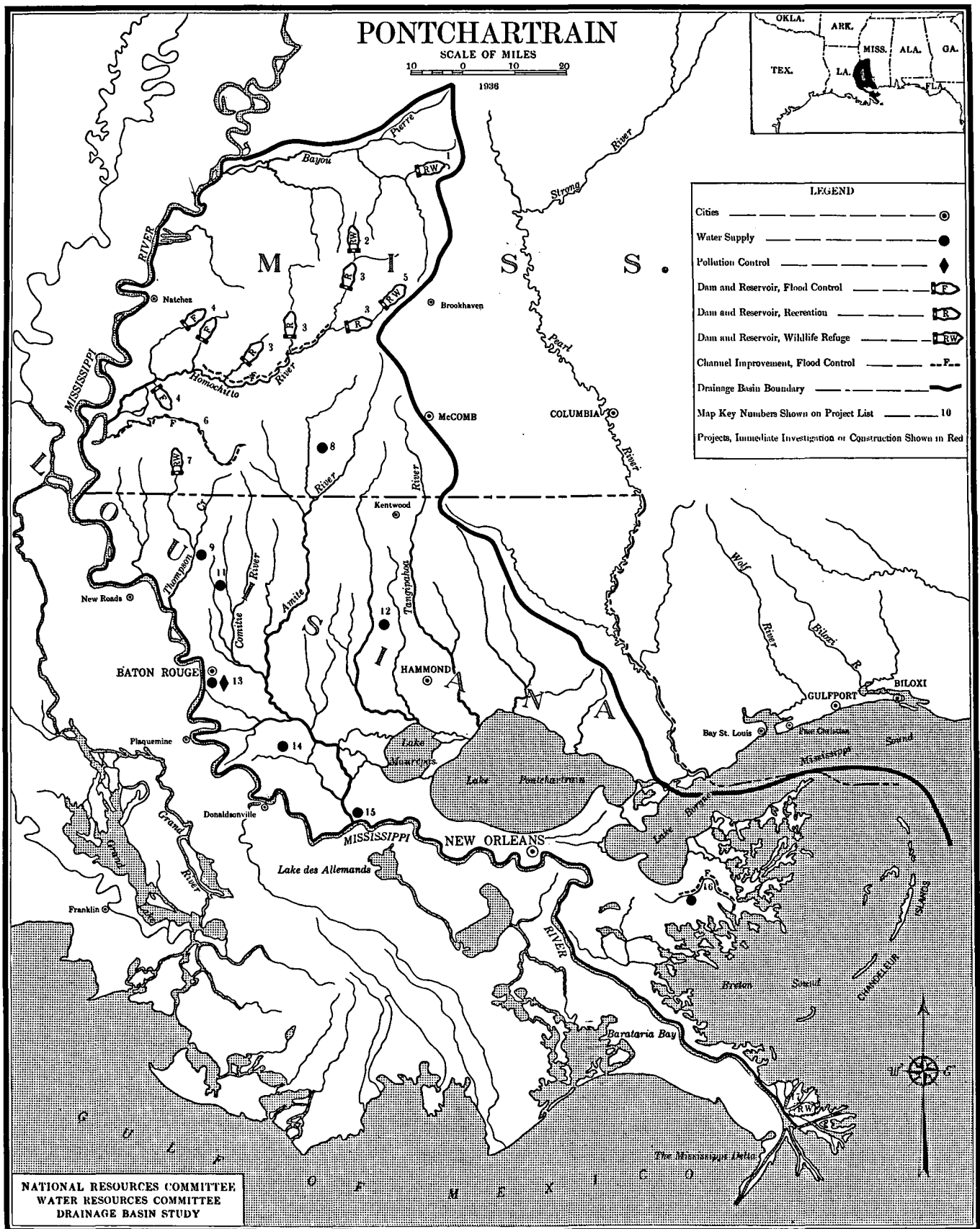
Recreation facilities are well provided for, but there is need for development of wildlife facilities. This basin possesses many large lakes stocked with fish. The lakes are used extensively by the public and also by migratory waterfowl.



Yazoo-Black Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION AND CONSTRUCTION			
11	Study to devise a coordinated plan of drainage for the entire lowlands area known as the Yazoo Delta, and to improve agricultural conditions and plantation methods.	\$150,000	Necessary to the success of many dependent and conflicting drainage districts now in existence. Final plans and specifications are in progress. Cost included in Lower Mississippi Project List.
10 (1)	Cleveland, Miss.: Sewer system and sewage treatment plant. Arkabutla (1), Coffeeville (6), Coldwater (2), Enid (5), Grenada (7), and Holcomb (8), Miss.: Flood control reservoirs for protection of Yazoo Delta lands against headwaters flood.	227,000	
GROUP B—FOR DEFERRED CONSTRUCTION			
(1)	Blue Mountain (3), Isola (17), Maben (14), Mathiston (13), Pickens (21), and Raymond (24), Miss.: Waterworks systems and improvements.	\$133,000	Final plans and specifications are in progress for all except Raymond, on which preliminary plans only are prepared. Final plans are in preparation.
20	Louise, Miss.: Waterworks and sewer systems.	18,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
23	Attala, Carroll, Choctaw, Claiborne, Hinds, Holmes, Madison, Montgomery, Warren, Webster, and Yazoo Counties, Miss.: Improvement of flood channel of Big Black River by clearing and realignment for a distance of 260 miles.	\$850,000	Project authorized by act of Congress of June 22, 1936. Contingent upon local interests furnishing rights-of-way and undertaking maintenance. Further study is advised before funds are expended. Preliminary plans completed.
(1)	Holmes County, Miss.: Improvement of levees at each of the following points: Silver City (19), for the Atchafalaya drainage district, and Velzoni (18).	95,000	
	Attala (15), Grenada and Leflore, (9) Yalobusha River, Petococowa district, and Holmes Counties (16), Miss.: Improvement and construction of channels and ditches.	187,000	
26	Claiborne County, Miss.: Small lake.	30,000	
(1)	Montgomery (12) and Yazoo (22) Counties, Miss.: Construction of lake for migratory fowl refuge.	95,000	

¹ Map key numbers shown following community names.



4. PONTCHARTRAIN

Water-use improvements needed in this basin include flood control on the Homochitto and Buffalo Rivers; acquisition by the United States of lowlands that cannot economically be protected against overflow, to be used as valley storage areas and forest reserves; construction of waterworks in certain communities; development of wildlife and recreational facilities; and the control of soil erosion in the headwater areas.

A general basin plan will not be required for this area for some time, because water is so abundant that conflicts of use are local or unimportant; but comprehensive plans for handling Mississippi floods will affect certain aspects of water planning in the basin, such as the treatment of lands in the flood plain.

General Description

The Pontchartrain Basin extends for about 230 miles along the east bank of the Mississippi River in Mississippi and Louisiana from the Big Black River Basin above Natchez, Miss., on the north to the Gulf of Mexico on the south. The total lowland area is 11,160 square miles, about nine-tenths that of Maryland. About a third is drained by small streams flowing westward into the Mississippi. Nearly half is drained by streams which flow southward into Lakes Maurepas and Pontchartrain. The remainder is low marsh land between Lakes Borgne and Pontchartrain and the Gulf of Mexico.

The basin contained 852,000 people in 1930, including 459,000 in New Orleans, a substantial increase over 1920. Baton Rouge and Natchez, with 30,700 and 13,400 inhabitants, are the next cities in importance. In the marsh country south of New Orleans the population is sparse, but its production of furs and fish amounts to many millions of dollars a year.

Most of the basin was originally covered with a heavy growth of timber. Lumbering has been one of the principal industries and is still important, although the timber reserves have been greatly reduced. Cotton, corn, and livestock are the other chief sources of income in the uplands. The coastal region produces sugarcane, oranges, and rice.

Artesian water is plentiful. New Orleans uses Mississippi River water, but most other communities obtain their supplies from wells. The moderate pollution of the tributary streams is therefore of minor importance.

Recommended Plan

Flood control is the chief water problem in the basin. In the Homochitto and Buffalo Valleys, above the

reach of Mississippi floods, some 35,000 acres of rich bottom land are subject to headwater overflows because the channels of these rivers are choked with drift and eroded soil from the uplands. Congress has authorized expenditures of \$50,000 on the Homochitto and \$35,000 on the Buffalo, for clearing and straightening the channels and building small dams on the headwaters. Incidental improvement in drainage and malarial conditions will follow. These works are recommended for construction as soon as local interests have arranged to furnish the necessary rights-of-way.

On the Mississippi bottoms the principal need is to withdraw a considerable area of land from private use and convert it into national forest and wildlife preserves, which will serve as valley storage when the river is in flood. These areas are too narrow to justify the cost of building levees to protect them, but wide enough to ease the main river noticeably and reduce flood stages both below and above. The boundaries of these districts should be determined and consideration should be given to their acquisition by the United States for conversion into forest and game preserves.

Urban water supply is not a serious problem because of the abundance of good underground water free from surface pollution. Local projects are under way or proposed for various places.

Pollution of streams is not serious because of the relatively small population and amount of injurious industrial wastes as compared with the large supplies of water. Pollution in the Mississippi River is so largely diluted that New Orleans has no difficulty in treating the water for domestic use. The New Orleans sewage is pumped into the river, or, in time of high water, into a bayou draining into Lake Borgne. A purification plant may be needed at some future time.

Recreation and wildlife conservation can be profitably developed in this area, especially as it lies in the established path of migratory waterfowl. Bird life has been seriously reduced in recent years, not only by hunting but by drainage of swamps. Several projects are proposed for creating wild fowl refuges in Mississippi, and the Bureau of Biological Survey has a project near Pilot Town, La., at the end of the Delta.

Many lakes are limited in recreational value because they are relatively inaccessible. The south shore of Lake Pontchartrain has been improved for recreational purposes with a seawall 5 miles long as protection against overflow by storm tides.

Pontchartrain Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
4	Adams and Wilkinson Counties, Miss: Headwater dams and channel improvements on Homochito River for flood control.	\$50,000	Detail plans in preparation. Construction authorized by Congress.
6	Wilkinson County, Miss: Channel improvements on Buffalo River for flood control.....	35,000	Plans completed. Construction authorized by Congress.
17	Plaquemines County, La.: Delta migratory waterfowl refuge; opening canals, repairing dykes, and restoring existing structures.	125,000	Plans completed. Lands required have been optioned and are being acquired by the Biological Survey.
16	St. Bernard, La.: Water supply for livestock and other purposes, and mosquito control, involving clearing channel of Bayou Terre Aux Boeuf and building bulkheads.	41,000	Plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
13	Baton Rouge, La.: Additional water supply and sanitary sewers to supplement existing facilities...	\$110,000	Preliminary plans completed.
(1)	Gonzales (14), Independence (12), and Jackson (9), La.: Liberty (8), Miss.; Litcher (15), and Slaughter (11), La.: New waterworks or extensions.	195,000	
3	Brushy, Clear Springs, Molls, and Pretty Creeks, in Homochitto National Forest, Miss.: Creation of small lakes for recreational purposes.	83,000	No plans prepared. Lands being acquired.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(1)	Copiah (1), Jefferson (2), Lincoln (5), and Wilkinson (7) Counties, Miss.: Construction of lakes for migratory fowl refuges, fishing, and recreation.	\$177,000	Preliminary plans completed.

¹ Map key number shown following community name.

5. PEARL-PASCAGOULA

Problems of water use in this area relate to future rather than to present needs. Underground water supplies, particularly those from artesian sources, are among the more valuable natural resources of the region; their proper utilization should be studied as a part of the recommended national survey of underground waters. Reduction of erosion on productive lands and control of malaria mosquitoes should receive immediate attention.

General Description

This area occupies most of southern Mississippi and a small part of Alabama, comprising the watersheds of two river systems discharging into the Gulf of Mexico, the Pearl River and the Pascagoula River. The total surface is about the same as that of New Hampshire and Vermont combined.

Topographically the basins subdivide into the lowlands forming a narrow belt 3 to 5 miles wide along the Gulf coast, and the uplands, from 200 to 600 feet above sea level, which comprise the remainder. They were originally covered with dense forests of shortleaf pine in the northern part and longleaf pine in the southern part, and still retain in places large stands of virgin and second-growth timber. Most of the land has been cleared in the coastal region, where the soil is especially suited to raising truck and fruits. The climate is mild; mean winter temperatures are 46° to 53° in the south, somewhat less toward the north. Summer temperatures rarely exceed 96°. The annual precipitation ranges from 61 inches along the coast to 51 inches in the northern portion, and is distributed fairly evenly throughout the seasons.

The basins are well supplied with both surface and underground waters. Artesian water rises to the surface from sources 500 to 1,500 feet below, along the coast and in the river valleys; these free-flowing wells are widely used for town water supplies. In the uplands domestic and industrial water supplies are mainly obtained from deep wells by pumping. Data on stream flow are meager. Flood problems exist on the Pearl River and also on the Leaf and Chickasawhay Rivers, tributaries of the Pascagoula, but they have been of minor importance. Industrial expansion in the Pascagoula drainage has brought nearer the future need for flood control.

The population in the two watersheds in 1930 was 675,000, of which about 80 percent was rural. Jack-

son, the capital of Mississippi, on the Pearl River, has about 60,000 population; it doubled in size between 1920 and 1930, owing in large measure to the development of gas wells. There are only five cities, other than Jackson, with populations of more than 12,000.

Mississippi is primarily an agricultural State. Cotton and corn are the principal crops. Truck, legumes, stock, poultry, and dairy products are also important. Lumber is the principal industrial resource. The towns along the Gulf coast are noted seaside resorts.

Recommended Plan

Nearly all of the uplands are in an advanced stage of erosion and need corrective measures. These lands are a part of the great belt of badly eroded, poorly drained, and mosquito-infested uplands east of the alluvial valley of the Mississippi River, stretching southward from the Ohio to the general latitude of Baton Rouge; their rehabilitation should be made a part of the general program for the entire belt. The Chickasawhay, Leaf River, and Biloxi land purchase units have recently been established within this area with a view to their reforestation.

Underground waters.—Future development and especially industrial growth depend in considerable measure on the proper husbanding of the exceptionally good underground water supplies. Wasteful use, crowding of industries, and lack of knowledge concerning the natural limits of the available supply threaten to bring about dire consequences. The preservation of the artesian waters for maximum and lasting value calls for careful study.

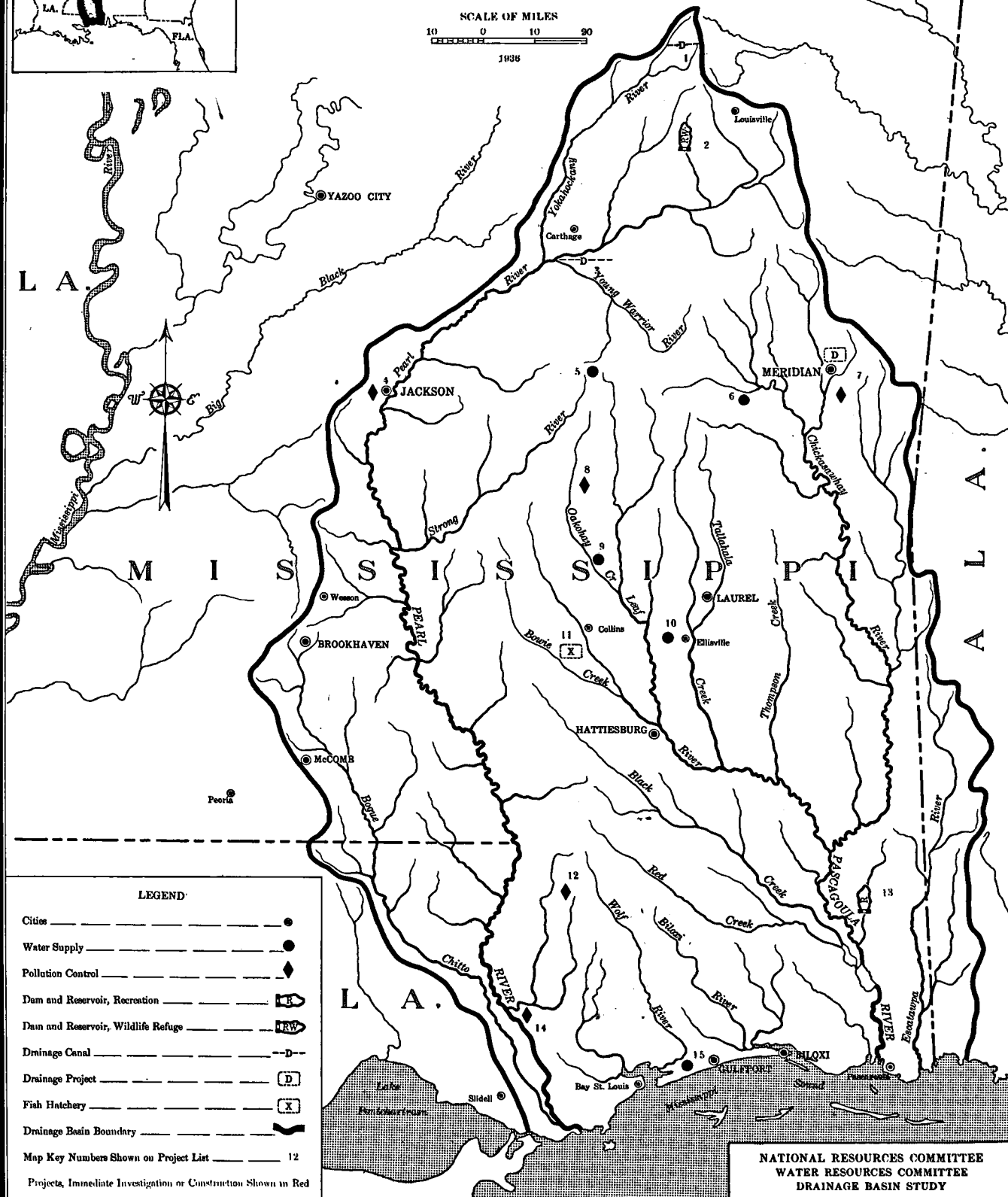
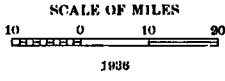
Flood control.—About 500 square miles of lands, mostly improved, are subject to overflow in the narrow valley of Pearl River, but no economically feasible plan for their protection has been developed. Studies are in progress in the Pascagoula Basin, but flood damage has not reached such proportions as to warrant large expenditures for flood-control works.

Pollution.—Owing to the abundance of surface waters, pollution by sewage of streams and waterways has not yet become a matter of consequence, but industrial wastes are causing complaint and legal action. Several sewage-treatment projects are recommended for deferred construction.

Drainage problems are minor for agricultural purposes but require attention for mosquito control.



PEARL - PASCAGOULA



LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir, Recreation ———— [D]
- Dam and Reservoir, Wildlife Refuge ———— [W]
- Drainage Canal ———— -D-
- Drainage Project ———— [D]
- Fish Hatchery ———— [X]
- Drainage Basin Boundary ———— [thick line]
- Map Key Numbers Shown on Project List ———— 12
- Projects, Immediate Investigation or Construction Shown in Red

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Pearl-Pascagoula Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
6	Hickory, Miss.: Complete waterworks, including deep well.....	\$27,000	Plans 75 percent completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
10	Ellisville, Miss.: Extension of existing waterworks.....	\$8,000	Plans 25 percent completed.
4	Jackson, Miss.: Storm sewers to correct drainage.....	30,000	Preliminary plans completed.
14	Picayune, Miss.: Sanitary sewer system, 15 miles of main sewers.....	112,000	Do.
12	Poplarville, Miss.: Sanitary sewer system.....	37,000	Do.
8	Raleigh, Miss.: Sanitary sewer system.....	38,000	Do.
3	Leake County, Miss.: Drainage ditch 4¼ miles long, for malaria control.....	65,000	Do.
1	Weir, Miss.: Drainage canal for Yockanookany drainage district.....	29,000	Do.
7	Meridian, Miss.: Drain swamps and ponds and build sanitary sewers.....	67,000	Do.
2	Winston County, Miss.: 30-acre lake for migratory waterfowl refuge.....	37,000	Do.
11	Seminary, Miss.: 480-acre fish hatchery.....	146,000	Do.
13	Beaver Dam Creek, Miss.: 72-acre lake for recreational purposes and mosquito control.....	27,000	Do.
5	Forest, Miss.: Extension of existing water supply; includes deep well.....	8,000	Plans 25 percent completed.
15	Gulfport, Miss.: Artesian well to supplement existing water supply.....	15,000	Detailed plans and specifications in preparation.
9	Taylorville, Miss.: Waterworks, including deep well.....	40,000	Plans 20 percent completed.

WESTERN GULF DRAINAGE BASINS

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1. SABINE

Salt water encroachment presents the most serious water problem of the Sabine-Neches area. Rice production is important here, and pumping from the streams into irrigation channels at periods of low flow permits the intrusion of salt water from the Gulf of Mexico.

This area is in a period of transition. What its future will be depends to a great extent upon proper planning at this time for conservation and judicious use of its water resources. Virgin timber is being cut, flush oil fields are in production, population is increasing, and potentially useful lands have not been developed.

Floods do little damage, but erosion is attacking cut-over areas. Reforestation is in progress and should be encouraged.

A major study project is recommended, because the time is strategic for sound planning, to cover both the Sabine and Neches watersheds. This project should include topographic mapping, survey and exploration of possible reservoir sites, installation of needed gaging stations, observation of salt pollution from oil wells, and investigation of means for correcting this evil, and research in malaria reduction. This study project is a prerequisite to determination of the possibilities of hydroelectric power production on these rivers.

General Description

The four rivers of this area drain about 26,000 square miles, 10,000 square miles in southwestern Louisiana, the balance in east Texas. The rainfall ranges from 40 inches to nearly 60 inches a year.

The flow of streams varies not only from year to year but also markedly from season to season. The minimum recorded annual discharge near the mouths of the Neches and Sabine Rivers has been 16 percent and 21 percent, respectively, of the mean annual discharge at those points, and the minimum recorded discharge of the Calcasieu and Mermentau Rivers was about 32 percent of the mean annual discharge. Floods, for the most part, merely overflow the undeveloped flood plain, and the flood peaks generally are not high.

Only about one-tenth of the Sabine-Neches area is used in crop production, although about half is owned by farmers. Most of the remainder is forest land. One national forest and five forest purchase areas will ultimately include about one-tenth of the timberland.

Most of the virgin timber of the upper watersheds has been cut. Part of the northern Sabine and Neches

River Valleys, a rolling country from 250 to 550 feet above sea level, is in crops following logging operations, but the soil is sandy and thin, and much damage from erosion has resulted.

The central portions of the Sabine and Neches and the upper Calcasieu and Mermentau watersheds are still primarily forest areas. The alluvial valleys have been cut over, but have not been shifted to crops. In the last few years, the central timber area has acquired renewed importance as a possible source of quickly grown pulpwood for paper manufacture. Construction of a paper mill at Houston is now under way.

The remaining part of this area is a strip less than 75 miles wide along the coast. It is bounded on the south by salt marshes at the edge of the Gulf of Mexico and on the north by the forests. Its fertile soil is underlain, in general, by watertight subsoil, making it especially adaptable to rice irrigation.

Oil structures underlie much of the Sabine-Neches area, and they are rather closely spaced. The east Texas oil field, on the upper Sabine, is the country's largest producer. In addition to oil, the Coastal Plain is underlain with sulphur and salt domes, each of which has made important contributions to the development of the area. Recent new development in the southern Louisiana and southeastern Texas oil fields has increased the oil tonnage on the intracoastal canal, and has made Sabine Pass, with its joint traffic to and from Lake Charles, Orange, Beaumont, and Port Arthur, one of the busier harbor entrances in the United States.

Population of the Sabine-Neches area in 1930 was 873,000, with 243,000 in cities and towns. The population is expected to reach 1,000,000 by 1950.

Recommended Plan

Salt intrusion.—Rice crop losses, more or less severe, occur about 1 year in 4 on the Mermentau River because of shortage of fresh water. When the flow of the Mermentau and its tributaries falls below the irrigation demand, salt water encroaches from the Gulf of Mexico by way of Grand and White Lakes. The amount of salt water finally reaching the rice fields varies with the severity of the deficiency in the fresh-water supply. It has been estimated that the losses due to salt water in this valley average \$200,000 annually. An annual fresh-water supply of at least 200,000 acre-feet is needed to prevent these losses. Several projects have been proposed to furnish this supply.

The most feasible plan appears to be one recently investigated in a preliminary way by the Corps of Engineers. It proposes construction of control works at the outlet of Grand Lake; a deepened channel with control works between Grand and White Lakes; rehabilitation of the present bypass to the north of the navigation lock in Schooner Bayou, and construction of an additional bypass channel and spillway around the lock to the south. During flood periods the control at the outlet of Grand Lake would be operated to cause Mermentau River to flow through Grand Lake into White Lake, pushing the salt water out through Schooner Bayou around the bypass channels and through the navigation lock. During low-water periods the fresh-water supply thus impounded in Grand and White Lakes would be drawn upon for rice irrigation and salt-water intrusion controlled by the structure at the outlet of Grand Lake.

A detailed survey of this project has not been made. The preliminary estimate of the cost of construction is \$1,400,000, with an average annual operating cost of about \$20,000. This project appears desirable.

As a result of the construction of the deep-water navigation channel up the Neches from Port Arthur to Beaumont, salt water has been brought to the latter city. The intake for the rice fields in Jefferson County is a short distance above Beaumont. The flow of the Neches frequently drops to low levels. At such times the irrigation demands are apt to exceed the flow. When this occurs, the pumps which supply the rice fields pull salt water from the navigation channel into the irrigation systems. Port Arthur and nearby oil refineries obtain their domestic and industrial supplies from this same source, and therefore the salt pollution is a matter of concern to them as well.

To meet this situation, construction of a high dam at Rockland on the Neches River 50 miles above Beaumont has been proposed to impound about 1,650,000 acre-feet. A gravity canal would be constructed to the rice fields of Jefferson County and to Port Arthur. This would eliminate not only the present danger of salt intrusion but also expensive pumping.

Present indications are that insufficient water would be controlled by the Rockland Dam to provide a reliable water supply for irrigation, municipal and industrial uses, and at the same time permit the generation of much firm power. It is recommended that the Rockland Dam project be studied thoroughly and that other storage possibilities on the river be investigated.

Water supplies for most of the municipalities of this area are obtained either from deep wells or from small reservoirs constructed to impound the run-off from tributary drainage areas. Longview has been an exception, having used water from the Sabine River. A fresh-water supply from a protected tributary is being developed, because of salt pollution in the main stream from the east Texas oil field.

There is a need for improvement and extension of waterworks facilities in several of the smaller municipalities of the area. Six projects, estimated to cost \$160,000, involving the construction of deep wells and other facilities, should be undertaken at the present time. Seven additional water-supply projects, proposed by other municipalities, are meritorious, but should be restudied before construction.

Sewage disposal systems should be provided for a number of the municipalities. The city of Lake Charles, La., has outgrown its antiquated system, the effluent from which now pollutes Lake Charles, a valuable recreational asset. Immediate construction is recommended of a project which would provide a main intercepting sewer and sewage-treatment plant. There is need also for modern sewage-disposal plants for the towns of Sulphur, La., and Cushing, Tex. Several other municipalities require sewage-disposal plants, but plans have not been prepared.

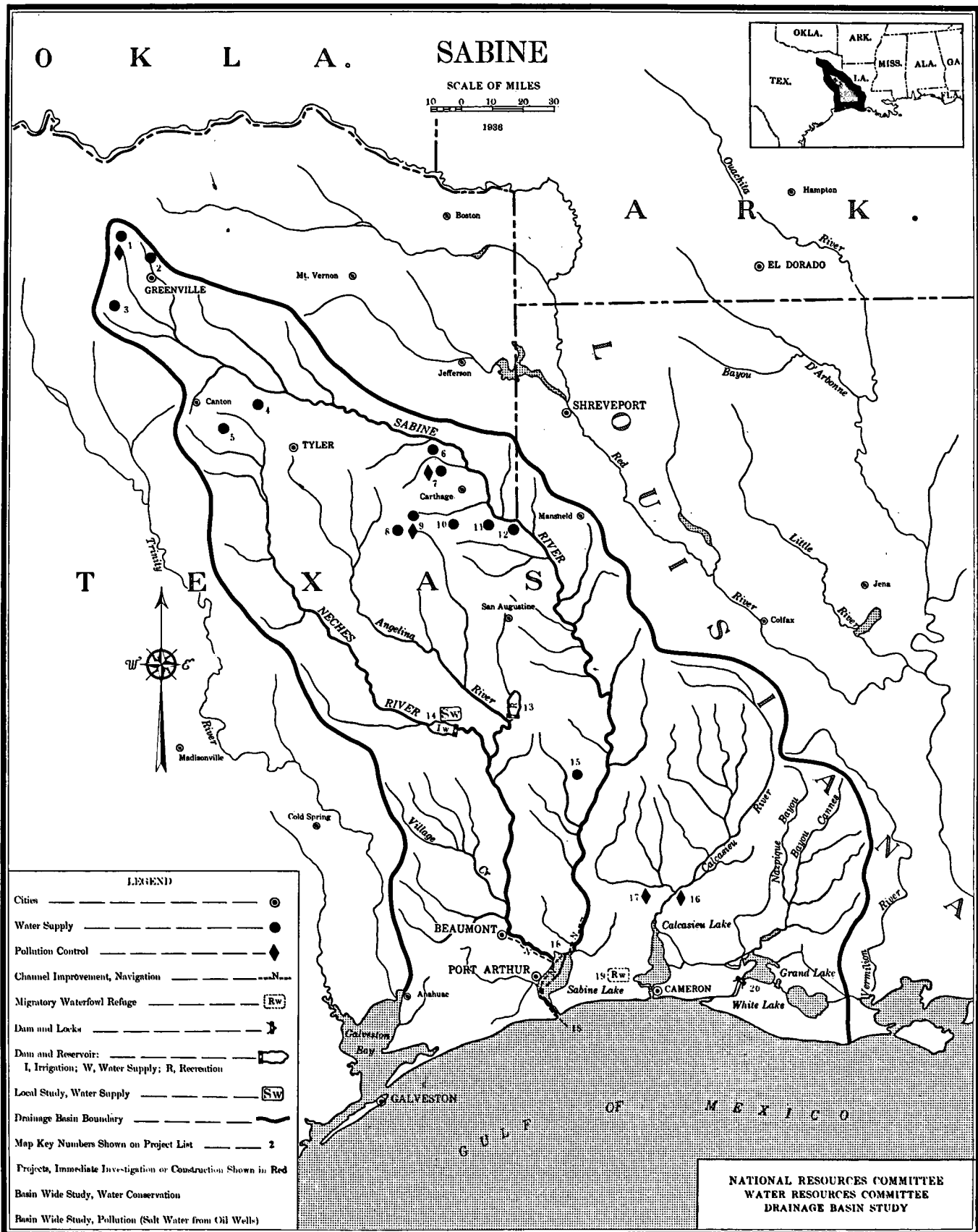
Consideration also should be given to the problem of *malaria* resulting from improper design and operation of various water projects.

Navigation.—As a means of relieving congestion at Sabine Pass, the Corps of Engineers is now studying a proposal to provide a ship channel from Lake Charles, La., direct to the Gulf of Mexico. Such a channel through Calcasieu Pass would give direct access to the developing oil fields of southwest Louisiana.

Flood damages have not been great, as the flood plains are used principally for grazing and logging. The damage in the Calcasieu Valley averages \$25 a year per square mile overflowed. Reclamation of the flood plains is not needed at this time.

Hydroelectric power generation in this area appears uneconomic due to low-cost gas and oil and to lack of suitable sites. The Corps of Engineers has been authorized to make a preliminary investigation of the area.

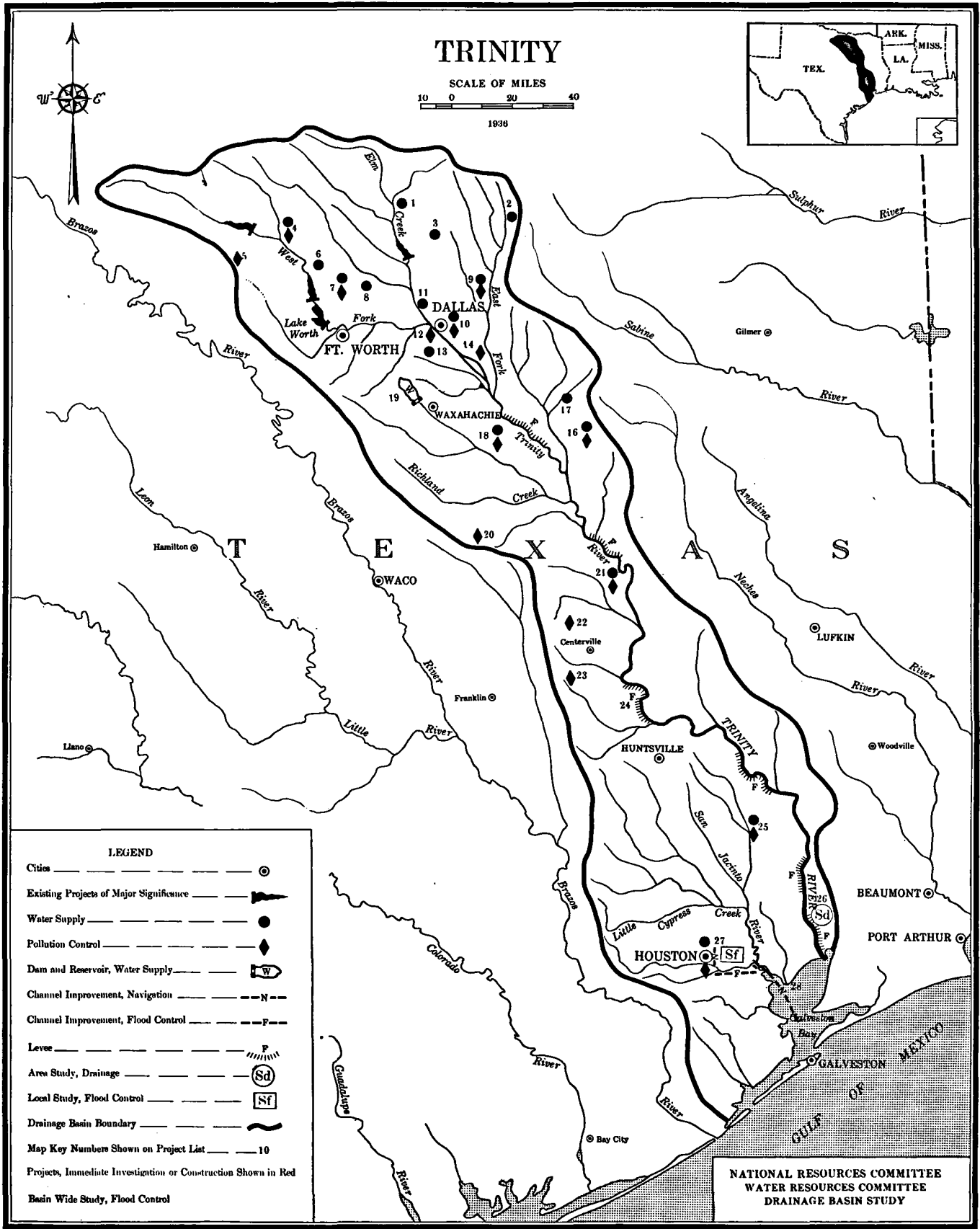
The Lacassine wildlife refuge under construction in Cameron and Jefferson Davis parishes should be completed.



Sabine Project List

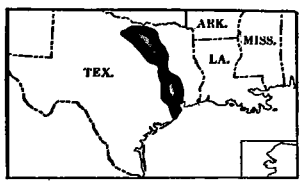
Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
14	Study to devise means for control of stream pollution by salt water from oil wells..... Rockland Dam project, Tyler County, Tex.: Study for supplemental water supply in Jefferson County.	\$50,000 50,000	Preliminary report prepared. Study to consist of dam-site exploration, water supply, and economic studies.
18	Sabine-Neches waterway, Jefferson and Orange Counties, Tex.: Channel enlargement from Sabine Pass to Fort Arthur, Beaumont, and Orange.	1,790,000	Plans completed to complete immediate project.
9	Cushing, Tex.: Waterworks, sewer system, and sewage-treatment plant.....	60,000	Preliminary plans made.
16	Lake Charles, La.: Intercepting sewer and sewage-treatment plant.....	160,000	Do.
(1)	Brownsboro (5), Commerce (2), Garrison (10), Lindale (4), Newton (15), and Tatum (6), Tex.: Water supply systems or improvements.	120,000	Do.
17	Sulphur, La.: Sewer system and sewage-treatment plant.....	86,000	Do.
13	Boykin Springs, Tex.: Dam for recreation purposes.....	18,000	
19	Lake Charles, La.: Sabine migratory waterfowl development dikes to keep out salt water; buildings and equipment.	144,000	Surveys are in progress.
GROUP B—FOR DEFERRED CONSTRUCTION			
	Sabine-Neches Conservation district: Study of flood and water conservation by means of dams and reservoirs and channel improvements.	\$250,000	General study project authorized by Congress. Directed at specific construction project proposed by Sabine-Neches Authority. To be an expansion of preliminary examination now under way by Corps of Engineers.
11	Tenaha, Tex.: Water-supply system.....	56,000	
1	Celeste, Tex.: Water-supply system, sewer system, and sewage-treatment plant.....	65,000	Preliminary plans made.
(1)	Beckville (7), Caddo Mills (3), Joaquin (12), and Mount Enterprise (8), Tex.: Water-supply systems.	126,000	Do.
7	Beckville, Tex.: Sewer system and sewage-treatment plant.....	18,000	Do.
20	Mormontau River fresh-water project, La.: Stream control and channel improvement for irrigation. Locks for control of salinity.	1,400,000	Preliminary report made by Corps of Engineers.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
14	Rockland Dam, Tyler County, Tex.: Dam and canal for irrigation and industrial water supply....	\$12,000,000	Preliminary surveys and reports made. Depends on study in group A.

¹ Map key number shown following community name.



TRINITY

SCALE OF MILES
10 0 20 40
1936



LEGEND	
Cities	○
Existing Projects of Major Significance	▲
Water Supply	●
Pollution Control	◆
Dam and Reservoir, Water Supply	Ⓜ
Channel Improvement, Navigation	—N—
Channel Improvement, Flood Control	—F—
Levee	—P—
Area Study, Drainage	Ⓢd
Local Study, Flood Control	Ⓢf
Drainage Basin Boundary	—
Map Key Numbers Shown on Project List	10
Projects, Immediate Investigation or Construction Shown in Red	
Basin Wide Study, Flood Control	

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

2. TRINITY

In the basins of the Trinity and San Jacinto Rivers, which are contiguous, problems of sanitation and water supply have been created by the rapid growth of cities. There is need for construction of additional storage reservoirs to curb floods and to regulate the streams. Additional land can be reclaimed for cultivation by construction of floodways.

General Description

The Trinity and San Jacinto Basins form an area about 70 miles wide, extending from the northern part of Texas in a general southeasterly direction about 350 miles to Galveston Bay. The principal tributaries of the Trinity drain a fan-shaped, hilly, and partly wooded area. They join the main stream near Dallas. The general character of the terrain changes approximately on a line running north and south through Dallas from a forest belt to the Black Waxy Prairie, an area of gently sloping hills with soil of great fertility, especially suited to cotton production.

The southern forest belt is encountered at Carsecana and extends nearly 100 miles, almost to Galveston Bay. The soil here is generally sandy and not as good as that of the northern section. The San Jacinto River Basin lies in the Coastal Plain. Houston is at its center.

The population of the northern section of the area is about 900,000, almost evenly divided between the cities of Fort Worth and Dallas and the rural sections. The southern forest area has a population of about 200,000, with less than 50,000 people living in the towns. The Coastal Plain contains 500,000 people, 80 percent living in Houston and Galveston.

Farming is prevalent throughout the area. In the central portion of the drainage basin crops are harvested from about one-seventh of the land area. Lumbering is an important industry and offers possibilities for future expansion. In the Coastal Plain region about a third of the land area is owned by farmers, but crops are harvested from only a small part of this land.

Rainfall varies from averages of 30 to 40 inches per year in the upper part of the drainage basins to averages of from 40 to 50 inches per year on the Coastal Plain. Much of this rainfall is concentrated in big storms which cause large floods, especially on the San Jacinto River.

The average annual stream flow of the Trinity River below Dallas is slightly more than 1,000,000 acre-feet,

but its flow is irregular. For the entire year of 1925 the flow was about 750,000 acre-feet; the average daily flow during July, August, and September was 400 acre-feet, so little that salt water backed 50 miles upstream.

Recommended Plan

Stream pollution is becoming more serious with the rapid growth of the larger cities. A sewer system and an adequate sewage-treatment plant are required at Houston. The sewer system of Dallas has lagged behind the increase in population and there is not enough water in the river at low stages to dilute the sewage sufficiently. It is necessary that the Dallas plant be enlarged and modernized as a means of improving the surface-water conditions of the Trinity River for domestic use.

Smaller municipalities scattered over the Trinity Basin and the San Jacinto area now require water supply and sewage-disposal plants as well. Existing systems should be expanded and completed promptly.

Water supply for municipal and industrial uses is a problem of comparable importance. Fort Worth and Dallas have constructed large reservoirs on the headwaters of the Trinity River. A water-supply system for the Dallas suburb of Highland Park is recommended to provide for current population growth. Houston obtains its water supply from drilled wells widely scattered. Recent increases in demand for water require the drilling of additional wells and coordination of the scattered operating units. This work is necessary to increase the operating efficiency of the entire system and to provide additional fire protection.

Flood control is important for the entire valley of the Trinity River. Floods affect the bottom lands reaching to the coast and are serious around Fort Worth and Dallas and in the adjacent rural area of the Black Waxy Belt. Storage reservoirs for control of floods and for municipal water supplies with a total capacity of 1,943,000 acre-feet have been provided in the headwater tributaries. This storage is equal to about one-quarter of the maximum annual run-off. Additional flood-water storage totaling 575,000 acre-feet is contemplated. Complete development of available storage sites for flood control will result in a marked reduction of flood stages at Fort Worth and Dallas. It will have an important bearing on the floodway to be provided by levee construction to reclaim agricultural lands along the valley. It will also

increase the low-water flow, increasing the supply for irrigation in the Coastal Plain and for dilution of the effluent from sewage-disposal plants. Little power will become available, however.

Houston was subjected in 1935 to a devastating flood caused by a tropical storm. Approximately 16 inches of rain fell within 3 days, causing a flow far in excess of the capacity of the water courses. The plans now under study for the relief of flood conditions provide

for the improvement of the water courses through the city as well as for a bypass channel west of the city. This work should be carried out as soon as studies are completed.

Navigation possibilities in the Trinity River are now under investigation by the Corps of Engineers. The improvement of the ship channel from Houston to Galveston Bay is included in the plan for immediate construction.

Trinity Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
27	Trinity River, Tex.: Plan to protect 750,000 acres of fertile alluvial land and reduce present damages from high waters.	\$500,000	Study project is an extension of the preliminary examination by the Corps of Engineers. Two projects undertaken by W. F. A. Coordinated plan needed. Estimate approximate. Study authorized by Congress.
	Houston, Tex.: Study for protection from flood damages due to high waters of Buffalo Bayou.....	60,000	
26	Chambers and Liberty Counties, Tex.: Study for drainage.....	50,000	Preliminary plans for mapping project completed. Authorized by Congress. Cost given is for next two years. Additional needed to complete, \$614,000.
28	Houston, Tex.: Ship channel to Galveston Bay, to be dredged to 34 feet in depth and width increased.....	2,900,000	
12	Dallas, Tex.: Sewer and sewage treatment improvements.....	1,320,000	Preliminary plans made.
27	Houston, Tex.: Sewer and sewage treatment improvements.....	909,000	
27	Houston, Tex.: Water system improvements.....	1,000,000	Do.
11	Highland Park, Tex.: Water system improvements.....	285,000	Do.
(1)	Eustace (17), Grapevine (8), Lancaster (13), Pilot Point (1), Prosper (3), and Rhome (6), Tex.: Waterworks improvements.	133,000	Do.
(1)	Centerville (9), Mesquite (10), and Oakwood (21), Tex.: Waterworks and sewer system improvements.	121,000	Do.
22	Jewett, Tex.: Sewage treatment plant.....	16,000	Do.
27	Cedar Bayou: Dredging channel for navigation.....	12,000	Preliminary plans completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
2	Blue Ridge, Tex.: Waterworks system.....	\$29,000	Preliminary plans should be revised before construction.
(1)	Alvord (4), Athens (16), and Rice (18), Tex.: Waterworks and sewer-system improvements.....	203,000	
(1)	Bryson (5), Dawson (20), Normangee (23), Roanoke (7), and Seagoville (14), Tex.: Sewer systems.....	145,000	Do.
25	Cleveland, Tex.: Waterworks system and sewage-treatment plant.....	129,000	Preliminary plans made. Proposed water system requires further study.
19	Waxahachie, Tex.: Water-supply reservoir and pipe line.....	273,000	Preliminary plans made. Excessive cost requires further study.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
24	Trinity Basin: Reservoirs for flood control.....	\$5,000,000	Should await completion of study project.
	Trinity River: Levees on main stream for flood control.....	11,000,000	
27	Trinity River: Levees on tributaries for flood control.....	18,700,000	Do.
	Houston, Tex.: Channel improvement or construction of bypass channel to Buffalo Bayou for flood control.	(?)	Should be undertaken after study reveals most feasible plan.

¹ Map key number shown following community name.

² Indeterminate.

3. BRAZOS-COLORADO

The most important water problem in the Colorado and Brazos River Basins is the control of floods. Generation of hydroelectric power is of secondary importance, but flood-control reservoirs should be operated, if practicable, to permit generation of power. Such reservoirs also should provide stream regulation for the benefit of rice irrigators and other water users. Soil conservation is needed to help prolong the life of the reservoirs. Various water supply and sewerage projects are needed in the basin. In the south, high plain development of underground water supplies is needed.

A study is under way by the Brazos River Conservation and Reclamation District to devise a plan for conserving the waters of the Brazos Basin.

General Description

The drainage basins of the Brazos and Colorado Rivers, considered together here, have an area of more than 83,000 square miles. They cover a district about 600 miles long and about 200 miles wide. These basins are divided into four major subsections.

The section of highest elevation is the south high plain, at an average altitude of 4,000 feet. It is 23,000 square miles in extent. This section is the southernmost extension of the Great Plains. It is surrounded on three sides by the Caprock, a prominent uplift. To the north is the Texas Panhandle.

South of the Colorado River is the Edwards Plateau, the second subsection, made up of rough and stony land, used chiefly for grazing. The rolling plain north of the river varies from valleys with gentle slopes and deep soil to rough hills. This district extends eastward from the Caprock escarpment to the zone of 25-inch average annual rainfall and has an area of approximately 22,000 square miles.

The third zone, through which the Colorado and Brazos Rivers flow, is the rolling and timbered country which includes the Grand Prairie and lies east of the 25-inch-average-rainfall line above the Balcones escarpment. It is known as the canyon section and has an area of about 20,000 square miles.

The fourth zone, with an area of about 18,000 square miles, lies below the Balcones escarpment and extends to the Gulf of Mexico. It is composed of the blackland prairie and the Coastal Plain, a fringe of forest separating them.

The population of the basins was 1,345,000 in 1930. The section west of the 25-inch-rainfall line was settled much more recently than the eastern section. In 1900

the humid eastern half of the basins contained 830,000 rural inhabitants. The semiarid western half reported 102,000 in the same year. In 1930 the eastern half had 811,000 rural inhabitants, practically the same as in 1900. The western half, on the other hand, reported 392,000 rural inhabitants. The larger cities are just below the Balcones escarpment. They are Austin on the Colorado River and Waco on the Brazos River. Each city had about 53,000 population in 1930.

Prior to 1910 the south high plain was—for the most part—ranch country. Farmers, penetrating from the northeast corner, where rainfall is heaviest, now have obtained about one-third of the total area. In 1910 there were about 4,000 ranch and farm units. In 1935 there were 23,000 ranches and farms. Crops were harvested in 1935 from 2,500,000 acres, or about 17 percent of the land. The more important crops are cotton and grain sorghum, the latter an important cattle feed. Irrigation from wells is increasing rapidly. The principal use of the underground water supply, however, still is for domestic and stock watering purposes.

On the rolling plain dry farming is competing with grazing. Irrigation is successfully practiced in the Colorado River Valley and has been considered in the Brazos Valley. The rolling agricultural lands are being terraced as a means of conserving the soil and the scanty water supply.

In the canyon section crops were harvested in 1935 from 785,000 acres, or about 7 percent of the area, while below the Balcones escarpment crops were harvested from 300,000 acres or about one-quarter of the area of this black prairie and coastal section. In 1930, 85,000 acres were irrigated for rice on the lower rivers, a decline of 56,000 acres from 1910. This decline does not necessarily indicate that the water supply is deficient.

Aside from agriculture, the oil industry is the chief economic activity, large oil fields having been discovered and exploited in the rolling plain zone.

Precipitation in the south high plain varies from 20 inches in the upper Brazos Valley to 14 inches at the southwestern edge in New Mexico. Rainfall in the rolling plain zone is erratic and comes in intense localized storms. The average rainfall in this zone is about 22 inches, but the rain actually received in any one year may drop as low as 11 inches or rise as high as 35 inches.

A number of important tributaries rise in the grand prairie area, joining the main rivers at or below the

Balcones escarpment. These tributaries, like the main streams, are subject to large flood flow.

At the point of entrance into the humid portion of the drainage basins the flow of the rivers is erratic. Both the Colorado and the Brazos at the Balcones escarpment have gone virtually dry and remained in that condition for several months at a time. The average annual flow at the escarpment on both the Brazos and Colorado Rivers is about 800,000 acre-feet. The rivers attain large size and importance only when they enter the humid zone at the 25-inch-rainfall line. Below this line they have carved deep canyons.

Recommended Plan

Flood control is the most important water problem in the Colorado and Brazos River Basins. It is, however, so interconnected with the power and irrigation problems that it will be necessary to consider them together. Devastating floods originate largely in the canyon section of the river above the Balcones fault and below the semiarid region. The fault, where it crosses the basin, is marked by a prominent escarpment. At times it causes moisture-laden winds from the Gulf to yield torrential rain. The steep and bare slopes of the canyon area cause rapid run-off, resulting in high floods of short duration. The floods originating below the Balcones fault are not so severe because of the smaller drainage area, the nearly flat terrain, substantial vegetal cover, and rather absorptive soils. Austin and its immediate vicinity are subject to frequent flood damage. From Austin to Lagrange, about 60 miles downstream, the river overflows infrequently since it is confined between high banks. From Lagrange to the mouth of the river the banks are lower, and a large acreage of fertile and highly productive agricultural land is subject to overflow.

Since 1900, 24 floods have occurred. The combined losses are estimated at more than \$78,000,000. The largest flood of record occurred in June 1935, when the peak flow at Austin reached nearly 500,000 cubic feet per second. Damages totaled about \$13,000,000. Studies indicate that a peak flow at Austin of 850,000 cubic feet per second may be expected.

The first necessity in regulating the Colorado River is a large flood-control reservoir immediately above Austin. Provision should be made for power installation to be completed when the demand justifies. Other dams, primarily for power, can be built farther up the river as the market warrants. The Hamilton Dam, partially completed by a utility company several years ago, is to be completed by the Lower Colorado River Authority, a local agency, which also will proceed with other parts of the program.

Levees are needed along the lower stretches of the river. The Reclamation Department of Texas has pro-

posed about 133 miles of new levees and the raising of 23 miles of old levees to a height of 12 feet. The work should proceed as soon as practicable, subject to the outcome of investigations which are now being made by the Corps of Engineers and the United States Bureau of Reclamation.

In the Brazos River Basin, as in the Colorado Basin, the major floods result from storms near the Balcones fault. The most disastrous flood on the main stream occurred in 1913, when 177 lives were lost and the property damage amounted to more than \$3,000,000. This flood was exceeded in 1921 by one on the Little River, principal tributary of the Brazos. It caused 164 deaths and damages amounting to nearly \$13,000,000.

About 1,000,000 acres of fertile and highly productive bottom land along the main river and the tributaries below Waco are subject to overflow. A much higher state of cultivation of the lands could be attained if adequate protective works were provided.

The Corps of Engineers concluded, as the result of a preliminary examination of the river, that adequate flood-control works should include six storage reservoirs above Waco and levees below the city.

The Brazos River Conservation and Reclamation District is studying a comprehensive system of flood control. The system will conserve water for various uses in the entire basin. In the preliminary report of the district, a plan is proposed which contemplates the construction of 13 reservoirs controlling approximately three-fourths of the watershed area on the river. The first storage unit of the proposed system, the Possum-Kingdom Reservoir, situated on the main stream above Waco, is being investigated by the Corps of Engineers. It is indicated that flood flows several times greater than any of record may be expected from the area tributary to the proposed dam. A preliminary examination and report on the Leon River, principal tributary of the Little River, also will be made.

In view of recent storms and floods in Texas, a larger amount of the capacity of the reservoirs than previously estimated may be required for flood-control purposes. The installation of hydroelectric plants at the flood-control reservoirs and the construction of dams primarily for the generation of power should be contingent upon cost and market for the power. The flood-control reservoirs should have sufficient capacity to permit some carry-over storage to relieve occasional severe shortages of water for irrigation.

Irrigation in the Colorado and Brazos River Basins below the Caprock and above the 25-inch annual rainfall line is dependent upon the control of the water supplies to supplement deficient precipitation. About 36,000 acres of land are now irrigated. The Upper

Colorado River Authority, created by State legislative act, proposes a project to irrigate 50,000 acres of land in the vicinity of Tennyson. There is a definite need for such a project in this territory, but the size of the area to be served would not justify the complete cost.

The Corps of Engineers has been authorized to make a study of flood control on the Colorado above the Coke-Runnels County line. This should be supplemented by a general study of irrigation and municipal supplies in this area.

In the south high plain area above the Caprock the surface run-off is small, but *water supplies* can be obtained from underground sources, generally at a depth of from 50 to 200 feet. Water is pumped for irrigation principally in the vicinity of Lubbock. The amount of underground water is not definitely known, but preliminary studies have been made of the area by the United States Geological Survey. In some places the water contains damaging quantities of flourine. Since development of the underground water to the limit of feasibility for municipal and irrigation uses will become important, such studies of this area should be continued. The most serious municipal water-supply problem at present is that of Big Springs. A number of other water-supply projects and sewer systems in the two basins are recommended for construction. There is need for water and sewer projects for a number of other municipalities in the area, but the projects proposed are too expensive and require re-study. Waco, formerly dependent upon artesian and well water, has been forced by deficiency in these supplies to develop a surface supply from a tributary of

the Brazos. Austin uses the Colorado River as its source of water supply, without storage. The water-supply systems of both these cities have suffered severe flood damage.

Erosion is more serious in the canyon country of the two rivers than elsewhere in these basins, due to the torrential rains, the steep slopes, and other conditions prevailing there. The streams at times are heavily laden with silt. A preliminary estimate made by the Corps of Engineers indicates an annual load of suspended silt in the Brazos River at Waco of about 19,000,000 tons. The Austin Reservoir, immediately above the city of Austin, has been silted practically full. Silt is a serious menace to the major flood-control reservoirs proposed for these basins. Some study is being made of the erosion and silt problem in the Brazos River Basin. This study should be expanded to include the Colorado River Basin.

Navigation is possible only along the coast. The Navigation District of Brazoria County proposes the construction of concrete mat revetments to take care of the sloughing of the banks of the river.

The Colorado deposits its silt in Matagordo Bay behind an island barrier and is gradually filling the bay. A pilot channel has been cut through a delta of recent formation and across the island, in the hope that the Colorado will empty directly into the Gulf.

The intracoastal canal has been completed to the west side of Galveston County. Its completion to Corpus Christi has been authorized by the Congress. In the construction of the project consideration should be given to preservation of wildlife habitat.

Brazos Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
43	Brazos River, Tex.: Study of flood control by means of levees, also topographic mapping for the lower Brazos.	\$175,000	Plans for study made.
11	Study to devise plans for flood control and irrigation through topographic surveys examination of reservoir sites, water supply studies, etc., in area between Caprock and the 25-inch annual rainfall line in this basin.	250,000	Corps of Engineers authorized to make examination and report on part of this area in the Colorado River Basin. Estimated cost only approximate. Study to expand scope and area of preliminary examinations.
25	Temple, Tex.: Extension of mains and new storage reservoir for water supply.....	65,000	Sketch plans made.
23	Kosse, Tex.: Water supply from well; sewer system and sewage treatment plant.....	58,000	Preliminary plans made.
(1)	Aspermont (4), Benjamin (3), Burleson (8), Calvert (24), Hempstead (36), Lexington (34), Soudan (2), Taylor (33), and Tehuacana (22), Tex.: Water supply and sewer systems.	230,000	Preliminary plans made.
46	Freeport, Tex.: Concrete mat revetment.....	44,000	Do.
7	Palo Pinto County, Tex.: Possum Kingdom Dam for flood control and power.....	6,600,000	Amount needed to complete.
5	Hamlin, Tex.: Reservoir, additional filters and improvement of present filters.....	145,000	Preliminary plans made. Requires further study.
1	Muleshoe, Tex.: Sewer system.....	32,000	Preliminary plans made. System needed but cost excessive. Requires restudy.
30	Round Rock, Tex.: Sewer system with sewage treatment plant.....	47,000	Do.

¹ Map key number shown following community name.

NOTE.—Completion of intracoastal waterways is covered by project list under Nueces Basin.

Brazos Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
10	Abilene, Tex.: Domestic water-supply improvements.....	\$614,000	Preliminary plans made. Requires further study.
36	Hempstead, Tex.: Water-supply system.....	60,000	Do.
26	Bell County, Tex.: Lampasas Reservoir.....	1,355,000	Under study. Estimate of cost approximate.
21	Bell County, Tex.: Leon Reservoir.....	2,382,000	Do.
35	Madison County, Tex.: Navasota Reservoir.....	2,143,000	Do.
6	Stephens County, Tex.: Breckenridge Reservoir.....	2,385,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
39	Lower Brazos River, Tex.: Levee construction and channel improvement for flood control.....	\$15,594,000	Estimate of cost only approximate. Corps of Engineers and Brazos River Conservation and Reclamation District are cooperating.
20	Brazos River and tributaries, Tex.: Dams for flood control and power.....	30,000,000	Preliminary report made. Studies under way.
46	Freeport Harbor, Tex.: Extension of 30-foot channel.....	9,000,000	Preliminary plans made by Corps of Engineers.

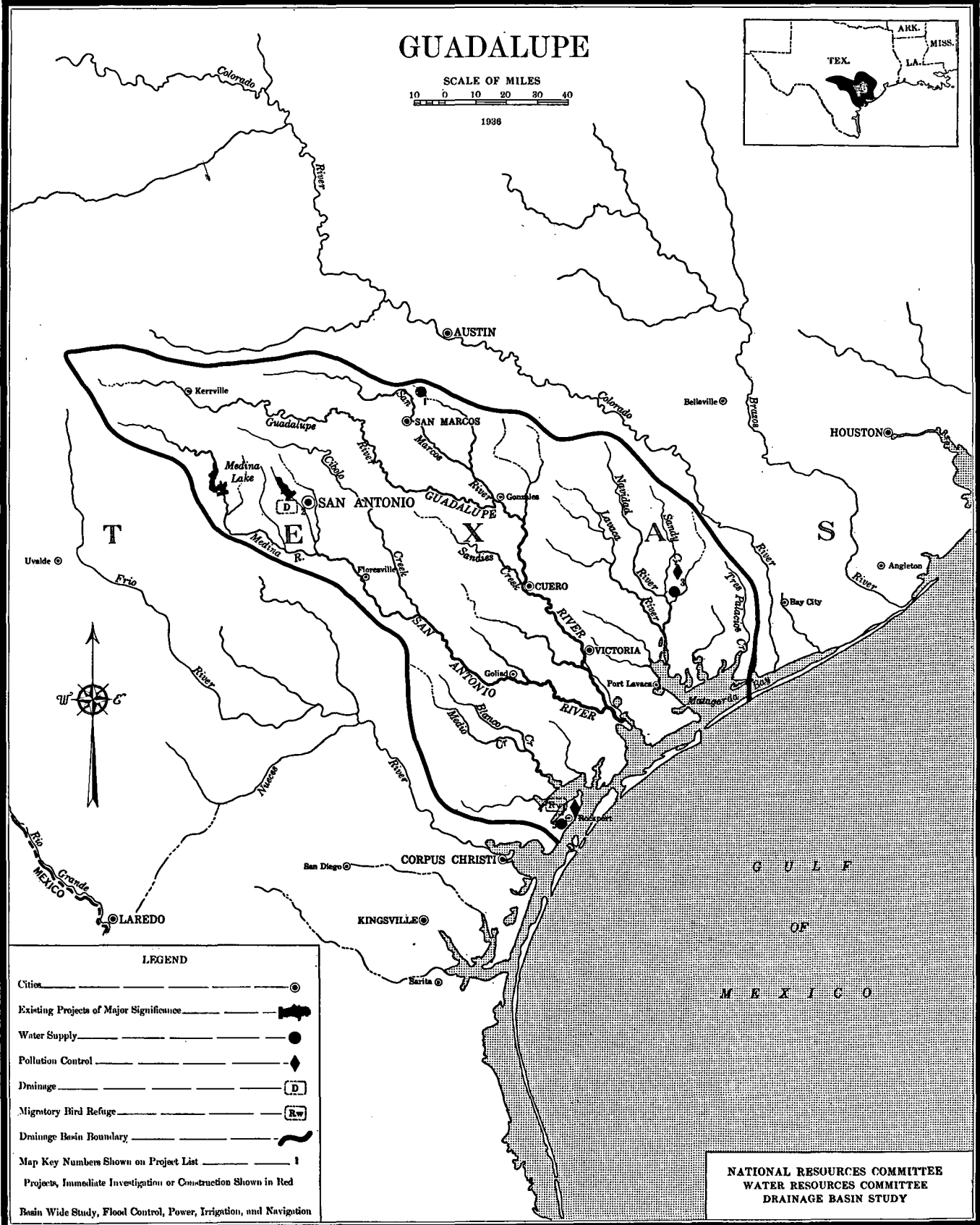
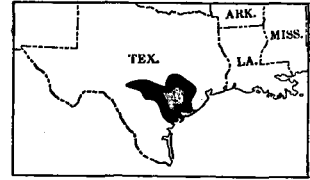
Colorado of Texas Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
44	Matagordo and Wharton Counties, Tex.: Topographic mapping and study of levee design for flood control of the lower Colorado River.	\$175,000	Plans made.
29	Marshall Ford, Tex.: Reservoir dam to be raised to provide extra capacity for flood control, power, and irrigation.	8,000,000	Plans practically complete. Cost given is for next two years. Additional needed to complete, \$13,750,000.
13	Big Spring, Tex.: Water-supply reservoir, pipe line; tanks and filtration plant.....	500,000	Preliminary plans made.
27	Eldorado, Tex.: Waterworks and sewer system including treatment plant.....	105,000	Do.
14	Hobbs and New Hobbs, N. Mex.: Sewer system and sewage-treatment plant.....	159,000	Do.
32	Elgin, Tex.: Water-supply system.....	13,000	Preliminary plans made.
42	Bay City, Tex.: Wildfowl refuge facilities and water-control works.....	42,000	Plans completed.
1	Muleshoe, Tex.: Muleshoe wildfowl refuge: Housing facilities and water-control works.....	33,000	Do.
16	Winters, Tex.: Dam, pumping equipment, and treatment plant for domestic water supply.....	84,000	Preliminary plans made. Requires restudy.
18	Bangs, Tex.: New filtration galleries and pumps for water supply, and sanitary sewers and sewage-treatment plant.	31,000	Preliminary plans made. Requires restudy on account of excessive cost.
GROUP B—FOR DEFERRED CONSTRUCTION			
17	Coleman, Tex., central Colorado Authority project: 3 small reservoirs for domestic stock and irrigation use.	\$567,000	Preliminary plans made.
12	Colorado, Tex.: Reservoir, filtration plant, pipe line, and pumping station for water supply.....	184,000	Preliminary plans made. Requires restudy because of excessive cost.
37	Smithville, Tex.: Deep well, surface reservoir, elevated tank, and distribution system for water supply.	185,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
38	Lower Colorado River: Levees and channel improvement for flood control.....	\$3,200,000	Preliminary examination being made by Corps of Engineers and U. S. Bureau of Reclamation.
15	Upper Colorado River Authority project near Tennyson, Tex.: Reservoirs and canals for irrigation.	7,000,000	Preliminary plans and report made. Project needed but cost excessive.
19	Brown County water improvement district project near Brownwood, Tex.: Outlet canal from reservoir for irrigation and domestic water supply.	1,000,000	Preliminary plans made and project needed but cost is excessive.
29	Travis County, Tex.: Marshall Ford Dam; generating equipment for power.....	828,000	Estimated cost only approximate.
31	Travis County, Tex.: Mount Bonnell Dam regulation reservoir, primarily for flood control.....	1,560,000	Preliminary studies made. Estimated cost only approximate.
31	Travis County, Tex.: Mount Bonnell power plant.....	743,000	Do.
28	Burnet County, Tex.: Granite Shoals Dam and power plant; reservoir used for flood control also.....	5,756,000	Do.

GUADALUPE

SCALE OF MILES
10 0 10 20 30 40

1938



LEGEND

- Cities _____ ●
- Existing Projects of Major Significance _____ ■
- Water Supply _____ ●
- Pollution Control _____ ◆
- Drainage _____ [D]
- Migratory Bird Refuge _____ [Rw]
- Drainage Basin Boundary _____ ~
- Map Key Numbers Shown on Project List _____ 1
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Flood Control, Power, Irrigation, and Navigation

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

4. GUADALUPE

The major problem of the Guadalupe and San Antonio River Basins is that presented by floods, the greatest of which occurred in 1936. The report by the Corps of Engineers on the Guadalupe River, made in 1935, should be revised and should be extended to include the San Antonio and Lavaca Basins.

Underground waters are generally ample and water supply is a minor problem.

General Description

These drainage basins are in southeastern Texas, extending from the Edwards Plateau to the Gulf of Mexico. They have an area of about 13,000 square miles. Included are the drainage basins of the Lavaca, Guadalupe, and San Antonio Rivers and those of several minor streams. North of the Balcones escarpment, which is the southerly boundary of the Edwards Plateau, these rivers are typical mountain streams with headwaters at an altitude of about 1,700 feet. From the Balcones escarpment they descend through a rolling and prairie country for a distance of from 30 to 150 miles.

The population of the area is about 555,000, with 30,000 on the Edwards Plateau where the density is less than 10 per square mile. Below the escarpment the density of population is about 50 per square mile. Half the population is urban. San Antonio, the principal city, is the industrial, commercial, and transportation center of southern Texas. Oil and gas are produced in several counties.

Quarries for production of crushed limestone are situated along the Balcones fault, and large gravel and sand plants are in operation at Victoria. Minor industries scattered through the basin are cotton ginning, cottonseed oil extraction, cotton textiles, brick, hydrate of lime, ice, dairying, and flour milling.

Agricultural and livestock products include raw wool and mohair from the Edwards Plateau, poultry and dairy products, raw cotton, pecans, corn, and beef cattle in the Coastal Plain section. The greater portion of the area of these basins is in farms.

The line of 25-inch average annual rainfall crosses the upper Guadalupe and San Antonio Valleys. Below the Edwards Plateau the San Antonio and Guadalupe Rivers receive large additional supplies from springs having their sources in the plateau. The flow of the San Marcos and New Braunfels Springs averages 457 cubic feet per second, or enough to supply nearly one-third of the water consumption of New

York City. San Antonio is supplied with water from wells tapping the underground flow. This area is subject to great variation in total annual rainfall. On the Guadalupe River at New Braunfels the 39-year average rainfall has been 30 inches, with a minimum of 13 inches and a maximum of 60 inches. Disastrous floods in 1936 indicate that previous estimates for flood control must be revised.

Recommended Plan

A *flood-control* study to evolve a complete plan for the area below the Balcones fault is recommended. The 1935 report of the Corps of Engineers presents a plan for the development of the Guadalupe River and its tributaries for flood control, hydroelectric power generation, irrigation, and navigation. Because of the unprecedented flood of 1936, further studies of the Guadalupe are under way, and similar studies of the San Antonio and Lavaca Rivers should be made. Rainfall records indicate that the 1936 flood was caused by water which fell below the storage dams proposed in the plan of the Corps of Engineers.

San Antonio has constructed a large flood detention reservoir a short distance above the city, but the business section is still subject to floods from areas below the reservoir. The Corps of Engineers has recommended storage reservoirs with a combined capacity of 401,000 acre-feet to cost \$4,400,000. Average annual flood damages on the Guadalupe River alone are estimated at \$190,000. The damage from the 1936 floods greatly exceeded the average. Construction of the reservoirs recommended by the Corps of Engineers will save at least half of these damages, which combined with benefits to power and irrigation would justify their construction now.

Power is produced by 23 hydroelectric plants with a total installed capacity of 21,800 kilowatts on the Guadalupe, Comal, and San Marcos Rivers. The cost of production of power by steam, using local oil and gas for fuel, is low and obviously a factor in further development of water power. Most of the hydroelectric energy is consumed within the area, chiefly at San Antonio.

Future construction of seven hydroelectric plants between Gonzales and Victoria having a combined installed capacity of 17,000 kilowatts, an increase of 70 percent over the present installation, is considered in a report by the Corps of Engineers.

Water supply.—Most of the communities obtain their supplies of water from deep wells or springs. Numerous water-supply projects have been completed in these basins with Public Works Administration loans and grants and others are under consideration. Construction of a pipe line from the springs at Comal or New Braunfels to supply Corpus Christi and intermediate cities has been considered.

Consideration also should be given to the problem of *malaria* resulting improper design and operation of various water projects.

Irrigation in the area has been practiced since 1730, but repeatedly has been affected by the fact that the

rainfall is adequate for crop production in many years.

The Corps of Engineers in its 308 report considers irrigation of 21,000 acres in Hays and Caldwell Counties in the vicinity of Kyle. However, there appears to be no economic need for further irrigation projects at present. Rice is irrigated in this section of the Coastal Plain, though not on a large scale.

The *Intracoastal Canal* has been authorized from New Orleans to Corpus Christi, has been in operation as far as Galveston and Houston since 1935, and is under construction west of Galveston. Traffic on the completed section is increasing rapidly.

Guadalupe Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study of the coordinated utilization of the water resources of the Guadalupe, San Antonio and Lavaca basins for flood control, water power, irrigation, and navigation.	\$100,000	Continuation of study made by Corps of Engineers.
2	Brooks Field, San Antonio, Tex.: Drainage of flying field.....	120,000	Preliminary plans made.
3	Ganado, Tex.: Waterworks and sewer system.....	54,000	Preliminary plans made. Requires restudy.
1	Kyle, Tex.: Waterworks.....	38,000	Do.
4	Rockport, Tex.: Migratory bird refuge. Improve existing facilities.....	56,000	Preliminary plans made.
GROUP B—FOR DEFERRED CONSTRUCTION			
5	Rockport, Tex.: Water supply system, sewer system, and sewage treatment plant.....	\$102,000	Preliminary plans made. Requires restudy because of excessive cost.

5. NUECES

The Nueces River Basin needs works to conserve for irrigation the water now largely wasted in damaging floods. Designs should be prepared, from the results of investigations now under way, to control the floods and utilize the water. Several communities need new or improved water systems for water supply or sewage disposal. Along the coast an important navigation improvement, the intracoastal canal, has been authorized by the Congress.

General Description

The Nueces River and its tributaries drain an area in southern Texas roughly equal to that of Massachusetts, Connecticut, and Rhode Island, and discharge into the Gulf of Mexico at Corpus Christi, Tex. The basin as treated in this report includes also an area of coastal lowlands about half as large. With its longest tributary the river is 350 miles in length.

The headwaters are in the Edwards Plateau at a maximum altitude of 2,500 feet—a region of steep slopes with shallow soil and little cover. From the plateau the land drops in less than 40 miles to an altitude of 1,000 feet in the region of the Balcones fault and the outcrop of the Carrizo sandstone, a belt 25 to 30 miles in width. Here much of the normal flow coming down the typical mountain streams from the Edwards Plateau seeps away, making it a problem to bring the water from possible reservoirs above the fault down to irrigable land below without excessive seepage loss.

The soils, in general, are thinner and relatively more drought resisting than the Blackland Prairie soil found in the humid regions of the coastal plain. There is little alluvial soil. Only a small part of the area is in crop production, and of this only about half is irrigated. The irrigated lands comprised about 38,000 acres in 1930, lying immediately below the Carrizo sandstone outcrop in the area commonly called the Winter Garden. The dry farming country near Corpus Christi produces vegetables and a large amount of cotton. Some citrus fruit is grown.

The total population of the Nueces drainage basin in 1930 was 250,000, an average density of 10 per square mile; about one-quarter was urban. Corpus Christi, a deep-water port, is much the largest community; its population was 28,000 in 1930, has grown rapidly, and is now estimated at 50,000.

Oil production is of minor importance at present. There is a sulphur mine west of San Diego. An alkali

plant has recently been put in operation at Corpus Christi, taking advantage of the low cost of natural gas. The completion of the intracoastal canal from Galveston Bay will increase the importance of Corpus Christi, which will then be the western terminus of the barge canals from the Mississippi River Valley and the Gulf coast.

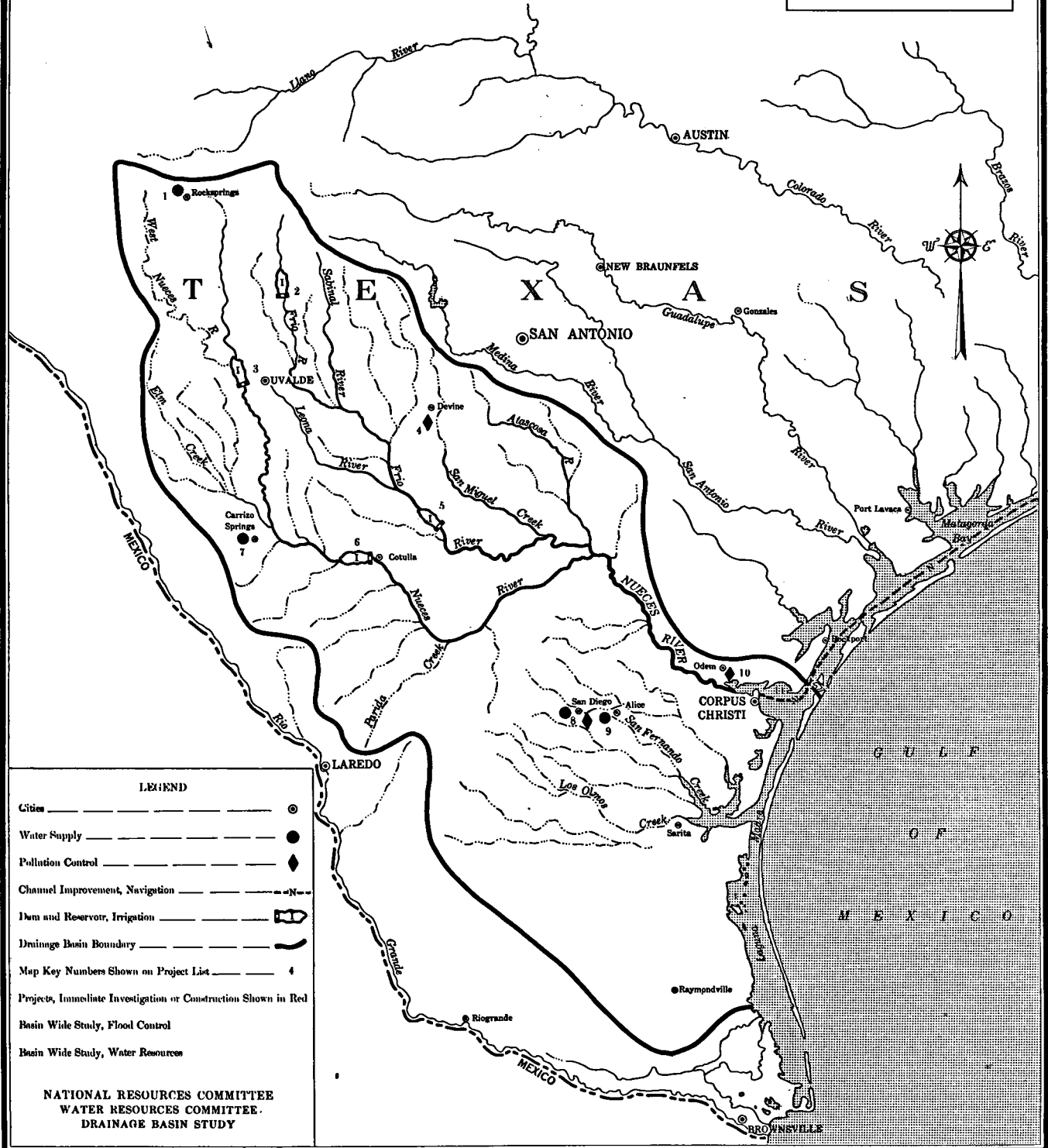
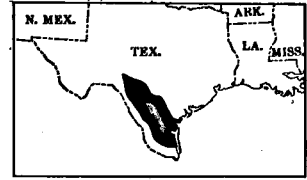
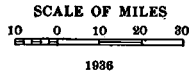
The basin is in the subhumid zone; annual precipitation ranges from 8 to 45 inches and averages about 25 inches. Most of the rainfall occurs during the growing season of from 250 to 300 days. Farming without irrigation is successful around Corpus Christi. Run-off is highly variable, some of the streams being dry at times. The average annual discharge of the Nueces River at Three Rivers is about 450,000 acre-feet; the minimum annual flow is 5.4 percent of the maximum. Some of the most intense rains ever recorded in Texas have centered over the headwaters of the Nueces Basin. Because of such storms and the steep and scantily covered slopes, flood crests are among the highest in the United States in proportion to the drainage area.

Recommended Plan

Flood control and irrigation.—The two major problems of this basin are the control of floods and the conservation of water for irrigation. Neither of these related problems has yet been adequately studied. The Corps of Engineers has been authorized to make a preliminary examination of the flood problems of the basin. The Nueces River Authority, organized under Texas law, is also engaged in a preliminary study. On the foundation to be provided by these preliminary surveys it is recommended that a major study project be undertaken.

This study should include topographic mapping of the overflowed area in the vicinity of Three Rivers and of other parts of the basin; survey and exploration of possible reservoir sites; installation of needed gaging stations; investigation of seepage losses across the Balcones fault zone; studies of surface-water supply and reservoir operation; and a continuation and expansion of the surveys of underground-water supplies now under way. The results of this basin-wide study would determine the amount of water available, proper means for its control, the land to which it could be applied with maximum benefit, and the cost and nature of flood-control measures. A complete investi-

NUECES



- LEGEND**
- Cities _____ ●
 - Water Supply _____ ●
 - Pollution Control _____ ◆
 - Channel Improvement, Navigation _____ -N-
 - Dam and Reservoir, Irrigation _____ [Dam Symbol]
 - Drainage Basin Boundary _____ [Thick Line]
 - Map Key Numbers Shown on Project List _____ 4
 - Projects, Immediate Investigation or Construction Shown in Red
 - Basin Wide Study, Flood Control
 - Basin Wide Study, Water Resources

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

gation of the major irrigation projects already proposed should be included. Full consideration should be given to proper coordination between flood control and irrigation.

The magnitude of the flood-control problem may be visualized by considering the greater of two floods that occurred in the basin in 1935. In June of that year there was a peak flow estimated at more than 400,000 cubic feet per second from a drainage area of 400 square miles. Depths of 31 feet at Cotulla and 44.7 feet at Three Rivers were reached. The damage was estimated at about \$10,000,000.

The lower end of the basin, with its almost flat slopes and poor natural drainage, has experienced flood waters more than 20 miles in width, covering this agricultural land to an average depth of nearly 2 feet.

There is more agricultural land adaptable to irrigation, under subtropical climatic conditions, than can be supplied by the water available. The marked variations in annual stream flow and the prospect of seep-

age losses in the Balcones fault and Carrizo sand zone have so far prevented the utilization of any great amount of the surface water for irrigation. About 27,000 acres in the Winter Garden region are irrigated from wells; the average annual withdrawal of water, 20,000 acre-feet, equals the recharge rate. There is need for proper legislation to provide for administration of the use of underground-water supplies.

Four irrigation projects have been listed to await the results of the general study of the basin.

Water supply for municipalities in this district is not an urgent problem. Most of the communities obtain their supply from underground sources. Corpus Christi, however, gets its supply from the Nueces River, impounding the water in Lake Corpus Christi. Improvements are proposed for the water-supply systems of several smaller towns. These projects should be restudied to determine whether their costs are excessive.

Nueces Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
11	Sabine River to Corpus Christi, Tex.: Intracoastal waterways.....	\$3,900,000	Authorized by Congress. Cost given is for next two years. Additional needed to complete, \$1,500,000.
9	Alice, Tex.: New well and improvements to water supply system.....	98,000	Preliminary plans made.
1	Rocksprings, Tex.: Water supply system.....	26,000	Do.
(1)	Devine (4) and Odem (10), Tex.: Sewer systems and sewage treatment plants.....	67,000	Do.
7	Carrizo Springs, Tex.: Deep well and extensions to water supply system.....	46,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
8	San Diego, Tex.: Water supply system, sewer system and sewage treatment plant.....	\$158,000	Preliminary plans completed. Requires restudy due to excessive cost.
	Study to provide plan for control and development of water resources throughout entire basin.....	500,000	Preliminary examination under way. (Controls design of 4 construction projects in group C.)
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
5	La Salle and McMullen Counties, Tex.: Fowlerton project, irrigation, reservoir, and canal.....	\$2,500,000	Preliminary plans completed. Should await result of study project.
3	Zavalla County, Tex.: No. 2 project, irrigation, reservoirs and lined canal.....	5,000,000	Do.
6	La Salle County, Tex.: Cotulla project, irrigation, reservoir and canal system.....	5,800,000	Do.
2	Uvalde County, Tex.: Shut-In project, Frio River, irrigation, reservoir and lined canal.....	3,500,000	Do.

¹ Map key number shown following community name.

6. LOWER RIO GRANDE-PECOS

The prime necessity so far as the lower Rio Grande-Pecos Basin is concerned is a treaty with Mexico covering the division and control of the waters of the Rio Grande below Fort Quitman and providing for the construction and operation of reservoirs on the main stream where it forms the international boundary.

Despite the fact that an average of about 4,000,000 acre-feet of unused flood waters flow annually from the Rio Grande into the Gulf of Mexico, Texas irrigators who are dependent on the stream for a livelihood suffer severe losses because at low flow the supply of water is insufficient for their needs. A survey of actual and potential water requirements on the Texas side of the Rio Grande must precede treaty negotiations, and by treaty alone can the difficulties of the basin be solved.

A problem more or less similar exists on the Pecos River, an interstate stream, the waters of which are being used, not without friction, in both New Mexico and Texas. Negotiation of an interstate compact covering this stream is in progress. It should be completed expeditiously so that use of the waters of the Pecos may be stabilized and the maximum benefit obtained.

Water supply for irrigation and domestic use presents other problems. Studies of soil erosion in the upper Pecos Basin and of underground water resources are needed.

General Description

The Rio Grande, the boundary for 1,300 miles between the United States and Mexico, drains an area below Fort Quitman nearly as large as California. More than half of this area is in Mexico. About 70 percent of the water in the lower Rio Grande originates south of the boundary. The Pecos River, the largest northern tributary of the Rio Grande, drains an area about equal to that of Kentucky.

The Pecos River and its chief tributaries rise in mountainous National Forest areas in New Mexico. Altitudes of 11,000 feet are reached. The irrigated valley floor lies at an altitude of 2,500 to 3,500 feet. It is broad, treeless, and semiarid. The Rio Grande from Fort Quitman, which divides the upper and lower Rio Grande Basins, to Del Rio; the Pecos from Sheffield to its junction with the Rio Grande below Langtry; and the Devils River from Ozona to its junction with the Rio Grande above Del Rio, all flow through rough canyon country. From Fort Quitman to its junction with the Pecos near Langtry, the Rio

Grande flows in a big bend around the Davis Mountains of Texas. From Del Rio, at an altitude of 950 feet, to Penitas, which lies 800 feet lower, the Rio Grande traverses nearly 400 miles of rough, broken country. The lower Rio Grande Valley, as opposed to the lower basin as here defined, extends from Penitas to the Gulf of Mexico, a distance of 195 miles by the river but only 70 miles in a straight line.

The present population of the lower Rio Grande-Pecos area in the United States is more than 450,000, of which 200,000 are urban. About 250,000 live in the lower Rio Grande Valley. It is estimated that by 1950 the population of this basin will increase one-third and that two-thirds of the population will be in the lower valley.

The entire lower Rio Grande-Pecos River Basin is semiarid. The rainfall ranges from less than 10 inches in the upper section to about 25 inches annually near the Gulf of Mexico. With the exception of a comparatively small area near the Gulf, all the cultivated agriculture is the result of irrigation. The dry farming practiced in the region of the Gulf consists of cotton raising and the production of winter vegetables and citrus fruits. In the vast area where dry farming is not practicable and where insufficient water is available for irrigation, encompassing all the central part of the basin, stock raising is the chief industry.

Other than agriculture, the chief industries of the basin are the production of minerals and oil.

Although the Pecos River is dry for months each year, it may also have disastrous floods. The normal flow of the river and its tributaries disappears from place to place in river bed sands, reappearing in part farther down the stream.

Because of shoaling, due to the heavy silt burden of both the Pecos and Rio Grande, navigation is no longer practicable. At times the entire flow reaching the lower valley is used for irrigation, and there is need for more water. At other times, when the river is in flood, not only the main channel but also two floodways on the Texas side of the river and overflow lands on the Mexican side carry water to the Gulf.

More than 100,000 acres are irrigated in the Pecos Valley, with about 70,000 acres of the total in New Mexico. Wells provide water for half this land. The largest irrigated areas are the Carlsbad, San Solomon, Comanche, and Roswell projects, the last named of which is irrigated from artesian wells. The Pecos Valley supports 120,000 people, principally clustered where irrigation water is obtained.

In the lower Rio Grande Valley, of 1,000,000 acres available for use on the Texas side of the river, 400,000 acres now are irrigated and about 200,000 acres are dry farmed. The crops produced by irrigation in the lower Rio Grande-Pecos River Basin are of wide variety, with cotton, winter vegetables, citrus fruits, and alfalfa the leaders.

While the concern here is with the part of the basin within the United States, that which lies in Mexico cannot be ignored. There is sufficient arable land on either side of the river to require in its development by irrigation all the waters of the stream. Construction of large-scale irrigation projects on the Mexican side has proceeded less rapidly than in Texas, but is now increasing. Three important tributaries enter the lower Rio Grande from the Mexican side; additional development on them will aggravate the situation in Texas.

Recommended Plan

Control of the Rio Grande and diversion of water from it are complicated by the fact that from El Paso to the Gulf the river is the international boundary, making allocation of water a treaty matter. Construction of dams on the Rio Grande for storage and diversion would enable areas now developed to obtain water at less cost than at present, and to have a reliable supply. It also would provide surplus water for expansion of the irrigated area. As a preliminary step to treaty negotiation a survey should be made of the actual and potential water requirements on the Texas side of the Rio Grande to determine, among other things, the size of the dams and reservoirs that should be constructed.

Soil erosion has become a major problem in the Pecos River Valley. A study of erosion control in this region to devise means for reducing serious soil losses should be undertaken. Plans are ready for an erosion-control project to conserve Government land within the Fort Stanton boundaries.

Irrigation needs of the lower valley can be met by constructing three reservoirs, two above and one below Laredo. The generation of a substantial amount of hydroelectric power also will be made possible by these dams, which have been proposed by the International Boundary Commission.

The basin of Lake McMillan on the Pecos River, which has been the main source of water supply for the Carlsbad irrigation project, has been silted and is leaky, making necessary the construction of the Alamagordo Dam. The completion of this project, including the lining of canals to reduce seepage losses, is recommended.

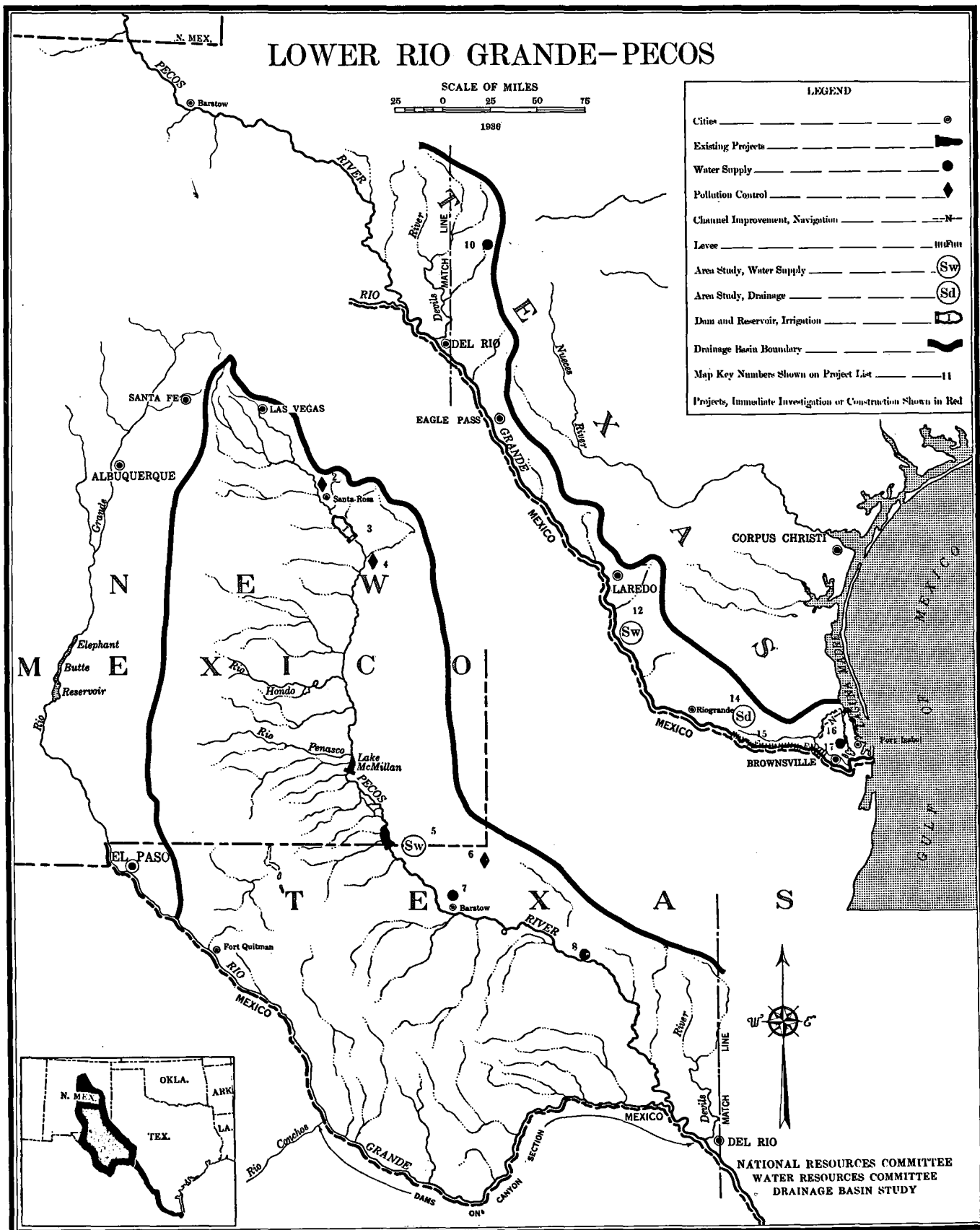
Municipal water supplies in the lower Rio Grande Valley come from the river itself, usually by way of some irrigation canal. In the Pecos Valley municipal supplies are obtained largely from wells and springs. There are no municipal water problems of basin-wide significance. There is need for improvement of waterworks for the towns of Rankin and Barstow, in Texas.

A study of underground water resources of the Pecos River Basin should be made to determine their extent and quality and to supply the basic data necessary for their proper development.

Pollution.—Sewage disposal facilities are lacking in about half the communities of the basin. Plans are being prepared which provide for a sanitary sewer system and disposal plant for the town of Wink, Tex., and replacement of the old systems in the towns of Santa Rosa and Fort Sumner, in New Mexico.

Consideration also should be given to the problem of *malaria* resulting from improper design and operation of various water projects.

Flood control.—Through an informal agreement with Mexico for flood control in the Rio Grande Delta, each nation is constructing flood works within its territory in accordance with a joint plan. Completion of the levees and floodways along the Rio Grande above Brownsville is essential to protect the large investment in the delta area on the Texas side.



Lower Rio Grande—Pecos Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
12	Study of water uses and water supply in Texas along the Lower Rio Grande below Fort Quitman.....	\$200,000	Factual data now in hand should be supplemented and extended in cooperation with State of Texas. Preliminary plans for study completed.
14	Study of the lower valley of the Rio Grande to form basis for design of needed drainage system, including topographic mapping and water table and seepage investigation.	75,000	Preliminary plans for study completed.
5	Study to determine the interstate phases of the Pecos River and the facts in regard to the water supply and uses which will form a basis for the compact negotiations between New Mexico and Texas.	75,000	Estimated cost approximate.
15	Lower Rio Grande Valley, Tex.: Flood control by levees and floodways.....	3,290,000	Levees and flood ways more than half completed. Amount needed to complete.
	Fort Sumner, N. Mex.: Alamogordo Dam on Pecos River 15 miles above Fort Sumner to replace capacity of Lake McMillan depleted by silt. Lining of irrigation canals to prevent seepage losses.	400,000	Under construction. Cost given is for next two years. Additional needed to complete \$200,000.
8	Rankin, Tex.: Improvements to water supply system.....	40,000	Preliminary plans made.
	Santa Rosa, N. Mex.: Replacement of old sewer system.....	35,000	Plans being prepared.
	Fort Sumner, N. Mex.: Replacement of old sewer system.....	60,000	Do.
10	Sonora, Tex.: Water-supply system.....	93,000	Preliminary plans made.
6	Wink, Tex.: Sewer system and sewage-treatment plant.....	51,000	Preliminary plans in preparation.
17	Port Isabel, Tex.: Water supply, purification plant, and extension of mains.....	75,000	Preliminary plans made.
GROUP B—FOR DEFERRED CONSTRUCTION			
16	Harlingen, Tex.: Completion of light-draft channel between Port Isabel and Harlingen	300,000	Plans completed.
7	Barstow, Tex.: Water supply.....	\$51,000	Preliminary plans made. Requires restudy.

COLORADO BASIN

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1. COLORADO

The Colorado River Basin, semiarid to very arid, includes parts of seven western States and a small area in Mexico. The problem of devising a comprehensive plan for use of the waters of the Colorado River is complicated because the aridity of the region through which it flows gives these waters a special significance and because the Colorado is both an interstate and an international stream.

Almost all the agriculture of the basin, which in area comprises about one-thirteenth of the United States, is dependent upon irrigation from the river or its tributaries. Likewise the urban centers are dependent on its waters. In addition, water is diverted from the Colorado Basin into other basins for irrigation and domestic supply.

Conservation of the waters of the Colorado River system is most important. In the negotiation of the Colorado River compact, approved by six of the seven States, a start was made toward settlement of conflicting water claims and contests between States and between smaller subdivisions. A treaty with Mexico and additional interstate agreements must precede final settlement of controversies and full utilization of the river.

An extensive system of storage reservoirs will be required before the ultimate development can be obtained. The key dam and the key reservoir have been completed, however, with the construction of Boulder Dam and the creation of Lake Mead.

General Description

Included in the drainage basin of the Colorado River and its tributaries are the southwestern corner of Wyoming, the western portion of Colorado, the eastern half and southwestern corner of Utah, a strip of New Mexico along its western boundary, virtually all of Arizona, a narrow strip of southern Nevada, a small area in California along the Arizona and Mexican boundaries, and about 2,000 square miles in Mexico north of the Gulf of California. The Imperial Valley in southern California, for the purposes of this study, has been included as a part of the Colorado River Basin, although the valley drains into the Salton Sea, a closed basin. The Colorado River Basin contains 245,000 square miles in the United States.

A rugged mountainous plateau between 5,000 and 8,000 feet in altitude comprises the northern portion of the basin lying between the crests of the Rocky Mountains on the north and east, and those of the Wasatch

Mountains and lower ranges on the west. Hundreds of peaks more than 13,000 feet in altitude and nearly two score exceeding 14,000 feet rise in these mountain chains. The southern portion of the basin generally is rugged with occasional level valleys and plateaus. It is extremely arid. Stupendous canyons have been cut by the main river and its tributaries and, although they have retarded local development in various ways, they afford many fine possibilities for storing water. The principal gorge of the Colorado is the world-famed Grand Canyon. The river has built a great delta, which extends entirely across the Gulf of California, cutting off the upper end to form the Imperial Valley.

Forests of spruce, fir, aspen, yellow pine, oak brush, pinon, and cedar cover part of the basin lying at altitudes between 7,000 and 11,000 feet. Below 7,000 feet are found typical desert plants—sagebrush, manzanita, greasewood, and cactus.

Precipitation varies in the basin from 3 to 35 inches annually depending principally on the altitude, with nearly all the habitable lands at the arid levels and only the high mountains humid. Most of the rain and snow is received in the winter and the growing season is dry. Temperatures range from 35° below zero to 130° above.

The annual flow of the Colorado and its tributaries has varied from a recorded minimum of 4,000,000 to a maximum of 26,000,000 acre-feet. Principal tributaries are the Green, Gunnison, Dolores, San Juan, Little Colorado, Virgin, Williams, and Gila Rivers.

The population of the basin is approximately 774,000 with 225,000 living in cities. Its principal communities, most of which are small, are: Gallup and Silver City, N. Mex.; Durango, Montrose, and Grand Junction, Colo.; Green River, Wyo.; Moab and St. George, Utah; Phoenix, Flagstaff, Tucson, Kingman, and Yuma, Ariz.; Pioche and Las Vegas, Nev.; and Needles, Blythe, and El Centro, Calif. Farming by irrigation, stock raising, and mining are the principal industries. At present 2,609,000 acres are under irrigation in the basin within the United States. The extent to which this acreage may be increased is uncertain, but it probably cannot be more than doubled.

Recommended Plan

Distribution and maximum use of the waters of the basin require construction of a series of reservoirs, principally for domestic and irrigation water require-

ments. Most of these reservoirs would, however, develop hydroelectric power, improve sanitation and recreational facilities, and provide wildlife refuges. Deposition of silt, particularly in the lower reaches, will slowly rob these reservoirs of their useful storage capacity.

Other problems, attendant on the use of water for irrigation, include the increase of alkalinity of return flow waters, subjugation of desert soils entirely lacking in humus, and the problem of increasing the efficiency of present irrigation practices.

In addition, as already noted, there are problems relating to conflicts between States, conflicts between localities within the States, and an international problem. Moreover, there is a controversy with respect to the pooling of rights from water storage and stream regulation. The conflicts between States can be eliminated by interstate compacts. One of the more pressing needs is for basic data upon which these compacts can be founded.

A long first step was taken toward removal of these artificial barriers in the way of utilization of the waters of the Colorado River when the Colorado River compact was signed by six of the basin States, Arizona alone dissenting. Negotiated with Federal authorization, the compact has determined the general allocation of the water supply as between the upper and lower States of the basin, with the dividing point on the river at Lees Ferry in Arizona, close to the Utah-Arizona boundary.

Two provisions in the compact are of particular importance. First, out of the normal annual flow of the Colorado River system, 7,500,000 acre-feet are apportioned to the upper basin States and 8,500,000 to the lower basin States. To compensate for annual variations, the upper basin States shall not deplete the flow at Lees Ferry below a yield of 75,000,000 acre-feet in any successive 10-year period. Second, any apportionment to Mexico established by treaty shall be supplied from surplus waters, but in the event this supply is insufficient, the deficiency shall be made up equally by the upper basin and the lower basin.

The Boulder Canyon Project Act, enacted in 1928, authorized construction of Boulder Dam and the All-American Canal, the latter to serve the Imperial Valley. It also authorized the States of California, Arizona, and Nevada to enter into an agreement to divide the waters allocated to the lower basin on the basis of 4,400,000 acre-feet to California, 2,800,000 acre-feet to Arizona, and 300,000 acre-feet to Nevada. These three States have not reached an agreement, although California has accepted its allotment of 4,400,000 acre-feet by an act of the State legislature.

No treaty has been made with Mexico concerning division of the waters of the Colorado River. Mexico

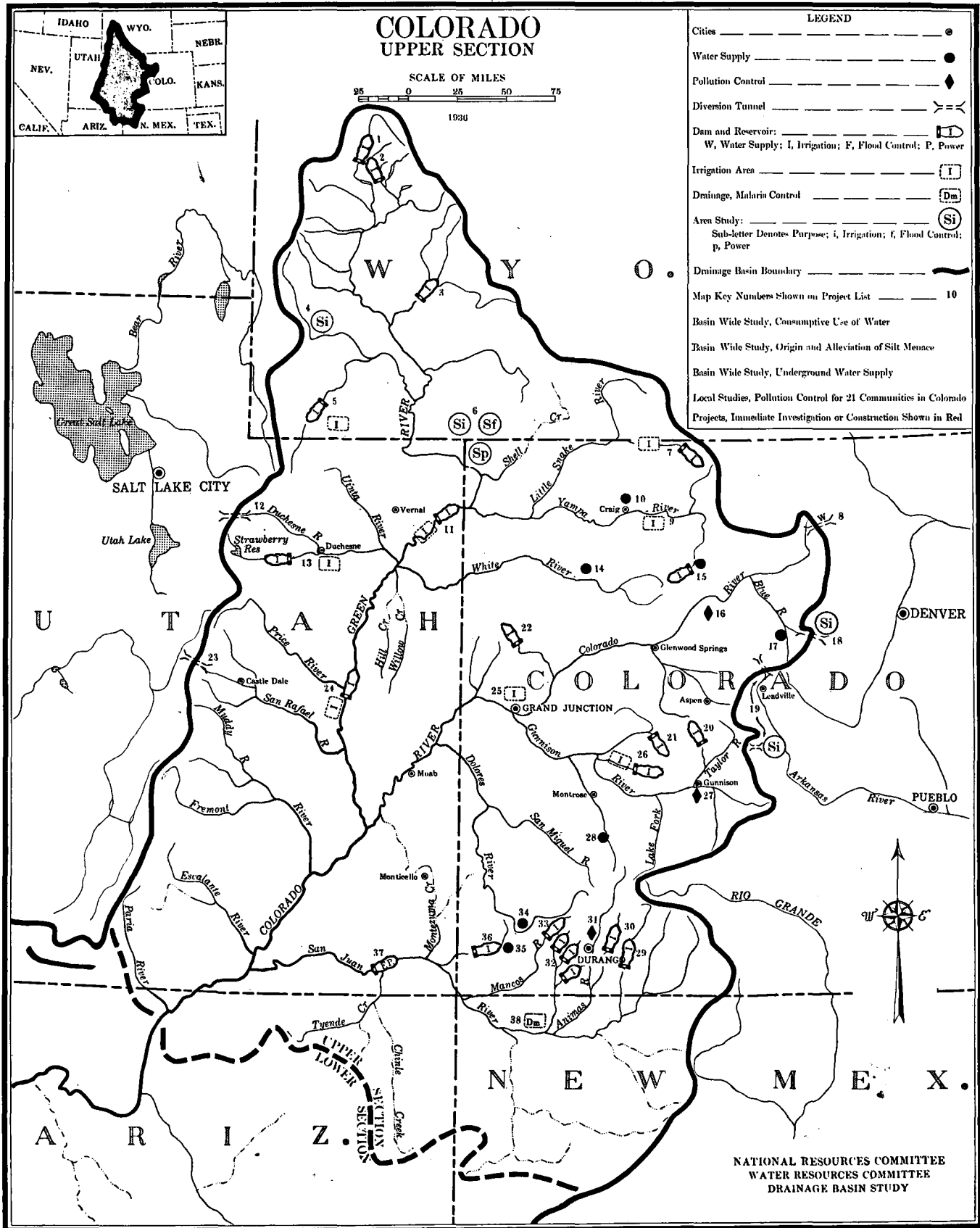
contributes virtually none of the water in the river. However, about 200,000 acres are irrigated there from the river. This acreage could be expanded by more than 600,000 acres. Now that the river has been regulated a reliable supply of water is entering Mexico. This supply will be available at least until additional use is made under the Colorado River compact of the waters of the stream within the United States.

The Boulder Canyon project is the major development within the basin. This project is composed of Boulder Dam and power plant in Black Canyon about 25 miles southeast of Las Vegas, Nev., and of the All-American Canal. The All-American Canal, with the Imperial diversion dam and desilting works, will serve the Imperial Valley by replacing its present main canal which loops through Mexico for 50 miles. It also will serve the Coachella Valley, and the Yuma and Gila Federal reclamation projects. Boulder Dam, which rises 726 feet from base to crest, created Lake Mead, a reservoir with a capacity of 30,500,000 acre-feet. Portions of the storage are used for regulation of the river to improve irrigation and domestic water supplies, for control of floods, for silt storage, and for hydroelectric power generation. The power plant will have an ultimate installed capacity of 1,835,000 horsepower, and an initial capacity of 500,000 horsepower. The first unit went into service in October 1936. Contracts have been made under which the power is sold at rates which in 50 years will repay the cost of the dam and power plant with 4-percent interest; make substantial payments to Arizona and Nevada; and provide a fund of \$65,000,000 for further construction on the Colorado River.

The Boulder Canyon project, now nearing completion, should be finished in conformity with the present program.

The regulation of the lower river by Boulder Dam has made it possible to undertake other projects, among them the aqueduct of the metropolitan water district in southern California, estimated to cost \$220,000,000, by which 1,100,000 acre-feet of water a year will be diverted to Los Angeles and 12 other cities of the coastal plain.

Reservoirs proposed for construction in the plan for the basin include those on the San Juan and Little Colorado Rivers for the primary purpose of storing silt. Firm power output at Boulder Dam can be increased materially by constructing upstream reservoirs which also may be used for flood control, power, and silt storage. When power demands require the release from Lake Mead of quantities of water in excess of the demands for irrigation, Bullshead Reservoir, below Boulder Dam, can be built with a capacity of 1,500,000 acre-feet for re-regulation of water released for power, holding the water until it is required



for irrigation. The usable storage capacity of 200,000 acre-feet at Parker Dam (the next structure below Bullshead and now under construction) will be used for the same purpose, and also to control floods from the Williams River.

Domestic water supply is of first importance in the uses of water in the basin. Most of the cities and towns in the region obtain water from the river or its tributaries and many cities in the lower basin possess complete desilting and treating works.

Southern California's coastal plain has exhausted other sources of domestic water supply and shortly will have a supply from the Colorado River for future growth. Denver, Colo., obtains a part of its water supply from the Colorado Basin and plans to obtain an additional amount. Salt Lake City, Utah, contemplates diverting water from the Colorado to supplement its present supply.

Irrigation is of major importance, following the requirements for domestic use. Because of the wide variation of flow in the Colorado and its tributaries, storage generally will have to be provided for irrigation projects in the basin. Major existing developments include the Imperial Valley, where about 500,000 acres are irrigated; the Yuma project in Arizona and California, 110,000 acres; Salt River project in Arizona, and other Gila Valley developments, 450,000 acres; Grand Valley and Uncompahgre projects in Colorado. Construction to provide supplemental storage for several of these areas now is in progress. In addition, one large new irrigation project is under construction, the Gila project in Arizona near Yuma, the first unit of which will contain about 150,000 acres.

Exportation of water from the basin for irrigation has been completed for lands near Provo, Utah, and for some lands on the eastern slope in Colorado. Other diversions are being investigated and one near Ephraim, Utah, is under construction. At present approximately 200,000 acre-feet are exported annually into adjacent watersheds for irrigation and domestic supply.

The volume of water exported annually may reach several million acre-feet. Each diversion project should be investigated thoroughly in the light of its economic feasibility. The fact that diversions from the Colorado River reduce, in proportion to their magnitude, the ultimate possible development within its basin has regional and national significance.

Drainage is necessary soon or later on all irrigation projects, and in parts of this basin it is difficult because of the uneven surface of the underlying bedrock or the fine texture of the soils. Another problem is introduced where drainage water is used and reused several times for irrigation. Alkaline salts are dissolved by the water with each usage until the water

becomes unfit for further irrigation. Adequate drainage and proper methods of irrigation constitute the only solution for this problem. Plans for all new irrigation systems should include provision for drainage of the lands.

Flood control is no longer a serious problem in the basin below Boulder Dam, which has relieved the Imperial Valley from the constant threat of destruction by inundation from the river. Flashy floods on the lower reaches of the Gila River and along the San Juan and Little Colorado Rivers have caused considerable local damage. Protection along these rivers can be given only at undue expense.

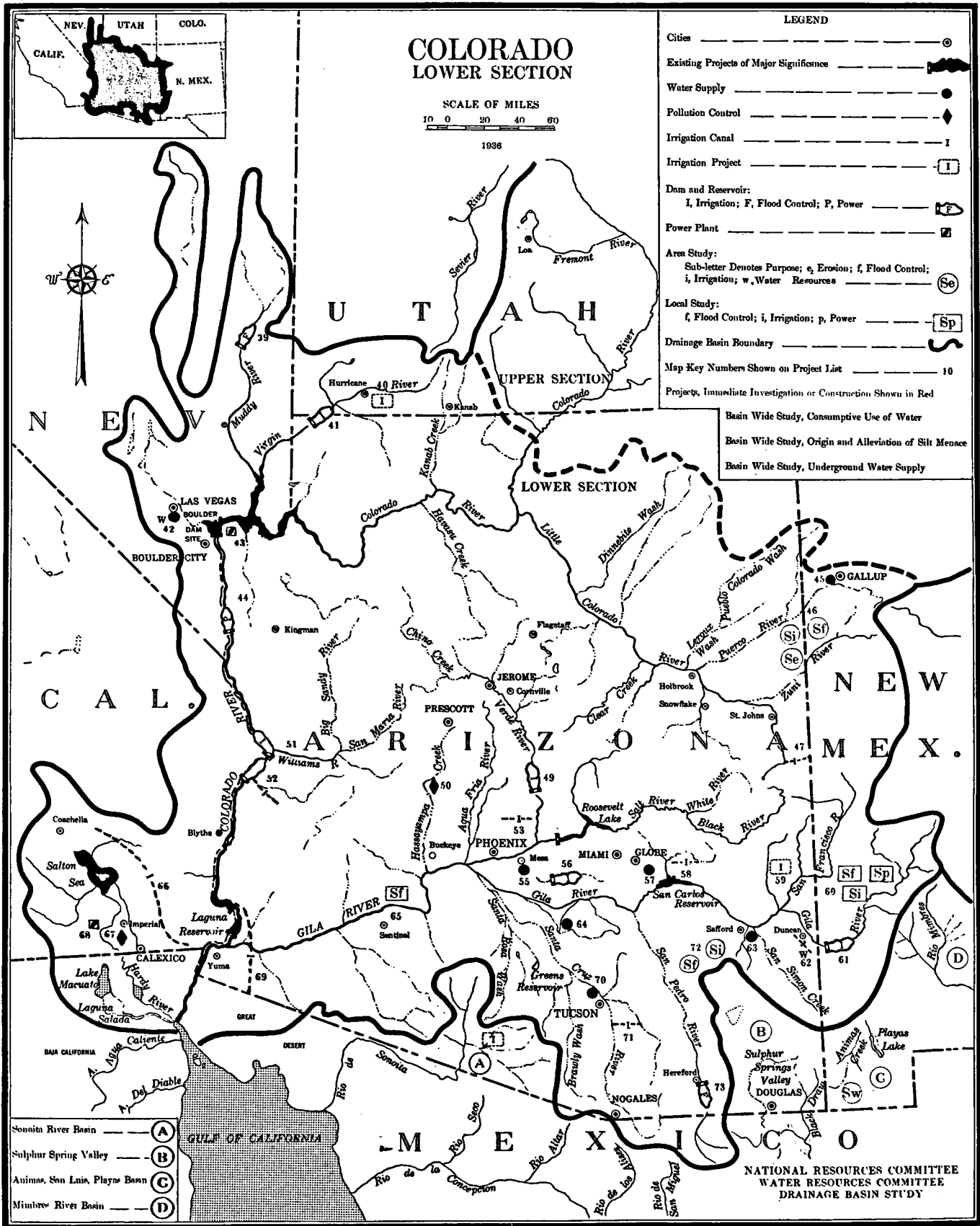
Hydroelectric power development has not been extensive, the greatest aggregation of power in the basin being at Boulder Dam where units developing approximately 500,000 horsepower are installed. Elsewhere in the basin the total installed capacity is about 175,000 horsepower, of which 125,000 is in the Salt River Valley near Phoenix. Many excellent sites for power plants are available along the Colorado River and its principal tributaries, but at the present time few, if any, are being contemplated for development.

Pollution of the basin streams from domestic sewage and industrial wastes is not a serious problem, although several cities that now dump their sewage into the streams should provide partial treatment. Mine and smelter wastes pollute streams in certain sections, and steps should be taken to abate these nuisances.

In some localities the dissolved solids in the streams have been increased to harmful proportions by the reuse of drainage and return waters from irrigation. This condition will be aggravated as irrigation expands. An economic limit exists beyond which this practice of reusing water cannot be carried safely.

Dissolved solids carried to the Gulf of California by the river amount to about 12,000,000 tons per year. These solids average about 1,200 parts per million during the low-water period and about 300 during flood periods. A high percentage is alkaline salts, detrimental to the use of water for irrigation and domestic purposes. Before construction of Boulder Dam the waters of the lower Colorado River were becoming increasingly alkaline as the proportion of return waters from upstream irrigation increased. However, since storage in Lake Mead began in 1935, the mixing of waters has materially reduced the alkalinity. As upstream irrigation expands, the alkaline concentrations in the lower basin may be expected to increase.

The silt load of the lower Colorado and its tributaries constitutes a real menace to development in the lower basin States. Before Boulder Dam was built the river annually deposited an average of 200,000,000 tons, or more than 100,000 acre-feet, of silt in the delta.



The lower basin is arid, as already noted, and has scanty vegetal cover. Rains, often of cloudburst intensity, bring tremendous quantities of mud and debris into the river. The spring flows from melting snows in the mountains of the upper basin also bring moderate loads of silt. The plateau region drained by the Virgin, Little Colorado, and San Juan Rivers, comprising some 65,000 square miles, contributes only 10 percent of the water but fully 75 percent of the silt of the Colorado.

Silt increases the cost of maintaining irrigation canals, but it is a greater menace to reservoirs. No adequate remedy has been found for the silt problem, and a special study of it is recommended.

Where erosion is serious, terracing, the building of debris basins and protection works to prevent caving of banks, and similar measures will give temporary relief. In certain localities natural erosional forces have been aggravated by overgrazing, cultivation, excavation for roads and ditches, and careless cutting of timber. In these areas and in many others additional vegetal cover is needed.

Recreation is an important phase of the utilization of the Colorado River. The basin contains a number of national parks and monuments, some of them unexcelled in magnificence and appeal. Lake Mead with its sheer canyon walls is already popular with vacationists and tourists.

Colorado Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
43	Boulder Canyon Dam, Arizona-Nevada.....	\$4,000,000	Dam is finished. Cost given is for next 2 years. Additional needed to complete power plant, \$2,740,000.
66	All-American Canal, Calif., including Coachella main canal.....	3,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$8,500,000.
49	Salt River irrigation project, Ariz.: Bartlett storage dam on Verde River and canal improvements.....	1,200,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$494,000.
23	San Pete County, Utah: Diversion tunnel to divert Cottonwood Creek from Colorado Basin to San Pitch watershed in the Great Basin, for irrigation.....	-----	This project with its estimated cost is listed among the Great Basin (Great Salt Lake) projects.
27	Gunnison, Colo.: Partial sewage treatment plant.....	12,000	Plans completed.
31	Durango, Colo.: Partial sewage treatment plant.....	50,000	Do.
15	Yampa, Colo.: Filter plant and replacement of old pipe.....	40,000	Surveys and detail plans completed.
10	Craig, Colo.: Filter plant.....	20,000	Detailed plans completed.
28	Ridgway, Colo.: Replacement of pipe lines.....	43,000	Plans completed.
34	Dolores, Colo.: Waterworks improvement.....	100,000	Do.
38	Malaria control, San Juan County, N. Mex.: Draining and filling mosquito breeding areas, San Juan Valley.....	43,000	Do.
35	Cortez, Colo.: Waterworks improvements.....	100,000	Detailed plans and specifications completed.
55	Mesa, Ariz.: Water mains.....	74,000	Plans completed.
5	Lyman irrigation project, Uinta County, Wyo.: Reservoir for supplemental supply.....	1,000,000	General plans and land classification completed.
-----	Silt study, Colorado River drainage area: Study of origin of silt and alleviation of silt menace in basin.....	1,000,000	Total cost will run to several millions and extend over 25 years or more.
-----	Upper Colorado River: Continuing investigations surveys and land classification, as contemplated in sec. 15 of the Boulder Canyon Act.....	500,000	
-----	Research: Consumptive use of water in Colorado River Basin.....	200,000	A 20-year study to cost a million or more dollars.
54	Roosevelt irrigation district, Maricopa County, Ariz.: Lining canals, flumes, and spillways with gunite.....	605,000	Plans completed.
20	Crested Butte, Colo.: Storage reservoir.....	11,000	Do.
50	Wickenburg, Ariz.: Pipe lines and sewage treatment plant.....	38,000	Do.
64	Papago Indian domestic and stock water development, Pinal and Pima Counties, Ariz.: Sink 8 wells, install pumps and improve irrigation structures.....	53,000	Plans completed. Cost given is for next 2 years. Additional needed to complete, \$79,000.
17	Breckenridge, Colo.: Storage reservoir and supply system.....	17,000	General plans completed.
36	Montezuma irrigation project, Montezuma County, Colo.: Diversion by present tunnel from Dolores River, reservoir for supplemental supply.....	2,000,000	General study completed.
52	Colorado River Indian Reservation project: Diversion dam, irrigation canals and pumping unit.....	3,000,000	General plans completed and lands classified. Cost given is for next 2 years. Additional needed to complete, \$7,000,000.
61	Virden Dam, Grant County, N. Mex.: Diversion dam to supplement supply for irrigation in New Mexico and Arizona.....	50,000	Preliminary plans completed.
58	San Carlos Indian irrigation project, Gila County, Ariz.: Canal improvements.....	25,000	Plans completed.
71	San Xavier, Pima County, Ariz.: Wells, pumps, and irrigation distribution system.....	288,000	Do.
69	Lower Gila irrigation project, Yuma County, Ariz.: First unit of project, including Parker power plant. Pumping from main canal to irrigate 150,000 acres.....	3,500,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$13,950,000.
4	Green River and Bear River, southwest Wyoming and north Utah: Study of diversion from Green River in Colorado Basin to supplement supply for irrigation along Bear River in the Great Basin.....	-----	See the Great Basin List for cost estimate.
6	Tri-State investigations on Green River in Wyoming, Utah, and Colorado: Study for irrigation, power, and flood control, prior to creation of Ladore game preserve.....	50,000	This area proposed as a game preserve.
-----	Aspen, Breckenridge, Delta, Fruita, Glenwood Springs, Grand Junction, Gypsum, Hayden, Hotchkiss, Ignacio, Meeker, Montrose, Oak Creek, Olathe, Ouray, Palisade, Paonia, Red Cliff, Rifle, Silverton, and Telluride, Colo.: Investigation for sewage treatment plants.....	25,000	Sewage treatment ordered by State board of health.
18	Blue River diversion, Summit County, Colo.: Study needed of economic feasibility of diverting water from Colorado Basin to Missouri Basin.....	-----	This study with its estimated cost is listed among Missouri (Platte) Basin projects.
19	Colorado-Arkansas River diversion: Study to determine practicability and desirability of diverting headwaters of Gunnison and Fryling Pan Rivers to the Arkansas River Basin and feasibility of Tennessee Pass tunnel for irrigation.....	-----	This study with its estimated cost is listed among southwest Mississippi Basin (Upper Arkansas) projects.
14	Meeker, Colo.: Replacement of old wooden pipe line.....	54,000	Preliminary plans made.
16	Eagle, Colo.: Sewage treatment plant.....	11,000	Plans completed.
-----	DeBeque, Colo.; Fredonia, Ariz.; Fruita, Ignacio, New Castle, Norwood, Nucla, Pagosa Springs, and Palisade, Colo.; and Mogollen, N. Mex.: Investigation for sources of supply, purification, and improvements to domestic water supplies as may be required.....	15,000	Some towns are without adequate fire protection, some require new supplies, others desilting and purification works.
29	Pine River irrigation project, La Plata County, Colo.: Storage reservoir for supplemental supply.....	1,300,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$300,000.
42	North Las Vegas, Nev.: Waterworks improvement.....	35,000	General plans completed. Details lacking.

Colorado Project List—Continued

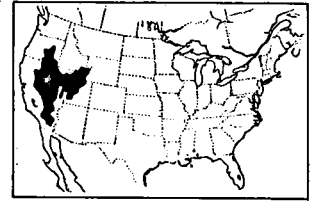
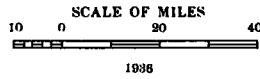
Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION—Continued			
63	Safford, Ariz.: Purchase of privately owned system and construction of supplementary works.....	496,000	Preliminary plans completed. Final plans 50 percent completed.
3	Eden irrigation project, Sweetwater County, Wyo.: Reservoir for supplemental supply.....	1,000,000	General plans and land classification completed.
47	Round Valley Water Users Association, Arizona: Repairs and construction for irrigation system.....	3,000	Preliminary plans made.
46	Little Colorado River in New Mexico and Arizona: Comprehensive investigation for irrigation, flood control, silt, storage, soil conservation, and forestry.	75,000	Preliminary data available.
	Investigation of underground waters (quantity and chemical quality) in various areas scattered throughout the basin.	300,000	A study extending over a period of years and probably costing a million dollars.
72	Investigations for flood control and irrigation in Santa Cruz and San Simon River Basins, Ariz.....	75,000	Preliminary data available.
56	Queen Creek irrigation, Eastern Maricopa County, Ariz.: Queen Creek to be spread to replenish ground waters.	20,000	Project studied 30 years ago by Bureau of Reclamation.
41	Mesquite Reservoir near Littlefield, Mohave County, Ariz.: Study for Reservoir to store floods for supplemental irrigation use and to retain silt from Lake Mead.	8,000	Preliminary studies made.
60	Complete the physical and economic investigations of Cliff Reservoir, Grant County and Alma Reservoir, Catron County, N. Mex.: For storage required to reduce floods, provide water for irrigation, and develop power.	20,000	A study and report was made by Bureau of Reclamation but without final conclusion; it recommended further investigations.
59	White Mountain Apache Reservation in Navajo, Apache, Gila, and Graham Counties, Ariz.: Rehabilitation of irrigation system.	35,000	Cost given is for first 2 years. Additional needed to complete, \$75,000.
65	Sentinel Reservoir: Study of effect of Gila floods on lands of Colorado River Delta.....	30,000	Preliminary plans and some foundation exploration made.
67	Imperial, Calif.: Outfall sewer and filtration plant.....	111,000	Preliminary plans made.
45	Gallup, N. Mex.: Water supply.....	218,000	Do.
68	Imperial irrigation district, California: Power plants and distribution system. Foundations being built at drops in All-American Canal.	2,000,000	Plans 90 percent completed. Cost given is for next 2 years. Additional needed to complete, \$2,662,000.
GROUP B—FOR DEFERRED CONSTRUCTION			
8	Colorado: Big Thompson transmountain diversion of water from Colorado Basin to Missouri Basin for supplemental irrigation supply.....	-----	This project with its estimated cost is listed among Missouri Basin (Platte) projects.
12	Utah and Wasatch Counties, Utah: Diversion works to divert Duchesne River from Colorado Basin to Provo River in the Great Basin for irrigation and water supply.	-----	This project with its estimated cost is listed among the Great Basin (Great Salt Lake) projects.
15	Upper Yampa Reservoirs near Yampa, Colo.: Supplemental supply and new land irrigation.....	\$1,000,000	General plans completed.
22	Roan Creek irrigation project, near DeBeque, Garfield County, Colo.: Supplemental water for irrigation.	500,000	Final plans in preparation. Cost given is for next 2 years. Additional needed to complete, \$500,000.
21	Paonia irrigation project in Delta and Gunnison Counties, Colo.: Storage reservoir for supplemental supply.	1,000,000	Plans in preparation. Cost given is for next 2 years. Additional needed to complete, \$3,000,000.
32	La Plata irrigation project, La Plata County, Colo.: Building 2 dams and enlarging third to supplemental supply.	1,039,000	Plans practically completed.
30	Florida Mesa irrigation project, near Durango, La Plata County, Colo.: Storage reservoir for supplemental supply.	1,000,000	Land classification completed. Cost given is for next 2 years. Additional needed to complete, \$1,000,000.
26	Smith Fork irrigation project near Hotchkiss, Delta County, Colo.: Reservoir for supplemental supply.	500,000	Plans in preparation.
33	Mancos irrigation project, Montezuma County, Colo.: Storage reservoir for supplemental supply.....	600,000	Investigations and land classification, nearly completed.
53	Camelback water conservation district, Maricopa County, Ariz.: Irrigation works, pumping plant, power and pipe line for irrigation and domestic purposes.	335,000	Plans completed.
39	Meadow Valley flood diversion project near Overton, Clark County, Nev.: Earth dam to divert floods over wide plain.	100,000	Do.
62	Duncan Valley irrigation project, Greenlee County, Ariz.: Improvements of system by wells and pumping equipment.	80,000	Preliminary plans completed.
57	Globe, Ariz.: Replacement of pipe line.....	68,000	General plans completed.
70	Tucson, Ariz.: Waterworks improvements.....	504,000	Preliminary plans completed. Final plans under way.
GROUP C.—TIME OF CONSTRUCTION INDETERMINATE			
37	Bluff Reservoir, San Juan County, Utah: Dam on Colorado tributary for irrigation, power, silt storage, and flood control.	\$10,000,000	Preliminary plans completed.
44	Bullshead Reservoir, Nevada-Arizona: Dam on Colorado to store water for power and control floods; also form an afterbay to increase firm power output from Boulder dam.	30,000,000	Do.
2	Pinedale irrigation project, Sublette County, Wyo.: Irrigation of new lands.....	1,000,000	Do.
1	Kendall Reservoir, Sublette County, Wyo.: Irrigation of new lands.....	6,000,000	Land classification and preliminary plans completed.
9	Hayden Mesa, near Hayden, Routt County, Colo.: Irrigation of new lands.....	2,000,000	Do.
7	Little Snake irrigation project, near Dixon and Baggs, Routt, and Moffat Counties, Colo.: Irrigation of new lands.	4,000,000	Do.
11	Ratliff irrigation project, near Jensen, Uinta County, Utah: Irrigation of new lands.....	500,000	Preliminary plans completed.
13	Castle Peak irrigation project, near Myton, Duchesne County, Utah: Irrigation of new lands.....	8,700,000	Land classification and preliminary plans completed.
24	Green River irrigation project, near Green River, Emery County, Utah: Irrigation of new lands.....	2,300,000	Preliminary plans completed.
25	Grand Valley irrigation project, near Grand Junction, Mesa County, Colo.: Irrigation of new lands by pumping from main canal.	200,000	Plans completed.
73	Charleston Reservoir, near Hereford, Cochise County, Ariz.: Dam on San Pedro River for flood control.	1,200,000	Preliminary plans completed.

THE GREAT BASIN

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THE GREAT BASIN



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- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir: ———— [Symbol]
- W, Water Supply; I, Irrigation; R w, Wildfowl; F, Flood Control
- Irrigation and Water Supply Channel or Aqueduct ———— I.W.
- Irrigation and Water Supply Tunnel ———— I-W
- Local Study, Irrigation ———— [SI]
- Local Study, Underground Water ———— [SU]
- Area Study, Recreational Facilities ———— [SR]
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NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

1. THE GREAT BASIN

The Great Basin includes a series of smaller basins, each with its own peculiar problems. Conservation of the meager water resources is of vital importance throughout these arid and semiarid subdivisions. At best only limited opportunities exist for further development of supplies which are already proving inadequate. Importation of water into the basin is desirable, but is not generally feasible because of physical, legal, and economic barriers.

General Description

The Great Basin lies between the drainage areas of the Columbia River to the north, the Colorado River to the east, the Salton Sea to the South, and the coastal streams of the Sierra Nevada to the west. It includes most of Nevada, the south central part of Oregon, the southwestern corner of Idaho, a strip along the western boundary of Wyoming, nearly all of the western half of Utah, and a section of California east of the crest of the Sierra Nevada. Its area of nearly 200,000 square miles is one-fifteenth of that of the entire United States.

The Great Basin is divided by mountain ranges into several basins each isolated insofar as its water supply is concerned. Access to the sea is cut off in all directions and the streams of the basin drain into lakes or alkali sinks.

The basin is distinguished by its extremes in surface elevation, in temperature, and to a lesser extent, in precipitation. On the western border are the Sierra Nevada. Here many peaks have altitudes about 14,000 feet, and Mount Whitney, the highest in the United States, rises to 14,496 feet above sea level. Scarcely 100 miles to the west lies Death Valley, a region long dreaded and avoided but now fast becoming a popular winter resort, which contains the lowest depression in the United States, 280 feet below sea level. The Wasatch Mountains, forming the eastern boundary, contain many peaks above 11,000 feet, and several other ranges in the basin, most of which trend north and south, have similar altitudes. The average elevation of the lowlands lies between 4,000 and 6,000 feet.

Most of the region is a desert, thinly dotted with sagebrush, creosote bush, greasewood, and cactus. In the higher mountains are juniper, pinon, yellow pine, aspen, birch, and spruce. The mountains are usually covered with a good growth of grasses and furnish range for a large number of sheep, cattle, and horses. Much of the timber is too small to be of economic value except for fence posts and fuel.

The population of the basin is approximately 665,000, roughly that of Rhode Island. Salt Lake City, Utah, whose population is approximately 150,000, is the largest city; Ogden, Utah, contains more than 40,000 persons, and Reno, Nev., the third largest town, has a population exceeding 20,000. Much of the region is the most desolate and sparsely settled in the United States, the density of population in one-half or more of the area being as low as one person in about 3 square miles.

Stock raising and mining are the principal industries in the greater part of the basin. There are excellent irrigated areas in various localities, particularly in Utah and east central Nevada, where cereal, fruit, vegetable, and forage crops are grown.

Precipitation ranges from 35 inches in the high mountains to 5 inches or less in the lowlands. In Death Valley in a period of 43 months there has not been a rain exceeding $\frac{1}{10}$ of an inch. Most of the precipitation falls between November and April. Temperatures vary from 35° below to 135° above zero.

Although the drainage area of the basin is very large, the average annual run-off of all the streams scarcely exceeds 7,000,000 acre-feet. Approximately two-thirds of this run-off is supplied by the Bear, Weber, and Provo Rivers in the northeastern part of the basin. These rivers feed the Great Salt Lake which, covering an area of 2,300 miles, is the largest lake in the basin. Bear Lake is in the headwaters of Bear River and Utah Lake receives the waters of the Provo River, which the Jordan River carries on to Great Salt Lake. The Humboldt River is the only stream of importance in the central section of the basin. It drains into Humboldt Sink, with an average annual run-off of 304,000 acre-feet. In the northwestern corner of the basin, the Silvies and Quinn Rivers are the principal streams and have an average annual run-off of about 500,000 acre-feet. The run-off from the eastern watershed of the Sierra Nevada is collected primarily by the Susan, Truckee, Carson, Walker, and Owens Rivers. The approximate average annual run-off of this group of streams is 1,600,000 acre-feet. The Mojave River in California has an average annual run-off of about 54,000 acre-feet.

The principal source of underground water in the basin is the alluvial deposit of sand and gravel that underlies the numerous intermontane valleys. These water-bearing beds serve numerous desert watering places and provide supplies for domestic, livestock, mining, and municipal purposes; in some sections they

also yield important irrigation supplies. There are numerous areas of artesian flow, but most of the water for irrigation as well as for other purposes is pumped. Although some surveys have been made, the extent of the supplies is not fully known; a thorough investigation would, quite possibly, find and make available additional underground water in certain parts of the region. It would certainly provide information of great value in the protection and conservation of supplies now fully utilized.

Recommended Plan

Irrigation is necessary to growth of crops in the Great Basin, and it is practiced wherever the requisite supply of water is now economically available. Water has been diverted from the Colorado River Basin to a project near Provo, Utah, and other diversions from that basin are contemplated, chiefly to provide supplemental water for lands already irrigated.

In the Steptoe Valley of eastern Nevada, investigations indicate that there is underground water sufficient for a small irrigation development. Ruby Valley, northwest of Steptoe Valley, has similar geological characteristics and investigations of the underground water resources also should be made there.

In the central part of the basin water for irrigation is principally obtained from the Humboldt River and its tributaries in north central Nevada. Rye Patch reservoir located 20 miles above Lovelock, Nev., has recently been completed and water will henceforth flow unused into Humboldt Sink only in years of unusually heavy run-off. Numerous plans have been proposed for an extension of irrigation beyond the river bottom lands, but few, if any, of the schemes have been proven economically feasible. A stream channel improvement project has been proposed in the Little Humboldt River to increase the water supply of 32,000 acres of cultivated lands in Paradise Valley, but the plan has not been studied sufficiently to determine whether or not it is practicable.

Irrigation is practiced in several valleys in the portion of the Great Basin known as the Mojave Desert region. In Antelope Valley about 12,000 acres were opened to cultivation in 1919; of these about 9,000 acres were irrigated from wells and the remainder from surface streams. The valley contains 250,000 acres or more of arable land, but it is estimated that the available annual supply of underground water does not exceed 50,000 acre-feet. It appears probable that some additional land could be irrigated from this source and from surface streams. Several projects have been proposed for storing the waters of the Mojave River, now largely unused, but none has been constructed. In 1918 possibly 10,000 acres were irrigated and it seems likely that with complete utiliza-

tion of both the surface and groundwater resources of the valley a considerable additional area could be reclaimed. In this valley, as in others, the reconciliation of human interests rather than the water supply may present difficulties that will limit the areas to be cultivated. Smaller areas are irrigated from wells in Indian Wells, Fremont, and Lucerne Valleys and it may be possible to reclaim additional small areas in these and other valleys.

In the northwestern corner of the basin, a considerable acreage near Burns, Oreg., is irrigated from the Silvies River and Silver Creek, principally for the growing of winter feed for livestock. Some runoff is wasted but the amount is so small that storage development is not economically justified. These irrigated valleys are already capable of producing more winter forage than can be consumed by the livestock now grazed on the nearby ranges, and nearby markets for farm produce are unavailable. Additional water supplies for livestock are needed in order to get full utilization of the mountain pastures. An investigation should be made of the underground waters available for this purpose.

In Nevada, south of this area, an irrigation project will eventually be needed for the Summit Lake Indian Reservation.

Irrigation development has been extensive in the Great Basin region fed by rivers from the Sierra Nevada, and most surface waters economically available have been used. The Susan, Truckee, Carson, and Walker Rivers all provide water for this development. The supply from the Susan River is inadequate for the area now served.

The principal irrigated area on the Truckee River is in Washoe County, Nev., near Reno. Construction of the Boca Dam, now underway, on the Little Truckee River will provide needed upstream storage. The Pyramid Lake Indian Reservation obtains irrigation water from the Truckee and improvements in this development are contemplated, including extension of laterals and lining of main canals to provide for the future irrigation of the entire area of 3,133 acres.

Several thousand acres of land are irrigated by water from the Carson River supplemented by a supply from the Truckee River. Part of the water from the Truckee River is obtained from Lake Tahoe, in the regulation of which the district participates.

The Walker River furnishes water for irrigating several thousand acres of land, but the supply has been inadequate in the recent dry years. There is little prospect for further irrigation development, as existing projects need more water than can be supplied.

There are many other valleys in this region of small water supply where old settlements are in distress. Malad Valley, Idaho, is perhaps illustrative of these.

Here a community of several thousand people, established many years ago, depends upon a water supply that is not sufficient for irrigation in some seasons. About 13,000 acres are irrigated with surface water. Studies have shown that considerable additional acreage could be irrigated by constructing several small dams for impounding surface water and by pumping from wells. Preliminary plans for dams have been drawn. Exploratory drilling and test pumping are necessary to ascertain more fully the underground water possibilities. The resources of the community are inadequate, however, for financing these minor structures needed for the utilization of a water supply that could thus easily be made available. The problems in other valleys pertain to small communities ranging downward from that in Malad Valley to the few ranchers who would be supported by a few hundred acres of irrigated land.

Water losses could be reduced where they are caused by wasteful irrigation, or by evaporation or seepage from canals and conduits that are unnecessarily complex. Such conservation if practiced throughout the basin would materially assist in relieving the distressing shortage in supplies. Salvage of waters now wasted would be as valuable as the procurement of new supplies. Study of the possibility of reducing losses in transit between the rivers and the land are recommended. Introduction of irrigation methods that are more economical of water is advised.

Domestic water supplies are obtained from direct stream flow or from underground sources and except in a few cases they are ample for present needs. Salt Lake City, Ogden, and other Utah cities have suffered water shortage in recent dry years, and plans are being made for supplemental supplies. Furthermore, many of these communities are served by water from the Wasatch Mountains carried in conduits which cross the Wasatch fault, along which movement may occur at any time. If a fire should accompany an earthquake induced by the movement a disaster might result such as that which befell San Francisco in 1906. Local storage should be provided west of the fault zone, and provisions made for quick repair in the fault area.

The city of Los Angeles is diverting water from Owens River and has under construction diversion works in the Mono Lake Basin, which will preclude further irrigation development in these basins.

Polution of water supply is not a problem of importance. Most of the larger towns have sewage treatment plants, some of which are in need of extensions or

improvements. Plans have been made for the correction of bad pollution conditions existing in the areas adjoining Salt Lake City and Ogden in Utah, and the city of Barstow in California is planning the construction of a sewage treatment plant.

Flood control is not a serious problem in this basin due to the small flow of the streams and the nearly complete use of their waters. However, flash floods from rains of high intensity do great damage to ranches at the base of the Wasatch Mountains, while on their slopes erosion has become a serious problem. Investigations looking toward the amelioration of these conditions are now being conducted by the Forest Service and some terracing and replanting has been done in the watersheds.

Water power is developed in the basin only in insignificant quantities, but there are many potential sites of small capacity to be considered for future development in the Wasatch Mountains and the Sierra Nevada.

Recreation activities already form an important source of income in several sections of the basin, and vacation uses of various playgrounds, such as Lake Tahoe and Death Valley, are growing year by year. Streams of the eastern slope of the Sierra Nevada and the western slopes of the Wasatch and other ranges within the basin are well stocked with fish and attract thousands of anglers. The Great Salt Lake is scenic and is being adapted for game and waterfowl refuges, as is Donner and Blitzen Valley. Much of the shoreline of Lake Tahoe is occupied by summer cottages and resorts. Recreational use of this lake has been recognized in the operation of its outlet works in connection with irrigation and hydroelectric development.

The Great Salt Lake Diking Project, a unique proposal of much interest in Utah, contemplates a freshwater embayment enclosing about 96,000 acres in the southeastern corner of the lake to impound water principally from the Weber and Jordan rivers. It is proposed to use the fresh water thus impounded principally in condenser cooling at a steam-electric power plant, burning Utah coal, the output of which would be available for expansion of industries based on the nonferrous and chemical resources of the State. Construction of the project is physically possible, but its economic advisability is undetermined. There are several alternative measures that might accomplish similar ends. Because of the rich latent resources in this area and the inadequacy of the water supply, an investigation, which should also extend to other means, is recommended.

The Great Basin General Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Study to ascertain the location and extent of the underground water resources of the Great Basin especially in those areas not heretofore investigated for use in irrigation.	\$200,000	Preliminary plans made.
	Study to determine methods for avoidance of losses in distribution and application of irrigation waters.	50,000	

Central Great Basin Project List

GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
35	Barstow, Calif.: Sewage treatment plant.....	\$87,000	Plans completed.
33	Study of water development for recreational facilities throughout the Basin.....	30,000	Preliminary plans made.
34	Lancaster, Calif.: Study of Little Rock Dam, Little Rock Creek, and Palmdale Irrigation Districts, to devise method of repairs to dam and to determine economics of projects and plans of financing.	15,000	No plans have been prepared. Complete engineering, legal, and financial investigation necessary.
GROUP B—FOR DEFERRED CONSTRUCTION			
31	Current, Nev.: Wildfowl refuge in Railroad Valley.....	\$16,000	Plans completed.

Northern Great Basin Project List

GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
1	Study to determine extent of underground water in the Fort Rock-Christmas Lake Valley and the possible effect its development will have on supplies now utilized on north end of Summer Lake, Lake County, Oreg.	\$14,000	Investigation can be started immediately.
6	Study to determine the extent and development of underground water in Catlow Valley, Harney County, Oreg.	9,000	Do.
2	Lake County, Oreg.: Repairs to dams and reservoir, Silver Lake Irrigation District.....	6,000	Preliminary plans completed.
3	Lake County, Oreg.: Repairs to dam and canal system, Summer Lake Irrigation District.....	7,000	Do.
4	Harney County, Oreg.: Dikes for flooding of Malheur Migratory Waterfowl Refuge.....	117,000	Plans completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
5	Crane, Oreg.: Waterworks system.....	\$13,000	Plans completed.
14	Humboldt County, Nev.: Irrigation system for Summit Lake Indian Reservation.....	30,000	Do.

Sierra Nevada Project List

GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
24	Churchill County, Nev.: Waterfowl refuge near Fallon.....	\$52,000	Preliminary plans prepared. Land acquired.
27	Nevada County, Calif.: Earth-fill dam on Little Truckee River near Boca, for irrigation in Reno Valley and Newlands project.	250,000	Work under way. Sum indicated is needed for completion.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
26	Washoe County, Nev.: Extension of irrigation system at Pyramid Lake Indian Reservation.....	\$150,000	General plans completed.
32	Mineral County, Nev.: Extension of irrigation system at Walker Lake Indian Reservation.....	85,000	Do.

Great Salt Lake Project List

GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
11	Weber County, Utah: Pineview Reservoir on Ogden River for irrigation of lands near Ogden, Utah..	\$450,000	Work under way. Sum indicated needed for completion.
12	Ogden, Utah: Sewage treatment plant.....	100,000	Plans completed.
18	Central Park, Salt Lake City, Utah: Improvements to sewer system.....	365,000	Do.
(1)	Bingham (23), Bountiful (17), and Manti (30), Utah: Improvements to water supply system.....	89,000	Do.
10	Box Elder County, Utah: Dam and dikes to enlarge Bear River Migratory Bird Refuge.....	230,000	Preliminary plans completed.
(1)	Utah and Wasatch Counties, Utah: Deer Creek Reservoir (21) and enlargements of Weber-Provo (19) and Provo Reservoir (24) canals	2,000,000	Work under way. Cost given is for next two years. Additional needed to complete, \$1,800,000.
29	San Pete County, Utah: Diversion tunnel to divert Cottonwood Creek from Colorado Basin to San Pitch River watershed in the Great Basin for irrigation.	30,000	Work under way. Cost given is amount needed to complete.
25	Utah County, Utah: Dikes and outlet control to decrease evaporating surface of Utah Lake.....	800,000	Preliminary study completed. Cost given is for next two years. Additional needed to complete, \$1,574,000.
9	Green River and Bear River, southwest Wyoming, and north Utah: Study of diversion from Green River in Colorado Basin to supplement supply for irrigation along Bear River in Great Basin.	200,000	
13	Davis County, Utah: Study of project for dams to form embayment in Great Salt Lake and for construction of steam electric power plant.	50,000	Study of alternative methods to accomplish similar ends and of market for power.

1 Map key numbers shown following community name.

Great Salt Lake Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP B—FOR DEFERRED CONSTRUCTION			
7	Malad Valley, Idaho: Construction of dams for irrigation, including exploratory work.....	\$170,000	Plans completed. Deferred pending decision by Salt Lake City on question of participation in Deer Creek project. Cost given is for next two years. Additional needed to complete, \$1,600,000. Plans completed. Cost given is for next two years. Additional needed to complete, \$4,100,000.
8	Preston, Idaho: Water supply system.....	333,000	
20	Utah and Wasatch Counties, Utah: Diversion works to divert Duchesne River from Colorado Basin to Provo River in the Great Basin, for irrigation and water supply.	500,000	
22	Salt Lake City, Utah: Aqueduct from Deer Creek Reservoir for water supply.....	500,000	

Humboldt Project List

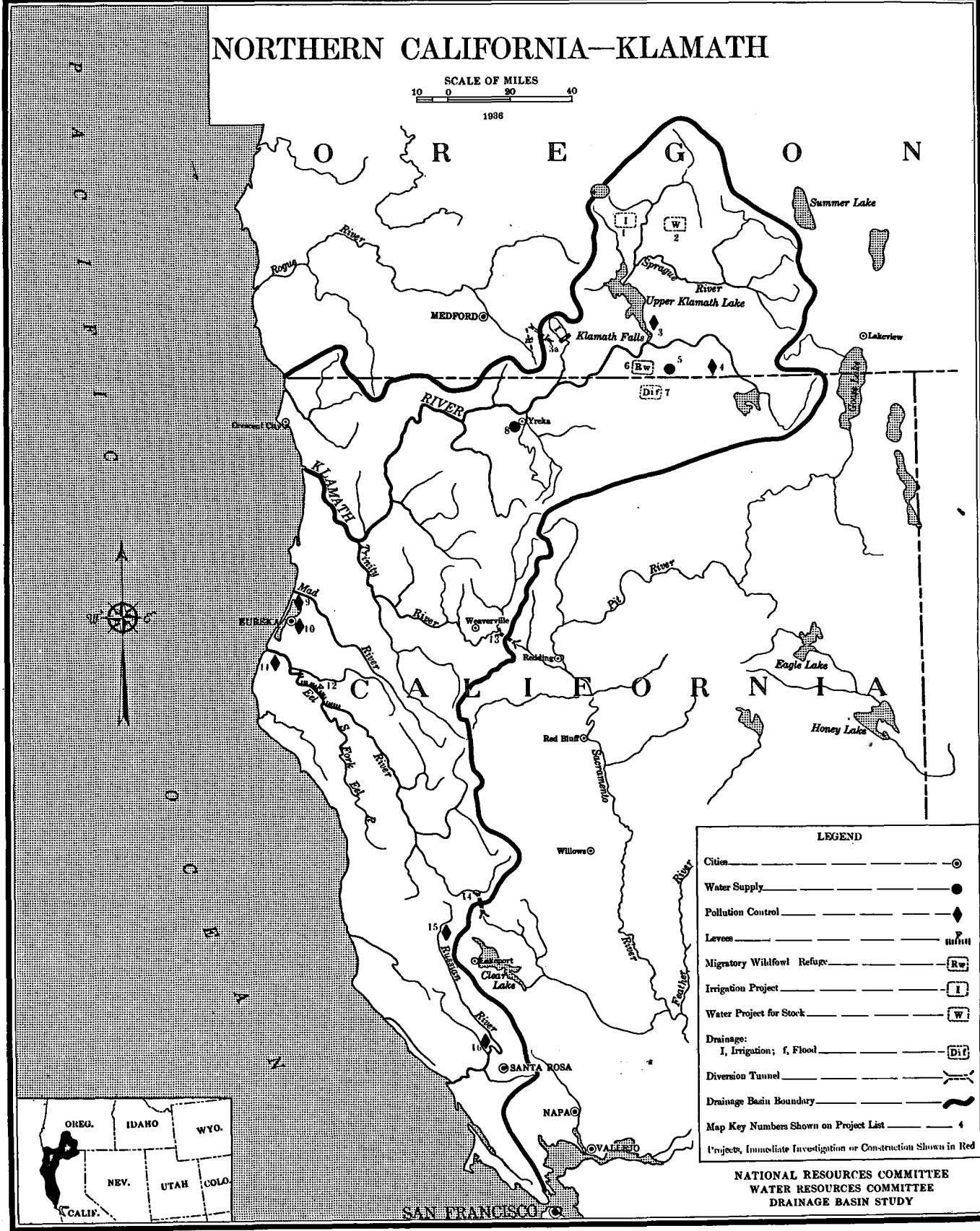
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION

15	Study to determine plans for improvement of channels in Little Humboldt River, Nev., and tributaries, including necessary engineering and legal details.	\$8,000	Preliminary plans completed.
16	Study to determine the value and feasibility of channel improvements of Humboldt River, Nev., to reduce water losses, including necessary engineering and legal details.	18,000	No plans developed.

CALIFORNIA DRAINAGE BASINS

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NORTHERN CALIFORNIA—KLAMATH



LEGEND

- Cities _____ ○
- Water Supply _____ ●
- Pollution Control _____ ◆
- Levees _____ [f]
- Migratory Wildfowl Refuge _____ [Rw]
- Irrigation Project _____ [I]
- Water Project for Stock _____ [W]
- Drainage:
I, Irrigation; f, Flood _____ [Dif]
- Diversion Tunnel _____ [~]
- Drainage Basin Boundary _____ [~]
- Map Key Numbers Shown on Project List _____ 4
- Projects, Immediate Investigation or Construction Shown in Red

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY



1. NORTHERN CALIFORNIA—KLAMATH

In the Northern California—Klamath Basin, generation of hydroelectric power will be the principal objective of the future development of water resources. Maximum benefits can be obtained, however, only if due consideration also is given to municipal and industrial water supplies, followed in order by irrigation, recreation, pollution control, and navigation. Unrestricted use of water for municipal and irrigation purposes will not greatly deplete the supplies available for power uses. An interstate plan and agreement will be necessary to avoid legal conflicts.

Immediate needs are: The improvement of two existing irrigation systems, a study of water supplies in the Oregon portion of the basin, construction of sewage treatment plants for two communities, and a definite plan for fire protection of the extensive California forests which guard the watershed. The full development of the large potential water power of the area will have to wait for growth of a market.

General Description

This L-shaped area of about 23,000 square miles extends for 300 miles along the Pacific coast north of San Francisco, and is bounded by the Cascade, Siskiyou, and Coast Ranges, merging on the east into the Oregon Plateau.

The principal river is the Klamath, the flow of which varies through a wide range in changing weather cycles from 3,700,000 to 22,000,000 acre-feet per year. The Klamath River flows through a narrow canyon from Keno, Oreg., 235 miles to its mouth at Requa, Calif., and in this stretch falls 4,000 feet. Other streams arranged in decreasing order according to their volume of water are the Trinity, Eel, Smith, Russian, Noyo, Mad, and Mattole Rivers. All flow directly into the Pacific except the Trinity, which is a tributary of the Klamath. The streams of this area combined have an average annual flow of 26,000,000 acre-feet, one-third of the total for all California. The present agricultural area is 650,000 acres, with about one-third irrigated. Most of the basin is rugged and mountainous with wide plateaus of volcanic origin. Forests cover a large portion of the basin, a third of which is in national forests.

Seventy percent of the people of the basin live on farms or in small villages; there is no city of more than 16,000 population. Industries are limited almost entirely to lumbering, agriculture, and placer mining.

Three ports on the Pacific coast are available for ocean shipping.

The climate has well-defined wet and dry seasons. Most of the precipitation occurs from October to March. The rainfall is heavy in the mountains, reaching 100 inches a year on the western slopes near the Oregon line. At the southern end of the basin the rainfall averages only 30 inches, and on the Oregon Plateau the average falls to 10 inches.

Recommended Plan

Preliminary investigations indicate 2,500,000 kilowatts of hydroelectric power can be developed in this basin. Many reservoir sites exist. The amount of land potentially irrigable is small and the water supply large.

Irrigation is practiced most extensively in the northeastern part of the area where the rainfall is scanty. In Oregon the lands most favorably situated and best suited to irrigation have been developed or are now in process of development. Further projects of immediate value include improvements and extensions to the Klamath irrigation system, and irrigation improvements on the Klamath Indian Reservation. Irrigation possibilities should be studied further. The demand for water for irrigation will always be small in comparison with the total supply, but on account of the interstate character of the area, Oregon and California should be encouraged to reach an agreement by which existing water rights may be adjusted with a minimum of friction.

There are two small diversion projects for export of water for irrigation from the Klamath Basin to the Sacramento River. Other interbasin diversions are proposed in the long-range California State water plan. Projects of this type serve as a means of obtaining the most efficient use of water in regions such as that of the Pacific coast, where water is abundant in some valleys and scarce in others nearby.

Power production will be the chief feature of future programs for the use of waters of this basin. Steep slopes, large flow, and excellent chances for storage reservoirs provide good power potentialities. Local demands for power are supplied by eight hydroelectric plants, with a total installed capacity of 56,690 kilowatts. There is no prospect for development of a market for all the potential power of this basin in the near future. The power resources of the basin

should be considered in connection with the recommended power study of the Pacific northwest region. California law prohibits construction of dams on the lower Klamath River to prevent interference with the salmon run in that stream. Further research into methods of helping the salmon over the dams may render this restriction unnecessary by the time there is a demand for the Klamath River water power. Diversions of water now proposed would reduce the potential water power of this basin by decreasing its water supply by 1,300,000 acre-feet annually. This loss would be partially offset, however, by a consequent increase in the power potentialities of the Sacramento River Basin.

Recreation in this area will be of increasing economic importance. Abundant water and magnificent forests, including those of the giant redwoods, ocean shore, and a delightful climate offer unusual recreational opportunities. Consideration should be given to the possibility of restoring Lower Klamath Lake to its former status as a migratory bird refuge.

Commercial fishing is of importance and plans should be made for its restoration, with due regard to the relative values of power and fisheries.

Stream pollution from urban communities is negligible because of sparsity of population. Industrial waste pollution is of little consequence. Due to local conditions, sewage treatment at Klamath Falls and Malin, Oreg., is desirable. Placer mining is still active to a limited extent on the headwaters of the Klamath River. Hydraulic mining is prohibited from July 15 to October 15, because of the pollution of streams with silt and interference with fishing.

Navigation probably will always be confined to logging operations and small pleasure craft. Harbor improvements, however, are desirable in a few locations on the Pacific coast, and one project of this kind has been completed.

Underground waters in the Oregon area are undefined and little used, but are an important reserve resource. Pumping for irrigation has been employed to a small extent in the lower river valleys during dry periods.

Forest cover is necessary for protection of the watershed. The United States Forest Service is actively engaged in acquiring 98,000 acres of timber land in California at an estimated cost of \$3,045,000.

Northern California—Klamath Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
7	Klamath, Oreg.: Construction of Tule Lake division of Klamath Federal reclamation project for drainage, flood control and irrigation.	\$120,000	Plans completed. Cost given is for next 2 years. Additional needed to complete \$480,000.
1	Klamath Indian Reservation, Oreg.: Irrigation improvements.....	26,000	Plans completed.
(1)	Klamath Falls (3), Malin (4), Oreg.: Extensions to sewer systems.....	103,000	Do.
2	Oregon: Stock water development, conservation of range, utilization of ungrazed areas.....	19,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
3a	Beaver Creek, Oreg.: Dam for irrigation.....		See Oregon-Pacific Basin project list for cost.
5	Merrill, Oreg.: Improvement to water supply system.....	\$30,000	Plans incomplete.
12	Eel River, Calif.: Retards, bank protection, and levees.....	144,000	Authorized by Congress. Construction set for 1939. Plans in preparation.
8	Yreka, Calif.: Improvement to water supply system.....	235,000	
16	Hearlsburg, Calif.: Outfall sewer and partial sewage treatment plant.....	15,000	Preliminary plans completed.
6	Lower Klamath Lake, Oreg.: Bird Refuge.....	1,500,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
13	Transmountain Diversion from Trinity River in northern California-Klamath Basin, to Sacramento River in Central Valley-San Francisco Bay Basin: For power, irrigation, navigation, and salinity control.		See Central Valley, San Francisco Bay Basin.
14	Transmountain diversion from Eel River in northern California-Klamath Basin, to Sacramento River in Central Valley-San Francisco Bay Basin: For power, irrigation, navigation, and salinity control.		See Central Valley, San Francisco Basin.
10	Eureka, Calif.: Sewer system.....	\$100,000	
(1)	Arcata (9), Ferndale (11), Ukiah (15), Calif.: Sewer systems.....	100,000	

¹ Map key number shown following community name.

2. CENTRAL VALLEY—SAN FRANCISCO BAY

A comprehensive plan for efficient utilization of the water resources of the Central Valley-San Francisco Bay Basins must provide an assured water supply for domestic and industrial uses; furnish supplemental irrigation water for a large amount of intensively cultivated land now critically short of supplies; regulate stream flow for amelioration of saline encroachments and of pollution from domestic sewage and industrial wastes, for curtailment of floods in the Sacramento River, and for improvement of navigation; and include hydroelectric power development. The demand for recreational benefits is increasing, particularly in the San Francisco Bay area, and consideration should be given in any plan to its effect on recreational opportunities.

General Description

The basins of the Central Valley-San Francisco Bay include all of inland central California, a small bit of southern Oregon and a section of the Pacific coast at San Francisco Bay. It is 600 miles long and averages about 120 miles wide. It is bounded by the crests of the Sierra Nevada on the east and the coast ranges on the west. All of its streams drain into San Francisco Bay. The basins contain 40 percent of the area of California, two-thirds of its agricultural land, and more than half of its water resources.

The Central Valley includes Sacramento Valley, lying north of San Francisco Bay, and San Joaquin Valley south of the bay. The San Francisco Bay Basin, exclusive of the Central Valley, includes the area that is drained by the short streams flowing into the bay.

The topography varies widely, and altitudes range from sea level to more than 14,000 feet. Approximately two-thirds of the region is mountainous and one-third valley lands. The altitude of the latter for the most part is less than 600 feet. Foothills and mountains are covered with forests chiefly of pine and fir, large areas of which are of commercial importance. The valley lands in their natural state are covered with brush of the arid and semiarid types with scattered oaks. Cottonwood trees grow along the river bottoms.

The climate of the valleys is mild, the mean annual temperature being about 60°. Summers are dry and hot and winters wet and cool. The growing season extends from March to October. Irrigation is essential for crop production. The usual mountain condi-

tions of relatively short cool summers and cold winters with heavy snow are found in the higher altitudes. Precipitation ranges from 60 inches annually in the Sierra Nevada to 5 inches at Bakersfield in the southern end of the San Joaquin Valley.

Principal streams of the basin are the Sacramento and San Joaquin Rivers. They join and flow through a common mouth into Suisun Bay and thence into San Francisco Bay. The mean annual run-offs from the mountainous area of the basin are 23,000,000 acre-feet from the Sacramento River Basin and 11,300,000 acre-feet from the San Joaquin River Basin. The chief east-side tributaries of the Sacramento are the Feather, American, Yuba, and Bear Rivers, and from the west Cache and Stony Creeks. The main tributaries of the San Joaquin, all from the east, are the Tuolumne, Kings, Stanislaus, Merced, and Mokelumne Rivers. The principal streams of the San Francisco Bay Basin are the Napa River and Alameda and Coyote Creeks. In addition to these, there are numerous intermittent streams flowing from the coast range and the Sierra Nevada, many of which disappear in the alluvial valley floors.

The average run-off from the mountainous areas of the basins is approximately 35,500,000 acre-feet, varying from more than 2.5 times this average in the wetter years to about one-fourth in the drier. Several trans-mountain diversions have been proposed for the importation of a fraction of the abundant water supplies of the North Pacific—Klamath Basin, but none is considered for early construction.

Underground waters are available throughout the valley region, and more than 1,000,000 acres are being irrigated by pumping. During the last 20 years the underground supplies have been heavily depleted and in many places, particularly in the southern San Joaquin Valley, the water table has been falling several feet a year.

The population of the basin has been increasing rapidly. It now is approximately 2,500,000. The San Francisco metropolitan area contains approximately 1,230,000 persons. In the Central Valley 60 percent of the population is rural but in the San Francisco Bay Basin only 15 percent is so classified.

Agriculture by irrigation, manufacturing, mining, oil production, and stock-rearing are among the leading industries. San Francisco is an outstanding Pacific coast seaport. Thirteen harbor and port areas in the district have an aggregate water-borne traffic of 25,000,000 to 40,000,000 tons annually. The climate and soils in the

valleys are adapted to growth of citrus fruits, olives, cotton, and grapes. Fruits of many other varieties are grown, as well as grains, alfalfa, rice, and truck crops. Dairying and the raising of beef cattle, sheep, hogs, and poultry also are important industries. Large oil fields have been brought into production in the southern San Joaquin Valley, and prospects farther north are being tested. A large amount of hydroelectric energy is generated in the Sacramento Basin. Some is used within the basin but most of it is transmitted to the area around San Francisco Bay and to the San Joaquin Valley. A large amount of water power generated in the San Joaquin Basin is exported to southern California.

Recommended Plan

Water for domestic and industrial purposes is obtained both from underground sources and surface flow. Most of the towns and cities in the basins have sufficient supplies at hand or readily available. However, San Francisco and other bay cities have had to go far afield to obtain, store, and import through costly conduits reliable and adequate water supplies. Two notable interbasin diversions from the San Joaquin Basin have been made by cities at San Francisco Bay. They are the 155-mile long Hetch-Hetchy transmountain water system of the city of San Francisco, and the system serving Oakland and adjacent cities from the Mokelumne River, 100 miles away. The ultimate importation of San Joaquin Basin waters through these conduits will amount to 650,000 acre-feet annually, accomplished at a capital cost of \$250,000,000.

A shortage of water for industrial, irrigation, and municipal purposes is apparent in Contra Costa County on the south side of Suisun Bay, and there is a local need for domestic water supplies for State institutions north of the bay. The furnishing of a supplemental supply of water for these districts is planned, the first, by the Contra Costa conduit, which will obtain water from the San Joaquin River, and the second by the Rector Canyon project, which proposes the development of a water supply from the Napa River.

Irrigation is the dominant use of water in the basins, where 3,000,000 acres are irrigated. Irrigation development has been so rapid and extensive, particularly in the San Joaquin Valley, that the local water supplies have been badly overdrawn and are insufficient to meet the needs of present irrigated areas.

Run-off without surface storage from all the streams of the San Joaquin Valley has been used to a high degree for many years. As a result the expansion of irrigated areas devoted to permanent crops has occurred chiefly through the development of underground water supplies. The replenishment of underground water here commonly results from percolation from

stream flow and rainfall, and from ample surface-irrigation applications. Irrigation has so expanded in many localities that the draught on underground water storage exceeds the average seasonal replenishment. The result has been a depletion in underground water which is apparent in a continuously receding water table, a depletion followed by exhaustion of supplies in some places.

Out of a total irrigated area in the San Joaquin Valley of 2,200,000 acres drawing their supplies both from streams and wells, more than half need additional water, and 400,000 acres are critically short. Studies reveal that the supply in southern San Joaquin Valley is only about half that now required. With the recession of ground water levels, water supplies in some areas have been exhausted, as already noted, or have become too salty for use, while in other areas pumping lifts have become excessive and economically prohibitive. Farms and homes on about 50,000 acres already have been abandoned because of the lack of an adequate and reliable water supply and it is estimated that 200,000 acres more must return to desert if a supplemental supply is not obtained in the near future.

In the fertile and highly productive Sacramento-San Joaquin Delta of more than 400,000 acres, a seasonal shortage of irrigation water exists. During periods of shortage, salt water invades the channels from which the irrigation water is obtained. Serious damage has occurred to crops in dry years from salinity, and the entire delta agricultural output, valued at \$30,000,000 a year, is menaced. Just west of the delta, along the south shore of Suisun Bay, is a highly attractive industrial area occupied by about 100 manufacturing plants, supporting a large population and producing finished goods valued at more than \$100,000,000 annually. This area has been damaged and its growth stopped by salt water encroachment.

Water shortages occur in the Sacramento Valley during summer months of low-water years but the condition is not as critical as that in the San Joaquin Valley. Water supplies available in the Sacramento River Basin are in excess of its full requirements. Since additional water in large quantity must be imported to the San Joaquin Valley, the plans for water development in these two valleys must be considered as interdependent and interrelated. Intensive and extensive engineering studies for present and future uses of water in the Sacramento and San Joaquin Basins, termed the "Central Valley", have been made by California and by Federal agencies. As a result of these examinations a plan of coordinated development has been designed by the Department of Public Works of California to satisfy all needs.

In the San Francisco Bay Basin, underground waters are used extensively for irrigation. As a result of over-

drafts the ground water plane has been lowered as much as 50 or 60 feet and corrective measures are imperative. Five reservoirs recently have been completed for control of surface waters and replenishment of the depleted underground supply of the Santa Clara Valley. One year's operation of the project has demonstrated the efficacy of the system. A marked restoration of the underground supply is apparent.

A shortage of underground water for irrigation is reported in the Napa Valley and along the south side of Suisun Bay. The Contra Costa conduit and the Rector Canyon project, previously mentioned, will provide additional water for these areas.

Supplemental water supplies are needed in many of the valleys along the tributaries of the San Joaquin and Sacramento Rivers.

Rehabilitation of the Goose Lake irrigation project near Lakeview, Oreg., is proposed. Water-supply reports recently made by the Oregon State engineer's office indicate that there is water available for irrigation of an area of approximately 10,000 acres.

Pollution of streams from domestic sewage and industrial wastes is not a problem of pressing importance, except in the cases of the Sacramento River near Sacramento and the San Francisco Bay region. Communities bordering San Francisco Bay discharge raw sewage into tidal waters of the bay. Several small cities have constructed settling basins and San Francisco has developed a long-time plan of improved sewage disposal. Construction of a large proportion of the necessary works is contemplated. Additional study should be given to the problem in the region of Mare Island Strait, and action should be taken to rectify the condition in this area.

Pollution of streams in the interior of the basin is local in character and small in extent. However, in the delta area, vegetable canneries discharge celery and asparagus waste products in large quantity into the river channels, presenting a problem that will require solution in the not far distant future.

As previously mentioned, salinity control in the San Joaquin-Sacramento delta is a pressing problem in the summer months of low-water years. A solution of the salinity invasion problem is provided in the Central Valley project.

Mining auriferous gravels by the hydraulic process in early days sent millions of cubic yards of debris into the streams of the valley and out over adjacent farm lands during flood periods. To protect navigation on these streams and to protect the agricultural lands, this form of mining was practically terminated by a Federal court decision in 1884. Some hydraulic mining is now carried on behind dams which restrain the debris. Gravels are also worked for gold by dredges. Proposals have been made for the construc-

tion of debris storage dams on the Yuba, Bear, and American Rivers. These would, as well, have direct benefits for Sacramento River navigation and flood control.

Navigation on the Sacramento River was formerly practiced from its mouth to Red Bluff, a distance of 250 miles. The city of Sacramento, about 50 miles from the mouth, now is the head of reliable all-year navigation, because upstream diversions have affected the low water flow. Many individuals and companies operate freight-carrying facilities on the river and a material increase in water-borne commerce has been noted in recent years. The economic importance of maintaining navigation on the river is generally recognized. The Federal Government has expended substantial sums in maintaining and improving the stream. The River and Harbor Act of August 30, 1935, authorized a special direct appropriation of \$12,000,000 toward the cost of a storage dam on the Sacramento River to control floods and to improve navigation to Red Bluff.

The port facilities of San Francisco Bay are generally adequate, but a few channel dredging projects are needed. The Guadalupe River Channel project has been authorized by the Congress, and surveys of the Suisun Channel have been completed by the Corps of Engineers.

Flood control in Sacramento Valley has been a major problem, but a project which is now practically completed will provide protection against floods of normal height. Much of the San Joaquin Valley lands have been subject to overflow during seasonal high water but irrigation uses and channel reservoirs have reduced the frequency of overflow. Flood control problems here will be reduced further by the Central Valley project.

Hydroelectric power developments are already extensive, but possibilities for future developments are great although few inexpensive sites remain. Most of the power development is in the Sierra Nevada and water is thus available for reuse in the lower valleys. It is recommended that a power market study for the undeveloped power resources of the area be undertaken.

Recreation activities are numerous and varied in this area. It contains Lassen, Yosemite, General Grant, and Sequoia National Parks as well as several large groves of giant sequoias. Fishing streams are numerous and lakes in the mountains are used extensively for boating, fishing, and swimming. During the winter the high Sierra, which has a snow pack unequalled in this country, attracts many winter sports enthusiasts. Sloughs in the delta region furnish fine wild waterfowl grounds. The number of birds appearing in them is now greatly reduced. The mountains provide excellent hunting grounds. Increased fire protection for forests

and brush areas is needed if these recreational areas are to be preserved.

The Central Valley project embodies a plan for the conservation, regulation, distribution, and utilization of the water resources of the Sacramento and San Joaquin Rivers to provide urgently needed water supplies for existing agricultural, industrial, and municipal developments in the Sacramento and San Joaquin Valleys and upper San Francisco Bay regions, which contain 3,000,000 acres of settled, irrigated and productive land, and a population of 900,000 persons. In addition to providing new water supplies to meet serious problems of water shortage, the project contemplates the restoration of commercial navigation on the upper Sacramento River, increased flood protection for the valley lands, and the generation of about a billion and a half kilowatt-hours annually of hydroelectric energy. The key unit of the project is the Kennett storage reservoir on the Sacramento River to regulate floods and store 3,000,000 acre-feet of water. Water released from the reservoir, after generating hydroelectric power, will flow down the Sacramento channel, maintaining adequate depths for navigation and furnishing ample supplies for irrigation and for municipal and industrial use along the main river and in the delta region.

Intrusion of salt water from the bay into the delta channels will be prevented by the released waters. In addition, water supplies will be made available in the delta channels for various uses in the nearby upper San Francisco Bay area, and for utilization in the San Joaquin Valley. Conduits to carry the supplies to these areas are provided. The supply for the San Joaquin Valley will be conveyed up the San Joaquin River through a series of pumping plants and intervening natural and artificial channels a distance of 150 miles, lifting the water to an elevation of 160 feet above sea level. This water will replace San Joaquin River water now used for irrigation in the northern San Joaquin Valley, thus permitting the entire flow of the river to be regulated in Friant Reservoir, the second storage unit of the project, and to be utilized in the southern part of the valley where local supplies are deficient. Water from this reservoir will be delivered by gravity through conduits extending north and south to serve developed irrigated lands in an area extending from Madera County on the north to Kern County on the south. The cost of the project, estimated at \$170,000,000, will be repaid by revenues from the sale of water and power.

The sources of water supply for the project are the Sacramento and San Joaquin Rivers and their tributaries. The State of California, pursuant to acts of the State Legislature, has filed notices of appropriation on the principal streams. Studies made by the Department of Public Works of California, the Corps of Engi-

neers, and the Bureau of Reclamation indicate that the works of the project will provide an adequate water supply for all purposes.

The principal engineering features of the project are as follows:

Sacramento River storage unit.—The Kennett Reservoir, the key unit of the project, is located on the Sacramento River near Redding in Shasta County. The dam will be 420 feet high and store 3,000,000 acre-feet of water. A 275,000-kva power plant will be located below the dam. A reregulating afterbay with a 50,000-kva power plant will be constructed below the Kennett Dam. From the power plants a 200-mile power transmission line will extend to a main distributing substation near Antioch on Suisun Bay. Investigations in progress by the Bureau of Reclamation may result in an increase of capacity or possibly in a change of location of the site within the same general canyon section, but the utility of the storage unit will be the same.

Contra Costa conduit.—A canal with pumping plants will extend west from the San Joaquin delta for 50 miles through Contra Costa County to supply municipal, industrial, and agricultural water requirements.

San Joaquin pumping system.—The works for this pumping system will comprise a dam and other works in the Sacramento delta to divert the regulated flow through a channel into the San Joaquin delta for salinity control, irrigation, and other purposes; dredging of existing channels in the San Joaquin delta; five dams and pumping plants on San Joaquin River to the mouth of the Merced River; and four pumping plants and 65 miles of canal on the west side of San Joaquin Valley which will deliver water to Mendota weir on the San Joaquin River, at an altitude of 160 feet. These works will be capable of furnishing a substitute supply of 900,000 acre-feet to 300,000 acres of land now irrigated from the San Joaquin River.

Friant Reservoir.—A dam, 260 feet high, will be constructed on the San Joaquin River, which will store 450,000 acre-feet of water and will permit the diversion of San Joaquin River water southward.

Friant-Kern Canal.—The Friant-Kern Canal will extend south from Friant Reservoir to Kern River, a distance of 157 miles and will be capable of supplementing deficient supplies for an area of 1,000,000 acres of developed land.

Madera Canal.—The Madera Canal, maximum capacity 1,000 second-feet, will extend north from Friant Reservoir to Chowchilla River, a distance of 35 miles and will be capable of furnishing irrigation water to an area of 140,000 acres.

The Central Valley is highly developed. Its products are largely noncompetitive with other sections of the country, since production of many of them, such as

nuts, figs, raisins, and asparagus, is confined largely to California. The project is not designed to bring new lands into cultivation. Part of the water supply is to be obtained by the purchase of water now used for flood irrigation of pasture lands and this will result in the retirement from use of 250,000 acres of sub-marginal land.

The economic values of the project are of great magnitude. Of the 3,000,000 acres now irrigated, 1,000,000 face acute water shortage, and abandonment is proceeding rapidly. The values in jeopardy are large, as, without water, communities will vanish and whole sections return to desert. Part of the loss would be suffered by persons not residing in the areas directly affected.

Control of salinity in the delta of the two rivers is also a part of the agricultural maintenance phase of the project. Some abandonment has occurred and this whole area is endangered.

Alternate plans have been proposed for some features of the Central Valley project and investigations of the most promising of these schemes have been made

by State and Federal agencies. One such proposal was that storage dams be constructed on the American River, which enters the Sacramento River at Sacramento, in lieu of provision for storage on the headwaters of the Sacramento River. This is one of the most favorable of the alternate plans. Extensive studies have shown that storage on the Sacramento River is superior for the following principal reasons:

1. Navigation improvements and additional flood control will be provided on the Sacramento River above the city of Sacramento, and irrigated lands along the stream above this city will be benefited by construction of storage works in the upper reaches of the Sacramento River.

2. Reservoirs on the Sacramento River will store much greater amounts of water.

3. Although the capital cost of the Sacramento River storage will be larger than the cost of storage on the American River would be, the net annual revenues of the Sacramento storage will be much greater since it will provide larger amounts of hydroelectric power.

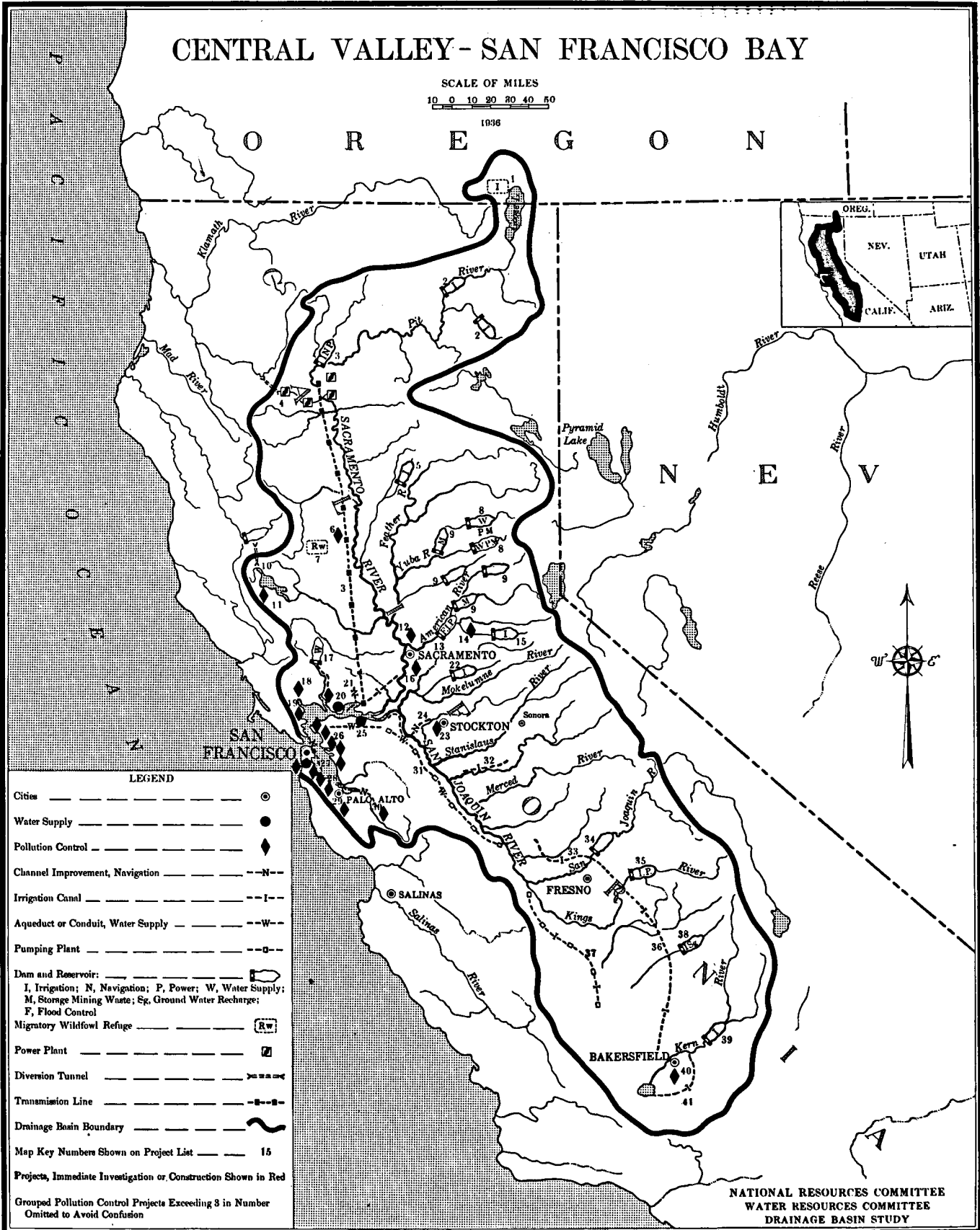
Central Valley—San Francisco Bay Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
1	Goose Lake Valley, Oreg.: Improvement and rehabilitation of irrigation works..... Central Valley project of California: Comprehensive irrigation, navigation, flood and salinity control, domestic and industrial water supplies and hydro-electric power project covering entire Central Valley. Project consists of the following:	\$92,000 40,000,000	Plans made. Under construction. Cost given is for next 2 years. Additional needed to complete \$115,000,000. Authorized by Congress. Construction program will require about 8 years.
	<i>Estimated cost</i>		
3	Kennett dam, reservoir and power plants.....	\$ 84,000,000	
3	Kennett transmission line and substation.....	14,000,000	
25	Contra Costa conduit.....	2,500,000	
31	San Joaquin pumping system.....	18,500,000	
34	Friant Dam and Reservoir.....	14,000,000	
36	Friant-Kern Canal.....	26,000,000	
33	Madera Canal.....	3,000,000	
24	Rights-of-way, water rights, and general expense.....	8,000,000	
33	Stockton, Calif.: Dredging 9-foot feeder channel.....	112,000	Sum needed to complete project.
17	Napa County, Calif.: Supplemental domestic water supply to State institutions in Napa Valley; reservoir and pipeline.....	1,000,000	Plans completed.
32	Stanislaus County, Calif.: Modesto irrigation district service ditch improvement.....	380,000	Do.
7	Glenn and Colusa Counties, Calif.: Sacramento Valley bird refuge; wild fowl concentration refuge on Sacramento River.....	369,000	Sum needed to complete project.
27	San Francisco, Calif.: Extension and repairs to water, sewer, and drainage systems of Letterman General Hospital.....	24,000	Plans completed.
25	Pittsburg, Calif.: Replacements and extensions to water distribution system.....	140,000	Do.
30	Santa Clara County, Calif.: Dredging deep sea channel and turning basin in lower San Francisco Bay and Guadalupe River.....	560,000	Authorized by Congress.
9	American, Bear, and Yuba Rivers, Calif.: 4 debris storage dams to control gravel waste from placer mining.....	6,945,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
13	Sacramento County, Calif.: Folsom Reservoir in American River.....	\$4,000,000	Preliminary plans completed. Cost given is for next 2 years. Additional needed to complete \$8,000,000.
35	Fresno County, Calif.: Pine Flat Reservoir to control seasonal peak flows of the Kings River for supplemental water supply.....	3,000,000	Preliminary plans completed. Cost given is for next 2 years. Additional needed to complete \$7,000,000.
21	Solano County, Calif.: Dredging and straightening Suisun Channel to 8-foot depth from Suisun Bay to town of Suisun.....	140,000	Survey completed.
5	Butte County, Calif.: Supplemental water and improvements for Paradise irrigation district.....	300,000	Plans completed.
15	El Dorado County, Calif.: Supplemental water and improvements for El Dorado irrigation district.....	360,000	Do.
2	Modoc and Lassen Counties, Calif.: Supplemental water for Big Valley irrigation project.....	325,000	Plans under way.
8	Nevada County, Calif.: Water for hydraulic mining, Black Rock placer mining district.....	249,000	Do.
27	Nevada County, Calif.: Water for hydraulic mining, Black Rock placer mining district.....	45,000	Survey completed.
18	Petaluma, Calif.: Outfall and complete sewage treatment.....	316,000	Preliminary plans completed.
40	Bakersfield, Calif.: Partial sewage treatment plant.....	100,000	Do.
12	North Sacramento, Calif.: Complete sewage treatment plant.....	20,000	Do.
29	Palo Alto, Calif.: Sewage treatment plant for veterans' hospital.....	32,000	Survey in progress.
14	Placerville, Calif.: Outfall sewer and partial sewage treatment plant.....	50,000	Preliminary plans completed.
6	Willows, Calif.: Partial sewage treatment plant.....	10,000	Do.

CENTRAL VALLEY - SAN FRANCISCO BAY

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LEGEND

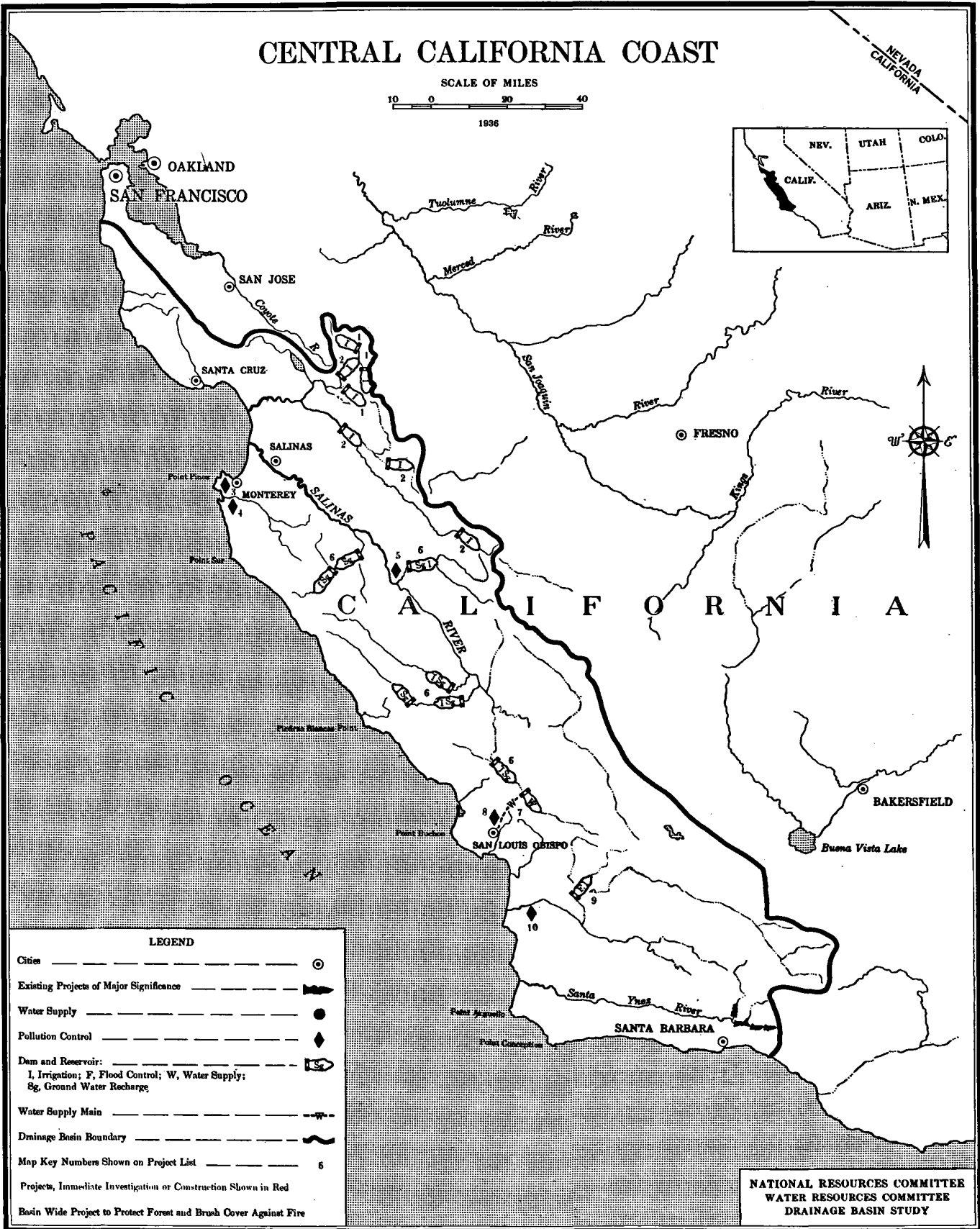
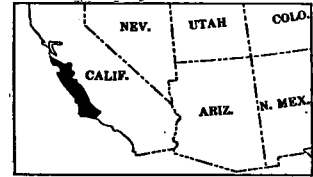
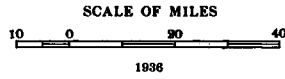
- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Channel Improvement, Navigation ———— N——
- Irrigation Canal ———— I——
- Aqueduct or Conduit, Water Supply ———— W——
- Pumping Plant ———— □
- Dam and Reservoir: ———— [Symbol]
- I, Irrigation; N, Navigation; P, Power; W, Water Supply;
- M, Storage Mining Waste; Eg, Ground Water Recharge;
- F, Flood Control
- Migratory Wildfowl Refuge ———— [Rw]
- Power Plant ———— [Symbol]
- Diversion Tunnel ———— [Symbol]
- Transmission Line ———— [Symbol]
- Drainage Basin Boundary ———— [Symbol]
- Map Key Numbers Shown on Project List ———— 15
- Projects, Immediate Investigation or Construction Shown in Red
- Grouped Pollution Control Projects Exceeding 8 in Number Omitted to Avoid Confusion

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Central Valley—San Francisco Bay Project List—Continued

Map key no.	Project	Estimated cost	Remarks
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
10	Transmountain diversion from Trinity River in northern California—Klamath Basin, to Sacramento River in Central Valley—San Francisco Bay Basin: For power, irrigation, navigation, and salinity control.	\$62,000,000	Preliminary surveys completed.
4	Transmountain diversion from Eel River in northern California—Klamath Basin to Sacramento River in Central Valley—San Francisco Bay Basin: For power, irrigation, navigation, and salinity control.	28,000,000	Do.
39	Democrat Flat Reservoir on Kern River: Pumping plant and reconstruction of canals for irrigation.	2,500,000	Do.
38	Pleasant Valley Reservoir on Tule River: To be operated in conjunction with ground storage for irrigation.	2,900,000	Do.
22	Ione Reservoir: For storage equalization of Dry Creek and Mokelumne River, principally for irrigation.	8,600,000	Do.
41	Kern River Canal: For irrigation of lands in the vicinity of Bakersfield, Calif.	9,000,000	Do.
37	Mendota west side pumping system and canals: For irrigation of land south of Mendota.	16,000,000	Do.
17	Napa County, Calif.: Dam and reservoir on Conn Creek and 40-inch pipe line for domestic, industrial, and irrigation water supply to Crockett and the Napa Valley.	5,000,000	Do.
20	Benicia, Calif.: Water-supply improvements for domestic use and fire protection, Benicia ordnance department.	125,000	
21	Solano County, Calif.: Irrigation and pumping system to supply water to lands between Elmira and Cordelia.	1,300,000	
	Chowchilla, Escalon, Lakeport, Maxwell, and Tehachapi, Calif.: Sewer systems.	135,000	
30	Willow Glen, Calif.: Sewer system.	100,000	
	Angels, Auburn, Grass Valley, Jackson, Mount Shasta, Nevada City, Oakdale, and Sutter Creek, Calif.: Sewer systems.	270,000	
16	Sacramento, Calif.: Sewer system.	500,000	
23	Stockton, Calif.: Sewer system.	300,000	
	Gridley, Gustine, Hanford, Isleton, Los Gatos, Napa, and South San Francisco, Calif.: Sewer systems.	255,000	
19	Marin sanitary district no. 1, California: Sewer system.	75,000	
26	Alameda, Calif.: Sewer system.	200,000	
	Albany, Antioch, Atherton, Bayshore, Belmont, Belvedere, Benicia, Corte Madera, Daly City, Fairfield, Hayward, Larkspur, Lomita Park, Martinez, Menlo Park, Mill Valley, Mountain View, North Palo Alto, Pinole, Pittsburg, San Carlos, San Leandro, Sausalito, Stege, Suisun, Sunnyvale, Calif.: Sewer systems.	623,000	
26	Emeryville, Calif.: Sewer system.	100,000	
26	Oakland, Calif.: Sewer system.	1,000,000	
26	Piedmont, Calif.: Sewer system.	100,000	
26	Redwood City, Calif.: Sewer system.	100,000	
26	Richmond, Calif.: Sewer system.	200,000	
27	San Francisco, Calif.: Sewer system.	20,000,000	
26	Vallejo, Calif.: Sewer system.	100,000	
	Maricopa, Marysville, Merced, Red Bluff, Redding, Rio Vista, Santa Clara, Tracy, Yuba City, Calif.: Sewer systems.	323,000	

CENTRAL CALIFORNIA COAST



LEGEND

- Cities ———— ○
- Existing Projects of Major Significance ———— ■
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir: ———— [Symbol]
- I, Irrigation; F, Flood Control; W, Water Supply;
- Sg, Ground Water Recharge
- Water Supply Main ———— [Symbol]
- Drainage Basin Boundary ———— [Symbol]
- Map Key Numbers Shown on Project List ———— 6
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Project to Protect Forest and Brush Cover Against Fire

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

3. CENTRAL CALIFORNIA COAST

The basins of the central coastal streams of California, the waters of which are used principally for irrigation and to supply municipalities, have large run-offs, but stream flow is erratic. Most of the water used in these basins is obtained from underground supplies. These have been depleted and now require artificial replenishment for maintenance of the cities and the irrigated lands.

Immediate needs are supplemental water supplies for two communities, supplemental water for irrigation, and adequate fire protection for brush and forest cover to prevent further aggravation of run-off problems; a program with benefits to soil conservation, flood control, grazing, stream regulation, and recreation is recommended.

General Description

These basins occupy a coastal area of 11,500 square miles extending southeasterly along the Pacific Ocean for 300 miles from San Francisco to Santa Barbara. The eastern boundary is the crest of the Coast Range which forms the divide between the San Joaquin Valley and the numerous coastal watersheds. The topography is generally rough and complex. Ridges and spurs of the Coast Range intersect the area both lengthwise and crosswise. Rolling hills and narrow valleys predominate, with the highest mountain peak attaining an altitude of 5,800 feet. Stream slopes are steep.

Four percent of the area is classed as forest or as potential timber land. Thirty-eight percent is brush-covered, 36 percent grazing land, and 17 percent agricultural land, of which 200,000 acres are irrigated. The Santa Barbara National Forest, chiefly in the southern part of the area, embraces one-sixth of the region.

The population is 220,000, of which 55 percent is urban. The principal industries are agriculture, oil production, livestock, and commercial fishing. Tourist travel is a material factor in the activities of the basins, Santa Cruz, Monterey, San Luis Obispo, and Santa Barbara being especially well known as tourist centers. There are three seaports, Monterey being the largest. In general, the basin is well suited to residential occupancy.

There are four stream systems of importance; the largest, Salinas River, drains the central part of the area. Next in importance are the Pajaro, Santa Ynez,

and Santa Maria Rivers. All have numerous tributaries and, in addition, 100 small creeks and water courses flow directly into the Pacific Ocean.

The year is divided into pronounced wet and dry periods. The dry season, practically without rains, lasts from April to October, inclusive; irrigation is therefore essential. Precipitation varies greatly with altitude and distance from the coast. In some portions of the basin the annual precipitation is less than 50 inches while in other sections it is less than 10 inches. Temperatures are mild throughout the year. Stream flow varies greatly in different years and during the wet and dry periods of each year. Winter flood flows are of large magnitude. Summer stream flow is almost negligible. The average annual run-off of these basins is 2,000,000 acre-feet, but the range is from 8,000,000 down to 100,000 acre-feet. The ground water supplies, especially those of the river valleys, are of great importance, extended irrigation use being made of them. Some of the principal cities also are dependent upon ground water.

Recommended Plan

River regulation is called for by the erratic yearly stream flow and intermittent seasonal runoff, but steep river grades, such as those in these basins, make reservoir sites at a reasonable cost difficult to find. Consequently large volumes of the flood flow of the streams must always pass unused to the Pacific Ocean.

Water supply for both domestic and irrigation uses is inextricably tied up with conservation of the underground water. As large a percentage of the available moisture as possible must be held in the natural reservoirs of the earth itself. No opportunity exists for importation of much water from adjacent river basins. In one case, to supply municipal requirements, it is proposed to import water from an adjacent watershed within this area.

The underground water supply is more reliable than the surface runoff but it varies with wet and dry cycles of precipitation. It is now seriously overtaxed and the water table is receding in the irrigated areas. Replenishment is essential to avoid increasing pump lifts to uneconomic levels, and even to avoid exhaustion of the underground supplies.

One small hydroelectric plant has been constructed, but future development will be negligible because of lack of reliable flow.

Future water development, limited in scope, will be confined to the two present dominant uses, municipal supply and irrigation. The principal means of extending the uses of water will be through construction of stream channel reservoirs, despite the scarcity of reservoir opportunities. Water stored in such reservoirs will be used both directly and indirectly. Indirect use will be by spreading the water on porous valley bottoms for replenishment of underground water with subsequent pumping for municipal and irrigation uses. This method is already utilized to a considerable extent in southern California.

Numerous studies of channel reservoir sites have been made and some are worthy of development. Storage sites with an aggregate capacity of 970,000 acre-feet have been surveyed. Cost per acre-foot of water yield is prohibitive in some and is high in all instances.

Five specific projects have been included in the plan with a view to supplementing the water supply for irrigation, domestic, and industrial uses.

Fire protection is of paramount importance to a section which has a season of 6 dry, hot months, and which is dependent upon watersheds with brush and light-timber cover. Adequate fire protection is an immediate need and when achieved will provide

major benefits in stream regulation and related conservation functions.

Erosion affects much of the basin area. This problem is now being studied by the Soil Conservation Service with the establishment of a demonstration project near Santa Cruz. The prevention of erosion, protection of forested and watershed lands, and proposed extensions of the national forests are closely related to the conservation of the water supply and should have due consideration.

Pollution of streams is caused by the discharge of sewage and of a small amount of industrial waste. No plans for abatement of this pollution have yet been made, but eventually the problem must receive consideration.

Recreation is an important feature of these basins. The accessible beaches of the coastal area are heavily used for this purpose. While sanitation facilities are adequate at present, there will soon be serious pollution problems in the congested inland recreational areas adjacent to municipal water-supply systems.

Flood control is a problem that may become important in the future but if the contemplated projects for the conservation of the water supply are carried out floods will tend to become less serious in the lower parts of the valleys.

Central California Coast Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
7	San Luis Obispo, Calif.: Supplemental water supply involving intrabasin diversion, collection reservoir, tunnel and pipe line, regulating reservoir, and mains.	\$980,000	Plans completed.
1	Santa Clara and San Benito Counties, Calif.: Supplemental water supply involving construction of 3 reservoirs and 4 canals for irrigation and recharge of underground basins in Pacheco water district.	335,000	Do.
	Basin-wide project to protect forest and brush cover against fire with attendant benefits to grazing, soil erosion, and flood control.	226,000	Plans have been prepared by Forest Service for a continuous construction and maintenance program.
4	Carmel sanitary district, California: Complete sewage treatment plant.....	50,000	Plans completed.
8	San Luis Obispo, Calif.: Partial sewage treatment plant.....	24,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
6	Monterey County, Calif.: Storage on the Salinas River system for irrigation, recharging of underground water supplies and power.	\$1,000,000	Plans incomplete. Cost given is for next 2 years. Additional needed to complete \$1,700,000.
2	San Benito County, Calif.: Supplemental supply for Hollister irrigation district involving construction of 3 dams, 2 canals, and spreading grounds for underground percolation; the Pacheco project covers part of this plan.	500,000	Plans incomplete. Cost given is for next 2 years. Additional needed to complete \$800,000.
9	Santa Barbara and San Luis Obispo Counties, Calif.: Irrigation and flood control in Santa Maria Valley; dam and reservoir on Cuyama River and main canals.	1,500,000	Preliminary engineering work completed. Cost given is for next 2 years. Additional needed to complete \$2,500,000.
5	King City, Calif.: Outfall sewer and partial sewage treatment plant.....	20,000	Preliminary plans completed.
(1)	Pacific Grove (3) and Santa Maria (10), Calif.: Sewer systems.....	50,000	Plans incomplete.

¹ Map key number shown following community name.

² Annually.

4. SOUTHERN CALIFORNIA COAST

The major problem of the southern California coast area is that of providing a supplemental water supply for both domestic and irrigation uses. In this semiarid region, all agricultural and urban developments are dependent upon provision of adequate water. An exceptionally attractive climate and abundant resources have combined to make this one of the more rapidly growing sections of the United States. Water has been conserved to a great extent to meet increasing demands, but the local run-off became inadequate many years ago. Importation of water from another basin has been accomplished, but overdrafts upon underground water sources continue. A new diversion, from the Colorado River, is contemplated in the construction of an aqueduct 250 miles long, now under way.

Protection from fire of the brush and forest cover of the hills and mountains of these basins is important. Burned-over hills magnify the flood danger to cities and towns below them.

Despite the small amount of rainfall received, the fact that most of it is delivered by one or two major storms during the year results in a serious flood-control problem. Intermittent streams, generally dry, become torrents after heavy storms. Storage on these streams and protection of the wash channels are required.

General Description

The southern California coast basins occupy an area of 10,500 square miles, extending southeasterly from Santa Barbara to the Mexican boundary. A broad coastal plain extends to the low rolling foothills, from which rise abruptly the mountains which form the Coast Range, which is the eastern boundary of the area. Fifteen streams, of which the Santa Ana River is the largest, discharge directly into the ocean.

More than half of the area is in brush cover of the chaparral type, and one-quarter is occupied by three national forests. There are 600,000 acres intensively cultivated. This is irrigated land, largely devoted to citrus groves and deciduous orchards.

The area has a population of 2,800,000, seven-eighths of which is urban, the Los Angeles metropolitan area alone having a population of 1,900,000. The growth of the cities and towns within this basin has been rapid. The principal activities are agriculture, oil production and refining, and manufacturing. Tourist travel is of great importance. Harbor facilities are excellent, there being deep-water ocean ports at Los Angeles, Long Beach, and San Diego.

The climate is mild with dry summers and short rainy winters. The average annual temperature exceeds 60 degrees. In the citrus belt the temperature seldom falls below 30 degrees. The wet season extends approximately from November to March, and the remainder of the year is very dry. In the agricultural areas the annual rainfall ranges from 10 to 20 inches; in the mountains precipitation reaches as high as 40 or even 50 inches.

A large part of the stream flow is absorbed by alluvial cones and fans along the margin of the mountains, by porous stream beds and by unconsolidated gravels in the valleys and the coastal plain areas. Main streams are dry except during winter storm periods during which flashy floods pass largely unused to the ocean. Large annual variations are found in rainfall and run-off records. The average annual run-off amounts to 1,150,000 acre-feet with maximum and minimum values of 4,800,000 and 120,000 acre-feet, respectively. The erratic streams to be of service must be regulated through storage, either surface or underground, or both. Underground water storage is by far the more important.

Recommended Plan

Water supply development and use is in an advanced stage in this basin. Local supplies, with the exception of flood peaks, are practically consumed by municipal and irrigation uses in most sections of the basin.

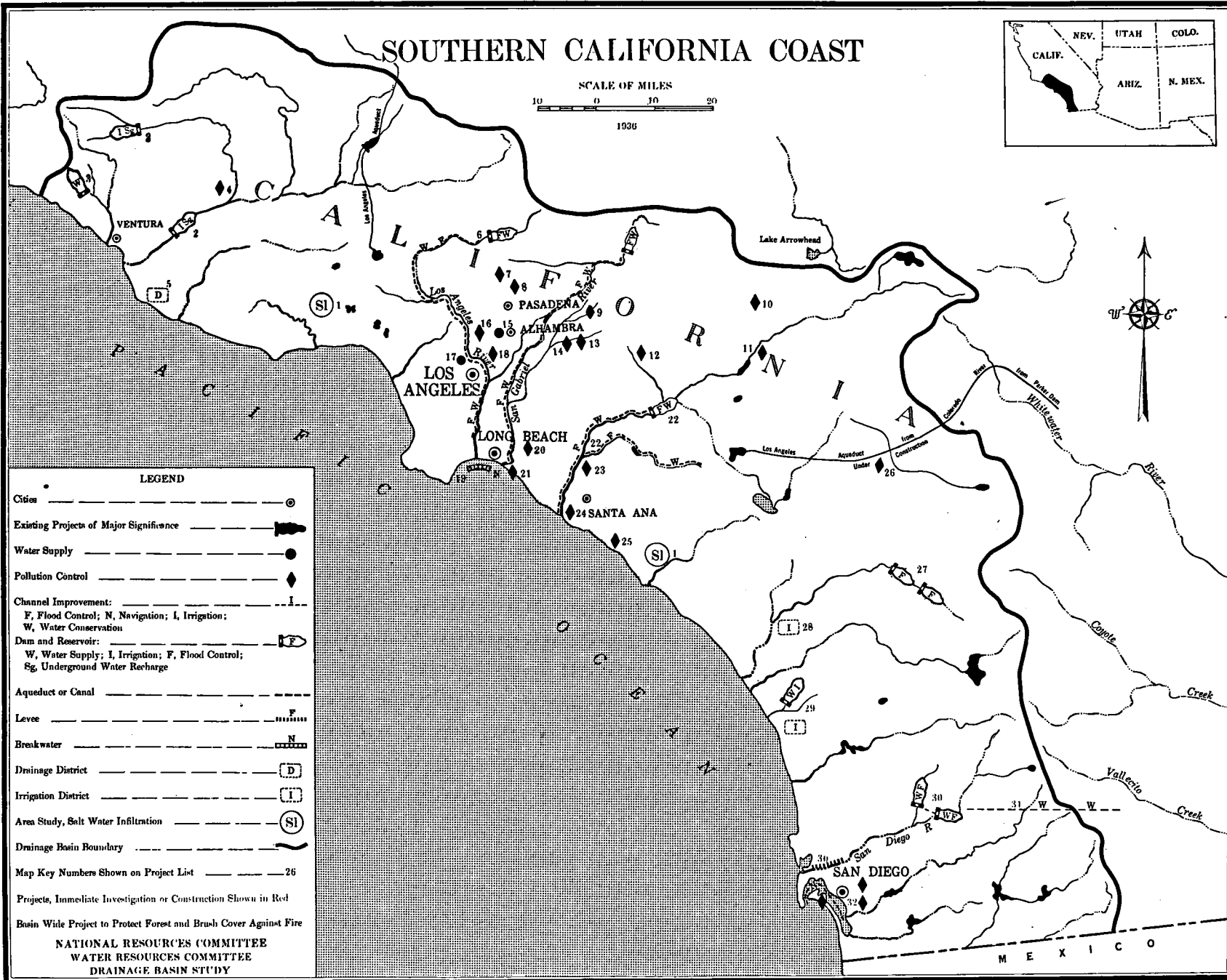
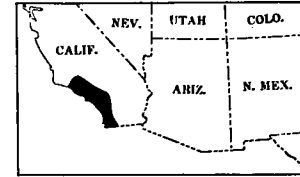
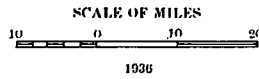
Underground waters, originally the chief sources of municipal and irrigation supplies, are greatly depleted. As a consequence, large volumes of supplemental water have been imported at great cost from adjacent basins to meet the pressing demands of rapid urban growth.

Further reservoir control of local water resources will be extremely costly, but will involve multiple purposes, including flood control by storage, spreading of the conserved flood waters for underground storage, and subsequent pumping for both municipal and irrigation uses. In some cases direct use from the reservoirs without underground storage will be possible.

Of the irrigated area much the greater part is supplied by pumping of underground waters. Overdraft has resulted in lowering the water table from 50 to 100 feet in large areas and this has entailed heavy pumping costs. Yearly water consumption by irrigated land is estimated at 1,000,000 acre-feet.

The metropolitan water district of Southern California, which includes Los Angeles and 12 nearby cities, has under construction an aqueduct which

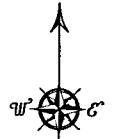
SOUTHERN CALIFORNIA COAST



LEGEND

- Cities ———— ●
- Existing Projects of Major Significance ————
- Water Supply ———— ●
- Pollution Control ———— ◆
- Channel Improvement: ———— I
 - F, Flood Control; N, Navigation; I, Irrigation;
 - W, Water Conservation
- Dam and Reservoir: ————
- W, Water Supply; I, Irrigation; F, Flood Control;
- Sg, Underground Water Recharge
- Aqueduct or Canal ———— - - - - -
- Levee ————
- Breakwater ————
- Drainage District ————
- Irrigation District ————
- Area Study, Salt Water Infiltration ———— (SI)
- Drainage Basin Boundary ————
- Map Key Numbers Shown on Project List ———— 26
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Project to Protect Forest and Brush Cover Against Fire

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY



MEXICO

will bring 1,100,000 acre-feet of water from the Colorado River. Construction is far advanced. The cost of this project will exceed \$220,000,000. The city of San Diego is considering a transmountain diversion from the Colorado River by way of the All-American Canal, for importation of 110,000 acre-feet annually.

Imported water and surface flood-control reservoirs will assist in refilling the depleted underground reservoirs, thereby decreasing excessive pumping lifts for irrigation and municipal uses. Imported water not needed for immediate municipal and industrial supplies will be used for supplementing the supplies of existing irrigated areas. Increased urban development will encroach upon existing irrigated areas and water now used for irrigation purposes will be freed for domestic use as this shift occurs.

Water projects involving salvage of flood waters through reservoir control with spreading on porous alluvial areas are listed for construction in the future, as is, also, the proposed transmountain diversion of Colorado River water for San Diego.

Flood control and erosion are serious problems in this basin. Artificial changes resulting from settlement and development in the foothills and plains areas have decreased channel capacities, increased flood run-off and accelerated erosion. At the same time these have increased the potential damage to property. Flood run-off and mud and debris flow from burned foothill areas are excessive. Several methods should be used in effective combination for flood control. They are: Adequate fire protection to maintain brush cover and prevent excessive erosion on steep mountain slopes; detention storage in channel reservoirs on steep mountain streams; debris sumps to catch mud and rock; artificial channels of adequate capacity in foothills and plains areas; and distribution of flood water over porous stream channels for absorption in underground reservoirs. These measures will also contribute greatly to water conservation.

The prevention of forest and brush fires in foothill and mountain areas is of prime importance, needs emphasis, and should be a first line of defense in flood control in southern California. Unless the brush cover is preserved the costly reservoirs will soon be filled with muck and rock debris. A plan proposed by the United States Forest Service is recommended.

The estimated cost of flood protection in Los Angeles County is \$130,000,000, of which amount \$55,000,000, has already been expended or authorized for expenditure by the local flood-control district. Orange County flood-control plans contemplate an expenditure

of \$16,500,000. The estimated cost of proposed flood-control works in the vicinity of San Diego is set at \$10,000,000.

Future units of the Los Angeles County flood-control project, estimated to cost about \$72,000,000, are now being restudied by the Corps of Engineers with construction authorized by the Congress. The Orange County flood-control project has been authorized by the Congress, with construction placed under the direction of the Corps of Engineers. Detailed plans are in preparation.

Navigation facilities are afforded through the deep-water ocean ports at Los Angeles, Long Beach, and San Diego. A dredging project at San Diego Harbor has been proposed by the Corps of Engineers.

Pollution abatement measures are needed in limited areas. Sewage of large cities is mostly discharged into the Pacific Ocean after preliminary treatment or screening. Harbor areas appear to be the most seriously affected by pollution. In these areas mud flats collect sewage. Fish canneries at San Pedro, Long Beach, and San Diego add heavily to pollution of harbor waters.

Recreation and conservation of wildlife should be considered in planning for future development. With a rapidly increasing population these subjects become increasingly important. No projects are presented at this time.

Salt water intrusion is causing concern in this area. During the last 30 years the ground water in the central coastal section has lowered progressively. The gradient is now away from the ocean, and at its lowest point the water table is about 60 feet below sea level. In some parts of this district the chloride content of the ground water is alarmingly high. Whether this condition is due to the intrusion of sea water is not certain but it is certain that the danger of such intrusion is serious. Capital investments to the extent of tens of millions of dollars are at stake and comprehensive studies that will determine the physical conditions involved and the remedy, if any, should be made.

International relations.—The Tia Juana River, a small stream along the California-Mexico boundary is international. Reservoirs have been constructed on the Tia Juana River system both in California and in Mexico. San Diego has constructed two channel reservoirs in California on Cottonwood Creek, a tributary of the Tia Juana River and uses the water there stored for municipal supply. No definite plan has been developed for settlement of this international water problem.

Southern California Coast Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
1	Los Angeles and Orange Counties, Calif.: Study of salt intrusion into wells and coastal basin.....	\$30,000	Preliminary plans made.
	Basin wide project to protect forest and brush cover against fire, with attendant benefits to grazing, soil erosion, and flood control.	844,000	Plans completed.
3	Ventura, Calif.: Reservoir on Coyote Creek for supplemental water supply.....	¹ 393,000	Plans have been prepared by Forest Service for a continuous construction and maintenance program.
17	Bell, Calif.: Extension and improvement of water supply system.....	314,000	Plans completed.
15	Rosemead, Calif.: Waterworks.....	242,000	Do.
6	Los Angeles County, Calif.: Flood control and water conservation on Los Angeles and San Gabriel rivers by Los Angeles County flood control district.	35,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete \$37,500,000. Authorized by Congress.
19	Los Angeles and Long Beach Harbors, Calif.: Breakwater.....	1,375,000	Sum needed to complete project. Authorized by Congress.
32	San Diego, Calif.: Sanitary sewer system and treatment plant.....	2,000,000	Plans completed.
16	San Gabriel, Calif.: Sewer system and treatment plant.....	450,000	Do.
14	Arusa, Calif.: Sewers and complete treatment plant.....	180,000	Do.
25	Laguna Beach, Calif.: Sewers and complete treatment plant.	190,000	Plans completed.
18	Monterey Park, Calif.: Sewers and complete sewage treatment plant.....	200,000	Plans completed.
24	Newport Beach, Calif.: Sewers, outfall and complete sewage treatment plant.....	230,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
22	Orange County, Calif.: Flood control and water conservation.....	\$16,500,000	Authorized by Congress.
32	San Diego Harbor, Calif.: Dredging.....	4,184,000	Survey completed.
5	Oxnard, Calif.: Drainage district no. 3. Drainage to remove alkaline salts.....	318,000	Preliminary plans completed.
2	Ventura County, Calif.: Conservation of waste water of Santa Clara River for irrigation and recharging underground basin.	1,000,000	Investigation under way. Cost given is for next 2 years. Additional needed to complete \$2,200,000.
28	San Diego County, Calif.: Fallbrook irrigation district, water supply from San Luis Rey River for irrigation of 5,000 acres.	250,000	Preliminary plans made. Cost given is for next 2 years. Additional needed to complete \$536,000.
8	Arcadia, Calif.: Sewer system and sewage treatment plant.....	271,000	Plans completed.
32	San Diego, Calif.: Outfall sewer and two sewage treatment plants.....	500,000	Preliminary plans completed.
26	San Jacinto, Calif.: Sewers and partial sewage treatment plant.....	20,000	Do.
21	Sunset Beach sanitary district, California: Sewers and partial sewage-treatment plant.....	60,000	Do.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
29	Carlsbad Mutual Water Co., Carlsbad, Calif.: Water supply for domestic use and irrigation of 5,000 acres.	\$140,000	Preliminary plans completed.
30	San Diego County, Calif.: Flood control and conservation of water.....	10,000,000	Do.
27	Santa Margarita Reservoir, Calif.: For flood control and water conservation.....	200,000	Do.
31	San Diego, Calif.: Importation of water from Colorado River for future needs.....	22,500,000	Project being studied by Board of Engineers.
(1)	Covina (13), Fillmore(4), Glendora (9), Rialto (10), Tustin (23), and Westminster (20), Calif.: Sewer systems.	350,000	
7	Sierra Madre, Calif.: Sewer system.....	100,000	
11	Riverside, Calif.: Sewer system.....	250,000	
(1)	Chino (12), and Coronado (32), Calif.: Sewer systems.....	50,000	

¹ Map key number shown following community name.

² Annually.

PACIFIC NORTHWEST DRAINAGE BASINS

	Contents	Page
Columbia River—General Plan		510
1. Snake		514
2. Upper Columbia		518
3. Middle Columbia		522
4. Lower Columbia-Willamette		526
5. Puget Sound		530
6. Oregon Coast		535
7. Washington Coast		537

COLUMBIA RIVER—GENERAL PLAN

The plan for the Columbia River contemplates the building, step by step, of an agricultural, industrial, and commercial empire in the Northwest that will be a major asset to the whole Nation.

Utilization of the immense resources of the Columbia River for this purpose involves several factors. Irrigation in the upper and middle reaches of the basin and flood protection and drainage of lowlands near the coast will increase the relatively small acreage of farm land now available. Ocean navigation to The Dalles and shallow-draft navigation beyond would provide an extensive water transportation system. Water power will serve to stimulate industry and agriculture.

These purposes will all be served by a comprehensive plan involving an ultimate system of 10 dams on the main stream. This plan, based on studies by the Corps of Engineers, is discussed here separately from the various sub-basins into which the Columbia Basin logically divides itself because in scope it overruns their boundaries. Individual structures included in the general plan are discussed in greater detail in the sections of the report devoted to the separate sub-basins. This chain of dams ultimately would use 92 percent of the head of the Columbia River main stem in developing 8,520,000 kilowatts.

Of the 10 dams proposed, 1, at Rock Island, has already been constructed by private interests; 2 others, Grand Coulee and Bonneville, have been undertaken by the United States and their completion is recommended. The rest should be built as the need arises over a period, perhaps, of many years.

This work should be supplemented by channel and levee works for navigation and flood protection, irrigation developments, soil conservation, projects to provide water on the ranges for cattle, and measures to protect the fishing industry from interference by the dams and by pollution of the spawning areas. These matters are of general importance in development not only of the main stem of the Columbia River but also its extensive system of tributaries and the expanse they drain. They also receive attention in the sections on the individual sub-basins. Various lines of research should be undertaken at once by the proper agencies to fill out the details of the plan on sound engineering and economic bases, including an investigation to guide the orderly marketing of the power in conjunction with other power resources of the region.

General Description

The Columbia River system drains most of Washington and Oregon, nearly all of Idaho, a section of western Montana, small areas in Wyoming, Nevada, and Utah, and a headwater region in Canada. Its principal tributaries are the Snake and Willamette Rivers. The headwaters rise in the Rocky Mountains on the western slopes of the Continental Divide. By a series of detours to north and south the river flows through the Selkirk and Bitterroot Mountains, across the wide semiarid plateau of eastern Washington, down a series of rapids and through the Cascade Range to tidewater at Bonneville; then through the Coast Range and finally into the Pacific Ocean. In its journey through the United States the main stem of the Columbia River travels 750 miles, falls 1,300 feet. It is with this segment of the river that the plan for 10 dams deals.

The area of 259,000 square miles drained by the Columbia River system is a region of high mountain ranges running generally north and south, with wide valleys and plateaus between. In the tributary basins are rich agricultural lands and a diversity of natural resources.

The population is about 1,500,000, concentrated mostly in the lower section where the density is about 40 per square mile as compared with 8 for the rest of the basin. Less than 55 percent of the population lives in communities of 1,000 or more. The principal cities and their 1930 populations are Portland, Oreg., 302,000; Spokane, Wash., 115,000; Butte, Mont., 40,000; and Boise, Idaho, 21,000.

The average annual flow of the Columbia River at The Dalles is about 200,000 cubic feet per second; minimum flows occur during the winter with a normal low-water discharge of 50,000 cubic feet per second, and a maximum flood discharge of 1,170,000 cubic feet per second, in 1894.

Farming and grazing, lumbering, fishing, and mining are the principal occupations. General farming, dairying, and fruit raising are extensively practiced in the Willamette Valley. Large areas are suitable for irrigation. The Wenatchee, Yakima, Hood River, and White Salmon Valleys are famous for their fruit and berries. Farther east are the range lands and grain fields. Copper, lead, silver, and some gold are mined in the Butte-Anaconda and Coeur D'Alene districts. Timber is a major resource.

The climate is wet and mild near the coast, semiarid and arid in the inland plateaus. Still farther to the east, toward the Rockies, precipitation increases again.

The tidewater section of the river extends to Bonneville Dam and is navigable for ocean-going vessels as far as Vancouver, Wash. Portland and Astoria, Oreg., and Vancouver and Longview, Wash., are important seaports. Shallow-draft open river navigation is provided for in the Middle and Upper Columbia, lower Willamette and lower Snake, but is relatively little used.

Recommended Plan

The central problem of the Columbia River Basin is the orderly and progressive development of the river for irrigation, water power, and incidentally navigation. The plan based on a series of 10 dams on the main stream has been worked out by the Corps of Engineers as the logical solution. These projects will make possible the irrigation of an area greater than the States of Rhode Island and Delaware combined and add about one-tenth to the total irrigated land of the West; will make the river navigable for ocean-going vessels for nearly 200 miles, and for shallow-draft vessels much farther; and will provide electric generating capacity of over 7,500,000 kilowatts, about equal to the present total generating capacity in New York and Pennsylvania.

The dams should be built only as the growth of population, the need for irrigation of additional lands, and the market for power warrant them. Details of the plan should, however, be worked out shortly. Precise locations and exact heights of the dams should be decided upon so that conflicts with other developments may be avoided.

Power developments on the Columbia River or elsewhere in the basin should not be permitted to obtain priority of rights to low flow, thus precluding later upstream diversion for irrigation and domestic use. The right to divert water in the future for these two purposes without compensation to hydroelectric plants then existing should be protected by interstate compact or by proper provisions in all power permits issued.

The Grand Coulee Dam for irrigation and power will raise the level of the river 355 feet and will create a lake extending 150 miles to the Canadian border. The portion of the project under construction will serve as the foundation of the high dam, which should be completed. Plans for this project contemplate construction of facilities for irrigation of the first unit—possibly 150,000 acres—of the lands to be watered, so that this initial tract can be developed as soon as possible after completion of the high dam. Additional lands may be irrigated from time to time as new

settlers require them, and additional power capacity may be installed as fast as the market can absorb its output.

Bonneville Dam at the head of tidewater will form a pool 72 feet above sea level, submerging the Cascade rapids. The locks, 76 by 500 feet, will have the highest lift in the world. The initial power installation will be of 86,400 kilowatts capacity and the ultimate installation of 432,000 kilowatts. Output of power will be increased by the regulating effect of Grand Coulee Dam.

The project to dredge a 27-foot navigation channel from Vancouver to Bonneville is recommended, together with the extension of the Vancouver turning basin and the dredging of channels at Elokomin Slough, St. Helens, and Youngs River.

Above The Dalles, construction of a 7-foot open-river channel between the Celilo Canal and Umatilla Rapids has been planned by the Corps of Engineers and is recommended. This improvement will accommodate modern barge transportation for an additional 100 miles. Development of Grand Coulee and other irrigation projects may eventually justify further improvements up the river to Priest Rapids, the practicable head of navigation.

The Columbia is one of the more important fishery streams of the United States. It furnishes spawning grounds for fish which range along the North Pacific coast and furnish an annual product valued at approximately \$10,000,000. This important natural resource should be conserved. Any unavoidable losses should be replaced by artificial propagation through the period of development of the river for navigation, power, and irrigation use. The final effect of complete slack-water development of the Columbia River upon salmon and other migratory fish is not known. Elaborate works have been designed to permit them to pass Bonneville Dam to reach the spawning grounds in the tributaries beyond. Fish ladders and screens are needed also at a number of existing projects. The spawning grounds are also threatened by pollution from cities and industries. Contamination in the lower Willamette, if not corrected, may stop the salmon runs up the Columbia. The increase in the dry-weather flow of the Columbia resulting from the planned reservoirs will be an improvement, but the danger to fish life is immediate and studies leading to corrective measures are needed.

On the tidal section of the river below Bonneville, spring freshets and high tides combine to flood a large area of low rich land suitable for general farming and dairying. A group of projects to protect and reclaim such land is recommended. They are discussed in the section dealing with the Willamette and lower Columbia Rivers.

COLUMBIA GENERAL

SCALE OF MILES
10 0 10 20 30 40

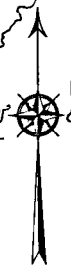
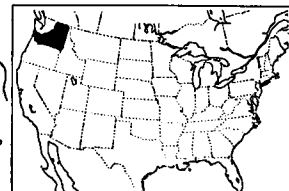
1938



LEGEND

- Cities ———— ●
- Existing Projects of Major Significance ————
- Dam and Reservoir:
P, Power; I, Irrigation; N, Navigation ———— P
- Levees ————
- Channel Improvement, Navigation ———— -N-
- Drainage Basin Boundary ————
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Forest Cover, Stream Flow, Silting,
Irrigation and Drainage
- Basin Wide Study, Pollution
- Basin Wide Study, Fish Spawning Areas
- Basin Wide Study, Reservoirs, Springs and Wells for Stock Watering

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY



Throughout the upper basin and the area drained by the Snake and other tributaries there is a scarcity of water holes for cattle, tending to cause overgrazing in the vicinity of the drinking places. Many small improvements to springs, dams, reservoirs, and wells should be constructed for stock watering over widely scattered areas to provide better grazing for large numbers of cattle. This subject is discussed more fully in the individual basin reports.

Interstate and international problems arise in connection with the development of the basin plan. The question of conflicting water rights for power and irrigation has been mentioned. Use of storage facilities

in upstream States for the benefit of downstream States is a problem which requires mutual understanding and agreement. The Columbia and several of its tributaries cross the Canadian line and cooperation between Canada and the United States would be mutually advantageous. The level of Kootenay Lake, in Canada, will substantially affect drainage districts in the United States. A dam, which has been proposed in Canada on Clark Fork, would back water into the United States at a level too high for proper utilization of the next higher site on one of the tributaries in the United States. Such matters illustrate the need for comprehensive planning for the region as a whole.

Columbia River Valley—General Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Stream pollution studies throughout basin.....	\$120,000	
	Irrigation and drainage surveys other than Columbia Basin projects.....	100,000	
	Oregon: Irrigability classification of project lands.....	50,000	
	Oregon: Municipal water supply investigation.....	16,000	
	Big Blackfoot Valley: Reconnaissance survey of water supply for irrigation.....	10,000	
	Camas Prairie: Reconnaissance survey of water supply for irrigation.....	50,000	
	Upper Flathead Basin: Reconnaissance survey of water supply for irrigation.....	30,000	
	Missoula Valley: Reconnaissance survey of water supply for irrigation.....	50,000	
	Bitterroot Valley: Reconnaissance survey of water supply for irrigation.....	20,000	
	Forest cover: Streamflow studies.....	475,000	
	Washington and Idaho: Silt load measurements.....	53,000	
	Washington: Preliminary surveys of likely demonstration areas for soil and water conservation.....	4,000	
	Survey of spawning areas throughout basin.....	50,000	
13	Bonneville Dam, Columbia River, Oregon and Washington: Navigation and power dam.....	5,650,000	Work in progress. Amount shown needed for completion of dam and initial appurtenances. Total cost is \$45,065,700.
2	Grand Coulee Dam, west of Spokane, Wash.: High dam irrigation storage reservoir and power plant.....	40,000,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$34,250,000. Total cost \$180,000,000. Construction will cover a period of years.
14	Columbia River, Oregon and Washington: Navigation channel from Celilo to Umatilla.....	287,000	Cost given is for next 2 years. Additional needed to complete, \$450,000. Surveys completed. Authorized by Congress.
7	St. Helens Channel: Dredge 30-foot channel, Columbia River to St. Helens.....	50,000	Surveys completed. Authorized by Congress.
10	Levee improvements, with drainage at some points to reclaim land subject to overflow of Columbia River or its backwaters from Bonneville to the sea at 4 districts near Portland; at districts 1, 3, 4, and Skamokawa, upper Gray and Day Rivers in Wahkiakum County; at Deer Island, Prescott, Westland, and Sauvie Island; and along Cowlitz, Longview, Wallcut, and Lewis Rivers in Washington and Oregon.....	5,521,000	Sum needed to complete. Sketch plans complete and detailed plans in preparation for some projects.
9	Yonnes Bay and River, Oreg.: Dredge 10-foot channel, Columbia River to Havens Island.....	5,000	Surveys completed.
	Idaho, Oregon, and Washington: Reservoirs, springs, and wells on the public range and national forest, for watering stock.....	222,000	Can be started at once. Needed to arrest decline of herds and spotted overgrazing.
GROUP B—FOR DEFERRED CONSTRUCTION			
12	Columbia River: Dredge 27-foot channel Vancouver to Bonneville.....	\$2,380,000	Surveys completed.
11	Vancouver, Wash.: Extension of lower turning basin.....	22,000	Do.
8	Elokomin Slough: Dredge 10-foot channel to Columbia River, for navigation.....	16,000	Do.

1. SNAKE RIVER

The procurement of supplemental water supplies for areas now under irrigation is by far the most important water problem in the Snake River Basin. The basin is largely semiarid, but irrigation projects have made agriculture its leading industry. About 90 percent of the agriculture of Idaho is within this basin. The problem second in importance in the basin is that of developing additional supplies of water for stock on the ranges of eastern Oregon and southwest Idaho.

Surveys by the Bureau of Reclamation disclose that supplemental water for irrigation can be provided by construction of storage reservoirs which will fit into any comprehensive plan for the use of the waters of the basin. These surveys should be extended so that plans may be made to expand, at the proper time, the irrigated areas. Potentially irrigable areas total 1,291,000 acres, of which 1,053,000 are in Idaho, and the remainder scattered in Oregon, Washington, and Nevada.

General Description

The Snake River rises in Yellowstone National Park and flows southward to the vicinity of Alpine, Wyo. There it turns west into Idaho, traversing the southern portion of the State. From the vicinity of Boise, Idaho, it flows north forming the boundary between Oregon and Idaho and also between Washington and Idaho. At Lewiston, Idaho, it turns west to join the Columbia River at Pasco, Wash. The Snake River is more than 1,000 miles long and drains 109,000 square miles.

In general, the Snake River flows in a narrow valley between the plains of the upper basin and the rolling uplands of the lower basin. Between Weiser, Idaho, and Asotin, Wash., it flows in a deep canyon. There are also deep canyons in the headwater reaches. Except in the upper and lower plains areas the tributaries generally flow in deep, narrow canyons, but in places these widen to form broad basins. The Salmon River basin has a great surplus of water but very little potentially irrigable land.

Altitudes of the upper plains range from about 2,000 feet at Weiser to more than 5,000 feet in eastern and northeastern Idaho, while in the lower plains they range from a few hundred feet at Pasco to about 2,500 feet in the prairies of the Palouse and Clearwater River Basins. Mountains of more than 10,000 feet are found in the headwaters of the Clearwater, in the Salmon and Sawtooth Mountains of central Idaho, and in the ranges of western Wyoming. These ranges are forested.

The agricultural areas receive little precipitation. In the upper plains the annual rainfall ranges from less than 10 to about 15 inches, varying principally with altitude. In the lower plains region the range is from less than 10 inches near the mouth of the river to about 25 inches in the higher valleys near Colfax, Moscow, and Grangeville, Idaho. In the mountains precipitation reaches 50 inches or more.

The heavy winter snows in the mountains melt and run off rapidly with the advent of summer. Unless this water is stored, most of it cannot be used. The agriculture of the area is dependent, however, on irrigation by water obtained largely from melting snow. At present, due to insufficient storage, many areas experience water shortages late in nearly all irrigation seasons.

In the high areas of the basin, winters are cold and summers short and cool, but the lower Snake River has a growing season from 140 to 167 days long.

Because of the topography and the existence of permeable lava and sedimentary deposits, underground water is plentiful in many parts of the upper basin. Several thousand cubic feet per second of water from underground sources reach the river below Twin Falls.

Sagebrush covers the upper plains, but grasslands appear in high valleys. There are only scattered areas of forests in the southern part of the basin, but the northern and extreme eastern portions are heavily forested. The lowest plains are grasslands except for the arid lower stretch where sagebrush predominates.

The population of this basin is about 475,000, less than 5 persons per square mile. There has been no increase since 1920. The population is 65 percent rural. Boise, with 21,500, and Pocatello, with 16,900, are the only cities with more than 10,000 population. The irrigated districts surrounding Idaho Falls, Twin Falls, and Boise, are relatively densely settled.

Agriculture, based almost exclusively on irrigation, leads by a wide margin all other industries in the Snake River Basin. The principal crops are potatoes, sugar-beets, alfalfa, wheat, beans, and peas. Much of the area of the basin is suited to stock raising. Lumbering is an important industry in the extreme northern portion of the basin. Mining commands considerable attention in central Idaho and eastern Oregon. There are large undeveloped deposits of phosphates near the eastern edge of the basin.

Yellowstone National Park is the most famous recreational area in the basin, but there are many scenic areas, some of them at present undeveloped.

Recommended Plan

Procurement of supplemental water supplies for existing *irrigation* projects, as previously noted, is the water problem of greatest importance in this area.

In the upper Snake River Basin, extending roughly from the headwaters to Bliss, Idaho, water shortages occurred in 11 of the past 40 years. In 1924, 1931, and 1934 these shortages were severe. This area has 1,200,000 acres of irrigated land, and within its boundaries are the Idaho Falls, Twin Falls, Rupert, and Jerome districts, well populated and intensively farmed.

To provide the water needed here, diversion of flood water from Yellowstone Lake into the headwaters of the Snake River for storage has been proposed. Proponents state that 350,000 to 500,000 acre-feet could be thus obtained without in any way detracting from the scenic and recreational values of Yellowstone Lake. A proposal made by the Bureau of Reclamation is that diversions of water in winter be stopped and other diversions be curtailed, partly by retirement of land from irrigation in areas not tributary to the stream. Storage of the water thus conserved would eliminate shortages like many of those that have occurred, and would greatly reduce even the most severe shortages which may be expected. Other plans have been suggested, and should receive consideration in future studies.

The eastern Oregon area tributary to Snake River suffers from shortages of water both for livestock and irrigation. Except for the irrigation projects in the valleys of streams, this area is largely devoted to stock raising. The forage resources have been depleted through a combination of overgrazing and drought. Because of failure of numerous small water supplies, grazing has been concentrated around those remaining, thus intensifying the problems of those localities. This situation can be eased by developing springs, constructing small reservoirs, and drilling wells.

The Owyhee project, now nearing completion, will provide supplemental water for 45,000 acres and will irrigate 65,000 acres of new lands.

Waterpower.—The Snake River Basin has 2,250,000 kilowatts of undeveloped waterpower. No market exists at the present time for any considerable fraction of this total. However, in the future, large blocks of power probably will be used in pumping water for irrigation, especially along the main river between Milner Dam and Weiser, Idaho.

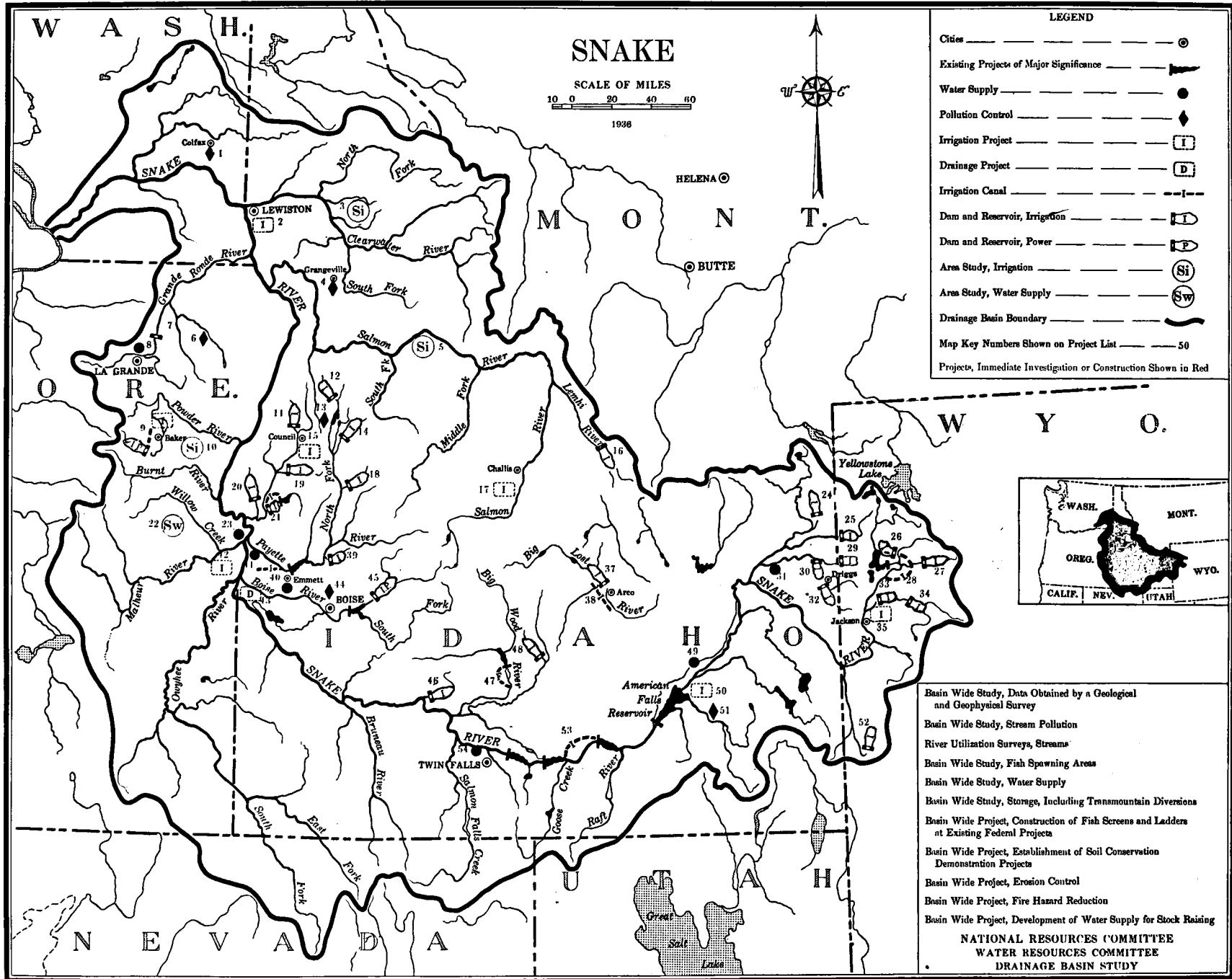
Sewage disposal.—Virtually all municipalities of the area deliver untreated sewage to streams. In some places the dilution factor is great enough to prevent the creation of nuisances, but some streams are badly polluted. The problem is localized, however, and no general remedial program has been proposed. A growing popular demand for sewage treatment in the region is noted.

Recreation and wildlife.—A score or more of national forests blanket the mountainous sections of this area. They have become great recreational centers, and undoubtedly will be frequented by much larger numbers of vacationists in future years. Wyoming, central Idaho, and northern Idaho are sections of special importance in this regard. Elk and deer are present in great numbers; moose, mountain sheep, mountain goats, antelope, bear, beaver, fox, martin, mink, ermine, and badgers are plentiful. The streams are well stocked with trout. Some of these wild tracts should be kept as primitive areas. Others should be made more accessible to the public, and developed to a greater extent for recreational purposes. Future development of streams within national forests for recreational and wildlife purposes should be carefully planned in order that it will not interfere with the provision of supplemental water supplies for irrigation projects.

Fisheries.—Investigations are needed to determine the conditions and needs with respect to the conservation of the valuable fishery resources of the Snake and its major tributaries. The construction of auxiliary works, such as fish screens and ladders, at a number of dams and structures also is needed. The Salmon, Clearwater, and other tributaries of the Snake River are important spawning regions affecting the commercial catch of salmon in the lower Columbia River. This general problem is discussed in the section on the "Columbia River—General Plan."

Soil erosion is serious both on the overgrazed foothills and on the hilly farm lands. On the rolling Palouse area, water and wind are eroding valuable grain lands. Demonstration work has been undertaken in that area. Several important grazing areas such as the Owyhee Valley and uplands are likewise affected.

Floods are serious in only two areas in the Snake Basin; a small area near Boise along the Boise River, and about 100 square miles of agricultural land on the upper Snake River north of Idaho Falls. In the former only a limited amount of bank protection is warranted, and the Corps of Engineers is studying the other problem.



SNAKE PROJECT LIST

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Snake River Basin: Study of the data obtained by a geological and geophysical survey.....	\$185,000	Plans completed by U. S. Geological Survey.
	Snake River Basin: Study of stream pollution.....	59,000	
3	Snake River Basin: River utilization surveys of the streams.....	15,000	
5	Clearwater River Basin in Idaho: Study and surveys to determine irrigation possibilities.....	30,000	
10	Salmon River and tributaries in Idaho: Study and surveys to determine irrigation possibilities.....	50,000	Necessary for construction projects under group B.
22	Snake River Basin in Oregon: Study of classification of project lands for irrigation.....	15,000	
10	Snake River Basin in Oregon: Study of municipal water supply investigations.....	4,000	
	Snake River Basin in Oregon: Study and surveys of irrigation and drainage conditions.....	100,000	
	Snake River Basin: Study of survey of spawning areas.....	11,000	U. S. Bureau Fisheries.
42	Study of water supply and storage including trans-mountain diversions.....	300,000	Continuation of present studies.
	Malheur County, Oreg.: Owyhee irrigation project.....	800,000	Under construction. Cost given is for next 2 years. Additional needed to complete main canals and laterals, \$300,000.
24	Ashton, Idaho: Squirrel Meadows storage reservoir for irrigation in Idaho.....	200,000	
40	Emmett, Idaho: Diversion canal for Black Canyon irrigation district.....	2,500,000	Under construction. Cost given is for next 2 years. Additional needed to complete, \$1,300,000.
54	Twin Falls, Idaho: Storage for water supply.....	144,000	Sketch plans completed.
52	Lincoln County, Wyo.: Star Valley Reservoir for supplemental storage for irrigation.....	57,000	Plans completed.
30-32	Driggs, Teton County, Idaho: Storage on Teton River for irrigation.....	1,050,000	Investigation completed.
49	Snake River Basin, Idaho: Development of supplemental water supply by well drilling for stock raising in Taylor grazing districts.....	113,000	General plans completed.
	Snake River Basin, Idaho, Oregon, and Washington: Development of water supply for stock raising.....	258,000	Do.
19	Indian Valley, Welsler River drainage, Idaho: Reservoir for irrigation.....	128,000	Sketch plans completed.
37	Aroo, Idaho: Diversion dam on Big Lost River.....	55,000	Do.
50	Fort Hall, Idaho: Indian reservation irrigation project.....	150,000	Preliminary plans in progress. Cost given is for first 2 years. Additional needed to complete, \$235,000.
17	Custer County, Salmon River drainage, Idaho: Challis irrigation canal improvements.....	44,000	Survey not completed.
44	Boise, Idaho: Sewage treatment plant.....	273,000	Sketch plans completed.
4	Grangeville, Idaho: Sewage treatment plant.....	11,000	Preliminary plans completed.
1	Colfax, Wash.: Sewage treatment plant.....	97,000	Plans completed.
41	New Plymouth, Idaho: Water supply system.....	49,000	Do.
13	McCall, Idaho: Sewer system.....	32,000	Sketch plans completed.
6	Lostine, Oreg.: Sewage treatment plant.....	11,000	Preliminary plans completed.
35	Jackson, Wyo.: Irrigation system for Elk refuge.....	49,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
16	Leadore, Salmon River drainage, Idaho: Texas Creek, dam for irrigation.....	\$189,000	Sketch plans completed.
47	Lincoln County, Idaho: Bypass canal on Big Wood River.....	39,000	No plans.
38	Butte County, Idaho: Bypass irrigation canal on Big Lost River.....	96,000	
48	Picabo, Idaho: Irrigation storage reservoir on Silver Creek.....	\$206,000	Sketch plans completed.
43	Caldwell, Idaho: Drainage system in drainage district no. 6.....	131,000	Do.
2	Lewiston, Idaho: Replacements to existing irrigation system.....	160,000	Detail plans in preparation.
53	Rupert, Idaho: Diversion canal to the salmon tract.....	61,000	Preliminary plans completed.
14	Roseberry, Idaho: Additional irrigation storage in Boulder Lake Reservoir.....	24,000	Do.
7	Elgin, Oreg.: Diversion dam.....	18,000	Do.
8	LeGrande, Oreg.: Improvement to water supply system.....	194,000	Do.
31	Teton, Idaho: Replacements to existing water supply system.....	48,000	Sketch plans completed.
23	Ontario, Oreg.: Improvements to water supply system.....	94,000	Preliminary plans completed.
34	Teton County, Wyo.: Upper Slide Lake Reservoir for Teton irrigation project.....	10,000	Do.
46	Gooding County, Idaho: Irrigation storage reservoir on Clover Creek.....	66,000	Do.
12	Valley County, Idaho: Irrigation storage in Upper Fayette Lake.....	186,000	Do.
11	Council, Idaho: Lost Valley Dam and storage reservoir.....	20,000	Do.
9	Baker, Oreg.: Storage reservoir on Powder River for irrigation and power.....	\$3,665,000	Preliminary surveys completed.
20	Washington County, Idaho: Irrigation storage reservoir on Upper Manns Creek.....	101,000	Do.
39	Boise County, Idaho: Jerusalem Valley Dam and reservoir on Porter Creek, for irrigation.....	35,000	Do.
18	Valley County, Idaho: Clear Creek Dam and storage reservoir, for irrigation.....	25,000	Do.
21	Washington County, Idaho: Dam and irrigation canal on Lower Manns Creek.....	100,000	Do.
	Idaho, Washington, Oregon, and Wyoming: Fish screens and ladders for Snake River Basin at Federal projects for protection of fish life.....	355,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
45	Boise and Elmore Counties, Idaho: Twin Springs Dam and Reservoir on Boise River for irrigation and power development.....	\$7,050,000	
28	Teton County, Wyo.: Irrigation reservoir and earth dam at Emma Matilda Lake.....	58,000	
27	Teton County, Wyo.: Storage reservoir on Buffalo Creek for supplemental irrigation.....	257,000	
23	Teton County, Wyo.: Irrigation project east side of Snake River, upper part of Jackson Hole.....	1,400,000	
33	Teton County, Wyo.: Lower Slide Lake storage reservoir for Teton Irrigation Project.....	13,000	
40	Emmett, Idaho: Replace water mains.....	38,000	Plans completed.
15	Mesa, Idaho: Reconstruction of irrigation system.....	53,000	Sketch plans completed.
25	Teton County, Wyo.: Lake of the Woods irrigation and storage reservoir.....	10,000	Plans not completed.
29	Teton County, Wyo.: Irrigation and storage reservoir in Teton Canyon.....	59,000	
51	Pocatello, Idaho: Storm sewers.....	38,000	
	Idaho, Oregon, and Washington: Establishment of soil conservation demonstration projects at appropriate places in the Snake River Basin.....	2,620,000	
	Idaho, Nevada, and Wyoming: Erosion control—Snake River Basin.....	1,982,000	Forest Service. Plans not completed.
	Idaho, Oregon, Washington, and Wyoming: Fire hazard reduction in the entire basin.....	300,000	Do.

2. UPPER COLUMBIA

The upper Columbia Basin affords abundant water in excess of that which can be used for irrigation of available lands. Hydroelectric power may be produced in quantities vastly greater than present needs within the basin. The irrigation and power resources must be developed concurrently if growth within the basin is to be sound.

The Grand Coulee Dam, principal unit of the Columbia Basin Federal reclamation project, is under construction, but the present contract will complete only the foundation and lower portion of the high dam which is proposed. Unless the high dam is constructed on this foundation, the project will remain unproductive of either irrigation water or hydroelectric power. The most important single project in the basin is the completion of this high dam, the installation of the initial generators, and the construction of the first irrigation unit of the Columbia Basin project. While this project eventually will provide water for irrigation of 1,200,000 acres, several decades will pass before the full acreage will be cultivated. Already there is an economic demand for some of this new agricultural land.

The Columbia River is both interstate and international. Cooperative planning will become more and more a necessity in this region.

The Columbia Basin irrigation project and the growth of other irrigation districts may justify additional improvements for navigation to Priest Rapids.

Description of Basin

The upper Columbia Basin includes all that vast region tributary to the Columbia River above its junction with the Snake River. In the United States 64,000 square miles are included, and in Canada 39,000 square miles. Only that section south of the Canadian border is treated here. It lies in three States; Montana, Idaho, and Washington. It is bounded on the east by the Continental Divide, on the south by the Snake River Basin, and on the west by the crest of the Cascade Mountains.

Much of the region is mountainous, with fertile river valleys and lake basins interspersed. However, the area lying within the great bend of the Columbia River in southeastern Washington is a broad, almost treeless plain ranging in altitude from 500 to 2,000 feet. This area is semiarid, but contains much land adaptable to irrigation and some suitable for dry farming.

The rivers entering the Columbia from the west originate in the Cascade Mountains, which have altitudes of from 5,000 to 10,000 feet and which have many snowfields, glaciers, and lakes. The valley lands of these rivers have a moderate climate and many are well suited to agriculture under irrigation.

The Okanogan highlands, about 5,000 feet above the sea, form a link between the eastern spurs of the Cascade range and the Selkirk range of northern Idaho, where peaks rise to 6,000 or 7,500 feet between the valleys of the Clark Fork and the Kootenai Rivers. These two streams, together with the Spokane and its tributaries, form the main drainage of the well-timbered "panhandle" of Idaho. This area includes a series of large and beautiful lakes, of which the more important are Pend d'Oreille and Priest Lakes in the Clark Fork system and Coeur d'Alene Lake from which the Spokane River flows. These lakes are important factors in river regulation.

The Cascade Range acts as a barrier to cut off moisture borne by the prevailing westerly winds from the Pacific. Whereas the annual precipitation along the summit of the Cascades is roughly from 80 to 120 inches, it is only 6 to 10 inches along the Columbia River. The average at the Washington-Idaho line is 20 inches and that at the summit of the Coeur d'Alene Mountains about 60 inches. Beyond these mountains it drops to 20 inches along the Clark Fork in Montana, but rises again to 40 inches or more toward the summits of the Rockies. In contrast to the seasonal cycle of precipitation on the Pacific slope, the area east of the Cascades shows a more nearly equal division of rainfall among the four seasons.

In the valleys the mean temperature is about 53°, with a range from 10° below to 100° above zero. The growing season is from 115 to 270 days long. At higher altitudes temperatures are lower and the growing season has a length of from 135 to 180 days.

The underground water resources in this basin are little known and largely unsurveyed. There is an exception in the vicinity of Spokane, which obtains its municipal supply from wells.

The population of the basin in 1930 was 596,000, half rural. The density is only about 9 persons per square mile. Spokane, with a population of 115,000, is the chief city of the region. Other cities exceeding 10,000 population are Butte, 39,500; Yakima, 22,100; Missoula, 14,650; Anaconda, 12,500; and Wenatchee, 11,600.

The principal industries of the region are lumbering, mainly coniferous species; agriculture, fruit and

nuts, wheat and other cereals, peas, hay and forage, dairy products, and garden vegetables; mining, with two very large metal-producing districts, Butte-Anaconda and Coeur d'Alene, producing silver; lead, copper, zinc, manganese, and some gold; and some manufacturing, chiefly connected with forest products.

Recommended Plan

The Corps of Engineers has recommended, as noted in the section on "Columbia River—General Plan", the construction of a chain of 10 dams on the Columbia River. One of these dams, the Rock Island Dam, has been constructed in this basin by private interests, and another, Grand Coulee Dam, now is being constructed with Federal funds. In all, 6 of the 10 sites lie in the upper Columbia Basin. Efficient marketing of the power output of these projects, when completed, will make possible development of a large part of the 2,300,000 acres of irrigable land in the upper Columbia Basin.

The Columbia Basin reclamation and power project ultimately will provide for the irrigation of about 1,200,000 acres of land. The ultimate power installation may amount to 2,000,000 installed kilowatts. Grand Coulee Dam will impound about 9,500,000 acre-feet of water in a reservoir stretching 150 miles to the Canadian border. The reservoir will be an important factor in river regulation, substantially increasing the output of power at times of low stream flow at all downstream power plants and incidentally improving navigation conditions at low water. Its value in checking major floods will be negligible. The proposed high dam, which will contain some 10 million cubic yards of concrete, will be 4,100 feet long and will raise the water about 355 feet above the low-water surface of the river.

Construction of Grand Coulee Dam was begun late in 1933, coincidentally with that of the Bonneville navigation and power dam east of Portland as the first steps in the realization of the comprehensive plan for the development of the Columbia River. Speedy authorization of construction of the high dam would result in a substantial saving in construction costs.

Plans to irrigate the lands of this project involve raising the water 360 feet from the dam to a storage lake, to be formed in the great dry glacial gorge known as the Grand Coulee. Water will be distributed from the lake through canals and ditches by gravity, with additional pumping at some points on a few canals. Immediately desirable in preparation for the full and efficient development of this project is a series of studies covering land classification, costs, methods of distribution of water and power, and power markets, especially those of the seaboard industrial districts. Policies for marketing power should be defined soon so that contracts may be made for the sale of all firm power not required for pumping water for the irrigation project.

The feasibility of using Grand Coulee power for pumping purposes at other irrigation projects at a distance should be investigated.

Irrigation.—There are about 800,000 acres under irrigation in the basin at present, and 2,300,000 acres additional are irrigable. The Yakima project is the largest, with a present development of about 306,000 acres and a potential development of about 300,000 additional acres. This project is close to the lands of the Columbia Basin project. The Yakima irrigation project supports a population of 110,000 and produces new wealth in crops, livestock, and dependent industries estimated by the Washington State Planning Council at \$50,000,000 annually.

Other important irrigated areas are in the Wenatchee, Okanogan, and Spokane districts in Washington; and on the Clark Fork system, including the Bitterroot, Flathead, and Kootenai Rivers in Idaho and Montana. Substantial additions may be made to the irrigated lands of all these districts, as well as to those of the Spokane valley in Idaho and the Clark Fork in Washington.

The Roza unit of the Yakima project, now under construction, and the Flathead Indian project should be completed. Other primary needs are for the improvement of the supplies of several Montana irrigation districts.

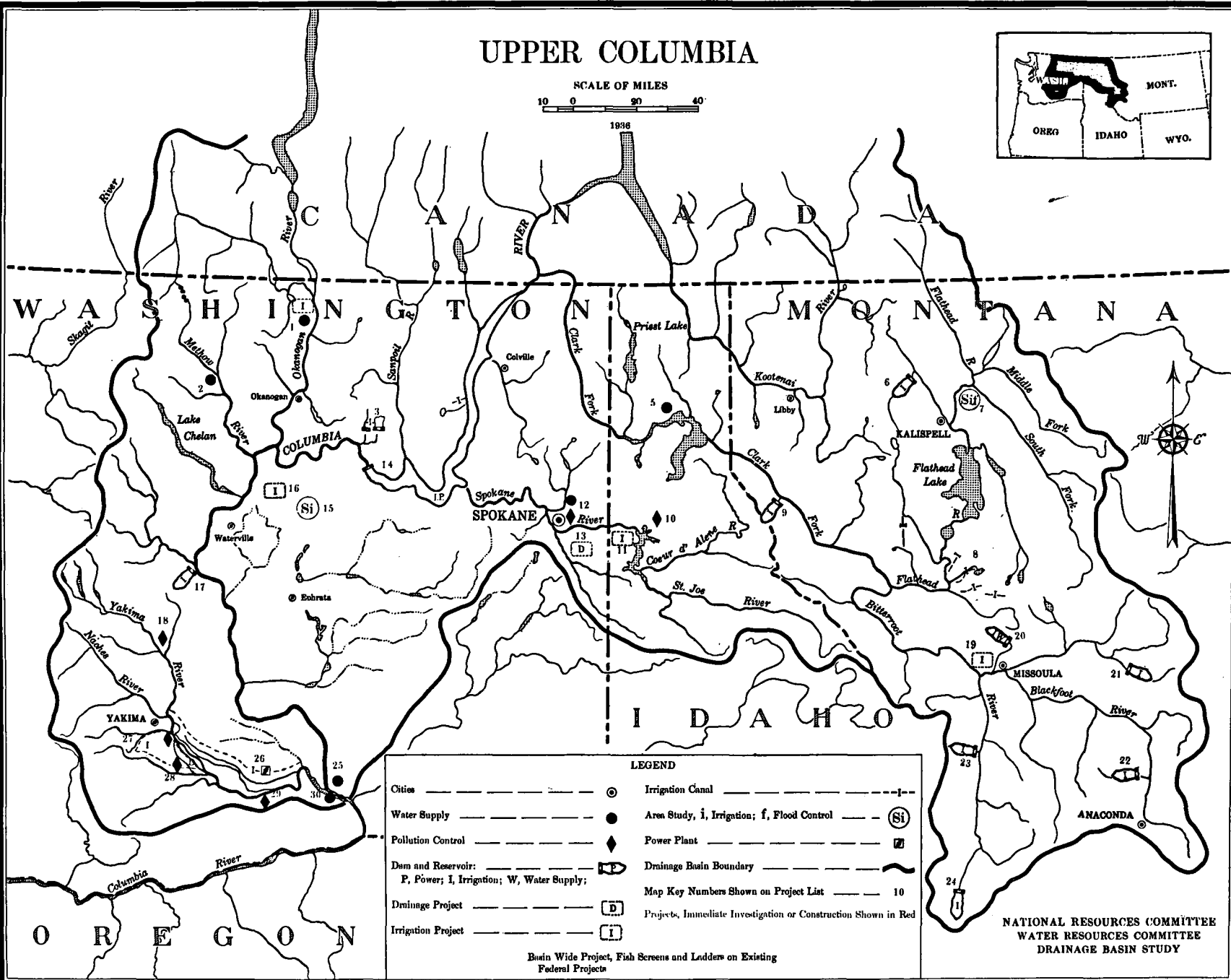
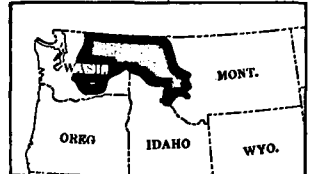
Stock water improvements are needed to promote conservation and economic utilization of public lands in the national forests and on the public domain. Dams, reservoirs, wells, and improvements of springs, all small works, are needed. Such watering places at frequent intervals will provide better general grazing for larger numbers of stock.

Power, as previously pointed out, is one of the outstanding features of this drainage. The developed capacity in kilowatts is about 630,000 and the potential is about 3,900,000, an amount far beyond the needs of the basin itself for decades to come. This, together with the pending development of a firm power capacity of more than a million kilowatts at Grand Coulee Dam, emphasizes the necessity of a thorough investigation of the prospective uses and markets for this power; of interconnection, transmission, and distribution; and of reciprocal power and other relationships with the larger markets on the seaboard.

There is no general *flood control* problem in the Upper Columbia Basin. A series of local problems of varying degrees of importance exists on the Spokane, Flathead, Kootenai and Yakima Rivers. The Hungry Horse Reservoir, if constructed, would help in relieving flood conditions in the Kalispell district on the Flathead River.

UPPER COLUMBIA

SCALE OF MILES
10 0 20 40



LEGEND

Cities	○	Irrigation Canal	---
Water Supply	●	Area Study, I, Irrigation; f, Flood Control	(Si)
Pollution Control	◆	Power Plant	■
Dam and Reservoir:	Ⓟ	Drainage Basin Boundary	---
P, Power; I, Irrigation; W, Water Supply;		Map Key Numbers Shown on Project List	10
Drainage Project	(D)	Projects, Immediate Investigation or Construction Shown in Red	
Irrigation Project	(I)		

Basin Wide Project, Fish Screens and Ladders on Existing Federal Projects

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Important needs are protection works on the Spokane River and tributaries, now under study by the Corps of Engineers.

Pollution of waters is not a widespread problem in this region. However, in the Yakima Valley, sewage and other types of pollution are distributed by irrigation waters, endangering local and farm supplies and causing in this area the highest typhoid rate in the State of Washington.

The Spokane River receives wastes from a number of communities in the Coeur d'Alene mining district through Lake Coeur d'Alene, and from Spokane. At flood stages pollution from the Spokane River contaminates some of the Spokane water supply, which is obtained from wells in the river valley.

There is also an appreciable amount of pollution in the Wenatchee River. There are severe local problems due to the discharge of mining wastes of the Coeur d'Alene and Butte districts into the Coeur d'Alene and Silver Bow Rivers, respectively. These affect fisheries more than public health.

Fish screens and ladders are needed at a number of existing irrigation and power diversion works. A

comprehensive investigation should be made of fishery conditions in various parts of the river system, with a view to determining relative values, relationships to other projects and improvements, and the best means of conserving fish life.

Recreational use of many of the waters and adjoining land areas of this region is growing in importance. Outstanding recreational areas are included in the mountains and forests on the east side of the Cascades and in the mountains, lakes, and streams of western Montana and the Idaho "Panhandle." In some of the more remote and thinly populated parts of the area, as in the North Cascades, the Kootenai Valley in Montana, and parts of northern Idaho, recreational values have a relatively high economic importance. In some instances, the recreational use of the water may well be considered as superior to any conflicting uses. Priest Lake has been cited by the Idaho State Planning Board as an example of a water resource in this category. The natural objection of local interests and of upstream States to the use of such lakes for the benefit of downstream lands is a problem growing more acute.

Upper Columbia Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
15	Columbia Basin project, Washington: Classification of irrigable lands for best use of water available from Grand Coulee Dam.	\$500,000	Sum is amount needed to complete. Work will cover a period of years.
7	Flathead County, Mont.: Investigation of Hungry Horse Reservoir project.....	150,000	
26	Rosa project, near Yakima, Wash.: Irrigation canal and power plant.....	11,500,000	Sum needed to complete. Total cost \$15,000,000.
8	Flathead irrigation project, Lake Sanders, Missoula, Mont.: Complete Indian Reservation irrigation project, pumping, storage, and drainage.	1,000,000	Detail plans in preparation. Cost given is for first 2 years. Additional needed to complete, \$1,096,000.
22	Race Track Creek, Powell County, Mont.: Irrigation dam and reservoir for supplemental water...	254,000	
21	Nevada Creek, Powell County, Mont.: Irrigation dam and reservoir for supplemental water.....	248,000	
24	West Fork of Bitterroot River, Ravalli County, Mont.: Irrigation dam and reservoir for supplemental water.	450,000	
27	Wapato, Wash.: Complete irrigation project.....	350,000	Preliminary plans made. Cost given is for first 2 years. Additional needed to complete, \$750,000.
4	Inchelium, Wash.: Diversion dam for storage in Twin Lakes to irrigate Indian lands.....	35,000	Under construction.
3	Nespelem River, Nespelem, Wash.: Complete diversion and dam for irrigation storage in Owhi Lake.	24,000	Sum needed to complete. Total cost \$216,000.
17	Wheeler Dam, near Wenatchee, Wash.: Raise dam to increase irrigation storage.....	21,000	Plans completed.
12	Spokane, Wash.: Additions to sewer system and sewage treatment plant.....	909,000	Do.
27	Wapato, Wash.: Sewage treatment plant.....	22,000	Do.
10	Coeur d'Alene, Idaho: Improve existing sewer system.....	69,000	Do.
1	Whitestone, Wash.: Water system, including repairs to irrigation system.....	37,000	Do.
12	Spokane, Wash.: Install 1,800 horsepower pumping plant for city supply.....	330,000	Do.
30	Kennewick, Wash.: Improvements and extensions to water system.....	31,000	Do.
2	Twisp, Wash.: Water system.....	36,000	Do.
	Fish screens and ladders on existing Federal irrigation projects throughout basin.....	345,000	
13	Latah Creek, near Spokane, Wash.: Drainage improvements to prevent stagnant pools.....	81,000	Do.
28	Yakima near Toppenish, Wash.: Improvements to drainage system.....	87,000	Do.
14	Grand Coulee Dam, West of Spokane, Wash.: High dam for irrigation storage reservoir and power plant.	See remarks.	Estimated cost shown in Columbia River—General project list.
GROUP B—FOR DEFERRED CONSTRUCTION			
20	Rattlesnake Creek near Missoula, Mont.: Irrigation storage dams and city water supply.....	\$22,000	
9	Swamp Creek, Sanders County, Mont.: Irrigation storage dam for supplemental water.....	60,000	
23	Kootenai Creek project, Ravalli County, Mont.: Irrigation storage dams.....	36,000	
6	Talley Lake project, Flathead County, Mont.: Irrigation dam, canal and tunnel.....	600,000	
11	Post Falls, Idaho: Improvement to irrigation system, pumps, and canals.....	100,000	Sketch plans complete.
18	Ellensburg, Wash.: Sewage treatment plant.....	80,000	
28	Toppenish, Wash.: Sewage treatment plant.....	30,000	
29	Prosser, Wash.: Sewage treatment plant.....	20,000	
25	Pasco, Wash.: Water purification plant.....	40,000	
30	Kennewick, Wash.: Water purification plant.....	30,000	
5	Sandpoint, Idaho: Improvements to city water system.....	88,000	Do.
16	Columbia Basin project: Irrigation works.....	1,000,000	Construction may require 50 years. Cost given is for first 2 years. Additional needed to complete, \$196,000,000.
GROUP C—TIME FOR CONSTRUCTION INDETERMINATE			
19	De Smet, Missoula County, Mont.: Pumping plant to raise supplemental irrigation water.....	\$204,000	

3. MIDDLE COLUMBIA

The most important project of the middle Columbia Basin is Bonneville Dam and related improvements to navigation combined with the development of large quantities of hydroelectric power.

Bonneville Dam is under construction at the head of tidewater 146 miles upstream from the mouth of the Columbia River. When this dam and channel improvements in the lower Columbia are completed, The Dalles, more than 40 miles farther upstream, would become a port for sea-going ships. Above The Dalles, channel improvements planned by the Corps of Engineers, including a 7-foot open river improvement between the present Celilo Canal and the Umatilla Rapids, will provide barge transportation for an additional 100 miles. This will afford a water outlet to tidewater and the markets of the world for the crops and industrial products of part of the inland empire east of the Cascades.

The production of large quantities of hydroelectric power should help to foster the growth of industries in the region. Steps should be taken, however, to preserve the beauty of the Columbia Gorge. The early availability of large quantities of power presents a marketing problem which should be speedily worked out.

The Bonneville Dam is the unit farthest downstream in the comprehensive plan of development of the Columbia River over the 750 miles from the Canadian boundary to the sea. Four of ten dams proposed in this plan are in the middle basin.

Another important problem is that of providing stock watering facilities on the range lands east of the Cascades. By construction of a large number of small earth dams, reservoirs, and wells, and by the development of springs, the range can be made to support greater numbers of stock and at the same time can be protected from spotted overgrazing and soil erosion in the vicinity of the existing watering places.

Most of the agriculture of the basin is dependent upon irrigation, and extensive areas of new irrigated lands will probably develop in the future concurrently with industrial growth. No major irrigation projects are proposed for immediate construction. On the Deschutes and Crooked Rivers, irrigation projects totaling nearly 75,000 acres are proposed for deferred construction.

Problems of flood control and sanitation are largely local.

General Description

The middle Columbia Basin includes all of the Columbia River Basin lying between the Cascade divide on the west and the Blue Mountains divide on the east, from the south rim of the Yakima and Snake River drainages on the north to the Great Basin divide at the headwaters of the Deschutes River on the south. It has a double frontage for about 180 miles along the Columbia from Bonneville Dam on the west to the mouth of the Snake River on the east. The basin contains 29,700 square miles, four-fifths of which is in Oregon.

With the exception of the slopes of the Blue and Cascade Mountains, the entire basin is within the great Columbia basaltic plain. Plateaus 3,000 to 4,000 feet above the sea, west of the John Day River in Oregon, descend gradually to the rim of the Columbia River gorge. Many deep canyons cut the plateaus, but a number of the streams cascade into the Columbia River. Mount Adams, 12,307 feet high, is the highest point in the basin.

Forests cover the slopes and spurs of the Cascade and Blue Mountains, accounting for 44 percent of the vegetal cover in the basin. Standing timber, chiefly ponderosa and lodgepole pine, amounts to more than 44 billion board feet. Sagebrush covers most of the plateaus, although grasslands are found in the rolling country northwest of the Blue Mountains. In this area wheat is produced by dry-farming. Much of the basin is arid or semiarid, and future expansion of agriculture is possible only through increased irrigation in the fertile valleys of the tributary rivers, as well as along the Columbia. Some of the irrigation projects in this basin, such as that on the Walla Walla River, had their beginnings more than 100 years ago. Some 214,000 acres are now irrigated in the basin out of an estimated total irrigable area of 816,000 acres. Over most of the tillable lands of the region the soil is light, open, well drained, and fertile, without alkali, although it is shallow in places.

The climate of the middle Columbia region is dry, with extremes of heat and cold. Cloudy or foggy weather is rare. The precipitation reaches 100 inches on the Cascade divide, but on the east side of this divide the rainfall rapidly fades out to some 10 inches. As little as 6 inches is obtained at Hanford on the banks of the Columbia. On the Blue Mountain divide, as much as 50 inches is received. The major part of

the area, however, has a precipitation of 10 inches or less, almost all of it falling in winter and spring.

There is little information regarding the extent or quality of underground waters which would be valuable for stock watering and for domestic use on irrigation projects both present and future.

The population of the basin in 1930 was 127,400, three-fifths rural. Walla Walla, Wash., with a population of 16,000, is the largest city in the basin. Bend, with 8,850, is the largest Oregon city in the basin, and Pendleton, 6,600, The Dalles, 5,900, and Dayton, 2,500 are the only remaining towns above 2,000 population.

None of the streams of the basin is navigable except the Columbia.

The chief products of the region are grains, fruits, berries, forage, and root crops. Much of the area is good grazing land, producing wool and livestock, with some dairy products. Lumbering is also important, centering around Bend. There is a considerable fishing industry along the Columbia. Many of the smaller streams should be preserved for sport fishing. A few mining districts lie in the higher country drained by the John Day and Deschutes Rivers.

Recommended Plan

The principal problem in the middle Columbia Basin is the orderly development of navigation and of power projects at certain sites in the basin which have been selected as units in the comprehensive long-range plan for the fullest utilization of the water resources of the Columbia River from the Canadian boundary to tide-water. This plan is discussed in the section "Columbia River—General Plan."

First priority in power development should be given to the completion of the Bonneville plant. Transmission lines will be needed to carry the energy to major load centers as well as connections with existing distributing systems to the west and east. Studies and plans looking toward the completion of the power plant to economic capacity and toward the development of uses and markets to permit such expansion without costly delay are also considered urgent. This basin possesses potential water power in excess of its needs.

Irrigation.—In the Pacific Northwest there is need for new agricultural land, resulting from migrations of settlers into this region in recent years. Although many projects and additions have been under consideration for a number of years, only a few projects in the middle Columbia Basin could qualify for immediate construction. An exception is a small amount of work at the Warm Springs Indian Reservation. Two projects within the Deschutes watershed have been investigated recently by the Bureau of Reclamation. Each of these projects was found to involve rather high costs per acre. They may very likely become feasible

in the future, and have accordingly been listed for deferred construction. They are the Wikiup Reservoir for the north unit of the Deschutes project, and the Crooked River project, involving the construction of a reservoir on Ochoco Creek to irrigate 22,800 acres in the vicinity of Prineville. The north unit project contemplates irrigation of 50,000 acres near Madras in a large, open, and more or less rolling upland plateau. Dry-farming, indifferently successful because of unreliable precipitation, has been practiced here. More studies are needed in the Deschutes Basin.

Stock water projects are needed in this basin, where much of the land is not adaptable to cropping on either an irrigated or dry-farming basis. Overgrazing has occurred near available watering places, while large areas, now without stock water facilities, remain almost unused. Construction of a large number of small reservoirs and wells and the development of springs will relieve this situation and enable a larger number of cattle and sheep to graze without overtaxing the ranges.

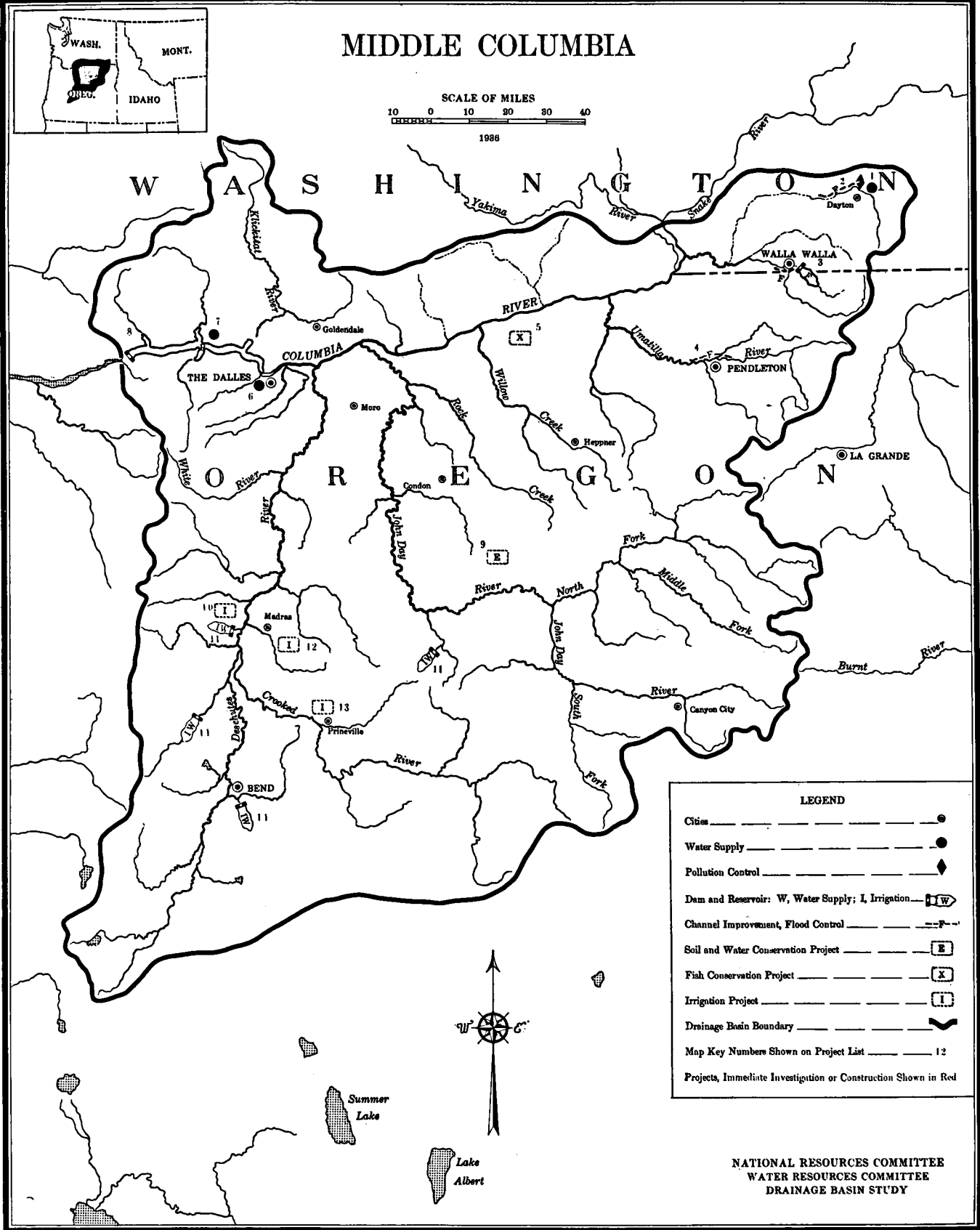
Stock water and small irrigation reservoirs proposed at specific points near Bend, Sisters, and Mitchell, Oreg., should be constructed soon.

There is no general *flood-control* problem on the tributaries in this basin, and none on the main stem of the Columbia that cannot be handled by diking and drainage. There are, however, serious local problems on some of the streams, particularly where there are intensively developed agricultural areas. Control projects have been proposed for several such areas, including Walla Walla and Dayton, Wash., and Pendleton, Oreg.

Water supply and pollution problems in this basin are local in character. Several municipal projects are recommended for early construction, including a water system for White Salmon, Wash., and a water system and sewers for Dayton, Wash. Early consideration should be given also to the project for the improvement of water supply for The Dalles, in anticipation of accelerated industrial and population growth.

Fisheries.—Construction of fish screens and ladders at various irrigation and power diversions is immediately desirable. General investigations of streams, their spawning areas, obstructions, and conflicting water uses, are recommended.

There are a number of scenic and *recreational areas* of present or potential importance in this drainage, including the Columbia Gorge zone, mountain, lake, and stream areas east of the Cascade summits, and parts of the Blue Mountains. Conservation of the gorge values should be given consideration in connection with power, and transportation developments resulting from the Bonneville project.



MIDDLE COLUMBIA

SCALE OF MILES
 10 0 10 20 30 40
 1986

LEGEND

- Cities ———— ●
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir: W, Water Supply; I, Irrigation — [W]
- Channel Improvement, Flood Control ———— F —
- Soil and Water Conservation Project ———— [E]
- Fish Conservation Project ———— [X]
- Irrigation Project ———— [I]
- Drainage Basin Boundary ———— V
- Map Key Numbers Shown on Project List ———— 12
- Projects, Immediate Investigation or Construction Shown in Red

NATIONAL RESOURCES COMMITTEE
 WATER RESOURCES COMMITTEE
 DRAINAGE BASIN STUDY

Middle Columbia Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
11	Warm Springs Indian Reservation near Mitchell, Wheeler County; and near Bend and near Sisters, Deschutes County, Oreg.: Irrigation and stock watering dams.	\$78,000	Survey completed only for Warm Springs Indian Reservation.
4	Pendleton, Oreg.: Flood channel improvements in Umatilla River.....	200,000	Detail plans in preparation.
1	Dayton, Wash.: Sewer system and sewage-treatment plant.....	50,000	Plans completed.
1	Dayton, Wash.: Improvements to water system.....	35,000	
7	White Salmon, Wash.: Reconstruct water system.....	90,000	Do.
8	Bonneville Dam, Columbia River, Oregon and Washington: Navigation and power dam.....	(1)	Estimated cost shown in Columbia River Valley—general project list.
GROUP B—FOR DEFERRED CONSTRUCTION			
3	Mill Creek near Walla Walla, Wash.: Flood control works, including storage and flood-channel improvements.	\$1,794,000	Detail plans completed.
2	Touchet River near Dayton, Wash.: Channel improvements.....	22,000	Plans completed.
10	Warm Springs Indian Reservation, Oreg.: Addition to irrigation works.....	50,000	Surveys completed. Cost given is for first 2 years. Additional needed to complete, \$215,000.
13	Prineville, Oreg.: Improvements to existing Ochoco Irrigation system.....	85,000	Surveys completed.
12	Madras, Oreg.: Canal and dam for irrigation of Deschutes north district.....	3,000,000	Surveys completed. Cost given is for first 2 years. Additional needed to complete, \$5,000,000.
6	The Dalles, Oreg.: City water system.....	551,000	Preliminary plans completed.
5	Oregon and Washington: Construct fish ladders and screens at dams and irrigation ditches to prevent destruction of fish life, at Federal projects on tributaries in Middle Columbia Basin.	125,000	Estimate is approximate. Survey needed to supply accurate information as to location and cost.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
9	Oregon: Establish demonstration and control projects—soil and water conservation.....	\$740,000	

¹ See remarks.

4. LOWER COLUMBIA—WILLAMETTE

The Willamette River affords excellent opportunities for comprehensive planning in the use of water resources and is now being studied by the Corps of Engineers. In general the plan will encompass regulating reservoirs on the tributaries, some channel straightening, and levee work, to reduce the danger from floods, to provide irrigation for highly productive lands, and to increase the low flow of the stream. Navigation will be improved, the degree of pollution decreased, and power production increased. Pollution abatement calls also for sewage-treatment plants at Portland and other places upriver.

Navigation dredging in the Columbia River channel is discussed in connection with the general problems of the river. Studies are recommended to lay the ground work for future action in abating further stream pollution and protecting important fish-spawning areas. Drainage of the lowlands, and supplemental irrigation of the better farmlands to offset the dry summers, should be undertaken. A few water-supply improvements are locally needed.

General Description

The Columbia River breaks through the snow-peaked Cascade Range at the deep Columbia Gorge, a place of extraordinary beauty and grandeur. West of the Cascades, the river and its tributaries drain an area of 17,500 square miles, one-third in Washington and two-thirds in Oregon. Most of the Oregon portion lies in the wide valley of the Willamette River, flowing northward into the Columbia between the Cascades and the Coast Range. The principal tributaries north of the Columbia are the much smaller Lewis and Cowlitz Rivers. Between the Gorge and the ocean the Columbia flows through a flood plain with a number of large islands, subject to overflow. About two-thirds of the area is covered with forests of Douglas fir, cedar, spruce, and hemlock; more than one-quarter, in the Willamette Valley, is fertile farm land capable of intensive production. Diking projects on the flood plain of the lower Columbia have reclaimed a comparatively small area of rich bottom land. Additional works for this purpose are recommended.

The population of the basin in 1930 was 721,000, an increase of 50 percent in the last two decades. Nearly 61 percent lives in communities of more than 1,000. The population density is about 41 per square mile. Cities of more than 10,000 population are Portland (301,800), Salem (26,300), Eugene (18,900), and As-

toria (10,350) in Oregon; Vancouver (15,800) and Longview (10,650) in Washington. All except Salem and Eugene are on tidewater.

Tidewater extends throughout this section of the Columbia River and up the Willamette River to Willamette Falls above Portland, where locks permit shallow-draft navigation as far as Salem. Both the Columbia and the Willamette have been extensively improved and provide good fresh water harbors.

The chief industries of the area are based upon forest and farm resources—lumber, pulp and paper, furniture, dairy and poultry products, vegetables, berries, and fruit. Meat and textiles are other important products. Excellent transportation and terminal facilities are already available, including deep-water navigation to the heart of the area at Portland. Not counting the Bonneville project, which is just beyond the eastern border of the area, about 150,000 kilowatts of installed water power have been developed and the streams afford 10 times as much potential power.

The climate is mild and, except for July and August, wet. Rainfall is 40 to 50 inches in the valley, twice as much in the mountains. Snowfall is heavy in the mountains, especially in the Cascades, but infrequent in the valleys which have only occasional frosty weather. The normal temperature range is from 32° to 80° and the growing season is long.

Recommended Plan

The comprehensive plan for this basin is closely related to the plan described in the section of the report on general problems of the Columbia River. The Oregon State Planning Board, guided by studies made by the Corps of Engineers, has tentatively stated a plan to fit into the larger scheme and to realize effectively the possibilities of the Willamette Valley. This plan involves primarily the construction of storage reservoirs in the foothills to impound the flood run-off, increase summer flows for navigation and for dilution of wastes, provide for supplemental irrigation of productive lands, and develop power as needed. Construction recommendations also include levees, bank-protection work, channel and lock improvements, and sewage-treatment plants.

Seven reservoirs are tentatively proposed for the initial development, located on tributaries of the Willamette River above Salem. They will control the run-off from 30 percent of the 11,000-square-mile Willamette

Drainage basin which contributes more than half of the flood discharge. The total storage proposed is 1,300,000 acre-feet. Such construction is recommended, but is necessarily classified as indeterminate pending the completion of the detailed investigation now under way.

Flood damage is severe on the lowlands above Salem, particularly between Albany and Eugene, and also along the Long Tom River. It is estimated that the seven initial reservoirs will serve to reduce the flood discharge at Albany one-half and the flood height 9 feet for the expected 25-year flood; at the highest flood stage expected to occur on an average once in 25 years, only a small fraction of the usual area would be flooded.

Serious flood damages have been experienced also along the lower Columbia River and its tributaries, particularly the Cowlitz and Lewis Rivers, and protective measures have been authorized. Of immediate need are projects for bank-protection work, cleaning of flood channels, and construction or improvement of levees and drainage works.

Water power.—Three of the seven initial reservoirs of the comprehensive plan, on Middle Fork, McKenzie, and North Santiam Rivers, could be later developed for power by increasing their height. The total firm power would be a quarter of a million kilowatts. Regulation of the river by the proposed reservoirs would increase the minimum power available from the present installation at Oregon City from 7,630 to 19,000 kilowatts.

For the present, Bonneville Dam will supply the power requirements of the region. A transmission line is needed to bring this power from the dam to the Portland-Vancouver industrial area 40 miles away. The Federal Power Commission has been directed by Executive order to make a study of rates for the wholesale marketing of output at Bonneville. An investigation is also recommended of power markets and resources in the entire Pacific Northwest.

Irrigation needs will be served by six of the seven reservoirs under the initial plan, which will provide water for 325,000 to 370,000 acres. Supplemental irrigation will permit a considerable increase in production on the better lands of the valley, where summer rainfall is now deficient.

Drainage.—Surveys indicate that some three-quarter million acres of valley lands need drainage. Drainage projects fostered by the Agricultural Experiment Station at Corvallis have increased crop values on 20,000 acres two and one-half times, from \$10 per acre to \$25 per acre.

Stream pollution by industrial wastes and domestic sewage is a serious problem on the lower Willamette River. Increased flow from the seven reservoirs will somewhat alleviate this condition, but collection and treatment of the Portland sewage and industrial waste is needed at once. Likewise of immediate urgency are a number of sewage-treatment plants above Portland. The threat to the existence of the fisheries industry from the pulp and paper wastes requires immediate attention.

Water supply needs are well served at present. Three projects are listed for later action. Intelligent planning will reserve certain areas for future metropolitan supplies, now obtainable at low cost. The admirable supply of the city of Portland, cold, clean, soft, and safe, is an example of wise long-range planning to be followed by cities in other parts of the country.

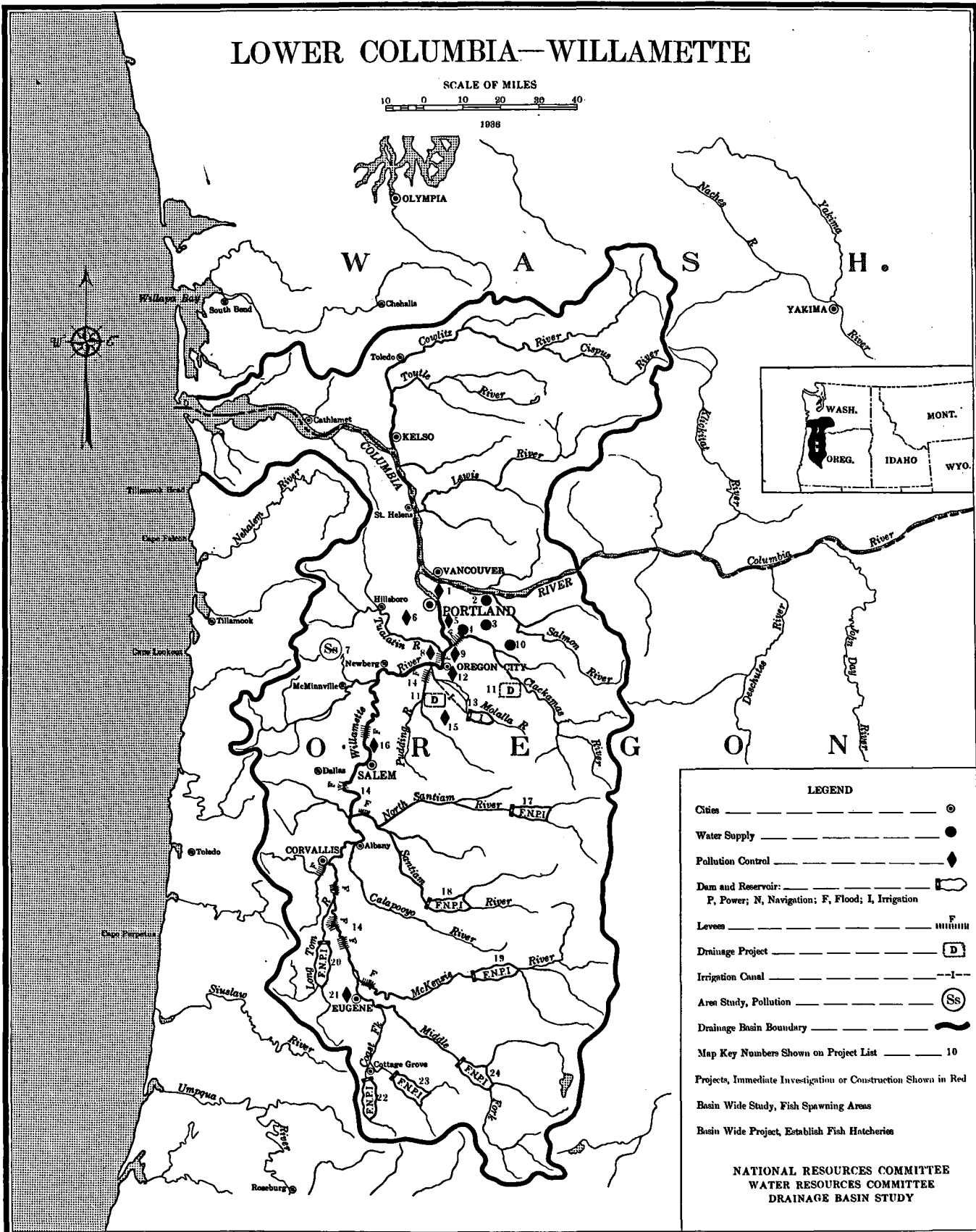
Recreational assets of the region include the Columbia Gorge, the long pool above Bonneville Dam, Mount Hood, and other features of national importance which should be conserved during the period of development. Recreational needs will increase with the growth of urban population, and provisions for meeting such needs should have careful consideration in water-utilization plans.

LOWER COLUMBIA—WILLAMETTE

SCALE OF MILES



1986



LEGEND

- Cities ———— ○
- Water Supply ———— ●
- Pollution Control ———— ◆
- Dam and Reservoir: ———— []
- P, Power; N, Navigation; F, Flood; I, Irrigation
- Levees ———— F
- |||||
- Drainage Project ———— [D]
- Irrigation Canal ———— -I-
- Area Study, Pollution ———— (SS)
- Drainage Basin Boundary ———— []
- Map Key Numbers Shown on Project List ———— 10
- Projects, Immediate Investigation or Construction Shown in Red
- Basin Wide Study, Fish Spawning Areas
- Basin Wide Project, Establish Fish Hatcheries

NATIONAL RESOURCES COMMITTEE
WATER RESOURCES COMMITTEE
DRAINAGE BASIN STUDY

Lower Columbia-Willamette Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
7	Stream pollution study.....	\$50,000	
	Fishery survey of spawning areas.....	17,000	
14	Willamette River Basin: Bank protection and clearing flood channels on Willamette River and tributaries.....	2,430,000	Detailed plans in preparation. Authorized by Congress.
1	Portland, Oreg.: Sewage treatment plants and interceptor sewers to improve Willamette River.....	9,575,600	Preliminary plans only.
16	Salem, Oreg.: Intercepting sewer and primary sewage-treatment plant.....	360,000	Preliminary plans completed.
12	Oregon City, Oreg.: Intercepting sewer and sewage-treatment plant.....	106,000	Preliminary plans made.
6	Beaverton, Oreg.: Outfall sewer and sewage-treatment plant.....	79,000	Do.
(1)	Milwaukie (5), Mollala (15), Oregon City (12), and West Linn (9), Oreg: Sewer system extensions and sewage-treatment plants.....	430,000	
9	Gladstone, Oreg.: Intercepting sewer and sewage-treatment plant.....	35,000	Do.
<p>1 Map key number shown following community name.</p> <p style="text-align: center;">GROUP B—FOR DEFERRED CONSTRUCTION</p>			
2	Maplewood water district, Multnomah County, Oreg.: Reconstruction of water system.....	\$22,000	Preliminary plans completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
(*)	Willamette Basin: 7 reservoirs for flood control, navigation, power, and irrigation on following streams: Coast Fork (22), Row (23), Middle Fork (24), Long Tom (20), McKenzie (19), and North (17) and South Santiam (18).	\$55,000,000	Comprehensive coordinated plan for Willamette River now under study by Corps of Engineers. Estimate is approximate only.
13	Canby, Oreg.: Small reservoirs, canals, ditches, and pumping plant for supplemental irrigation for Canby irrigation district.....	200,000	Plans incomplete.
21	Eugene, Oreg.: Sewage-treatment plant to improve Willamette River.....	156,000	Preliminary plans made.
(1)	Oak Grove (3), Jennings Lodge (4), and City of Sandy (10), Oreg.: Extensions to waterworks systems.	68,000	Preliminary plans prepared.
11	Clackamas County, Oreg.: Drainage for land reclamation, Clackamas and Liberal drainage districts. Establish fish hatcheries.....	64,000	Do.
		700,000	

1 Map key number shown following community name.
 * Map key number shown following stream name.

5. PUGET SOUND

Flood control presents an outstanding water problem in the Puget Sound area. Pollution of important waters by sewage from several large communities is becoming serious and should be corrected. Navigation facilities, naturally excellent, should be further improved in detail to serve the heavy waterborne traffic. In addition to the hydrologic, soil erosion, and forest-cover studies recommended on a national scale, special investigations of several types are needed in this area to guide future action in conserving its rich water resources. The region contains important sources of hydroelectric power, already partially developed; their further exploitation by public and private agencies should be correlated in harmony with other power resources of the Northwest, including the Federal projects now under construction on the Columbia, to obtain the greatest total regional and national benefit from all of these potentialities.

General Description

The region comprises all of the territory surrounding and draining into Puget Sound south of the Canadian border. On the east are the high and rugged mountains of the Cascade Range with many glaciers and snow fields and two prominent snow-clad peaks: Mount Rainier (altitude 14,408 feet) and Mount Baker (10,750 feet). Between the precipitous slope of the Cascades and the tidewater of Puget Sound there is a rolling plain roughly 25 miles wide. On the west is the low peninsula separating Puget Sound from the long deep fiord known as Hood's Canal. On the south is the low range of hills separating the basins of the Nisqually River, in this area, and the Chehalis River in the Washington Pacific region.

The population in 1930 was 860,000, an increase of 16 percent since 1920 and 48 percent since 1910. About 70 percent is urban. The density is 77 per square mile, the highest in the Pacific Northwest. There are six cities of more than 10,000 population, all fronting on tidewater: Seattle (365,600), Tacoma (106,800), Bellingham (30,800), Everett (30,600), Olympia (11,700), and Bremerton (10,200).

In spite of the northern latitude the climate is mild. Temperatures above 80° in summer and below 32° in winter are infrequent in the settled parts of the area. The growing season in the lowlands is about 300 days. Average annual precipitation ranges from 30 inches on some of the islands to 50 inches along

the shore, 60 or 75 inches at altitudes of 1,000 feet, 140 inches at 5,500 feet, and perhaps 200 inches in the high mountains.

Underground water is available throughout most of the area and furnishes the domestic supply for about one-fourth of the population. Surface supplies are also abundant.

Most of the 700,000 acres of agricultural and pasture lands are already in use. Included are large areas of rich lowlands, producing vegetables, seeds, bulbs, berries, and small fruits. Poultry and dairy products are important. The soil, mainly of glacial origin, is generally good; it is light and open, with good drainage, except in some of the peat lands of the reclaimed marshes, but is easily eroded. Some additional agricultural land might be reclaimed by drainage. In certain places supplemental irrigation would be of benefit.

Industrially the Puget Sound region is the most active in the Northwest with products based mainly on the great resources of timber, lumber, pulp, and paper; furniture and other forest products are represented in the output. Processing or packing of food products, fish, grain, wool, and minerals are also important. A significant and comparatively recent development is the growth of a considerable electrochemical industry utilizing the available low-cost electric energy and water supply and the excellent water transportation facilities. Failure to anticipate a continued increase in industrial activity in the area would be unwise.

Navigation is well served by the great natural deep-water channels of Puget Sound, reaching all of the principal cities. The area is an important point of shipment to and from the Orient and has been the gateway to Alaska since Klondike days.

The industrial and general needs of the Puget Sound region provide the largest power market of the Pacific Northwest. The cities of Seattle and Tacoma have had municipal electric systems for many years, supplied by extensive publicly owned power installations. Privately owned utilities have also been active. Power rates are and have been low, and power consumption per capita is the highest in the United States.

Recreational opportunities on land and water are extensive, diversified, and accessible, with forest and mountain sports and salt-water bathing separated by only a few hours' drive.

Recommended Plan

Flood control in the low-lying lands and populated areas near the mouths of the rivers on the Sound is an immediate problem. The glacier-fed streams from the high Cascades, rapid and rough in their mountain gorges, flatten out abruptly as they reach the valley uplands at an altitude of about 1,000 feet and descend more gradually to tidewater across the intervening plain. Warm winds and heavy rains—chinooks—melting deep snow on the higher slopes, bring sudden freshets; slowed up by the level plains, the streams deposit silt, boulders, and debris, blocking their channels and causing overflows, erosion, and the seeking of new channels.

Flood-control works have been confined mainly to the tidal sections where dikes and bank revetments have been constructed to protect agricultural lands. Many of these have proved inadequate; but few favorable sites for flood-storage reservoirs have been found.

The Flood Control Act of 1936 authorizes surveys for flood and erosion control on the principal streams. Several construction projects were also authorized and are recommended for construction, including a reservoir at Mud Mountain to lessen floods on the White and Puyallup Rivers, a cut-off channel to divert the Skagit in flood into Padilla Bay for protection of rich lands in the Skagit delta, and channel improvements in the Puyallup River to protect a part of the city of Tacoma. Other control works are recommended on the Skagit, Sauk, Stilaguamish, and Black Rivers and on Hatt Slough.

The city of Seattle has begun a storage project for power purposes at Ruby Dam, on the Skagit above its power stations, which ultimately will reduce flood peaks on the lower river about 20 percent with a storage capacity of 3,000,000 acre-feet. The initial project toward which \$3,000,000 of Federal funds have been allotted will not sufficiently control the river. An extensive reservoir project for flood control and power on the Sauk River is listed for future consideration.

Water-power development presents an important problem in correlating future construction in this area

with other great power potentialities in the Pacific Northwest to operate all plants and market their output in an orderly manner without avoidable waste or conflict. A wise solution of this problem will affect not only the utilization of power resources in the several basins, but also the growth and general development of the inland areas upon which the commerce and industry of Puget Sound depend for a considerable share of their present and future prosperity.

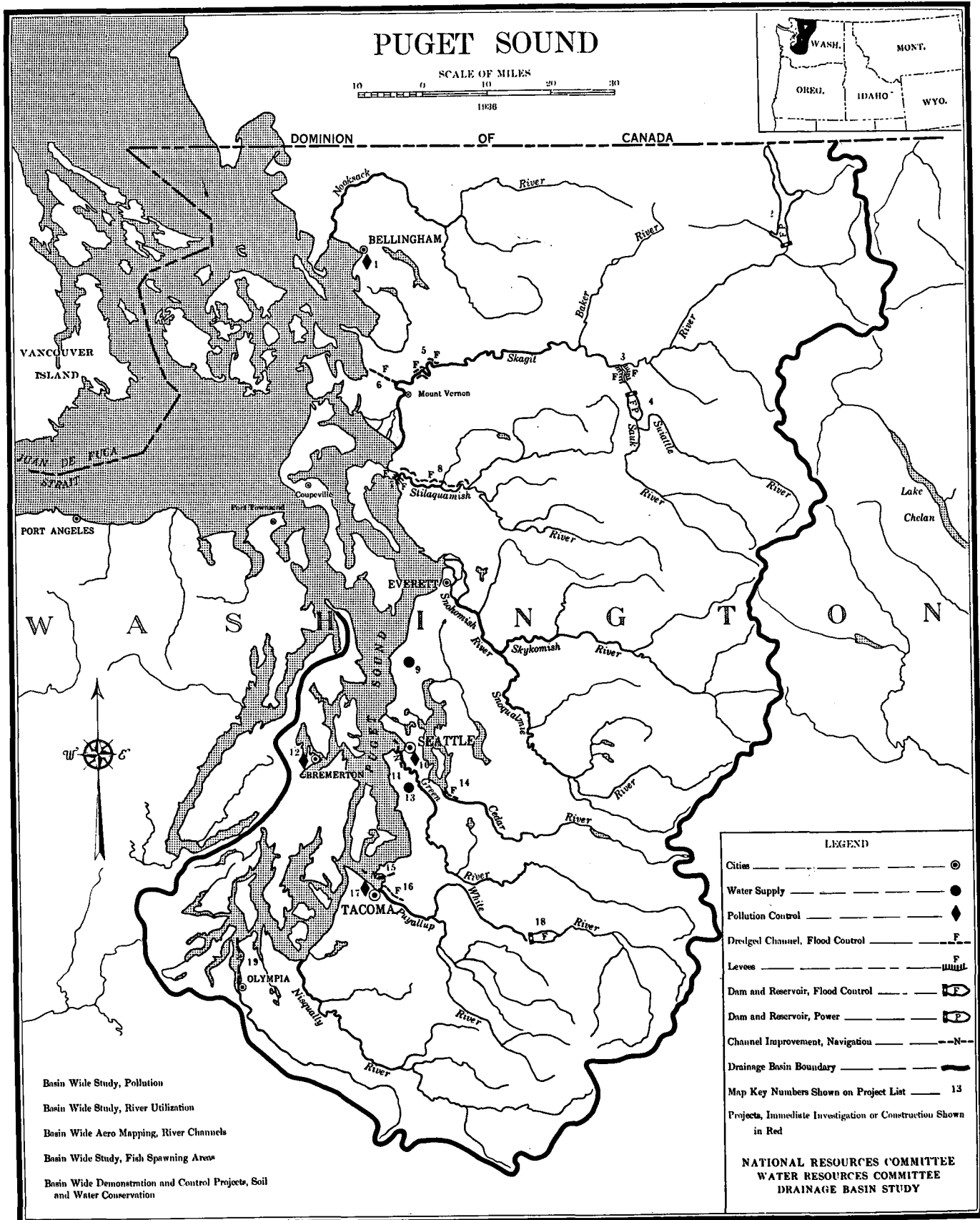
A study of these matters should form a part of the recommended investigation of the engineering and economic aspects of power production and consumption in the Pacific Northwest, with a view to determining a feasible program for construction and operation of new power facilities coordinate with navigation, irrigation, and flood-control improvements.

Pollution by sewage and industrial wastes at several places endangers public health, threatens valuable oyster and fishing activities, and interferes with recreation. Sewerage projects are recommended at Seattle, Tacoma, Bellingham, and Bremerton.

Water supplies are generally adequate in quality and quantity. Underground waters are used by some cities, including Tacoma, and are free from the silt or "glacial flour" found in many surface streams. A water-supply project near Everett is listed for future construction and a minor improvement in King County for immediate action.

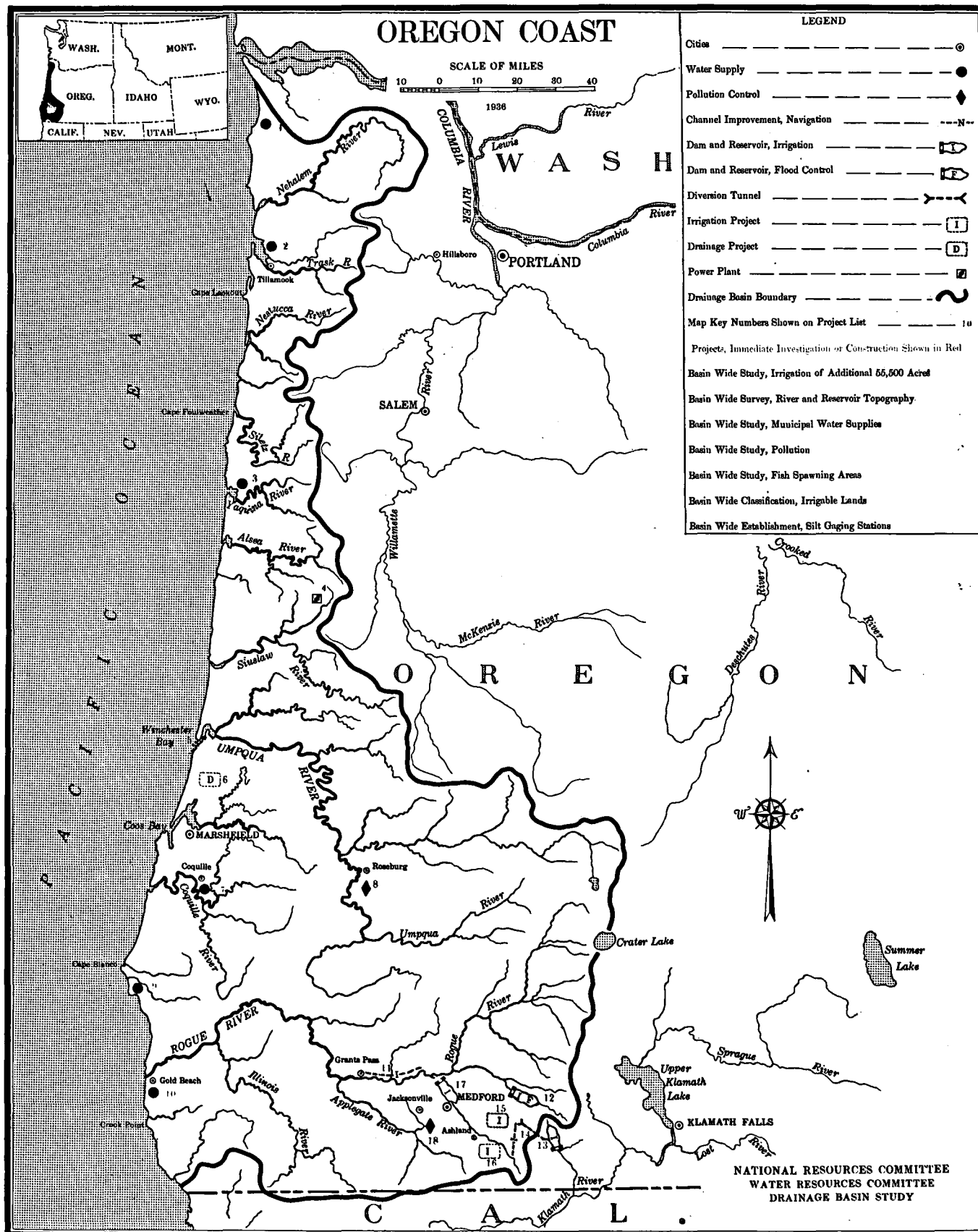
Navigation facilities in the many excellent deep-water harbors and along the Sound are already well provided, but should be improved by several minor projects at Seattle, Tacoma, and Olympia.

Investigations of stream pollution, river utilization, and fish-spawning areas are recommended, together with needed mapping of certain rivers and their drainage areas, which can best be done from the air, to provide the basis for wise future development. These studies are in addition to the hydrologic, mapping, and soil-erosion investigations recommended to be made on a national scale.



Puget Sound Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Stream pollution study: Public health and protection to fish life.....	\$120,000	
	River utilization surveys: Rivers, reservoirs, and dam sites topography.....	43,000	
	Aero mapping of river channels, and their drainage areas.....	30,000	
	Fisheries survey of spawning areas: Protection and propagation of fish.....	50,000	
18	Mud Mountain Reservoir on White River: For flood control of White and Puyallup Rivers.....	3,205,000	Detailed plans in preparation. Includes estimated cost of land.
16	Tacoma, Wash.: Channel improvement of Puyallup River.....	1,555,000	Do.
6	Skagit River: Cut-off channel.....	4,788,000	Do.
17	Tacoma, Wash.: Trunk sewers and sewage-treatment plant.....	631,000	Do.
10	Seattle, Wash.: Henderson St. sewer and West Oregon St. sewage-treatment plant.....	500,000	Do.
12	Bremerton, Wash.: Extension of sewer system.....	174,000	Do.
1	Bellingham, Wash.: New outfall sewer and sewer system additions.....	103,000	Do.
8	Stillaguamish River channel for flood and erosion control.....	261,000	Detailed plans in preparation.
13	King County water district no. 49: Domestic waterworks system.....	126,000	Plans completed.
15	Tacoma Harbor, Hylebos waterway: Dredging turning basin and channel.....	112,000	Surveys completed.
19	Olympia Harbor: Widen entrance channel.....	98,000	Do.
11	Seattle Harbor: Settling basin for flood relief and navigation.....	10,000	Do.
GROUP B—FOR DEFERRED CONSTRUCTION			
5	Skagit County drainage district no. 17: Flood control and drainage.....	\$107,000	Plans completed.
3	Sauk River Channel: Revetments.....	53,000	Do.
7	Hatt Slough: Reconstruction and repair of dikes.....	26,000	Do.
14	Black River: Channel improvement.....	23,000	
9	Alderwood Manor, Wash.: Extension of water-distribution system.....	102,000	Plans completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Soil and water conservation: Demonstration and control projects at 25 sites.....	\$580,000	
4	Sauk River: Reservoir for flood control and power.....	14,612,000	Preliminary plans made.
2	Ruby Dam project, Skagit River in Washington: Enlargement of project now under construction for flood control and power.....	25,532,000	Estimated sum necessary to complete ultimate development.



6. OREGON COAST

Problems of water use are local rather than regional in this group of comparatively small independent drainage basins. Basic data are needed to permit intelligent planning for future needs. Several local and general investigations are recommended to obtain such data and to determine appropriate action.

Works for local water supply and other requirements are listed for construction immediately in a few places and later in others where the need is not yet urgent or plans cannot yet be made.

General Description

The area comprises the drainage basins of all the streams discharging into the Pacific Ocean along the Oregon coast southward from the mouth of the Columbia. Two of the rivers—the Rogue and the Umpqua—cut through the Coast Range, rising in the Cascades and flowing through large intermountain valleys. The others rise in the Coast Range and flow more or less directly to the ocean. Of these the more important are the Nehalem, Tillamook, Coos, and Coquille Rivers. The total area is 16,900 square miles.

The region is mountainous except for the two inland valleys and narrow strips along the coast. Nearly nine-tenths is forest covered; the standing timber is the chief industrial resource of the area and is estimated at 177 billion board feet. Lumbering is the chief manufacturing industry. Fishing is of major importance. Agricultural and pasture lands are about 9 percent of the total; rich irrigated areas in the inland valleys produce fruits, berries, and other crops. Dairying is important along the coast.

Several of the harbors have been improved for navigation, which is limited to the short tidal sections of the rivers.

The total population is 176,000, a density of 10.4 per square mile. Towns of over 1,000 population contain only 40 percent of the total; Medford (11,000) is the largest. The population increased 32 percent from 1920 to 1930.

The climate is mild and humid on the coast, drier in the interior. Average annual rainfall ranges from 16 inches in the inland country to 96 inches in the coast mountains. Extremes of 90° and zero are seldom reached. The growing season is from 250 to 300 days.

The potential hydroelectric power of the streams is estimated at 833,000 kilowatts available 90 percent of the time, but this is mostly in sites of small capacity remote at present from large markets. A capacity of about 46,000 kilowatts has been developed on the upper Rogue.

Recommended Plan

Navigation facilities in the harbors have been generally well improved for present traffic by jetty construction and by dredging through ocean bars. The south jetty at the mouth of the Umpqua at Reedsport should be extended.

Stream pollution is not as yet a serious problem because of the many streams and the scattered population. The relation of pollution to water supply and to spawning grounds for fish should be studied. Roseburg, on the Rogue, needs a collecting sewer and a treatment plant.

Water supplies are generally abundant and of good quality. Underground water resources are extensive and economically available throughout the area. Surface waters are also abundant and are used by almost all of the 72 towns. New or improved water systems in several places are listed for future construction.

Irrigation can be extended to additional lands on the Rogue and Umpqua Rivers. A study to classify the irrigable lands is recommended.

Erosion has affected some of the soils. Silt gaging stations, to determine quantities of soil actually eroded, are recommended.

Reclamation of rich marsh lands along the tidal waters should be studied to determine the feasibility of diking and drainage.

Oregon Coast Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Surveys to determine best means of irrigating 55,500 acres.....	\$25,000	No plans; begin immediately.
	River utilization surveys: To obtain river and reservoir topography.....	20,000	Do.
	Municipal water supply investigations: To improve domestic water supply and sewage works.....	8,000	No plans; begin at once.
	Stream pollution surveys: To safeguard fish life and domestic use including that of campers.....	10,000	Do.
	Fisheries survey of spawning areas: Protection and propagation of fish.....	30,000	Begin at once.
	Classification of irrigable lands: To determine best lands and cull out inferior lands.....	13,000	No plans; begin immediately.
	Silt gaging stations: To determine quantities of soil actually eroded.....	169,000	
6	Oregon: Study diking and drainage for reclamation of marsh lands along coast.....	30,000	
8	Roseburg, Oreg.: Sewage treatment plant and sewers.....	86,000	Plans completed.
16	Talent, Oreg.: Line irrigation water tunnel.....	10,000	No plans required.
17	Medford, Oreg.: Diversion dam for Rogue River Valley.....	25,000	Right-of-way owned. No plans.
5	Reedsport, Oreg.: Extension of south jetty at mouth of Umpqua River.....	600,000	Authorized by Congress. Survey and plan completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
	Jackson County, Oreg.: Line Eastside Canal (14), Talent irrigation district, and main canal (15).....	\$125,000	
18	Jacksonville, Oreg.: Sewer system.....	24,000	
3	Toledo, Oreg.: Water supply system.....	130,000	
9	Port Orford, Oreg.: Water supply system.....	26,000	
7	Coquille, Oreg.: Water mains.....	35,000	
2	Bay City, Oreg.: Water supply system.....	40,000	
13	Beaver Creek, Oreg.: Dam for irrigation.....	425,000	Preliminary plans completed.
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
4	Lake Creek near Blachly, Oreg.: Hydroelectric plant and transmission lines.....	\$44,000	
1	Gearhart, Oreg.: Water supply system.....	23,000	Preliminary plans completed.
12	Medford, Oreg.: Flood control and irrigation storage dam on Little Butte Creek.....	400,000	Plans and specifications practically completed.
11	Grants Pass, Oreg.: Irrigation canal improvements.....	300,000	Plans incomplete.
10	Gold Beach, Oreg.: Water supply main between dam and reservoir.....	12,000	

7. WASHINGTON COAST

No general or regional problems of water use affecting large populations have yet arisen in this area, made up of many comparatively small independent drainage basins. Conservation of forest rather than of water resources needs regional attention for the present. Except for the completion of existing navigation improvements, the immediate water requirements are the collection and analysis of several kinds of basic information to guide action in the future.

General Description

The region comprises the drainage basins of all the streams in Washington north of the Columbia River that flow into the Pacific Ocean, the Strait of Juan de Fuca, and the long tidal estuary called Hood's Canal. Included are the coastal region of Washington, the inland valley of the Chehalis River, the entire Olympic Peninsula, and the eastern shore of Hood's Canal. The land area is 8,030 square miles. Nearly nine-tenths of the surface is forest covered and one-third is mountainous. About 3 percent or 156,800 acres is agricultural.

The population is 144,500 of which less than half is in communities of over 1,000; the total increased 59 percent from 1910 to 1930. The population density is about 18 per square mile. Cities of over 10,000 are Aberdeen (21,700), Hoquiam (12,800), and Port Angeles (10,200).

Lumber, forest products, and pulp and paper are the principal products of the region. The more accessible areas have been logged off, but there are still large stands of timber estimated at 130 billion board feet. With proper conservation practices these lands could become an important source of timber on a sustained-yield basis. Much of the area is unsuited to other uses. Pulp and paper manufacturing is encouraged by accessibility of raw material and water transportation and also by the low-cost power, good water supply, and easy waste disposal provided by the streams.

Fruit and vegetable farming, dairy and poultry products, and commercial fishing are important to the region. About 30 percent of the rural population is engaged in agriculture. Recreational opportunities are excellent and are increasingly used by the people of the neighboring Puget Sound country.

Surface waters have been ample to supply all needs and the underground waters have, therefore, not been fully investigated, although several communities use underground sources. Needs for irrigation in the Chehalis Valley and for expansion of the cellulose pulp industry may bring an increased demand for underground waters.

Navigation, except for the great waterway of the Strait of Juan de Fuca leading to Puget Sound, is limited to Hood's Canal and the bays and the tidal sections of the rivers where important quantities of lumber and forest products are loaded.

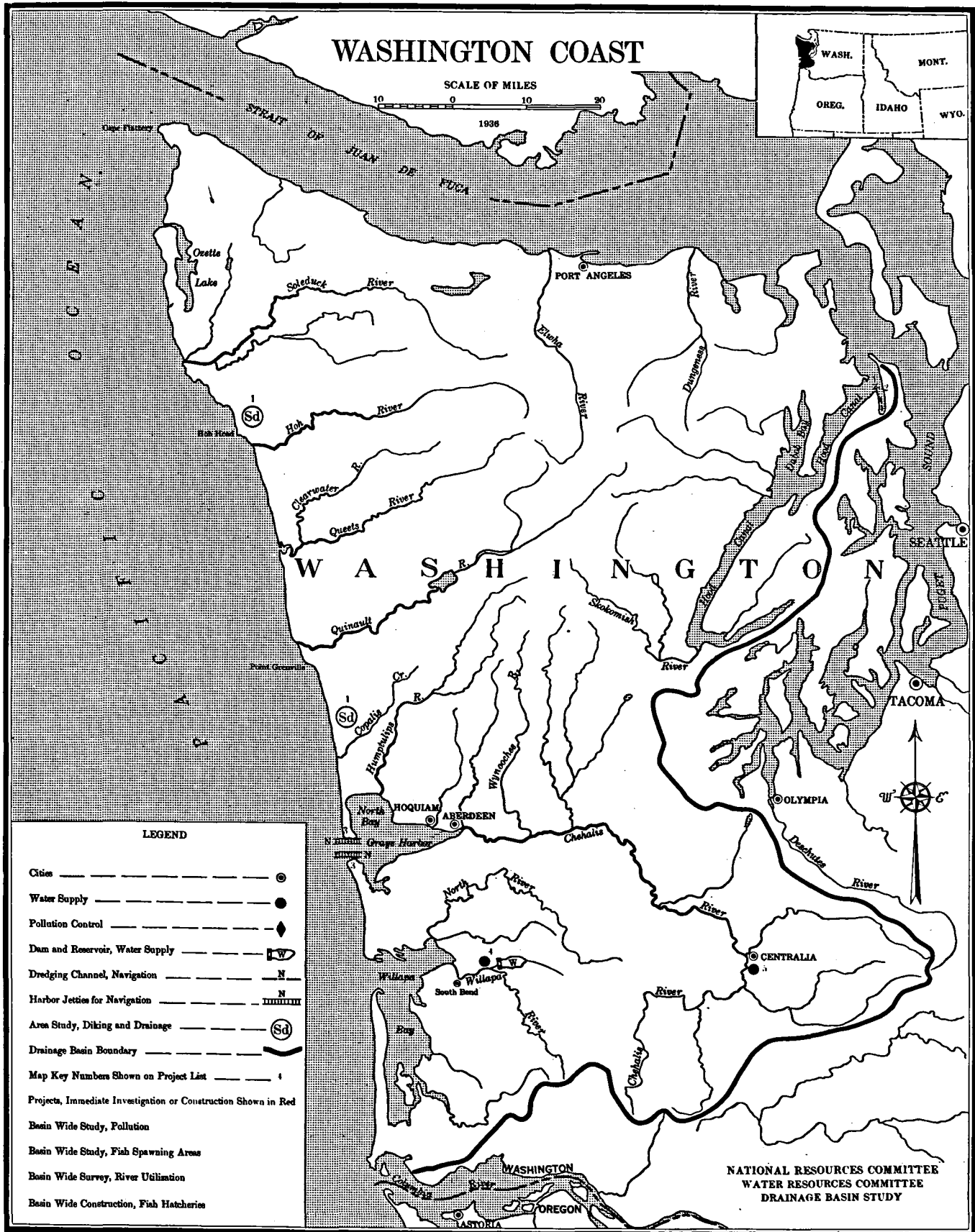
The total potential hydroelectric power in the area is estimated at 330,960 kilowatts 90 percent of the time. Installed capacity is 110,525 kilowatts, including two plants owned by the city of Tacoma.

Rainfall is abundant except for a small area in the lee of the Olympic Range at Sequim, where 8,700 acres receive supplemental irrigation. Average annual precipitation is probably greater than in any other drainage area in the United States, ranging as high as 125 inches along the western slope of the Olympics and perhaps 250 inches in the snowfields of the high Olympics. In the inland valley of the Chehalis the average is 45 inches. Temperatures are moderate wherever records are available. The average growing season in the Chehalis and Willapa Valleys is 185 days.

Recommended Plan

Navigation needs have generally been well supplied by improvements to the harbors and lower rivers. Completion of works at Grays Harbor and Port Gamble are listed.

Data upon which to plan the utilization of water resources in the future are inadequate or wholly lacking. In addition to the general hydrologic and topographic projects recommended for national attention, investigations are needed in this area to guide future action for the protection of waters for fishing and domestic use, to determine the character and extent of fish spawning areas, and to obtain local topographical data for river and reservoir planning.



Washington Coast Project List

Map key no.	Project	Estimated cost	Remarks
GROUP A—FOR IMMEDIATE INVESTIGATION OR CONSTRUCTION			
	Stream pollution studies: To safeguard fish and domestic use.....	\$24,000	Plans completed.
	Fishery survey of spawning areas.....	25,000	Begins immediately.
	River utilization surveys: To obtain river and reservoir topography.....	15,000	Plans completed.
1	Washington: Study of diking and drainage for reclamation of marsh lands along coast.....	See remarks.	Cost included in estimate shown on Oregon coast project list.
3	Grays Harbor, Wash.: Reconstruction of harbor entrance jetties.....	3,155,000	Amount needed to complete. Work under way.
2	Port Gamble, Wash.: Deepen entrance to bay.....	20,000	Surveys completed.
GROUP B—FOR DEFERRED CONSTRUCTION			
4	Willapa Valley, Wash.: Diversion dam on Stringer Creek, and water main extension.....	\$69,000	Plans completed.
5	Centralia, Wash.: Pumps for domestic water supply system.....	176,000	
GROUP C—TIME OF CONSTRUCTION INDETERMINATE			
	Establishment of fish hatcheries to meet demands on fish life.....	\$100,000	

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 Office Coordinator: B. S. DRANE

Assistant Director: MERTON L. EMERSON
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 Regional Coordinator: H. T. CRITCHELOW

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