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MISSOURI RIVER BASIN

CONSERVATION, CONTROL, AND USE OF WATER RESOURCES

OF THE

MISSOURI RIVER BASIN IN MONTANA, WYOMING, COLORADO, NORTH DAKOTA, SOUTH DAKOTA, NEBRASKA, KANSAS, IOWA, AND MISSOURI

(Report by Secretary of the Interior Harold L. Ickes on Bureau of Reclamation's Plan for Basin Development)

APRIL 1944

PRESENTED BY MR. O'MAHONEY

MAY 5 (legislative day, APRIL 12); 1944.—Ordered to be printed with illustrations

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MISSOURI RIVER BASIN

LETTER FROM THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D. C., May 4, 1944.

The Honorable the SECRETARY OF THE INTERIOR.

MY DEAR MR. SECRETARY: I have your letter of May 1 transmitting a copy of the report entitled "Conservation, Control, and Use of Water Resources of the Missouri River Basin."

I am not now able to advise you, because of the need for further consideration of certain recommendations of the proposed report, as to the relation to the program of the President of the various recommendations therein.

Since I am advised, however, that the congressional committees having jurisdiction of pending legislation, to which these recommendations relate, are contemplating early consideration of such legislation, I am writing to say that this office would, of course, have no objection to your making the report immediately available for the consideration of these committees. In doing so, the committee should be informed, I think, that you have not received from this office advice as to the relation of the report recommendations to the program of the President.

Very truly yours,

HAROLD D. SMITH, *Director.*

LETTER FROM THE DEPARTMENT OF THE INTERIOR

DEPARTMENT OF THE INTERIOR,
Washington, May 1, 1944.

The PRESIDENT,
The White House.
(Through the Bureau of the Budget.)

MY DEAR MR. PRESIDENT: There is transmitted herewith my report on the Missouri River Basin, which is the letter of April 28, 1944, of the Commissioner of Reclamation and its attachments, which I approve.

The report contemplates utilization of the waters of the Missouri River beneficially for multiple purposes in the stabilization of the agriculture and economy of this vast basin which includes the Northern Great Plains, where drought periodically deals devastation. The maximum degree of stabilization can be obtained only through full utilization of the waters of this river system.

The construction proposed in this report would be complementary, for the most part, to that recently suggested by the Secretary of War for flood control on the Missouri River. The two plans, while not identical, apparently can be successfully coordinated.

The initial stage proposed in this report would involve expenditures estimated at $200,000,000. The economic and human gains that can be expected will amply justify this step. The plan has engineering feasibility. Water users, rural and urban, would be expected to repay, in accordance with their ability and the benefits extended to them, parts of the costs, and I find that they probably can meet the charges indicated. Power users would be expected to repay additional parts of the costs. It reasonably can be expected that these returns to the United States Treasury will be effected. Flood control and navigation allocations would be non-reimbursable. Substantial and material benefits would accrue through recreational use of the waters and facilities proposed; through their use in fish and wildlife conservation; through pollution abatement, silt control, and the recharge of lakes and ground waters. These are not assessable in monetary terms, and no repayments are contemplated from them.

I find desirable and feasible the development of the Missouri River Basin in accordance with this report on the Conservation, Control, and Use of the Water Resources of the Missouri River Basin, and I recommend authorization for construction after the war of the initial stage in accordance with the report and as contemplated in Section 9 of the Reclamation Project Act of 1939.

Sincerely yours,

HAROLD L. ICKES,
Secretary of the Interior.

LETTER FROM THE BUREAU OF RECLAMATION

DEPARTMENT OF THE INTERIOR,
BUREAU OF RECLAMATION,
Washington, April 28, 1944.

The SECRETARY OF THE INTERIOR.

SIR: In accordance with section 9 of the act of August 4, 1939 (53 Stat. 1187, 43 U. S. C. 485), I transmit this report on Conservation, Control, and Use of the Water Resources of the Missouri River Basin.

I recommend it to you for your approval and for submission to the Congress, after submission to the Bureau of the Budget in accordance with section 4 of Executive Order 9384, and to the President in conformity with the 1939 act.

The reclamation plan proposes a total of 90 reservoirs with a combined capacity of 45,700,000 acre feet, most of the reservoirs on tributaries of the Missouri for use in irrigation, flood control, and power development, but two-thirds of the reservoir capacity on the main stream for use in flood control, aid to navigation, power development, and irrigation.

When fully developed, the plan would provide water for the irrigation of 4,760,400 acres of dry land, and supplemental water for 538,000 acres of land now irrigated but not assured adequate water in years of low run-off. Seventeen power plants, in the completed power system, would supply seasonal power for pumping water for irrigation,

and nearly four billion kilowatt-hours of firm power, annually, for domestic, commercial, and industrial uses.

The irrigation of numerous areas scattered widely over the Northern Great Plains and over other semiarid sections of the Missouri River Basin would add to an unavoidably precarious dry-farm and grazing economy the stabilizing influence of lands with insured crops and high yields.

The droughts of the last decade cost governmental agencies, principally Federal, a total of $1,246,557,087, and these expenditures were inadequate to the needs, since tens of thousands of families nevertheless were forced to migrate from their abandoned homes. These expenditures are roughly equal to the cost of full utilization of the waters of the Missouri River system. While it is not contended that full use of these waters will eliminate drought losses, it will reduce the catastrophic effects and prevent much of the human suffering.

I have submitted the report to the agencies of the Department of the Interior which have interests in the waters of the Missouri River Basin and have their approval or their comment, which is attached. I have submitted the report to the Interagency River Basin Committee, in accordance with the quadripartite agreement of December 29, 1943. I have the comment of the Corps of Engineers, which is also attached.

The Assistant Commissioner of the Office of Indian Affairs, on April 26, 1944, said with regard to the recommendations made in the report dated April 14, 1944 of the Board of Review, that the Office of Indian Affairs should construct, operate and maintain irrigation features including dams that predominantly serve Indian lands. I concur in the opinion, and I am sure that the members of the Board of Review will regret their oversight in this connection. The report should recognize the authority and responsibility of the Office of Indian Affairs in the matter of irrigating Indian lands.

The Chief of Engineers, War Department, in his letter of April 25, 1944 observed that the Reclamation plan included tributary reservoirs that would fit the plan presented by the Corps of Engineers in House Document 475, Seventy-eighth Congress, second session, and commented that modifications made in the proposals for the Yellowstone, Big Horn, Kansas, Smoky Hill, and Republican River Basins could be coordinated in advance of construction by further cooperation by the Corps of Engineers and the Bureau of Reclamation. With regard to the main stem of the Missouri River, however, the Chief of Engineers noted that the reclamation plan contemplated 10,250,000 acre-feet less storage than had been proposed by the Corps, and concluded that a high dam at the Garrison site, which was not included in the reclamation plan, and a dam at Gavins Point, which was omitted from the reclamation plan, are necessary. The main stem dams, the Chief of Engineers said, should be built, operated, and maintained by the corps, and the tributary dams should be built, operated, and maintained by the agency with the dominant interest. Flood control storage should be utilized in accordance with regulations prescribed by the Secretary of War, and irrigation storage in accordance with regulations of the Secretary of the Interior, he proposed. The Chief of Engineers noted that irrigation of the Souris area, as proposed in the Reclamation plan, would require diversion of waters from the Missouri River, and he advised further study of this undertaking pending fulfillment of existing and foreseeable needs within the Basin. He

questioned the computations in the reclamation report of benefits and allocations.

I agree with the Chief of Engineers that details can be worked out satisfactorily through cooperation as the projects are constructed on the tributary streams. I agree that the agency with the dominant interest should construct the dams and other works in the Basin, and I agree that the main stem storage dams should be constructed by the corps, owing to their close relationship with flood control and navigation. The Reclamation plan provides a storage capacity in main stem reservoirs of 24,950,000 acre-feet, which is 10,250,000 acre-feet less than that proposed by the Corps, but when considered together with more than 10,000,000 acre-feet of storage provided upstream, this amount is believed to be sufficient to provide full flood protection and ample storage for regulation for navigation. However, if continuing studies by the Corps and the Bureau of Reclamation should indicate the need of additional storage in the main stem after the high dam at Oahe is built, then there is and should be ample opportunity to provide the additional storage needed. The Oahe Dam, as proposed, would provide a reservoir of a capacity of 19,600,000 acre-feet as against the Garrison Dam proposed by the Corps which would provide a reservoir of only 17,000,000 acre-feet. In any event, one of these would constitute the initial flood-control facility. It would appear that the Oahe Dam would be more desirable from the flood-control standpoint, as it is also from the irrigation point of view.

The regional report of April 1944 is covered by the report of April 14 of the Board of Review. I approve the findings, the comment, and the recommendations made in the report of the Board of Review.

I find that the proposed development of the Missouri River Basin is needed, as conclusively shown in the report. The plan has engineering feasibility. The ultimate cost is estimated at $1,257,645,700, and the annual benefits of the completed development would be 2.57 times the annual costs. The annual benefits would be as follows:

Irrigation	$130, 000, 000	Navigation	$4, 165, 000
Power	17, 141, 000	Municipal water	500, 000
Flood control	16, 500, 000		

Irrigation would be expected to repay in 40 annual payments $298,000,000. Power revenues in 50 years would repay $423,100,000, and municipal water users would repay $20,000,000.

The initial construction proposed would require $200,000,000 and would be dominantly for irrigation and power. It includes none of the features that would be constructed by the Corps of Engineers in the development of the basin, but it would complement the flood-control construction proposed by the Corps.

I recommend that the construction, repayment, operation, and maintenance of the works proposed be in accordance with this report. I recommend the approval and authorization of the initial stage for construction after the war substantially in accordance with this report, but with such modifications by the Secretary of the Interior and the Commissioner of Reclamation as may be required to meet developing needs.

Respectfully,

H. W. BASHORE, *Commissioner.*

LETTER FROM THE OFFICE OF INDIAN AFFAIRS

DEPARTMENT OF THE INTERIOR,
OFFICE OF INDIAN AFFAIRS,
Washington, D. C., April 26, 1944.

MR. HARRY W. BASHORE,
Commissioner, Bureau of Reclamation.

DEAR COMMISSIONER BASHORE: I have examined the confidential copy of the Missouri River report you transmitted on April 20, 1944. This report, in my judgment, is an excellent presentation of the Missouri River Basin problem. I find myself in full agreement with your Bureau's recommendations concerning the priorities of irrigation, domestic and industrial use of the regulated flow of the Missouri River and its tributaries, especially in the upper part of the basin, and I hope that these priorities will be given congressional sanction.

Insofar as the Indian irrigation and power interests are concerned, the report seems to give them adequate consideration. However, I cannot agree with the recommendation of the Board of Review that "all works that may be authorized under the approved plan be constructed, operated, and maintained by the Bureau of Reclamation under the direction of the Secretary of the Interior wherever the dominant function of such works is other than navigation and flood control." This recommendation on page g of the report, is based on the discussion of the proposed division of operational authority in numbered paragraph 7, on page b. This paragraph proposes that, in effect, construction and operation of the features of the plan be divided between the Bureau of Reclamation and the Corps of Engineers on the basis of the dominant function of each feature, features in which navigation and flood control are the dominant functions to go to the Corps, all other features to be operated by the Bureau of Reclamation. The report in paragraph 7, adds: "In like manner, agencies with jurisdiction over other functions should be recognized." Inasmuch as the Office of Indian Affairs is exercising on Indian lands functions identical with those exercised by the Bureau of Reclamation on non-Indian lands, the language of the report seems to exclude the Indian Service from any participation in the planning, design, construction and operation of irrigation and power projects on Indian lands. I assume that this omission was unintentional and propose that it be corrected by changing the language of paragraph 7, page b, as follows: In line 9, after the words "All irrigation features" insert "except those on Indian lands or predominantly serving Indian lands which shall be constructed and operated by the Office of Indian Affairs." Similarly in line 12, at the end of the sentence reading "All reservoirs in which irrigation, restoration of surface and ground waters, or power, are dominant, should be operated by the Bureau of Reclamation" the following words should be added "except reservoirs on Indian lands or predominantly serving Indian lands which shall be operated by the Office of Indian Affairs."

Indian Service lands and irrigation projects are scattered throughout the Missouri River Basin. Many of the features proposed by the plan are in part or in whole based on Indian lands, affect Indian water rights and existing Indian irrigation projects. In order to make pos-

sible a reasonable degree of Indian Service participation in the planning, construction, and operation of those irrigation and power features vitally affecting Indian interests, I propose that language be added to paragraph (b) of the recommendations, on the bottom of page g, to make this recommendation read as follows:

(b) That all works that may be authorized under the approved plan be constructed, operated, and maintained by the Bureau of Reclamation under the direction of the Secretary of the Interior wherever the dominant function of such works in other than navigation and flood control, except that the Office of Indian Affairs shall construct and operate those works on Indian lands or serving Indian lands predominantly.

I request that these modifications in the language of the report be made before the report is submitted to the Congress.

The modifications in the language are deemed necessary in order to protect the Indian interests under the Winters decision and the terms of the Leavitt Act. They bring the recommendations into line with the Departmental policy as laid down in the Secretary's report on Senate Joint Resolution 55, by Wheeler, to transfer all Indian irrigation functions to the Reclamation Bureau, a proposal vigorously opposed by the Department and your Bureau.

Sincerely yours,

WILLIAM ZIMMERMAN, Jr.,
Assistant Commissioner.

LETTER FROM THE CHIEF OF ENGINEERS, WAR DEPARTMENT

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, April 25, 1944.

Mr. H. W. BASHORE,
Commissioner, Bureau of Reclamation,
Department of the Interior, Washington, D. C.

MY DEAR MR. BASHORE: Receipt is acknowledged of your letter of April 20, 1944, transmitting copies of your report on the Missouri River Basin and requesting comment thereon by April 25, in order that the report may be submitted to the Bureau of the Budget on the scheduled date of May 1, 1944.

The general comprehensive plan of this Department for flood control and other purposes as contained in House Document No. 475, Seventy-eighth Congress, contemplated that that plan would be be augmented by appropriate projects of other agencies duly constituted by law to perform such work. It appears that the upstream tributary reservoirs proposed in the report of the Bureau will fit into the expanded comprehensive plan for flood control and other purposes, provided main stem storage is not substantially reduced.

I note that your plan substitutes the Mission Dam for the Livingston project included in House Document 475 and greatly reduces the size of the Boysen Dam. Further studies by the Bureau of Reclamation and the Corps of Engineers preparatory to construction can definitely establish the developments for the Yellowstone and Big Horn Basins.

Similarly the plan in your report for the Kansas River Basin, including the Republican and Smoky Hill Rivers, differs in some details

from the War Department's plan as reported in House Document 475. In this river basin the fundamentals of the two plans are similar and I believe that the details can be worked out satisfactorily through cooperation as the projects are constructed.

With regard to the main stem dams in North and South Dakota, it is noted that the Bureau's report contemplates 10,250,000 acre-feet less storage than proposed in House Document 475. Since reservoirs on the main stem are the most beneficial from the standpoint of flood control below Sioux City and are vitally needed for cyclic storage, I consider that the maximum practicable amount of storage must be provided on the main stem in North and South Dakota. In this connection the plan outlined in House Document 475 makes possible the inclusion of a high dam at Oahe if found feasible from an engineering and economic standpoint. In any event a high dam at the Garrison site is essential, and a reregulating reservoir at Gavins Point is necessary.

Although I am not convinced that storage in reservoirs far upstream on the headwater tributaries would have appreciable effects on flood stages along the main river below Sioux City and on the Mississippi River, I agree that those projects would be of great benefit to agriculture, to the prevention of local flood damages downstream from the dam sites and to the solution of silting problems.

It is noted that your plan includes the irrigation of approximately 1,000,000 acres in the Souris project outside of the Missouri River Basin. The best over-all use of the multiple-purpose reservoirs in the Missouri River Basin would permit a diversion of water out of the basin into the Dakotas, urgently needed for domestic use and for other purposes, after sufficient water has been conserved and stored to provide for such diversion. However, until the existing and foreseeable needs for the conservation and use of water within the Missouri River Basin have been satisfied there is a question in my mind as to the advisability of developing a large-scale irrigation project outside the Missouri River Basin which would deprive the basin of a part of its natural water supply. In my opinion the advisability of such a large diversion should be the subject of further study and consideration.

The time available has not permitted a thorough study of the allocation of costs and benefits as contained in your report. I can state, however, that in view of the information contained in your report that the projects proposed will provide a dependable low water flow at Sioux City of something less than now exists, I do not understand the equity of charging to navigation a large part of the cost of the development. Also I question your method of computing flood-control benefits. It is noted that by the methods used the costs allocated to flood control and navigation under the heading "Repayment and returns" are very large compared to costs allocated to irrigation, whereas irrigation benefits are represented as several times the combined benefits to flood control and navigation.

It is essential that the main stem reservoirs in North and South Dakota be built, operated, and maintained by the Corps of Engineers as stated in my report and in your letter of December 17, 1943, both printed in House Document 475. Tributary reservoirs should, when advisable from the standpoint of basin-wide development, be con-

structed, operated, and maintained by the agency with dominant interest under existing law. In all reservoirs, utilization of storage for flood control should be in accordance with regulations prescribed by the Secretary of War and utilization of storage for irrigation should be in accordance with regulations prescribed by the Secretary of the Interior.

As stated before, my report contained in House Document No. 475 contemplates that the broad framework for the Missouri Basin as recommended in that document will be augmented by appropriate work of other agencies duly constituted by law to perform such work. I am sure that through the continued cooperative efforts of all concerned the details of the improvements can be worked out in a progressive manner as conditions warrant. I appreciate the opportunity to comment on the Bureau's report and I look forward with confidence to the development of the comprehensive and flexible plan for the Missouri Basin through the coordinated and cooperative efforts of Federal, State, and local agencies to accomplish the best over-all use of its water resources.

Very truly yours,

E. REYBOLD,
Major General,
Chief of Engineers.

LETTER FROM THE DEPARTMENT OF AGRICULTURE

DEPARTMENT OF AGRICULTURE,
Washington, April 25, 1944.

Mr. H. W. BASHORE,
Commissioner, Bureau of Reclamation,
Department of the Interior, Washington, D. C.

DEAR MR. BASHORE: We received from Maj. Gen. E. Reybold, Chief of Engineers, War Department, on April 22, a copy, marked "confidential," of the Missouri River Basin report of the Bureau of Reclamation with the telephone request that we transmit our comments on it to you by April 25 in order that you might submit the report to the Bureau of the Budget by May 1, 1944.

The responsibilities of this Department do not, of course, embrace the design or construction of major engineering works for irrigation, flood control, power, and other purposes, but we are very much interested in land and water development and use of concern to agriculture and rural people. The benefits from soundly conceived irrigation, power, flood control, navigation, wildlife, recreation, and other multiple-purpose developments on the Missouri and its tributaries will accrue in considerable measure to farm people and rural interests and will have a direct bearing on the use made of the natural resources of the area. In particular, the potentialities of providing irrigation where economically feasible to farming areas of low or uncertain rainfall are large and important in the Northern Great Plains.

The short time available has permitted only a very general review of the report. We are glad to see that many of the projects proposed in the report appear to be essentially in harmony with those that have

been proposed by the Corps of Engineers, War Department. We are not in position to judge the relative engineering merits of such proposals as are not reconciled but believe that through continued cooperative consideration by the agencies concerned a mutually acceptable means can be found to meet the broad objectives of both reports.

Various programs of the Department will be of material assistance in the achievement of the agricultural objectives in the coordinated plan for basin-wide development. We shall be glad to cooperate to the full extent our resources permit.

Sincerely,

E. H. WIECKING,
Land Use Coordinator.

LETTER FROM THE FISH AND WILDLIFE SERVICE

DEPARTMENT OF THE INTERIOR,
FISH AND WILDLIFE SERVICE,
Chicago, Ill., May 6, 1944.

Mr. H. W. BASHORE,
Commissioner, Bureau of Reclamation,
Washington, D. C.

MY DEAR MR. BASHORE: Reference is made to your letter of May 2 asking for any comment we may have to offer in regard to your report, "Conservation, control, and use of water resources of the Missouri River Basin."

I regret to say that this report was not received in our Chicago office early enough for us to review it carefully before your deadline on May 1. As yet we have had opportunity to make only a casual examination of the report, but we feel that in the main it is a good report and considers well the interests of the various agencies.

Thus far, there is only one statement to which exception might be taken, and that perhaps would depend upon interpretation of your statement. I refer to a statement in the report of the Board of Review. We heartily subscribe to the first part of paragraph 5, page b; but we feel that the sentence—"To the extent that the uses of water are competitive, the use of water for domestic, agricultural, and industrial purposes should have preference."—might be open to question. Considering the area as a whole, this statement is probably correct; but we could not subscribe to the thought that any particular plot or block of agricultural land, regardless of how submarginal it might be, should have prior use of water over an important muskrat marsh or other wildlife project. Likewise, every industrial use might not have so much value from the national standpoint as the wildlife benefits.

As a whole, the report seems to be well prepared and gives fair consideration to diverse interests.

Sincerely yours,

ALBERT M. DAY,
Acting Director.

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BOARD OF REVIEW'S REPORT TO THE COMMISSIONER

UNITED STATES DEPARTMENT OF THE INTERIOR,
BUREAU OF RECLAMATION,
Denver 2, Colorado, April 14, 1944.

From Board of Review.
To Commissioner.
Subject: Report on Conservation, Control, and Use of Water Resources of the Missouri River Basin.

1. Pursuant to instructions in your letter of February 2, 1944, the undersigned convened as a special board of review in Denver, Colo., April 10 to 13, 1944, to consider the report of April 1944 on the Conservation, Control, and Use of Water Resources of the Missouri River Basin, prepared by the Bureau of Reclamation staff of region 6, assisted by consultants, and representatives of other Government agencies. The results of our review of the report are respectfully submitted herein.

2. The water of the Missouri River system is a primary national resource which, up to the present time, has been inadequately controlled and developed. The two major problems of the basin are the control of devastating floods along the lower river and the stabilization of agriculture in the Dakotas and in eastern Montana.

3. The river and its basin long have been studied by Federal, State, and other agencies, but until recently the studies have not been coordinated or sufficiently broad to comprehend and outline a unified plan for the conservation and beneficial uses of water so as to realize the greatest procurable economic returns and human benefits for the entire region. In our opinion, the report presents a plan which, if carried out, would adequately meet these objectives. It is a comprehensive plan for the highest beneficial use of the waters of the basin. It provides for flood control, navigation, irrigation, power development, domestic and industrial water supplies, silt control, recreational use of waters, conservation of fish and wildlife, and pollution abatement, and will assist in the restoration and maintenance of groundwater levels and inland lakes.

4. The report is the result of long and intensive engineering, scientific, and economic study. The plan is technically and economically sound. It is not proposed or expected that the program as a whole should be undertaken immediately or at one time, but it should progress by starting with the parts that are urgently needed and continue as rapidly as funds become available and economic conditions demand. The greatest benefits will be attained through coordination of the advice and work of all interested Federal, State, and local agencies.

5. To the extent that the several functions of water control and utilization are conflicting, preference should be given to those which make the greatest contribution to the well-being of the people and to the areas of greatest need. To the extent that the uses of water are competitive, the use of water for domestic, agricultural, and industrial purposes should have preference. The plan would meet these objectives.

6. In determining the justification for this development and the subdivisional features thereof, the report recognizes and the Board confirms the principle that a project or a broad development is justi-

fied if the total value of all the benefits to be derived from it exceeds the total cost, whether or not all costs can be recovered from the direct beneficiaries. The report summarizes the benefits of the basin-wide project, and finds that they exceed the estimated costs in the ratio of 2.57 to 1. The Board concurs in this finding.

7. The agency with primary interest in the dominant function of any feature proposed in the plan should construct and operate that feature, giving full recognition, in the design, construction, and operation, to the needs of other agencies with minor interests. All reservoirs where flood control and navigation are dominant should be operated by the Corps of Engineers, and where the flood control and navigation functions are minor, the reservoirs should be operated in accordance with regulations of the Corps so far as flood control and navigation are concerned. All irrigation features should be operated by the Bureau of Reclamation or its agents. All reservoirs in which irrigation, restoration of surface and ground waters, or power, is dominant, should be operated by the Bureau of Reclamation. Where these functions are minor, the reservoirs should be operated under regulations of the Bureau of Reclamation so far as such functions are concerned. In like manner, agencies with jurisdiction over other functions should be recognized. The Bureau of Reclamation should construct and operate all power-transmission facilities, and should have the responsibility for the disposal of all power generated.

IRRIGATION

8. Land-use adjustments needed to stabilize the agriculture of the basin and mitigate the effects of future droughts can best be promoted by progressive development of the irrigation potentialities of the area. In addition, hundreds of thousands of new residents of the area can be provided opportunities to establish homes and to earn for themselves an adequate level of living. Many projects will be of prime importance in any program for the rehabilitation or settlement of returning servicemen and dislocated war workers. Irrigation water users should pay for the service rendered them an amount commensurate with the benefits they receive, and their payments should be based on ability to pay out of earnings of the irrigated land. Many of the project areas will be served with water by pumping. The power used in pumping will be provided from the seasonal output of installations proposed in the report. The power should be paid for as an integral part of operation and maintenance charges, and the resulting operation and maintenance charges should be equalized throughout the area by integrating them with repayment charges and the total to the ability of the land served to produce returns for the farmer.

POWER

9. The average unit costs of power and energy for the power developments described in the report will be such as to accomplish the repayment of the construction costs of power development within a reasonable period of years and, in addition, will permit substantial contributions from power revenues to assist in the repayment of other project features as well as providing low-cost power for irrigation pumping purposes.

10. The market studies indicate the ability of the basin and contiguous areas to absorb in a relatively few years the power to be developed. The large number of comparatively high-cost fuel-burning generating plants now operating in the area offer exceptional possibilities for sale of a large quantity of hydroelectric power as fast as it can be developed. This situation exists because of the immediate opportunity to eliminate high fuel and other generating costs by energy replacement in some cases, and by complete retirement of obsolete plants in others. Growth of load will soon absorb the balance of the output.

11. The low-cost power to be developed should be given the widest possible distribution for the benefit of the whole region. This could be accomplished best by clothing the Bureau of Reclamation with the responsibility for its distribution and sale. Preference in sales should be given to public bodies and cooperatives.

FLOOD CONTROL

12. The main-stream reservoirs in South Dakota, together with the reservoirs on the tributaries in eastern Kansas and in Missouri and the levee system, will provide the protection needed by the fertile bottom lands and the important cities along the Missouri River below Yankton. They will also aid in the control of Mississippi River floods below St. Louis. The reclamation plan supplements such flood control by the addition of a number of multiple-purpose reservoirs on tributaries of the Smoky Hill River and on the headwaters of the Republican River.

13. On the headwaters of the Missouri River, and its western tributaries in the Dakotas, and on the headwaters of the Platte River, the reclamation plan provides necessary flood control in the areas most seriously menaced, in the main, through the operation of multiple-purpose reservoirs.

NAVIGATION

14. Navigation possibilities are limited to the Missouri River up to Sioux City. While the traffic on this stream has never been impressive even below Kansas City, the Missouri River carries potentialities as an important waterway in the future as Kansas City, Omaha, Sioux City, and their tributary areas continue to grow. The utilization of the stream as a waterway should be planned, and such planning should be adapted to the flows to be expected with justified upstream development. The storage facilities contained in the reclamation plan provide the necessary stream regulation to insure a sustained and well-regulated flow through the years, regardless of the vagaries of precipitation.

SILT CONTROL

15. The control of silt is important in many localities. The most urgent silt problems are in the Big Horn River Basin, but the problem is also serious in the Yellowstone River and its other tributaries as well as in the western tributaries of the Missouri River in the Dakotas. The storage control provided throughout the Missouri River system above Yankton will desilt the streams and eliminate most of the silt problems in connection with operations of irrigation and municipal

water systems. The retention of the silt by these means will reduce the cost of maintaining the channels in the navigation section of the Missouri River and the Mississippi River below St. Louis.

DOMESTIC, MUNICIPAL, AND INDUSTRIAL WATER SUPPLIES

16. In many parts of the basin, surface waters are relied upon for domestic and municipal water supplies. In the future there will also be greater requirement for industrial water supplies. Regulation of flows of many tributaries as proposed, and the diversion of water from the Missouri River into eastern North Dakota and the Red River Valley, and into the James River Valley in South Dakota, will benefit many cities, towns, and populous areas by increasing low-water flows and restoring ground-water levels.

17. Some communities that depend on wells are faced with the necessity of searching for new water sources because of lowering ground-water levels. The falling water tables have also dried up or reduced to stagnant pools many old lakes in the northern plains. The plan calls for the restoration of some of these lakes, and will also have a beneficial influence on water tables through percolation of water from canals, irrigated farms, and small stream channels.

FISH AND WILDLIFE

18. The Missouri River Basin has areas of outstanding importance in the conservation of fish and wildlife. Notable among them are mountain fishing streams, and the waterfowl refuges and breeding grounds in the northern plains. The development of the water resources of the basin will adversely affect some of the existing facilities, but it will also create exceptional opportunities for expanding the fish and wildlife programs. No unnecessary injury should be inflicted, and construction plans should include such safeguards as fish screens at canal and other intakes, hold-over conservation pools in reservoirs (for maintenance of proper water elevations and stream flows during spawning and nesting seasons whenever practicable), and other good conservation practices. Facilities destroyed or damaged should be replaced by others of equal utility as a part of the new construction in the conservation programs, wherever possible.

RECREATION

19. The basin includes parts of three great National Parks, Yellowstone, Glacier, and Rocky Mountain along the Continental Divide, numerous national forests, and many smaller recreational facilities ranging from fishing grounds in the mountains to historical sites on the plains; but there are large areas where recreational facilities are inadequate. The restoration of Devils Lake and the construction of the numerous proposed reservoirs will provide recreational opportunities of major importance within these areas. These opportunities should be capitalized through stocking the lakes and reservoirs with fish, and providing facilities that will be needed to care for the public, such as campgrounds, boat landings, and shelters.

POLLUTION ABATEMENT

20. Along the Red River of the North, and in various other places within the basin, including some areas bordering the Missouri River itself, waters are polluted by discharge of untreated sewage into streams. In periods of low flow, pollution has become serious, threatening the safety of water supplies and creating nuisances. Diversion of water into the Sheyenne River and thence into the Red River of the North will abate some of these conditions. So far as possible, sufficient low-water flows should be maintained throughout the basin to prevent dangerous pollution; but this should not be considered as a substitute for the treatment of sewage where necessary to maintain proper sanitary conditions and the use of stream flows for dilution of sewage should be held to a minimum.

HYDROLOGY

21. Reliable stream-flow records covering sufficient time to reflect variations in flow are a prerequisite to sound project planning, to assure proper control and full utilization of the waters, and to avoid waste of construction funds on the one hand, and the hazards of water shortages, flood damages, and power shortages, on the other. No run-off records are available for many of the smaller streams, and on the larger streams the available records are often inadequate because of insufficient stations, particularly at critical locations. The present inadequate program of stream gaging being conducted by State and Federal agencies should be greatly expanded at once, to the end that the tentative project plans may be confirmed or modified on the basis of more complete stream-flow records, before it becomes necessary to start construction. This situation is particularly applicable to the numerous small projects on the minor tributaries. The appropriations for the United States Geological Survey for stream-gaging work should be substantially increased, and the lack of available State appropriations for matching Federal funds should not be permitted to delay a program at least sufficient to provide the needed records at many key stations.

DESIGNS AND ESTIMATES

22. The project plan includes hundreds of major engineering works, such as dams and power plants, and thousands of important structures. The plans on which the estimates are based were necessarily of a preliminary nature. At many of the dam sites, exploratory work has been carried far enough to obtain dependable basic data. At other sites, further exploratory work must be undertaken before details of the structures can be determined and better estimates made. All the works proposed in the report are of the same general type which the Bureau of Reclamation has been constructing in the West since 1902, and no novel or unprecedented problem are involved. All cost estimates are tentative, and are subject to revisions in the light of further information which must be developed by exploratory work and detailed design studies before construction is undertaken. A lump-sum allowance has been included for contingencies for unforeseen conditions, but no allowance has been included for major economic changes. All estimates are based on costs as of January 1, 1940, and an appro-

priate factor will therefore have to be applied to conform such estimates to prices existing at the time the construction of any feature of the development is initiated.

INITIAL CONSTRUCTION PROGRAM

23. The following list of projects is submitted as the initial stage of an orderly program to effectuate a plan of development presented in the report. The list is confined to projects or project features which should, in the opinion of the Board, be constructed by the Bureau of Reclamation:

Colorado:
- Transmountain diversion projects were not considered a part of this basin.

Kansas-Nebraska:
- Bostwick.
- Cedar Bluff.
- Frenchman-Cambridge.
- Kirwin.
- North Republican (Wray) (Colorado-Nebraska).
- Pumping.

Montana:
- Canyon Ferry Reservoir.
- Glasgow Bench Pumping.
- Hardin (including Yellowtail Dam).
- Marias.
- Missouri-Souris (Montana division).
- South Bench.
- Yellowstone River Pumping units.

North Dakota:
- Heart River.
- Knife River.
- Missouri-Souris (North Dakota division).
- Missouri River pumping units (5).

South Dakota:
- Angostura.
- Grand River (Shadehill-Bluehorse).
- Oahe (James River).
- Rapid Valley (including Brennan Reservoir).

Wyoming:
- Big Horn pumping units.
- Big Horn Project (Boysen Dam).
- Glendo Reservoir.
- Kortes.
- Owl Creek.
- Paintrock.
- Riverton.
- Shoshone project extensions.

Power transmission lines.

RECOMMENDATIONS

It is recommended:

(*a*) That the general plan for the development of the basin as contained in the report be approved subject to such modifications and changes as may be indicated, from time to time, as the plan is effectuated.

(*b*) That all works that may be authorized under the approved plan be constructed, operated, and maintained by the Bureau of Reclamation under the direction of the Secretary of the Interior wherever the dominant function of such works is other than navigation and flood control.

(c) That the Bureau of Reclamation under the direction of the Secretary of the Interior make all arrangements for the sale and distribution of electric energy generated at all hydroelectric developments hereafter constructed by any Federal agency within the basin as defined in the report, and be authorized to construct, operate, maintain, and improve such electric transmission lines and substations as it finds necessary or desirable in connection therewith.

(d) That the initial construction program as hereinabove presented be adopted and that an appropriation of $200,000,000 be authorized for the prosecution of construction work on the first stage of the program and for the continuation of investigations on the general plan of development.

E. B. DEBLER,
Chairman, Director of Branch of Project Planning.
S. O. HARPER,
Chief Engineer, Director of Branch of Design and Construction.
H. F. MCPHAIL,
Director of Branch of Power Utilization.
W. F. KUBACH,
Director of Branch of Fiscal and Administrative Management.
D. S. STUVER,
Assistant Director of Branch of Operation and Maintenance.

SUMMARY FOREWORD

Wheat, butter, meat, wool, leather, and many other valuable commodities used by the people of the United States come from a wide, sparsely populated area which lies between the highly developed Middle-West and Eastern States and the growing far West States, and extends from the Canadian border far down into Texas, almost separating the country into two distinct parts. This Great Plains area and the mountainous country which bounds it on the west yield not only foodstuffs and textile materials which are important to the prosperity of the country, but also certain valuable and strategic minerals, and a wealth of oil. Economically, it is a very important part of the Nation.

The cities and large towns, and much of the best agricultural land in the Great Plains area lie in the flood-plains of the rivers, and occasionally, like some eastern cities and farm lands, they suffer great damage from floods. The greater part of the area experiences serious variations in rainfall, and corresponding fluctuations in crop yields. Occasionally, it suffers long periods of drought, during which losses far exceed those due to floods. The effects of such disasters are not confined to the Great Plains; they extend to the whole country, because they disturb commerce in the hundreds of millions of dollars' worth of materials and articles which are exchanged annually between residents of the Great Plains States and residents of other States. On some occasions, enormously expensive relief and rehabilitation programs have been necessary after floods or droughts because, in the interest of national prosperity and security, the area cannot be abandoned, nor allowed to lose the fruits of developments by private initiative that are, or can be made to be, economically sound.

Man cannot exercise control over the weather—the fundamental cause of droughts and floods; but by devices known to engineers, he can modify floods and their effects, and by practices known to engineers and agricultural scientists he can alter the farming facilities and the farm and ranch practices in some localities so as to diminish both the direct and the indirect effects of droughts. For years, the Corps of Engineers, United States Army, has been engaged in designing and constructing river improvements for the purposes of reducing flood damages and aiding navigation; the Bureau of Reclamation has been putting water on arid land and finding supplemental water for distressed irrigation farmers; and the Department of Agriculture, the State colleges, the State experiment stations, and the county agricultural agents have been laboring to improve agricultural facilities and practices. In order to perform efficiently and to handle large-scale projects, these and other government and local agencies must cooperate closely, and in accord with broad plans, each plan being inclusive of all resources, problems, and possibilities that are properly related in one unit. So far as the cooperative activities of the Corps of Engineers and the Bureau of Reclamation are concerned, a river basin is a suitable unit on which to base plans.

This report deals with a plan for the conservation and control of the water resources of the entire Missouri River Basin, which includes the northern Great Plains, and the use of such resources in watershed development. Every water resource and all feasible beneficial uses of water, such as aids to navigation, flood control, the irrigation of land, the producing of power, the restoration of surface and groundwater levels and of domestic and municipal water supplies, the abatement of stream pollution, silt control, fish and wildlife preservation, and recreation, were taken into account in an effort to formulate a basin-wide plan most likely to yield the greatest good to the greatest number of people. The plan is based on specific information with respect to the character and needs of different sections of the basin, and on experience in designing, building, and operating works of the kinds that will be required in the Missouri River Basin. It is adapted to development in stages, and to such modifications as changes in physical and economic conditions make necessary. Agriculture is and always will be the primary basis of the economy of the Missouri River Basin. On agriculture, other economic activities in the basin largely depend. This fact has been recognized in designing a plan for water-resource development for the basin.

Plans of the Corps of Engineers cover channel improvements from Sioux City to the mouth of the river and a number of reservoirs on the upper river, mainly for flood control and aid to navigation. Such existing and proposed developments are referred to or are described in House Document 475, Seventy-eighth Congress, second session, and in the documents referred to therein. The plan here tendered incorporates the Corps of Engineers' proposed plans for flood control and aids to navigation in the river below Sioux City, with some modifications of Army plans for developments on the upper river, for the reason that certain reservoirs and related works further up in the river basin would facilitate navigation and flood control on the lower river, and, at the same time, serve other purposes.

This basin-wide plan provides for a number of reservoirs on the upper reaches of the Missouri River and its tributaries, for the pur-

poses of storing water, and releasing it during periods of low flow. Such reservoirs will contribute to flood control not only on the lower river but at all points from the mouth of the river to the reservoir sites; they will aid navigation on the lower river by reducing flood damages to navigation works and by increasing the dry-season flow; they will enlarge the supply of water available for irrigation; and they will make practicable the generation of electrical energy at many places.

The irrigation of land in the basin, generally in relatively small blocks along the streams, will add to an unavoidably precarious dry farming and grazing economy a dependable type of agriculture which will have a stabilizing effect on whole communities; it will supplement the ranges in supporting a larger, better, and less hazardous livestock industry; and by increasing the population and the farm yield and income, it will reduce the per capita costs of government and raise standards of living and of citizenship. In periods of severe and long-continued drought, such as have occurred at long intervals, and may occur again, forage raised on irrigated land will support foundation breeding stock, at least, and so speed recovery from drought damages.

The storing of water and the regulating of stream flow for purposes of irrigation will contribute not only benefits to downstream navigation and flood control, but, frequently, facilities for the production of power, one of the chief sources of wealth and well-being. Electrical energy developed at dams and canal drops will be used to pump water to land above gravity canals; and surplus power will be sold for domestic, municipal, and industrial applications.

The distribution of irrigation water in canals and the maintenance of year-round flows in some streams that ordinarily go dry in summer will relieve water shortages, and improve ground-water supplies. Return flow from irrigated land, and water diverted for the specific purposes will raise or restore ground-water levels in some areas, and abate stream pollution.

Both the creation of reservoirs and the regulation and maintenance of stream flow will aid in fish and wildlife conservation.

Present and future plans of State agencies and of various Government agencies, such as the Indian Service, the Fish and Wildlife Service, the National Park Service, and the Bureau of Reclamation, as well as the War Department, the Department of Agriculture, and the Federal Power Commission should be coordinated, in order to avoid the waste incident to conflicting plans and duplication of effort, and in order to gain the advantages of large-scale, coherent works and operations.

Comparison of estimated costs with repayments and returns computed pursuant to existing legal requirements, and supportable on the experience of operating Federal projects for like purposes, justifies the conclusion that the value of the benefits to be derived from the recommended program will exceed the cost of the project, and warrant the recommendation that the construction of the project as planned be approved.

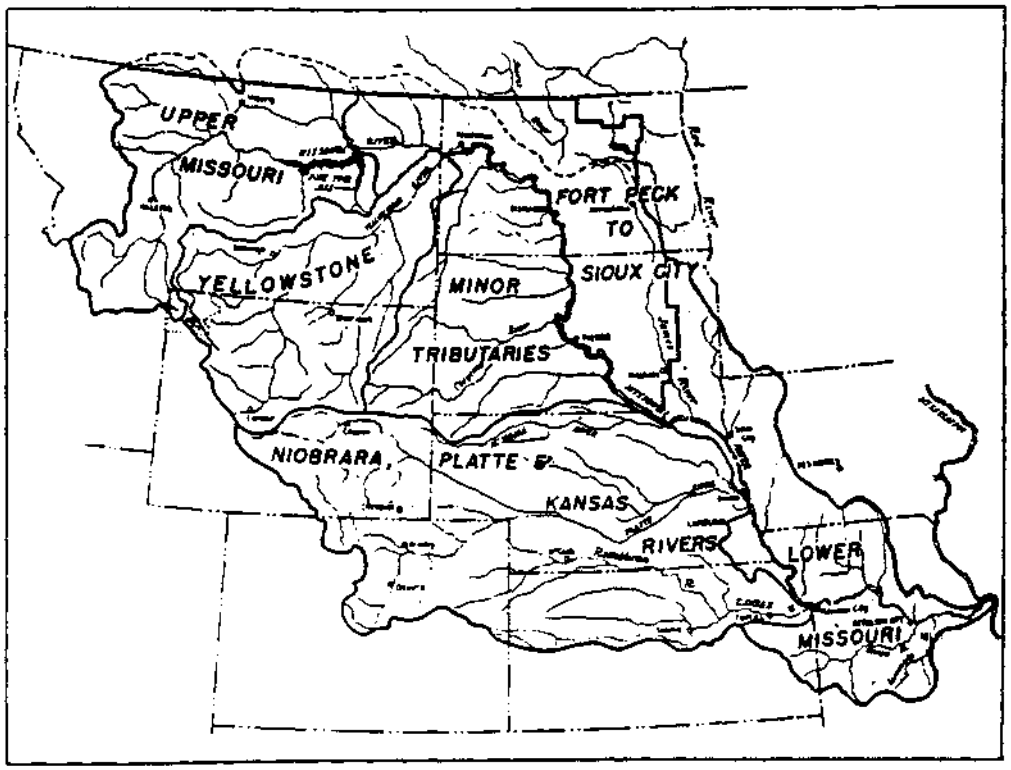
A general statement with respect to the Missouri River Basin and its economic problems, and a comprehensive plan for developing and utilizing its water resources is contained in this report. Supporting data are to be found in the reports and files of the Bureau of Reclamation and the Corps of Engineers.

AUTHORITY FOR THE REPORT

This report, the result of an investigation by the Bureau of Reclamation for the full conservation, control, and use of the water resources of the Missouri River Basin, proposes a comprehensive plan, to those ends, for the approval of the Secretary of the Interior and for submission by him to the Congress.

The report embodies a general discussion and conclusions respecting the engineering feasibility of the plan, and of its several physical features, and of the estimated cost of its construction and operation. also, recommendations as to the allocation of the estimated cost to irrigation, power, navigation, flood control, and other miscellaneous water uses, and estimated repayments and returns to the United States.

Statutory authority for such an investigation and report is found in section 9 of the act of August 4, 1939 (53 Stat. 1187, 43 U. S. C. 485).



DESCRIPTION, PRESENT DEVELOPMENT, PLANS FOR THE FUTURE

As a matter of convenience in description and discussion, the Missouri River Basin has been divided into six subdivisions, based on tributary drainage basins or on peculiarities of an area. In this section of the report, each subdivision is covered by a general description of the area, a statement with respect to economic developments, and an explanation of water-use developments proposed. A tabular summary of proposed works—reservoirs, irrigation units, power plants, and miscellaneous water uses—is given for each area. Power is treated on a basin-wide basis, in a succeeding section.

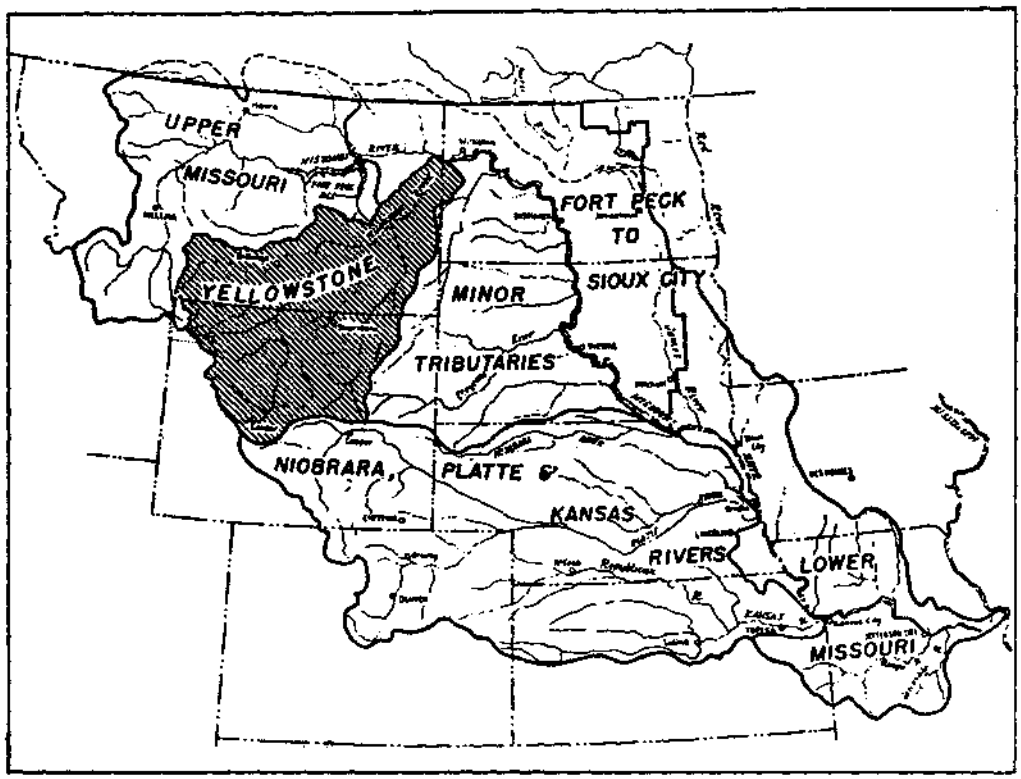
The basin subdivisions are best understood by studying the simplified basin maps which appear in many places with the text.

Yellowstone River Basin

FOREWORD

The Yellowstone River is an interstate stream draining portions of Montana, Wyoming, and North Dakota. The chief economic resources of the Yellowstone Basin are irrigated agriculture and its associated livestock industry. The development of 1,156,900 acres of irrigated land in the basin has created the greater part of the present total assessed valuation of about $322,000,000. Farming without irrigation yields only meager results because of low and variable rainfall.

An additional area of about 728,000 acres can be brought under irrigation in the future, and supplemental water can be supplied to



327,000 acres of land now irrigated. Plans for the development of water supplies for these lands are increasingly a source of concern and of possible dispute among the three States which include parts of the Yellowstone River Basin. Each seeks to protect the water now supplied for its irrigated areas and to establish rights to the water which will be necessary to develop its irrigable areas. The major contention, at present, relates to the basin of the Big Horn River, largest tributary of Yellowstone River, where it has been asserted that expanding irrigation developments in Wyoming have been responsible for reported water shortages along the Big Horn River in Montana.

Under present conditions, there is a large surplus of water, but its distribution is not suited to the requirements for maximum irrigation and power use.

The Yellowstone River and its tributaries, particularly the Big Horn River, are heavy silt carriers, contributing about 25,000 acre-feet of silt per year to the Missouri River. Considerable excess storage space must be provided in some reservoirs to prevent too rapid depletion of their effective capacities by silting.

Power developments within the Yellowstone Basin are far from adequate to supply present power demands. Deficiencies are supplied mainly by the Missouri River plants of the Montana Power Co. In the near future power from the Fort Peck Dam will be available to the lower part of the basin.

GENERAL DESCRIPTION

Physical features.—The Yellowstone River, most productive tributary of the Missouri River, drains southeast Montana and north central Wyoming. The length of its basin is about 440 miles, and the maximum width is 320 miles. The average annual discharge at the mouth of the river, during the 10-year period, 1931–40, was 6,870,000 acre-feet, compared with an average of 5,000,000 acre-feet from the Missouri River above the mouth of the Yellowstone.

The Yellowstone River and all of its principal tributaries rise in and receive most of their water from the Absaroka, Wind River, and Big Horn Mountains. A large part of the low-altitude area in the northeastern portion of the basin yields no perennial run-off.

Lakes are abundant in the upper part of the basin, but only one, Yellowstone Lake, is of notable size. It has an area of 142 square miles, and provides a considerable amount of natural regulation. Other important bodies of water in the basin are Lake De Smet, and the Shoshone, Bull Lake, Pilot Butte, Sunshine, and Tongue River Reservoirs.

Elevations in the basin range from 1,860 feet, at the mouth of the Yellowstone River, to a maximum of 13,785 feet at Gannet Peak, in the Wind River Range. Nearly half the area lies below elevation 4,000, with the remainder rising rapidly to elevations of 11,000 to 13,000, in the mountain ranges.

The Yellowstone River, after leaving Yellowstone National Park at Gardiner, Mont., flows in a steep, winding gorge for about 21 miles, emerging into a broad flat valley between high mountains. Near Livingston, Mont., the river cuts through a limestone ridge, forming a short but precipitous canyon. From Livingston to Columbus, Mont., the valley never reaches a width greater than about 1 mile, and is bordered by sandstone bluffs, generally gravel-capped, that stand 200 to 400 feet above the valley floor. North of the river, these bluffs are part of a series of tablelands, broken by steep escarpments that form the divide between the Musselshell River and the Yellowstone River. Southward, the bluffs blend smoothly into the stream terraces and foothills of the Absaroka Mountains.

Near Columbus the valley widens to a maximum of about 7 miles, and the mountains recede to the south, leaving the river bordered by the eroded and broken uplands of the central plains. The effects of erosion increase in prominence toward the mouth of the river, and east of Miles City, Mont., there are large areas of exposed shales and soft sandstone that have become typical badlands. These areas are maked by scanty vegetation. Infrequent but heavy rainstorms

move immense quantities of silt from the badlands into the Yellowstone River.

The slope of the river ranges from 2 feet per mile, at the mouth, to 30 feet per mile, near the mountains. The valley floor is generally smooth, with slopes of less than 8 percent. The stream channel is cut about 15 feet deep into the valley sediments, and the river bed is generally on or very close to shale or sandstone bedrock.

The Clarks Fork of the Yellowstone starts at Broadwater Lake, just east of Yellowstone National Park. Throughout its upper reaches, the stream and its many tributaries occupy deep gorges between high, glaciated plateaus and mountain peaks. The river leaves the mountains near Clark, Wyo., and enters a valley distinguished by broad flood plains and high bordering escarpments and terraces. An outstanding feature of the area is the Beartooth Plateau, a flat-topped glaciated mountain mass rising abruptly 3,000 to 4,000 feet above the foothills. The river falls 1,500 feet in a distance of 6 miles, through the deep gorge between this high plateau and the valley floor, thus offering tremendous advantages for power development. The lowland portion of the basin is a broad, smooth plain of sedimentary deposits, sloping northward toward the Yellowstone River. This region has been much eroded by streams, and warped and faulted by geologic forces, so that the present land forms include alluvial streams, terraces, badlands, and dry, desert-like basins.

The Big Horn River, largest tributary of the Yellowstone River, drains an oval-shaped basin between the Wind River Range and the Big Horn Mountains. Its basin is divided topographically into three segments or sub-basins, known in downstream order as the Wind River and Big Horn Basins, in Wyoming, and the Lower Big Horn Basin, in Montana. The three sub-basins are separated by two steep canyons. The basin floors are broad expanses of rolling plains, dissected by numerous deeply eroded valleys and stream courses. Stream slopes are rather uniform, ranging from 4 to 8 feet per mile along the Big Horn River, and from 25 to 30 feet per mile on the tributaries below the foothills. The main stream and its larger tributaries have cut deeply entrenched valleys that contain fertile flood plains up to several miles in width. The Big Horn River channel is 10 to 20 feet deep. Steep terraces, 100 to 200 feet high, separate the flood plains from the higher benchlands of the main basin floors.

The Tongue and Powder Rivers drain the eastern slopes of the Big Horn Mountains, from which they descend in deep, precipitous canyons. A large proportion of their drainage areas is low-altitude plains and badlands, productive of violent damaging floods of little volume. Below the mountains, both streams occupy narrow valleys confined by high bluffs and terraces. The lower flood plains are usually dissected by the meandering streams and the flood channels of intermittent tributaries.

Other tributaries in the western part of the Yellowstone River Basin are the Boulder and Stillwater Rivers, draining parts of the Absaroka Range, and the Shields River, draining a small basin between the Bridger Range and the Crazy Mountains. All are short, swift streams, snow-fed, flowing through deep mountain gorges and narrow valleys with limited flood plain areas.

Land use.—Major land use types in the Yellowstone River Basin are:

	Acres
Irrigated land	1, 156, 900
Arable dry land	3, 100, 000
Privately owned grazing land	16, 300, 000
Taylor Act grazing districts [1]	4, 820, 000
Timbered land	6, 400, 000
Miscellaneous	9, 232, 100
Grazing land in Indian reservations	3, 900, 000
Total	45, 000, 000

[1] Public domain within grazing districts.

The principal crops on irrigated lands are alfalfa, sugar beets, small grains, beans, and mixed hay. The production of beans and beets is largely concentrated in the Yellowstone and Big Horn River Valleys. Alfalfa and mixed and native hay are the principal crops in the higher areas. Most irrigated land provides, as a by-product, either late-season pasture or forage such as beet tops and pulp, and bean straw. Livestock feeding is practiced throughout the area. Minor quantities of flax, potatoes, peas, table vegetables, and berries are produced in certain parts of the basin.

Farming without irrigation is extensive in the Yellowstone River Basin. Rainfall is low and erratic, and undependable for crop production. Growing-season rainfall has varied during the past 40 years from 5 to 10 inches, with an average for the basin of about 7 inches.

The total area of dry farm land in the basin is estimated at about 3,100,000 acres. The area actually cropped varies from year to year according to weather conditions and crop prices. In 1939 crops were harvested from about 900,000 acres of dry farm land, and 2,200,000 acres were fallow, failed to produce a crop, or were used for pasture. The chief crop grown on nonirrigated farms is wheat, with barley, oats, mixed hay, and flax following in about that order. Yields are low and variable. Wheat averages less than 8 bushels per acre, ranging from complete failure to 20 or more bushels per acre.

Under the plan of development presented in this report, an area equal to 23 percent of the arable dry land would ultimately be placed under irrigation. The remainder may continue in its present status, but much of this land should be returned to pasture. Adjustments are constantly being made in the size of farms, the use of marginal lands, and the production of farm livestock. Several Government agencies, including the Farm Security Administration, Soil Conservation Service, Grazing Service, and Agricultural Adjustment Administration are actively sponsoring programs designed to stabilize agriculture. Development of new irrigation projects will aid this objective by providing new opportunities for settlement of the population from distressed areas, and by providing more assured feed to carry foundation stock in periods of drought.

Livestock raising has been a major industry of the Yellowstone River Basin since its earliest settlement. Practically all of the arable land in the basin was once devoted to grazing. During the homestead boom of 1900–1920, much of the grazing land in the central part was plowed and converted to farms, with consequent crowding and overgrazing of the remaining ranges. When drought and depressed prices caused dry farming to become unprofitable, large areas were abandoned to be gradually reseeded to wild grass.

The drought of 1931–36 caused a reduction of about 40 percent in the livestock population of the basin. This was due to depleted ranges and lack of feed reserves. Increased rainfall and better grazing practices have largely restored the ranges, and the livestock losses have been replaced.

About 38 percent of the Yellowstone River Basin is in national parks, forest reserves, Indian reservations, Taylor Act grazing reserves, and unreserved public domain. Timbered lands, including the national forests, embrace about 10,000 square miles, or 14 percent of the Yellowstone River Basin. In addition, much of the plains area, particularly in the northern part of the basin, is covered with a scattered growth of pines. All of the streams are bordered with a dense growth of cottonwood trees, willows, and shrubs.

There are considerable areas of the badlands in the Yellowstone River Basin, particularly in the southern and eastern portions. These areas of soft shale and sandstone are eroded to all manner of rugged outlines, ravines, conical buttes, pinnacles, and gullied escarpments, have scanty vegetation, and are of little agricultural use. They are the source of most of the silt carried by the Big Horn and Yellowstone Rivers.

Ground Water resources.—Development of ground water in the Yellowstone River Basin has been limited to wells for domestic and stock water use, and for the irrigation of small gardens in the dry land farming areas.

The chief source of ground water is the alluvial fill found in nearly all the stream valleys, and on their bordering terraces. The water in this material is derived from nearby surface sources, including seepage from irrigation canals or irrigated land. Its quality is variable, depending on the nature of the material in which it is found. It is generally hard, and contains much dissolved mineral matter, the total concentration varying from less than 500 parts per million to more than 6,000 parts per million. The principal constituents are the sulfates, magnesium, and carbonates of calcium and sodium. The more highly charged waters are found in areas underlain by shale. In certain limited areas, the water is so highly mineralized that it cannot be used for drinking, but is useful for stock water. Shallow wells near cities or industrial areas are subject to contamination from surface wastes, and therefore are not a satisfactory source of domestic water.

Wells driven below bedrock encounter water-bearing strata at depths of from 100 to as much as 4,400 feet. Deep wells are especially abundant in the central and northeastern portion of the basin. Deep drilling has met with little success in the upper Big Horn and Powder River areas. The water obtained from deep wells is soft, but high in dissolved minerals, especially sodium bicarbonate. It is generally usable for domestic or stock water, and is highly important in this respect. Flowing wells are numerous along the Yellowstone River east of Forsyth, and along the lower Powder River and the Tongue River. The necessary depth of wells and the resulting pressure and yield increase toward the northeast, since the aquifers dip in that direction. The average depth of flowing wells in the Yellowstone Valley ranges from about 150 feet at Forsyth to 700 feet at Terry. The yields vary from about 1 to 300 gallons per minute.

A number of flowing wells are located along the northern base of the Pryor Mountains. Wells from 450 to 3,200 feet deep yield up to about 450 gallons per minute. The water is similar in quality to that from deep wells in the northeastern part of the basin.

Another important source of ground water, particularly in the uplands and mountain areas, is springs, which have a rather widespread occurrence. The largest are the hot springs of Yellowstone National Park, which contribute a substantial portion of the flow of the Yellowstone River in its upper reaches. An especially large hot spring is located in the Big Horn Basin at Thermopolis, Wyo. Smaller springs are scattered throughout the basin. While most of them yield good quality water, some are strong with hydrogen sulfide. Ground water in this region is particularly valuable for stock water because of its availability in outlying ranges where surface streams are often dry, and because of its practically uniform temperature, ranging from 47° to 60° F. at different places, depending on the depth of the well. Livestock that has access to ground water during winter feeding periods makes better weight gains than it would with cold surface water. Development of ground water in the future is expected to be chiefly for stock water and domestic uses, with only a very limited use for irrigation.

The use of ground water for industrial purposes is not extensive, nor is it likely to become so. Water from shallow wells is hard, and causes scale in boilers. Deep-well water is frequently so charged with sodium bicarbonate that foaming is excessive. However, water from some wells can be used for steaming, as is the case in the vicinity of Miles City. Surface water will remain the principal source of industrial water supplies.

Municipal water supplies are generally obtained from surface water. Several small communities and nearly all the rural areas, however, depend on wells for domestic water.

Surface water resources—Sources of run-off

Stream	Location	Average annual run-off in acre-feet, 1931–40
Yellowstone River	Yellowstone Lake	783,000
Do	Corwin Springs	1,808,000
Do	Livingston	2,136,000
Do	Billings	3,136,000
Do	Miles City	6,436,000
Do	Sidney (Montana-North Dakota State line)	6,758,000
Do	Mouth of river	6,870,000
Big Horn River	Thermopolis	953,400
Do	Montana-Wyoming State line	2,137,400
Do	Mouth of river	2,457,000
Clarks Fork	Chance (Montana-Wyoming State line)	586,500
Do	Mouth of river	741,200
Powder River	Arvada	187,600
Do	Moorhead (Montana-Wyoming State line)	277,600
Do	Mouth of river	310,000
Boulder River	do	385,300
Stillwater River	do	464,700
Shields River	do	82,600
Tongue River	Decker (Montana-Wyoming State line)	239,500
Do	Mouth of river	214,200

Stream flow in the Yellowstone River Basin is characteristically high in the spring and early summer when the mountain snow is melting, decreasing to low base flows during the summer and winter. About 60 percent of the total annual run-off of the Yellowstone River occurs during the months of May, June, and July, making storage imperative for its utilization. With proper regulation, the water supply is adequate, with a very few minor exceptions, to provide a full irrigation supply for all irrigated and irrigable lands in the basin, as well as to produce large amounts of continuous firm power during such a period of drought as existed during the past decade, and, in addition, to yield substantial quantities of water and power for use outside the basin.

Quality of surface waters.—The surface water of the Yellowstone River Basin carries considerable quantities of dissolved minerals, and in certain streams, large amounts of suspended silt. The minerals are chiefly carbonates, sulphates, and bicarbonate of sodium, calcium, and magnesium, with carbonates predominating. The total concentration of dissolved minerals in the Yellowstone River at Billings averages about 300 parts per million. In the lower part of the river, at low water, this may be as much as 1,000 to 1,200 parts per million.

This water has been used for irrigation for nearly 60 years without serious soil deterioration. However, it is necessary that drainage systems be adequate to dispose of excess irrigation water. Otherwise, continued evaporation of the water from soil surfaces will deposit concentrations of salt. This has occurred in several large areas along the Yellowstone and Big Horn Rivers. Reasonable use of water, with adequate drainage, will prevent such accumulation on future projects, and no serious difficulty is anticipated from this source.

Measurements by the Corps of Engineers, United States Army, from September 1929 to November 1931, indicated that the Yellowstone River carried 55,711,200 tons of silt at Glendive, Mont., which is about 70 miles above the mouth of the river, and below 95 percent of its total drainage area. This is equivalent to about 25,000 acre-feet of silt per year, and was 93 percent of the silt carried by the Missouri River at Williston, 37 miles below the mouth of the Yellowstone River, and 23.7 percent of the silt content of the Missouri River at Kansas City. Measurements made during 1930 indicated that about 51 percent of the Yellowstone River silt came from the Big Horn River. The silt content of the streams varies widely from month to month. Other sources of silt in the Yellowstone River Basin are the Lower Tongue River and the Powder River, and to a lesser extent, the Clarks Fork River. Storm run-off from intermittent minor tributaries also contributes considerable silt.

The silt is very fine, with large contents of colloidal material. It hampers irrigation by filling ditches and control structures. When spread on the land, it reduces the aeration and permeability of the soil, and makes tillage more difficult. Entering municipal water works, it increases the cost of water clarification and clogs the intake works.

The only effective solution of the silt problem appears to be storage on the major contributing streams, particularly the Big Horn River.

Climate.—The Yellowstone River Basin has the rather rigorous climate which is characteristic of the Northern Great Plains. The growing season is relatively short, with a large proportion of sunny days and cool nights. Occasional late spring or early fall frosts damage the

less hardy crops, particularly beans. Frequent summer storms occur, occasionally of cloudburst intensity, and there is some damage to crops by hail. Winters are usually severe, with low temperatures and considerable snowfall. Winds of high velocity are common in the fall and spring. Weather records at representative stations in the basin are summarized in the following table:

Items	Glendive	Billings	Riverton	Cody	Sheridan
Number of years of record	52	57	26	32	38
Mean annual temperature, degrees	44.0	46.7	44.0	45.2	43.1
Minimum temperature, degrees	−50	−49	−46	−40	−45
Maximum temperature, degrees	117	112	101	105	106
Average annual precipitation, inches	14.62	13.13	9.61	8.97	15.31
Average annual precipitation, 1931–40, inches	11.74	12.73	8.47	8.66	14.33
Average May–September precipitation, 1931–40, inches	7.64	7.31	4.85	5.54	7.23
Average snowfall, 1931–40, inches	30.1	41.3	35.5	35.0	49.2
Average number of days between killing frosts	134	134	132	127	130

Soils.—Preliminary examination of the soils of the Yellowstone River Basin has resulted in their classification, on the basis of physiographic features, into four groups as follows: (1) Soils of the valley bottoms; (2) soils of the valley benches and terraces; (3) soils of the bordering slopes and uplands; and (4) miscellaneous soils and land types. The valley bottom soils, deposited by flowing water, are highly irregular, varying in texture from clay to sandy loam. They are generally fertile and well-drained. Much of the present irrigated land in the Yellowstone River Basin includes this soil group.

The second soils group occupies the terraces and benches bordering the stream valleys, rising 25 to 200 feet above the valley floors. They, also, are alluvial soils, but more mature and uniform than those of the valley bottoms. They are fertile, medium textured, and commonly friable and free-working. Under proper management, with an adequate water supply, they are capable of sustaining production of all of the crops grown in this region.

The last two soils groups named above are not generally irrigable. Because of rough topography, thin soil, or isolated positions with respect to an adequate water supply, their agricultural usefulness is limited to dry land farming or grazing.

The soils of the Yellowstone River Basin have developed under semiarid climatic conditions, which results in the formation of little organic material and the retention of a large proportion of soluble mineral salts. The successful irrigation of such soils therefore requires adequate drainage, natural or artificial, to assure removal of excess water that might otherwise be evaporated from the soil surface and leave a concentration of salts. Needed fertilization is generally limited to supplemental nitrogen and phosphate, in both of which the soils are deficient. The amounts of each needed depend on the crops grown. Deficiency of phosphorus in Yellowstone Basin soils causes the so-called phosphorous disease in range livestock. It is successfully controlled by feeding bonemeal, or salt containing phosphates.

Certain residual soils developed from shale contain sufficient selenium to produce injurious effects in livestock. The affected areas are limited in extent.

Markets and transportation.—Trading and shipping centers are well distributed throughout the agricultural areas of the basin, providing convenient outlets for crops and livestock.

Facilities for local processing of crops include beet sugar factories at Billings, Sidney, Sheridan, Hardin, Lovell, and Worland; canneries at Powell, Red Lodge, and Billings; numerous grain elevators, creameries, breweries, and a few cheese plants. Establishments for processing livestock and dairy products are inadequate to supply local consumption. The principal agricultural exports are livestock, wool, grain, sugar, and beans. Livestock—mostly feeder cattle and lambs go chiefly to the middlewest. Wool is shipped to Boston and other eastern areas, and grain and beans are marketed in the Chicago-Minneapolis region. Sugar is more widely distributed, through several large factory groups. Irrigation expansion, and more intensive farming, will bring more finish-feeding of livestock, and increased dairy production, which, with increasing local demands, will foster a relatively larger local processing of crops and animal products.

The Northern Pacific, Great Northern, Burlington, Milwaukee, and Northwestern railroads provide outlets in all directions, and a network of Federal and State highways and county roads provide good farm-to-market routes.

The important highway routes are paved, and are maintained for year-round travel. Some of the roads over mountain passes are closed during the winter, as are some secondary roads in remote areas. Drifting snow interferes considerably with highway travel during the winter.

Population and industries.—Total population of the Yellowstone River Basin in 1940 was 212,260, including 92,713 in communities with a population of 1,000 and over. The largest rural settlements are along the Yellowstone, Big Horn, and Clarks Fork Rivers, and on the upper Powder and Tongue Rivers. The uplands and mountain areas are very sparsely settled. The Yellowstone Basin include 23 percent of the total population of Montana, 33 percent of that of Wyoming, and 0.2 percent of that of North Dakota.

Farming and livestock raising are the principal industries in the basin, employing, in 1940, 34 percent of the total working population. The value of crops and livestock produced in 1939 was about $46,000,000. Mining and petroleum products in the same year had a total value of $11,860,000. Wholesale trade totaled $43,000,000, retail trade $80,000,000.

Industries other than those related to agriculture include oil refining, railroad, equipment repairing, brick making, small scale lumbering, coal mining, and the production of relatively small quantities of metals. By far the larger part of the population is supported directly or indirectly by agricultural production, processing, and marketing.

The present distribution of activities is expected to continue, with increasing agricultural activities matched by increasing employment in the production and processing of metals and minerals.

Minerals.—Mineral production of the basin includes coal, oil, natural gas, gypsum, bentonite, kaolin, various types of building stone, sulphur, and phosphate. Coal is the most widely distributed, being produced in commercial quantities in several districts in the central

and southern parts of the basin. It is of bituminous and sub-bituminous grades. A large open-pit mine is operated at Colstrip, Mont., by the Northern Pacific Railway Company. The other principal districts now in production are at Sheridan, Red Lodge, and the Gebo district, near Worland. The total coal production in the basin in 1940 was 2,240,000 tons. This was 28 percent of the total coal produced in Montana and Wyoming. A part is exported to other midwestern States.

There are a number of oil and gas fields in the basin. Their total production in 1940 was 9,800,000 barrels of oil and 23,000,000,000 cubic feet of gas. The largest fields are the Salt Creek oil and gas field in central Wyoming, the Baker gas field in eastern Montana, the Elk Basin and Oregon Basin oil and gas fields in northwestern Wyoming, and the Dry Creek oil and gas fields in northwestern, Wyoming. Oil is refined at Billings, Laurel, Cody, Lovell, Greybull and Thermopolis. Pipe lines from the Elk Creek field to Casper and Billings are now under construction. The output of the Salt Creek field is refined at Casper, Wyoming. "Black" oil, found in large quantities in the Big Horn basin, has found little use so far, but may be expected to be utilized in greater degree with approaching exhaustion of the lighter oils. Natural gas is piped from the Elk Basin and Dry Creek fields to Billings, and as far west as Bozeman, Montana. The Baker field serves all the towns from Miles City, Montana, to Bismarck and Williston, North Dakota, and Rapid City, South Dakota. Nearly all the towns in the Wyoming portion of the basin are served by pipe lines, and a line from Salt Creek extends into Nebraska. Proposals have been made to extend pipe lines from the Baker field to Minneapolis (620 miles), St. Paul (630 miles), and Duluth (668 miles), but no immediate accomplishment of such projects is in prospect.

Present industrial utilization of other non-metallic minerals is limited to the manufacture of building plaster from gypsum deposits, production of bentonite, and the quarrying of rock and gravel for local building, railroad ballast, and road surfacing.

Metallic minerals occurring in the mountains include gold, chromite, copper, tungsten, silver, iron, zinc, lead, molybdenum, nickel, and platinum. The most important of these at present is chromite, which occurs in lenticular deposits along the north face of the Beartooth Plateau, between the Clarks Fork and Boulder Rivers. The existence of chromite in this area has long been known. It is of low grade, and it was not until the overseas sources formerly utilized were made inaccessible by war, that extensive development was undertaken. A war expenditure of $14,000,000 has been made to develop the chromite deposits, only to have the entire works shut down after shipment of chromite ore from North Africa was resumed. The chromite ore is complex, and can be mechanically concentrated to only 41 to 45 percent, Cr_2O_3. Its use in the steel industry, according to available reports, is generally satisfactory, the chief disadvantages for competition with foreign ores being its lower Cr_2O_3 content and the high freight costs of delivery to consumers.

Production of other metals is limited to gold and copper. Several gold mines and a copper mine are operated near Cooke, Mont., and placer gold is being dredged near Livingston. The other metals listed above occur as traces or are insufficiently prospected to disclose commercial quantities.

Fish and wildlife.—The many tributaries of the upper reaches of the Yellowstone are supplied with clear cold waters arising from the melting of the snows of the humid mountain areas. The streams carry little or no silt or mud, for the run-off they receive is from slopes well clad with vegetation. They provide an ideal environment for trout. After these tributaries have traversed the less humid areas they enter semi-arid areas, along the lower reaches of the streams where they receive the run-off of storm waters from barren or sparsely vegetated slopes. Here rapid silting-up of the streams occurs and the environment becomes suitable for only coarse fish. The creation of numerous storage reservoirs, which reduce floods and catch silt, will result in not only the marked clarification of waters near the reservoirs, but in clarifying influences that will reach far downstream.

The plans proposed for the use of the waters of the Yellowstone recognize that flooded areas should be cleared before water is impounded, and that in the case of fish-stocked reservoirs subject to draw-down, provision should be made to prevent the stranding of fish during such draw-down periods. The plan also recognizes the necessity for proper screening at points where waters populated with fish are diverted into irrigation ditches, and provides that in the case of streams containing migratory fish, provision should be made for upstream passage over dams, where possible.

The lower course of the Yellowstone, receiving run-off from so large an upland semiarid area, will obviously not be changed materially from the point of view of the environment it provides for fish, inasmuch as much silt and mud will still reach it.

The general improvement in the productivity of irrigated areas, combined with a growing understanding that a small area on every farm may be dedicated to the propagation of wildlife, will provide winter cover and food for much upland game fowl and small game, now entirely dependent upon the hazards of nature. Many fur-bearing animals, especially the smaller species, will find a congenial environment near ditches, canals and impounded waters.

In the case of the larger reservoirs in the Yellowstone Basin, and in the basins of the other subdivisions, a lake-type of wildlife can be introduced and maintained, thus introducing diversity into the Basin. Problems of management will be changed; the necessity for the continued practice of sound conservation principles is fully recognized.

Recreational features.—The principal recreational area in this region is Yellowstone National Park. Yellowstone River—below Yellowstone Lake—drops a total of 417 feet in two abrupt and spectacular waterfalls, after which it flows for 15 miles through the Grand Canyon of the Yellowstone, a gorge 1,000 feet deep, cut in multicolored, volcanic rocks. Hundreds of active hot springs and geysers in Yellowstone National Park, of which the best known is Old Faithful, erupting intensely hot water to a height of 140 feet at about 60-minute intervals, make this an internationally well-known playground. About 500,000 persons visited the Park in 1940, coming from every State in the Union. The park is surrounded by national forests and primitive areas, in and adjacent to which are located many resorts, "dude ranches," and summer colonies that attract a large tourist trade. Catering to this trade is one of the major industries in the basin, the effects of which reach for long distances along the routes of travel the park. During the summer season, the railroads run special trai

and special air line and bus services facilitate tourist travel. The highways of Montana and Wyoming carry thousands of private touring automobiles.

Other important areas of interest to tourists are: Shoshone Cavern, near Cody, the Indian Reservations with their annual tribal ceremonials, and the badlands in the eastern portion of the basin. Fishing and hunting are almost year-round activities. Big game abounds in all the mountain areas, and game birds are plentiful in lowlands. Local parks and recreational areas are found in nearly every town in the basin.

PRESENT DEVELOPMENT OF WATER RESOURCES

General.—Water resources of the Yellowstone River Basin are now used chiefly for irrigation, with important but less extensive uses for power generation and municipal water supply. The combined output of all types of power plants in the basin is considerably less than the current demand for power. Large amounts of power are imported from other basins, chiefly the upper Missouri River. The use of power for irrigation purposes is limited because of high power costs and relatively low crop values.

Settlement in the basin began in 1807 with the establishment of a trading post at the mouth of the Big Horn River. For many years trapping and hunting were the sole occupations of the few white men in the basin.

Agriculture in the basin began with the establishment of the great cattle ranches about 1870. Between 1870 and 1890, hundreds of thousands of head of cattle were trailed northward from Texas to Wyoming and Montana. This was the era of the open range, which served to establish the livestock industry in the Yellowstone Basin. The first railroad, the Northern Pacific, was completed in 1882, and with it and the other rail lines that followed came a rising influx of settlers that continued until 1917. During this time, great portions of the arable range lands were taken up under the Homestead laws, and farmers began to crowd out the cattlemen. Dry land farming was expanded from 1906 to 1920, under conditions of high rainfall and high prices. Drought caused repeated failures, and dry land farming declined. Large areas were abandoned, and whole communities depopulated. Much of this abandoned land is now being returned to grazing use, for which it is best adapted.

Irrigation in the Yellowstone Basin began in the late 1860's, near Lander and Billings, and gradually increased as settlement progressed. This early irrigation was chiefly for the production of livestock feed. The greatest expansion of irrigation took place between 1900 and 1920, during which period nearly all of the existing projects were developed. More than a million acres of land are now under irrigation in the Yellowstone River Basin.

At present, agriculture in the Yellowstone River Basin is centered about irrigation farming and livestock production, with dry land farming of minor and diminishing importance. This results in a higher degree of economic stability than has heretofore been attained in this region.

Yellowstone River.—Irrigation projects on the main stem of the Yellowstone River contain a total irrigable area of 310,200 acres, of

which 236,500 acres were irrigated in 1940. These are distributed as follows:

Location	Irrigated in 1940	Additional irrigable land under existing works	Total
Montana:			
Yellowstone Park to Miles City	181,200	27,000	208,200
Miles City to State Line	40,000	41,300	81,300
Subtotal	221,200	68,300	289,500
North Dakota	15,300	5,400	20,700
Grand total	236,500	73,700	310,200

Between Yellowstone Park and Miles City, two projects of 10,000 and 3,000 acres have been constructed by the Montana State Water Conservation Board, one of 1,100 acres by the Department of Agriculture for the Fort Keogh range experiment station, and the Huntley project of 30,000 acres by the Bureau of Reclamation. All others have been constructed with private capital.

A project of 3,500 acres, called the Lockwood project, adjoining the city limits of Billings, pumps its water supply from the Yellowstone River in two lifts of 60 and 100 feet, and the Fort Keogh project near Miles City pumps its water supply through a 50-foot lift. All others are gravity ditches, diverting water from the river by low diversion dams or single head gates. No storage has been provided, and no serious shortages have been experienced.

Over one-half the total irrigated area along the main stream is within 30 miles of Billings. That area has become the most highly productive and diversified area in the Yellowstone Basin. No long-time records of production are available on the irrigated area, except for the Huntley project, which was constructed by the Bureau of Reclamation. During the period 1928 to 1943 inclusive, the average annual cash value of crops, exclusive of livestock and livestock products, was $35.40 per acre.

Between Miles City and the mouth of the river there are six projects in operation as follows, none of which has been built with private capital:

Approximate total irrigable area

Name	*Acres*
Kinsey	7,200
Buffalo Rapids:	
Division 1	18,000
Division 2	13,600
Lower Yellowstone	[1] 57,200
Sidney	5,300
Sioux	[1] 700
Total	102,000

[1] All of the Sioux and 19,900 acres of the Lower Yellowstone project are in North Dakota.

The Lower Yellowstone project was constructed by the Bureau of Reclamation in 1906. This is the only gravity project in the group, and until 1937 was the only irrigated area below Miles City. All others are pumping projects.

Although water has been available for practically all of the lower Yellowstone project since 1910, much of the land was dry-farmed until 1932, and crop values were always low The area dry-farmed continued to decrease as subnormal rainfall occurred until, in 1935 and ever since, no land has been dry-farmed. In the meantime, the irrigated area was expanded. The average crop values by 5-year periods from 1928 to date, are as follows:

Period:	*Crop value per acre*	Period—Continued.	*Crop value per acre*
1928–32	$28. 02	1935–42	39. 03
1933–37	34. 25	1943	59. 29

Construction of the Buffalo Rapids project was begun in 1937 by the Bureau of Reclamation. The first two divisions are now in operation, under the Farm Security Administration.

The Kinsey project was constructed by the Farm Security Administration in 1937, the Sidney project by the Montana State Water Conservation Board in 1938, and the Sioux project by the North Dakota State Water Conservation Commission in 1939.

Clarks Fork Basin.—Irrigation development in the Clarks Fork Basin now totals 132,000 acres, of which 11,360 acres are in Wyoming and 120,640 acres are in Montana.

All of the 42,100 acres irrigated from the Clarks Fork River are served by many small privately constructed ditches and canals, diverting by gravity, and utilizing simple structures of low maintenance cost. There is no shortage of water for present irrigation.

The area irrigated from tributary streams, also, is served by small private and cooperative ditches. The water supply is generally ample except on Thiel, Hogan, and Cole Creeks, which experience severe shortages. Supplemental water is furnished to lands along Rock Creek from Glacier Lake and Cooney Reservoirs, which were constructed in 1937 by the Montana State Water Conservation Board. The combined capacity of the two reservoirs, 31,700 acre-feet, is ample to meet nearly all the supplemental water requirements of the lands along Rock Creek.

Part of the area irrigated in the basin of Red Lodge Creek, a tributary of Clark Fork, obtains water from East Rosebud Creek, a tributary of the Stillwater River.

Big Horn River Basin.—The Big Horn River Basin is topographically divided into three sub-basins, called in downstream order the Wind River Basin, the Big Horn Basin, and the Lower Big Horn Basin. The area under developed projects in each sub-basin is as follows:

Name	State	Area irrigated in 1940 (acres)	Additional irrigable land under existing system (acres)	Total
Wind River Basin	Wyoming	110,900	99,900	210,800
Big Horn Basin	do	263,600	89,300	352,900
Lower Big Horn Basin	do	8,700	0	8,700
Subtotal		383,200	189,200	572,400
	Montana	79,300	12,000	91,300
Total		462,500	201,200	663,700

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Wind River Basin—Irrigated and potentially irrigable lands under existing projects
(acres)

Stream	Irrigated in 1940	New land under existing works [1]	Ultimate area under existing projects
Wind River	68,600	80,700	[2] 149,300
Little Wind River and tributaries	17,500	16,500	34,000
Popo Agie River, main stream	1,800	600	2,400
Little Popo Agie River	2,700	0	2,700
Middle Fork Popo Agie River	7,100	100	7,200
North Fork Popo Agie River	5,100	100	5,200
Baldwin Creek	1,400	100	1,400
Squaw Creek	900	0	900
Willow Creek	2,100	0	2,100
Beaver Creek	900	300	1,200
Badwater Creek	1,100	1,600	2,700
Big Horn River [3]	1,700	0	1,700
Total	110,900	99,900	210,800

[1] Includes minor areas of land previously irrigated.
[2] Includes 65,300 acres of irrigable land under the Riverton project, authorized for construction but for which distribution system has not been built.
[3] Above Thermopolis.

Probably the first irrigation works in the Big Horn River Basin were those constructed along the Popo Agie River, in the vicinity of Lander, by pioneers, in the late sixties. Private developments progressed steadily until 1920, when all present systems were completed. The ditches are numerous, but are generally relatively small. The Wyoming No. 2 canal, largest private project, was built in 1906. It serves an irrigable area of about 12,000 acres.

Government construction within the Shoshone Indian Reservation, which was established in 1868, began in 1873, in the vicinity of Fort Washakie, but progress on irrigation systems for the Indians during the ensuing 30 years was slow. In 1904, all of the area outside the present reservation boundaries was ceded to the United States. With the money received from the sale of these lands, more extensive developments were undertaken within the diminished reservation. Five units are now in operation, comprising an ultimate irrigable area of about 50,000 acres.

Construction on the Riverton project was begun in 1920 by the Bureau of Reclamation. It is the largest single project in the Wind River Basin. Most of the irrigable land south of Five Mile Creek is now under irrigation, amounting to about 35,000 acres. A concrete diversion dam on Wind River, about 35 miles upstream from Riverton, diverts water into the Wyoming Canal. The Bull Lake and Pilot Butte Reservoirs provide a total storage capacity of 182,000 acre-feet. Incidental electric power is produced at the Pilot Butte power plant.

Second in importance in this sub-basin are the Office of Indian Affairs projects, which, when fully developed, will include about one-fourth the aggregate area, roughly equal to that of private enterprises. The latter comprise more than 100 ditches and canals, serving areas of 20 to 13,000 acres (ultimate irrigable), and averaging about 500 acres. Private enterprises and Indian Service lands depend almost entirely on direct-flow diversions from the streams.

The Big Horn Basin, central sub-basin of the Big Horn River, will have an area of 352,900 acres irrigated under existing projects, when fully developed.

Big Horn Basin.—Irrigated and irrigable lands under existing projects (acres)

Stream	Irrigated in 1940	New land under existing works [1]	Ultimate area under existing projects
Shoshone River	125,000	[2] 69,000	[2] 194,000
Greybull River	40,000	13,000	53,000
Gooseberry Creek	2,800	2,400	5,200
Cottonwood Creek	6,400	0	6,400
Owl Creek	[3] 9,700	300	10,000
Nowood Creek	15,900	1,400	17,300
Shell Creek	12,800	1,600	14,400
Big Horn River	51,000	1,600	52,600
Total	263,600	89,300	352,900

[1] Includes small areas of land previously irrigated.
[2] Includes 41,000 acres of irrigable land under the Heart Mountain division of the Shoshone project.
[3] 16,300 acres dependent on Owl Creek have been irrigated in some years.

Irrigation development in this basin first began with small private projects along Owl Creek, about 1880, and was well under way on all streams by 1890. Larger developments, under the Carey Act, began about 1900, and were continued to include nine such projects, of which three are along the Big Horn River, one on Shell Creek, four on the Shoshone River, and one on the Greybull River. They range in size from 4,000 to 20,000 acres, and embrace a total of about 117,000 acres. Most private developments were completed about 1920.

Present irrigation in the Big Horn Basin may be roughly divided into three general categories with respect to location; developments along the Shoshone River, along other tributaries, and along the main stream.

Shoshone River developments consist of the Shoshone project and several private projects scattered along the river, both above and below that project, with largest areas in the vicinities of Cody and Lovell. There have been no water shortages on this stream. The Shoshone project is one of the oldest developments of the Bureau of Reclamation. Shoshone reservoir provides storage regulation of the Shoshone River for project use and for power production. Water was first delivered to irrigable lands of the Garland division in 1908, and the reservoir was completed in 1910. The project now has four divisions in operation, with areas as follows:

Area in acres

Division	Irrigated	Additional irrigable land	Total
Garland	33,470	8,430	41,900
Frannie	13,780	6,220	20,000
Willwood	10,450	1,350	11,800
Heart Mountain	1,200	39,800	41,000
Total	58,900	55,800	114,700

The Garland and Frannie divisions, north of the Shoshone River, are served by the Garland canal, which diverts from the river at the Corbett Dam. The Willwood division, on the south side of the river, opened for settlement in 1927, is served by the Willwood canal,

which heads at the Willwood Dam. Irrigation deliveries started in 1943 on the Heart Mountain division, which is north of the Shoshone River, between the Shoshone Reservoir and the Garland division. It is supplied by means of a 3-mile tunnel under Cedar Mountain, and a large pipe line across the river.

Developments on other Big Horn River tributaries embrace scattered areas or narrow strips in the stream valleys. Projects range in size from small tracts of a few acres to as much as 20,000 acres. Practically all of these areas depend on direct-flow diversions, but some storage has been undertaken. Although most existing projects are in a position to serve additional areas of suitable land, their primary need is for supplemental water for late-season use. During the past decade severe shortages have occurred on the Greybull River and on Gooseberry, Cottonwood, and Owl Creeks, causing abandonment of many farms. Shortages were also reported in the Nowood and Shell Creek watersheds.

Big Horn River main stream projects depend entirely on diversions from direct flow. All projects are developed to include practically all possible areas of suitable land. Reported serious water shortages on lands irrigated were analyzed by comparing stream flow records at Thermopolis with estimated daily irrigation requirements for the 48,500 acres irrigated in 1940, allowing a peak rate of demand of one second-foot of water for each 55 acres throughout the month of July.

Big Horn River—Irrigation water shortages—Thermopolis to Kane (acre-feet)

Month and year	1931	1933	1934	1935	1936	1937	1939	1940
June			730					1,520
July	2,130		13,700				4,750	10,300
August		650	3,080	1,540	220	2,690	410	[1] 2,930
Total	2,130	650	17,510	1,540	220	2,690	5,160	14,750

[1] Amount purchased from Bull Lake Reservoir.

The lowest run-off during the period 1931 to 1940, inclusive, occurred in 1934. It was probably the lowest in more than 50 years. The shortage shown above for August of 1940 is the amount purchased to supply the Lucerne pumping plant of the Owl Creek irrigation district, which has the latest priority. In addition, two ditches with late priorities, on Wind River, purchased a total of about 10,000 acre-feet of water from Bull Lake Reservoir. It is concluded that, under present conditions, storage developments are not seriously needed for any lands now irrigated from the main stream, but additional storage will be required for future increases in irrigated acreage in the Wind River and Big Horn Basins.

Lower Big Horn Basin—Irrigated and potentially irrigable lands under existing projects (acres)

Stream	Irrigated in 1940	New land under existing works	Ultimate area under existing projects
Big Horn River	51,100	10,400	61,500
Little Horn River	35,100	1,600	36,700
Soap Creek	1,800	0	1,800
Total	88,000	12,000	100,000

Irrigation in this subbasin was pioneered by the Office of Indian Affairs with the construction of the Reno ditch on the Little Horn River in 1885. By 1925, that agency had completed six additional canals on the Little Horn River, the seven projects covering an ultimate irrigable area of about 70,000 acres. Reduction in the size of the Crow Indian Reservation, 1890 to 1904, caused a considerable amount of irrigated land to pass into private ownership. A few small private ditches have also been constructed within the reservation.

Big Horn River water is used to supply the Big Horn canal (built by the Office of Indian Affairs), the Two Leggins canal, and three small private ditches. The first two canals serve about 80 percent of the irrigated land supplied by the river in this subbasin. The Two Leggins canal is owned by private interests, but Indian lands thereunder are supplied under contract. Serious shortages have been reported on the Big Horn River during the past drought period, caused chiefly by inadequate diversion facilities.

About 8,700 acres of the land irrigated in the Little Horn Basin, from tributaries of Pass Creek, are in Wyoming. The Willow Creek Reservoir, which provides storage for Lodge Grass Creek, was recently constructed by the Office of Indian Affairs to relieve shortages on lands irrigated from that stream and from the lower reaches of the Little Horn River. This is the only existing reservoir of consequence in the Lower Big Horn Basin.

Natural flows of Soap Creek, a minor tributary of the Big Horn River, entering immediately below the Big Horn Canyon, are diverted by a canal near its mouth to serve 1,800 acres of land above the Big Horn Indian canal. These lands suffered serious shortages during the drought period.

PLAN FOR FUTURE DEVELOPMENT

Yellowstone River.—Proposed irrigation projects along the Yellowstone River are, without exception, located on flood plains or on terraces rising 25 to 300 feet above the present river level. They are scattered along the valley in small units, separated by long stretches of rugged uplands. The river is entrenched in a cut-bank channel about 15 to 20 feet deep, and is usually bordered by a wide flood plain. All of the arable bottomland is already developed. Most of it is irrigated by gravity ditches, a few of which divert water by means of low overflow dams. The river has an annual fluctuation of about 12 feet, and canals without diversion dams sometimes experience difficulty in diverting sufficient water during low river stages. Construction of diversion dams on the Yellowstone River is expensive, and is justified only when a large acreage is to be served. The few potential projects that could utilize diversion dams are too small to warrant such structures. Long high-line canals serving several units are impossible because of the different elevations of the irrigable land and the roughness of intervening terrain. The most practicable irrigation plan is a series of individual pumping plants, lifting water directly from the river, without the use of diversion structures.

Electric power is not now available at the low rates necessary for irrigation pumping. High-voltage transmission lines traverse the Yellowstone Valley, except from Billings to Forsyth, this 110-mile section of the valley now being served only by low-capacity domestic

lines. The western part of the valley is served by the Montana Power Co., and the eastern part by the Montana-Dakota Utilities Co. Existing pumping projects purchase power from these companies at rates of 4 to 6 mills per kilowatt-hour. Such power purchases will be eliminated under the plans for the utilization of power to be generated at Fort Peck Dam, which include Federal transmission of power to serve all of the Yellowstone Valley below Forsyth, Mont.

Pumping power for the valley west of Forsyth will depend on the Tongue River and Big Horn River power plants, which are proposed as part of the future development plan for those basins. The date of their construction cannot now be foretold.

Proposed projects along Yellowstone River

Project	Irrigable area (acres)	Project	Irrigable area (acres)
Mission ditch	1,280	Colgate	1,300
Greycliff	350	Stipek	4,800
Cove canal extension	2,460	Intake	840
Huntley extension	2,960	Savage	2,390
Seven Mile flat	7,500	Elm Coulee	1,800
North Custer	3,750	Seven Sisters	1,800
Hysham	7,310	Sidney extension	2,450
Antelope flat	14,600	Cartwright	920
North Sanders	1,470		
Orinoco	1,600	Total	95,300
Chimney Rock	3,650	Less area now irrigated but included in above projects	2,200
Highland Park	10,470		
Hathaway	1,770	Net area of new land	93,100
Fort Keogh	3,120	Drainage projects	122,500
Saugus-Calypso	2,470		
Buffalo Rapids, third division	13,440	Total	215,600
Cracker Box	800		

Drainage projects: Seepage on some of the land now irrigated in the Yellowstone River Valley is becoming a problem of real importance. Most of the older private projects made no provision for drainage, and as irrigation expanded, seepage began to develop, with the result that there are now nearly 33,000 acres in the valley either waterlogged or damaged by concentration of soluble salts. It is proposed to reclaim this land by the construction of drainage systems, preferably with repayment provisions like those of the Reclamation Act.

The Yellowstone drainage project includes 87,200 acres of irrigable land under existing projects in the Yellowstone Valley, near Billings, Mont. Of this area, about 27,300 acres have been damaged by seepage. Half the waterlogged land is totally abandoned, and the remainder produces poor crops. Some of it has probably already been permanently lost by heavy salt concentrations. The waterlogged area is steadily increasing, and nearly the entire project area is threatened. Local efforts to install drainage have met with some success but a coordinated plan or method of financing has not been developed. Several irrigation projects are involved, and drainage, to be successful, must include the entire project area, extending protection to the unaffected land as well as affording relief for the damaged land.

A proposed drainage plan indicates that a total of about 130 miles of drains, and the lining of several leaky canals will be required for immediate relief of the land already waterlogged. Extensions of the drainage system may be necessary from time to time, as new areas of seepage develop.

The cost of such a project should be borne by all lands in the irrigated district, since protection must eventually be extended to the greater part of the entire area, and the burden of maintaining and operating the irrigation canals will rest on a constantly decreasing productive area, in the absence of drainage.

The Custer drainage project includes 35,300 acres of irrigable land under private projects, located in the Yellowstone Valley between Custer and Miles City, Mont. About 5,600 acres of this area are waterlogged and in need of drainage.

Main stream storage: The water supply of the Yellowstone River has, in general, been ample in the past for all irrigation requirements. Minor shortages in years of extremely low run-off have been reported by projects with inadequate diversion works. These cases are rare and have resulted in little damage to crops. Continued development of new projects throughout the Yellowstone River Basin, however, will eventually so deplete the summer flow of the main river that storage will be required to prevent irrigation shortages. Sufficient flow must be maintained throughout the river to meet domestic and sanitary requirements of the farms and communities along the valley. Residual flows in the lower part of the river must also be sufficient to avoid harmful concentrations of soluble salts washed from irrigated soils. Storage of about 150,000 acre-feet will be necessary to maintain this flow during the late season of most years, when diversions for irrigation are heaviest.

Selection of a reservoir site for the uses outlined above must be governed largely by practical operating conditions. The Yellowstone River is more than 500 miles long, and the discharge is subject to considerable variation from day to day, and at different points along the river. It would be impossible to operate a reservoir to meet the stated requirements with these daily fluctuations. The most practical solution is the release of sufficiently large flows to meet all requirements, with some to spare. Surplus releases will not be wasted as they will contribute to flows needed on the Missouri River.

The reservoir site best adapted to this purpose is the Mission Site, on the Yellowstone River, about 16 miles below Livingston. The Mission Reservoir would have a capacity of 892,000 acre-feet, which in addition to fulfilling all the above needs, is sufficient to generate 30,000 kilowatts of firm power and to provide flood protection for the Yellowstone River Valley.

Construction of the Mission Reservoir probably will not be necessary for irrigation for a considerable time to come, as irrigation shortages developing along the lower Yellowstone River, could be met with water from a proposed reservoir on the Big Horn River, which should be constructed first.

The limit to which development in the Yellowstone River Basin can proceed before providing storage for main-stream irrigation is not clearly defined. There are minor shortages at the present time which will gradually increase as more land is brought under irrigation. The determining factor may not be actual crop losses from water shortages, but occurrence of excessively low stream flow, causing difficulty with diversion structures, municipal water supplies, and sanitation, and a general deterioration of the quality of water. From this standpoint, storage for main stream use will be required early in the proposed program of development. The Big Horn reservoirs can meet this need satisfactorily until the Mission Reservoir is constructed.

Clarks Fork of the Yellowstone.—Present developments in the Clarks Fork section of the Yellowstone Basin include nearly all of the land suitable for irrigation. Only one small project, the Whitehorse Bench, of 1,500 acres, remains to be developed.

In its precipitous fall from the Beartooth Plateau to the valley floor, with an irrigation requirement of only 80,000 acre-feet out of its annual flow of approximately 500,000 acre-feet, the Clarks Fork offers exceptional opportunities for economical power development. The plan of development, therefore, is primarily for power. Many preliminary plans have been worked out for power production, and it is possible that a plan superior to the one presented herein will be developed after more detailed surveys and studies have been made.

A reservoir of 150,000 acre-foot capacity at the Hunter Mountain site, a combined conduit and penstock 36,000 feet long, and an installed capacity of 12,000 kilowatts will produce 71,000,000 kilowatt-hours of firm power annually, under an average head of 500 feet. Another reservoir of 130,000 acre-foot capacity at the Thief Creek site, 15 miles below Hunter Mountain, with a 35,000-foot pressure tunnel and penstock, and an installed capacity of 60,000 kilowatts, will produce 350,000,000 kilowatt-hours of firm power, under an average head of 1,250 feet. A reservoir of 40,000 acre-foot capacity on Sunlight Creek, 5 miles above its junction with Clarks Fork River, with a conduit 48,000 feet long, and an installed capacity of 20,000 kilowatts, will produce firm power output of 109,500,000 kilowatt-hours annually, under a head of 1,825 feet. The Sunlight and Thief Creek power plants are on opposite sides of the stream, about 8 miles above the mouth of the canyon. By a diversion dam 160 feet high in the canyon below these power sites, 3 miles of gravity canal and 4 miles of tunnel, and an installed capacity of 30,000 kilowatts, a firm power output of 166,500,000 kilowatt-hours can be produced annually, under a head of 450 feet. This combination of four power plants will utilize practically all of the available fall and water in the stream, and the resulting outflow will pass on to the Yellowstone River above all present and future irrigation development. The plan lends itself to progressive stages for development, as power market increases.

Big Horn River.—Wind River Basin: The basin contains the second and third largest tributaries of the Big Horn River, namely, the Wind and Popo Agie Rivers, and contributes more than 40 percent of the total run-off of the main stream at the mouth.

Future irrigation development is limited by water supplies. Several of the proposed units are combinations of new lands and lands needing supplemental supplies. The following units are proposed.

Unit	New acres	Land to receive supplemental water
Fremont	56,000	0
Little Wind River		34,000
Popo Agie		14,700
Hudson bench	5,700	
Shoshoni [1]	16,600	
Bad Water	1,100	2,700
Total	79,400	51,400

[1] Requires pumping from Wind River.

Five storage reservoirs are proposed, at DuNoir on the main Wind River, at Raft Lake, Sorrel Creek, Onion Flat, and Bad Water Creek, with a total aggregate capacity of 302,500 acre-feet, of which the DuNoir Reservoir will have 220,000 acre-feet. No additional power production is proposed.

Big Horn Basin: With the exception of the Shoshone River, all tributaries flow through valleys or near areas which contain far more arable land than can be irrigated from natural flows of these streams. This has led, on the tributaries, to much over-appropriation of water since about 1900, with the result that disastrous water shortages have occurred during the last 10 years.

All proposed unites will require storage regulation to augment the summer flows of the streams from which their supplies are derived, and, with the exception of those on the main stream, all are limited in extent by available water supplies rather than by any scarcity of arable land. The ultimate plan includes the following units in the Big Horn sub-basin.

Unit	New Land Irrigable (acres)	Supplemental Water for Irrigable Land (acres)
Shoshone project extensions	76,100	5,200
Owl Creek	0	10,000
Paintrock	2,700	6,000
Big Horn Pumping (14 units)	20,000	0
Shell Creek	0	10,200
Total	98,800	31,400

The largest development in this group, the Shoshone project extensions, will require considerable readjustment of existing supply systems. The irrigated area in the Greybull River Valley, now supplied with water from Sunshine Reservoir, and the irrigable lands in the Oregon Basin, will be supplied entirely with water from the Shoshone Reservoir, through canal diverting from Shoshone Canyon through the Oregon Basin, to the Greybull River. Sunshine Reservoir water will, in turn, be diverted to Wood River and then to Gooseberry Creek, for the irrigation of some 30,000 acres in the Buffalo Basin area. Four reservoirs, with an aggregate capacity of 185,000 acre-feet, are proposed as follows:

Reservoir	Capacity in acre-feet	Where used
Oregon Basin	150,000	Shoshone project extensions.
Anchor	15,000	Owl Creek.
Lake Solitude	7,000	Paintrock.
Red Gulch	13,000	Shell Creek.

The proposed Boysen Reservoir, of 730,000 acre-foot capacity, is at the upper end of the Wind River Canyon, on the main stream. This reservoir will provide sufficient capacity to desilt the stream, and to supplement the natural flow along the main stream in Wyoming and in the Lower Big Horn Basin in Montana. The Boysen Reservoir is one of the key structures in any solution of the interstate water con-

troversy between Montana and Wyoming, and should have first consideration in major developments. Discharge from the Boysen Reservoir will be so regulated as to produce firm power, and, in so doing, provide ample flows throughout the summer season for all irrigation needs in the Big Horn sub-basin. The average annual run-off at the Boysen Reservoir site during the past 10 years was 953,000 acre-feet of water, with a maximum monthly discharge of 300,000 acre-feet, and a minimum discharge of 25,000. After all upstream development, the minimum annual discharge will be reduced to 702,000 acre-feet, with a maximum monthly flow of 149,000 acre-feet, and a minimum of 58,000 acre-feet, the latter being more than twice the present minimum flow.

Regulation of the reservoir, based upon run-off forecasts from snow surveys, will permit the reduction of flood flows such as have occurred in the past to safe channel capacities.

Lower Big Horn Basin: Proposed developments are limited to suitable land which can be served from the Big Horn River and to the water supply available in dry years in the Little Horn watershed. New lands aggregate 64,000 acres, and supplemental supplies for 16,600 acres are planned.

The largest development is the Hardin project, at the lower end of the Big Horn Canyon, most of the area lying on benches above and west of the present irrigated area. The other six units are in the Little Horn watershed. Two of them will require pumping. Three reservoirs are proposed, two in Big Horn Canyon and one on the Little Horn River.

The Kane Reservoir of 750,000 acre-foot capacity, at the upper end of Big Horn Canyon, is planned to serve ultimately as a reserve silt storage and for flood control and power development. The Yellowtail Reservoir, of 470,000 acre-foot capacity, is a combination power and irrigation diversion dam. It is to be built of sufficient height to utilize all of the available fall in the lower canyon for power purposes. Diversion for the Hardin project is required at an elevation of 125 feet above the stream bed at the damsite. Flows from both the Kane and Yellowtail Reservoirs will be regulated to produce firm power. At the same time, they will furnish adequate irrigation water for all requirements on the river below them. A power plant at Kane will have an installed capacity of 30,000 kilowatt-hours, and one at Yellowtail 75,000 kilowatts. Below Yellowtail, the average annual discharge over the past 10 years has been estimated to have been 2,137,000 acre-feet, with a maximum monthly flow of 646,000 acre-feet and a minimum of 68,000. After all upstream development has taken place, the annual flow will be reduced to 1,560,000 acre-feet, with a maximum monthly flow of 329,000 and minimum monthly flow of 87,000 acre-feet.

Tongue River.—Limited water supply on Tongue River in Wyoming precludes additional irrigation there. A proposed reservoir of 25,000 acre-foot capacity on the south fork of Tongue River, together with existing reservoirs on other tributaries will afford sufficient regulation to furnish supplemental water to 38,000 acres now irrigated. Physical characteristics of the upper Tongue River Basin are in many respects similar to those of Clarks Fork of the Yellowstone. In passing from the high plateau area of the Big Horn Mountains to the Valley floor, the Tongue River affords opportunities for the development of power,

but such development is limited to seasonal output, as the requirements for irrigation preclude wintertime power production.

South Fork Reservoir, together with a low-pressure pipe line 15,000 feet long, a 2,500-foot penstock, and an installed capacity of 25,000 kilowatts, will permit the annual development of 55,000,000 kilowatt-hours of seasonal secondary power particularly adapted to meet the demands of irrigation pumping. Combined requirements of all proposed pumping projects in the Yellowstone River Basin are 51,282,000 kilowatt-hours annually.

Arable areas below Tongue River Reservoir in Montana lie in small tracts of from 100 to 500 acres along the meandering river bottom. Diversion dams for individual tracts are impractical. The plan of development provides for the irrigation of 26,000 acres of this land by the use of 67 small pumping plants distributed along the river, over a distance of 100 miles.

Powder River.—Above the Montana State line, Powder River is formed by numerous tributaries rising in the Big Horn Mountains, in Wyoming. Present irrigation development lies along the foothills adjacent to the mountains, and utilizes a complicated, extensive, interlaced system of private ditches, diverting the water from one tributary to another in such a manner as to preclude any grouping of the area into a single, coordinated irrigation system. Below the Montana line, the valley has characteristics similar to the Tongue River Basin, and must be developed in the same manner. Proposed irrigation projects in Wyoming include 44,460 acres of new land and supplemental water for 47,050 acres of land now irrigated. The above-mentioned area represents the maximum that can receive a reliable water supply, to be secured by the construction of Willow Park Reservoir of 9,700 acre-foot capacity, Triangle Park Reservoir of 4,000 acre-foot capacity, Bull Creek Reservoir of 14,000 acre-foot capacity, Smith Reservoir of 30,000 acre-foot capacity, and Middle Fork Reservoir of 50,000 acre-foot capacity. Present Lake DeSmet will be revised to increase its capacity by 44,000 acre-feet. Most of these reservoirs will furnish supplemental water to lands already irrigated in the upper Powder River watershed. In Montana, 42,600 acres of land, lying in the valley floor, between the Montana-Wyoming State line and the mouth of the river, are to be supplied by numerous individual pumping plants. The water supply is to be provided by the construction of the Moorhead Reservoir of 390,000 acre-foot capacity, a combination flood control, irrigation, and silt storage reservoir.

Shields River.—One supplemental water unit is proposed for the Shields River Basin. It will include a 9,000 acre-foot reservoir at an off-stream site on Antelope Creek, to be filled by a canal from the river. Lands along the lower part of the valley, amounting to 8,400 acres, will receive the supplemental supply. The heaviest shortages occur on tributary streams, notably Rock Creek and Cottonwood Creek, but the lands affected lie on such high benches that no reservoir site could be found to serve them.

Sweetgrass Creek.—A 12,000 acre-foot reservoir on upper Sweetgrass Creek is proposed, to augment an inadequate supply for 12,050 irrigated acres in Melville Valley and on Otter Creek. The additional storage water will permit a much needed readjustment of present water uses in the valley.

No additional units are proposed on the remaining tributaries of the Yellowstone such as the Boulder, Stillwater, Pryor, and Rosebud Creeks, either because water supplies are now sufficient and no more new land is available, or because adequate reservoir sites could not be found.

Summary.—The plan of development here outlined for the entire Yellowstone Basin includes all probabilities which surveys, land classification, water-supply studies, and engineering judgment have shown to have merit. The sites for 9 of the 27 dams proposed have been explored by diamond drilling for foundation geology. At others, test pits have been dug or satisfactory bedrock is exposed in the creek bottoms and abutments to such an extent as to render preliminary drilling unnecessary. Collateral engineering, such as canal surveys and land classification, has been done in sufficient detail to justify reasonable confidence in the results. On the whole, the plan is believed to represent a development adequate for basin needs for many years to come. Detail studies will show minor modifications to be desirable, but the plan as a whole will probably not be changed materially.

The following tables summarize the plans, the areas to be irrigated and furnished supplemental water, the reservoirs and their capacities, and the multiple purposes of various features of the plan.

Summary of proposed irrigation and drainage units (acres)

Unit	New land	Supplemental water	Total area benefited
Yellowstone River—Main stem:			
Mission Ditch	1,280	0	1,280
Greycliff	350	0	350
Cove Canal extension	2,460	0	2,460
Huntley extension	2,960	0	2,960
Seven Mile Flat	7,500	0	7,500
North Custer	3,750	0	3,750
Hysham	7,310	0	7,310
Antelope Flat	14,600	0	14,600
North Sanders	1,470	0	1,470
Orinoco	1,600	0	1,600
Chimney Rock	3,650	0	3,650
Highland Park	10,470	0	10,470
Hathaway	1,770	0	1,770
Fort Keogh	3,120	0	3,120
Saugus-Calypso	2,470	0	2,470
Buffalo Rapids, third division	13,440	0	13,440
Cracker Box	800	0	800
Colgate	1,300	0	1,300
Stipek	4,800	0	4,800
Intake	840	0	840
Savage	2,390	0	2,390
Rim Coulee	1,800	0	1,800
Seven Sisters	1,800	0	1,800
Sidney extension	2,450	0	2,450
Cartwright	920	0	920
Billings drainage	0	0	[1] 56,400
Custer drainage	0	0	[1] 35,300
Big Horn River Basin:			
Fremont	56,000	0	56,000
Little Wind River	0	34,000	34,000
Popo Agie River	0	14,700	14,700
Hudson Bench	5,700	0	5,700
Shoshoni	16,600	0	16,600
Badwater	1,100	2,700	3,800
Shoshone project extension	76,100	5,200	81,300
Owl Creek	0	14,400	14,400
Paintrock	2,700	6,000	8,700
Shell Creek	0	10,200	10,200
Big Horn pumping	20,000	0	20,000
Hardin	45,000	1,800	46,800
Little Horn	0	14,800	14,800
Custer Bench	11,400	0	11,400
Wyola	3,600	0	3,600

[1] This area is irrigable land under existing projects that will have to be drained before it can be irrigated.

Summary of proposed irrigation and drainage units (acres)—Continued

Unit	New land	Supplemental water	Total area benefited
Big Horn River Basin—Continued.			
Benteen Flat	1,600	0	1,600
Battlefield	1,200	0	1,200
Crow	1,200	0	1,200
Clarks Fork Basin: Whitehorse bench	1,500	0	1,500
Tongue River Basin:			
Sheridan Canal	0	38,000	38,000
Tongue River pumping	26,100	0	26,100
Powder River Basin:			
Piney	0	9,600	9,600
Buffalo	0	10,400	10,400
Crazy Woman	9,400	6,900	16,300
French Creek	0	3,850	3,850
Kaycee	10,400	6,400	16,800
Arvada	17,700	0	17,700
Ucross	6,860	5,050	11,910
Moorhead	42,600	0	42,600
Miscellaneous:			
Shields River	0	8,400	8,400
Sweetgrass	0	12,100	12,100
Riverton extension	57,500	0	57,500
Total	[1] 509,560	204,500	[2] 805,760

[1] An additional 218,440 acres remain to be irrigated under existing projects, and an additional 122,500 acres will receive supplemental water from existing projects.
[2] Includes drainage projects.

Proposed reservoirs

Reservoir	Stream	Unit served	Total capacity	Purpose
			Acre-feet	
Mission	Yellowstone River	Main stream	890,000	Power, irrigation, flood control.
Boysen	Big Horn River	Big Horn and Yellowstone.	730,000	Irrigation, power, silt, flood control.
Kane	do	do	750,000	Do.
Yellowtail	do	Hardin	470,000	Do.
DuNoir	Wind River	Fremont	220,000	Irrigation, flood control.
Raft Lake	North Fork Little Wind River.	Little Wind River	41,000	Do.
Boral Creek	Popo Agie River	Popo Agie	25,000	Do.
Onion Flat	Tributary of Little Wind River.	Hudson Bench	9,000	Do.
Badwater	Tributary of Badwater Creek.	Badwater	7,500	Do.
Oregon Basin	Shoshone River, offstream.	Shoshone Extension	150,000	Do.
Anchor	South Fork of Owl Creek.	Owl Creek	15,000	Do.
Lake Solitude	Paintrock Creek	Paintrock	7,000	Do.
Red Gulch	Shell Creek, offstream.	Shell Creek	13,000	Do.
Little Horn	Little Horn River	Little Horn	50,000	Do.
Antelope	Shields River, offstream.	Shields River	9,000	Do.
Sweetgrass	Sweetgrass Creek	Sweetgrass	12,000	Do.
Hunter Mountain	Clarks Fork		150,000	Power, irrigation, flood control.
Thief Creek	do		130,000	Do.
Sunlight	Sunlight Creek		40,000	Power, flood control.
South Fork	South Fork of Tongue River.	Sheridan	25,000	Irrigation, power, flood control.
Willow Park	South Fork of Piney Creek.	Piney	9,700	Irrigation.
Triangle Park	South Fork of Rock Creek.	Buffalo	4,000	Do.
Bull Creek	Clear Creek	do	14,000	Irrigation, flood control.
Lake DeSmet	Piney Creek	Ucross	[1] 44,000	Irrigation.
Smith	North Fork of Powder River.	Crazy Woman, Mayoworth	30,000	Irrigation, flood control.
Middle Fork	Middle Fork of Powder River.	Kaycee	50,000	Irrigation, flood, silt.
Moorhead	Powder River	Moorhead	390,000	Do.
Total for 27 reservoirs			4,285,200	

[1] Increase in present capacity.

Summary of proposed development, by States

IRRIGATION OR DRAINAGE

	New lands irrigated	Supplemental water furnished	Total area benefited
	Acres	*Acres*	*Acres*
Montana	227,230	{ [1] 91,700 37,100 }	356,030
North Dakota	2,270	0	2,270
Wyoming	280,060	167,400	447,460
Total	509,560	296,200	805,760

RESERVOIRS

	Number	Capacity
		Acre-feet
Montana	4	1,762,000
Wyoming	23	2,523,200
Total	27	4,285,200

POWER PLANTS

	Name	Installed kilowatts	Annual firm production
			Kilowatt-hours
Montana	Mission	50,000	263,000,000
	Yellowtail	75,000	332,000,000
Wyoming	Boysen	10,000	56,900,000
	Kane	30,000	139,300,000
	Hunter Mountain	12,000	71,000,000
	Thief Creek	60,000	350,000,000
	Sunlight	20,000	109,500,000
	Bald Ridge	30,000	166,500,000
	Tongue River	25,000	21,000,000
Total (9)		312,000	1,509,200,000

[1] Drainage.

Upper Missouri River Basin

FOREWORD

The Upper Missouri River Basin is defined as that part of the Missouri River Watershed lying in Montana and the Dominion of Canada above the mouth of Milk River, one of the principal tributaries of the Missouri River. Milk River drains 7,690 square miles in the Provinces of Saskatchewan and Alberta, in Canada. The use of its run-off, together with a part of the waters which originate in the St. Marys River Basin in the United States, and would normally flow into Canada in the St. Marys River, has been the subject of an international treaty that has been in effect for more than 20 years.

The development of 998,700 acres of irrigated land, and dry farming agriculture on 9,800,000 acres of land, has created the greater part of the present total assessed valuation of $516,476,000 in the basin. Practically the entire dry farming area experiences an average annual rainfall of 14 inches or less, and is therefore generally considered as marginal dry farming territory. An additional area of 460,900 acres

APPENDIX V

The Missouri River Basin Water Utilization Program and Its Effect on Fish and Wildlife

(Report of the U. S. Fish and Wildlife Service, Department of the Interior)

Unquestionably, the Missouri River Basin water utilization program, if consummated, will have profound effect upon the life and economy of our people, both in this drainage basin itself and throughout the Nation generally. The extent and nature of its effect—whether beneficial or detrimental—will depend upon the program adopted and the manner of its administration. To attain maximum benefits and minimum loss, it is essential that the program be broad in scope and judiciously designed for maximum multiple utility. Fish and wildlife production and conservation are certainly among the major public benefits of such a program. Adequate water supplies must be provided to insure a perpetuation of these public values.

A complete appraisal of the effects of this program upon fish and wildlife cannot be given until full details are known. It has been but a short time since the Fish and Wildlife Service was informed of the program, and even now this Service has only a very general outline of the proposal. When advised of the proposed program, the Fish and Wildlife Service sent a biologist and an engineer to the Bureau of Reclamation offices at Denver, Colo., and Billings, Mont., to confer with Reclamation engineers and to study whatever plans and maps were available. On the basis of the limited information obtained, it may be concluded that the effect of the program upon fish and wildlife will depend upon the character and location of the various developments and upon the priorities of water allocations. Without question, fish and wildlife will be benefited in some areas and damaged in others. The objective, of course, should be to develop and execute a program that will minimize the damage and increase the over-all benefits. Because of the importance of the Missouri River drainage basin to wildlife, this Service is deeply concerned with this water-utilization program and with any activity that affects the relationship of water to the land.

The importance of the Missouri River watershed in the management of wildlife can scarcely be overestimated. This watershed is highly productive of all forms of native wildlife, and the upper reaches of the watershed are considered by this Service to be the most important waterfowl breeding grounds in the Nation. This is particularly true of North Dakota. The map appended (see Appendix III, map 58–D–496) portrays the importance attached to this production area, and the extent to which the expenditure of Federal funds has been made for wildlife restoration work there.

Map 58–D–496 depicts the location and character of the various wildlife refuges and activities on the watershed, and it also indicates somewhat the importance of this area in the production of migratory waterfowl and other forms of wildlife.

A decade ago, American ducks, geese, and other waterfowl were at an all-time low in their population. Public concern over the future of waterfowl led to Congressional and other public action, and resulted in

substantial Federal expenditures designed to preserve and restore this national resource. Major emphasis was accorded the improvement of breeding grounds through the restoration of marshes and the control of waters.

The effectiveness of the waterfowl restoration program has been apparent to all concerned. In 1935 the continental waterfowl population was estimated at about 27,000,000, an all-time low. Today that population is estimated at approximately 120,000,000, an increase of well over 400 percent in 8 years. It does not seem consistent with national objectives that this progress shall be unnecessarily injured, or that projects established on the Missouri River watershed shall be sacrificed to new construction without replacement of these areas built with public funds and with sportsmen's dollars. It does seem evident that the proposed program should take into consideration all possible public benefits and should be presented to the Nation as the best possible proposal for the conservation and development of all of the basin's natural resources, including wildlife.

Wildlife is a product of the land just as is corn, cauliflower, or cattle. Maximum production comes only from proper stewardship. It seems self-evident that our national objectives should be the max mum yield of all products of benefit to the people, particularly where the people's money is being used to finance construction. With proper management, upland game and other beneficial wildlife can become abundant on the Missouri River watershed, and it is well known that small game can be produced in substantial numbers in conjunction with agriculture, if given adequate consideration in the planned manipulation of the land and water.

In view of all this, no program of the scope and size of the one under discussion here should overlook the adverse effects of proposed developments upon productive wildlife projects, nor the possibilities for beneficial effects upon wildlife as a planned part of such program. Multiple use is a necessary objective if the program is to have adequate justification and united support. Ten million sportsmen will insist that wildlife production be made an integral part of that multiple use.

PROBABLE EFFECTS OF THE PLAN

Though detailed information on which to base an estimate of all the effects of the program upon fish and wildlife is lacking, some predictions are possible. For example, it is evident that a number of major Federal wildlife refuges will be entirely eliminated or adversely affected.

The proposed storage reservoir in the Medicine Lake Valley will flood the Medicine Lake National Wildlife Refuge to a depth of 30 feet or more. This refuge represents a Federal investment of nearly $600,000 and is now a very productive area. The proposed flowage will bring on such adverse biological changes that the usefulness of this area for wildlife purposes will be practically lost.

The same situation exists with respect to the Arrowwood National Wildlife Refuge on the James River in North Dakota. This refuge, which has already cost the Government more than half a million dollars, will be inundated to a great depth by a proposed reservoir; the utility of the Arrowwood as a wildlife area will be completely eliminated.

The greater portion of the Des Lacs National Wildlife Refuge in North Dakota—which cost $651,000—will be permanently lost, and the remaining part will be adversely affected, at least temporarily. The Buffalo Lake and the Dakota Lake National Wildlife Refuges in North Dakota—totaling approximately $52,000—will be adversely affected.

The probable effect upon the Sand Lake National Wildlife Refuge in South Dakota—which cost $838,000—is undetermined. It is understood that a diversion ditch may be constructed to pass around this refuge. Such a ditch could be beneficial in times of high water but may lead to difficulties over water rights in times of low water.

Likewise, the important Lower Souris Refuge—representing an investment of some $1,300,000—might be adversely affected inasmuch as a diversion dam will be placed on the Souris at Simco, upstream from Lower Souris. The effect that this may have upon the Lower Souris Refuge will depend entirely upon the amount of water diverted from this refuge and the time that it is diverted.

On the other hand, it appears probable that wildlife will benefit by the restoration of such areas as Smoky Lake, Devils Lake, and Stump Lake. In these areas water levels must be controlled or stabilized to be of much benefit to waterfowl and other forms of wildlife. These areas are not now developed for wildlife purposes because existing supplies of water are inadequate. Their utility for wildlife purposes will by no means be so high as that of the major refuges which will be destroyed or seriously damaged, but these lakes will be of substantial size and of considerable value to wildlife. It is understood that the Sheyenne River Reservoir will be more or less stabilized. If this is done, the area should have value to waterfowl and other wildlife. Field studies may reveal several development procedures that will be advisable, if adequate control and jurisdiction over the water and land can be secured.

Undoubtedly, a number of smaller areas of value to wildlife will be restored or created. It also appears feasible to restore or further develop several larger areas such as Benton Lake in Montana, and Lake Zahl and Buffalo Lodge Lake in North Dakota. In fact, it appears probable that other but smaller wildlife areas can be restored or created throughout the drainage basin, especially along the diversion flowages in North Dakota and South Dakota. Detailed study of proposed impoundments throughout the basin will need to be made. Such studies are particularly needed in Kansas, Nebraska, Colorado, Wyoming, and Montana, where great improvement in wildlife habitat might be made at minimum cost, provided that a suitable water supply is assured for this purpose.

Such development, it is believed, can be effected by the allocation of limited flowage of water and by the utilization of waste water. As a matter of fact, it seems probable that if fish, fur, and game are given their just consideration in this program, the developments can make an outstanding contribution to wildlife conservation and production in the Missouri River drainage basin.

In this connection, attention is directed to the fact that wise utilization of water does not require that it always be used for irrigation. In the Dakotas, for example, there are today many marshes that yield a higher net cash return per acre in fur alone than the surrounding uplands yield in agricultural products. To this return from fur must be added the less tangible but nevertheless real value of fish

and game and other forms of wildlife. The best use of water—whether it be for culinary purposes, sanitation, industry, transportation, irrigation, for fish and wildlife, or for other purposes—depends upon the area and the local or national needs or conditions. It seems very evident that this whole Missouri River drainage basin program will fall far short of its maximum benefits to the people of the Nation if it fails to take full advantage of the potentialities of fur, fish, and game. The added justification and public support thus available appear to have been largely overlooked, but this situation must be promptly and adequately corrected if the program is to receive the support of all interests.

EFFECTS ON FISHERIES RESOURCES

Though it has not yet been possible to study the effects that this impoundment program may be expected to have upon the fisheries, experience in similar situations and understanding of general biological principles make it apparent that profound changes will result. Many of these changes will be sharply antagonistic to the well-being of the aquatic resources and their contingent recreational assets; however, if proper planning and appropriate management practices are followed, many beneficial results may be expected from the program.

It is not unlikely that impoundments in the mountain areas will destroy many miles of good trout streams by the mere mechanics of raising water levels, eliminating riffles, and otherwise upsetting present stabilized conditions that are essential for the successful maintenance of such trout waters. On the other hand, lake species may be favored by a program of impoundment, especially if measures can be taken to insure some degree of stabilization during the spawning season and if an adequate conservation-pool level is maintained. It would be helpful if water levels were permitted to fluctuate only between certain fixed elevations.

The increased shore line and water acreage occasioned by the formation of pools and lakes, should insure increased fish production. Moreover, the additional storage reservoirs will certainly reduce floods and silting, so that the quality of the water should be improved greatly, and this in turn would favor fish production. If sections of free-flowing streams occur below impoundments, they may become better streams than formerly because of the desilting action of the dams above these areas and the diminished threat of floods.

Before flooding, all areas to be impounded should be properly cleared; ditching facilities should be provided whereby low areas may drain directly into the main basin, thus minimizing the chance of fish becoming stranded during draw-down periods and increasing the chances of survival. Serious consequences to the fisheries will follow any program of irrigation that does not include adequate precautions to prevent the destruction of fish in diversion works. Fish screens must be installed to prevent these losses in channels that are only dead-end courses in irrigated lands. Where strongly migratory fish species are important, provision should be made for ladders that will insure free upstream passage over dams and other obstructions and permit the fish to carry on their spawning migrations.

Any program of impoundment on a free-flowing stream changes the aquatic life from stream types to lake types. In some areas this will be beneficial, as the lake life will be more desirable, and a change for the good will be effected. If, however, water levels on these impounded

streams are not operated in the interest of maintaining these lake types, both lake and stream types will have been dealt an irreparable blow.

The reservoirs and diversions will change most drastically the present flow of the river. It is obvious that these physical changes will affect the aquatic life of the river and of the lakes, as the character of any environment determines the character of the life dependent upon it.

The muddy and fluctuating Missouri River is not now very productive in the lower two-thirds of its course. The dams constructed in the plains region should clarify and greatly improve the quality of the water; this, in turn, should favor fish production. If conservation pools are maintained and if reasonable consideration is given to the problem of fluctuation of water levels in the reservoirs during the spawning season, the general program should greatly favor both the commercial and the sport fishery resources of the area.

An intensive fishery study of the entire basin area should be made.

NECESSARY POLICIES

The importance of the Dakotas and eastern Montana as a breeding ground for waterfowl can scarcely be overrated, as this is the heart of the Nation's production area. Because of this the Fish and Wildlife Service has here made its heaviest investment and greatest effort to develop and restore waterfowl breeding grounds. So great is the need for nesting habitat in this section that the Service has already secured every available area of size that could be obtained, together with water rights to keep the areas properly watered. Therefore, it must not be concluded that if this diversion destroys a few major refuges, others of equal worth readily can be acquired. Such a conclusion is tenable only to the extent that additional water may be permanently supplied from the diversion project to develop and maintain the new areas. Certainly no such possibilities now exist. It must be borne in mind that large bodies of deep water which fluctuate widely during the season are not conducive to waterfowl production; instead, shallow, marshy areas must be supplied if ducks, geese, and fur animals are to receive any appreciable benefits.

Because of the importance of the areas that will be destroyed or adversely affected by this development program, the Fish and Wildlife Service, representing the wildlife-conservation interests of the Nation, must insist that loss of these areas be duly compensated through development of other favorable areas to an equal stage of development and productivity, such areas to be turned over to this Service for administration to insure a perpetuation of the program now in effect. Where public funds are involved, it should be the policy not only to do as little damage as possible but also to consider reasonable development for wildlife resources an integral and essential part of the program.

The Coordination Act of 1934 (48 Stat. 401) suggests this policy. Section 3 of the Coordination Act of 1934 provides:

> (a) Whenever the Federal Government through the Bureau of Reclamation or otherwise, impounds water for any use, opportunity shall be given to the Bureau of Fisheries and/or the Bureau of Biological Survey to make such uses of the impounded waters for fish-culture stations and migratory-bird resting and nesting areas as are not inconsistent with the primary use of the waters and/or the constitutional rights of the States. In the case of any waters heretofore impounded

by the United States, through the Bureau of Reclamation or otherwise, the Bureau of Fisheries and/or the Bureau of Biological Survey may consult with the Bureau of Reclamation or other governmental agency controlling the impounded waters, with a view to securing a greater biological use of the waters not inconsistent with their primary use and/or the constitutional rights of the States and make such proper uses thereof as are not inconsistent with the primary use of the waters and/or constitutional rights of the States.

(b) Hereafter, whenever any dam is authorized to be constructed, either by the Federal Government itself or by any private agency under Government permit, the Bureau of Fisheries shall be consulted, and before such construction is begun or permit granted, when deemed necessary, due and adequate provision, if economically practicable, shall be made for the migration of fish life from the upper to the lower and from the lower to the upper waters of said dam by means of fish lifts, ladders, or other devices.

Through the Fish and Wildlife Service the Government owns or controls water rights on all areas that will be destroyed or adversely affected by this development program. Wildlife refuges and management areas are ineffective and of little value without control of their water supply. Consequently, it is essential that adequate and perpetual water rights be provided at the expense of this water-utilization program. Without such guaranties the proposed program will have little to recommend it from the viewpoint of wildlife. It should be realized that these wildlife benefits are not only of local value but are national in character as well.

CONCLUSIONS

The Missouri River Basin water-utilization program has vast possibilities of either seriously damaging existent wildlife-refuge areas, built at great public expense, or improving general wildlife conditions, depending upon how it is developed and administered.

To safeguard these present proven wildlife values, the program must guarantee that—

1. Federal wildlife refuges destroyed will be replaced as nearly as possible with other areas of equal value, including suitable improvements and permanent water adequate to meet the needs of wildlife. In the public interest, it is as important to replace destroyed marshes and breeding grounds as it is to move railroads, highways, and bridges now located in the areas to be flooded.

2. Suitable provision will be made to provide adequate fish screens and ladders, and to do the necessary initial stocking of the waters with appropriate species of fish.

3. Every major pool must maintain a conservation pool level, below which the water level cannot go; during the spawning season every effort will be made to maintain as constant a pool level as possible.

4. All units or areas of major wildlife values to be administered by the Fish and Wildlife Service.

5. Fish and wildlife values to be considered an integral and essential part of this program and given a fair and equitable place in the allocation of water priorities. Fish and wildlife values therefore must be developed wherever economically feasible throughout the entire system. To this end the Fish and Wildlife Service stands ready and anxious to assist.

ALBERT M. DAY,
Acting Director.