Supreme Court, U.S.
FILED
FEB - 9 2010
OFFICE OF THE CLERK

No. 137, Original

IN THE

SUPREME COURT OF THE UNITED STATES

STATE OF MONTANA,
Plaintiff,

v.

STATE OF WYOMING

and

STATE OF NORTH DAKOTA,
Defendants.

ON MOTION TO DISMISS THE BILL OF COMPLAINT

JOINT APPENDIX OF THE PARTIES

Volume II

(pages 499 – 957)

Montana v. Wyoming and North Dakota
Original No. 137

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PROGRESS REPORT
TO THE GOVERNORS OF THE STATES OF MONTANA AND WYOMING
AND TO THE CONGRESS OF THE UNITED STATES
REGARDING YELLOWSTONE BASIN COMPACT

Pursuant to the authority granted by Congress in Public - No. 237 - 75th Congress, Chapter 552 - 1st Session (S. 534) authorizing the States of Montana and Wyoming to negotiate and enter into a compact providing for an equitable division of the water supply of the Yellowstone River basin, the President appointed Mr. Clyde L. Seavey, (Acting Chairman, Federal Power Commission) to be the representative of the United States, and the Governors of the States of Montana and Wyoming respectively appointed representatives as follows:

Montana:

Mr. E. B. Donohue, Chairman, Helena, Montana
Mr. Rockwood Brown, Billings, Montana
Mr. J. D. Scanlan, Miles City, Montana
Mr. B. B. Armstrong, Livingston, Montana.

Wyoming:

Mr. John D. Quinn, Chairman, Cheyenne, Wyoming
Mr. L. F. Thornton, Thermopolis, Wyoming
Mr. J. R. Ellis, Basin, Wyoming
Mr. Will G. Metz, Cheyenne, Wyoming

The above representatives of Federal and State interests comprise the Yellowstone River Compact Commission.

Following the appointment of these representatives, meetings were held on May 5, 1938, in Billings, Montana and on November 21 and 22, 1938, in Thermopolis, Wyoming. In addition to members of the Commission, there were also present at these meetings representatives of federal bureaus and

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agencies, as follows: Bureau of Reclamation; Indian Service; Forest Service; Corps of Engineers, U. S. Army; National Park Service; and Federal Power Commission. The purpose of these meetings was to ascertain the character of information required for the drafting of the Yellowstone River Basin Compact, and the extent to which data on climate, topography, land ownership, population, and water development are available; to investigate the uses of water for irrigation, power, navigation, domestic and industrial purposes, and to study the laws of the States of Montana and Wyoming with respect thereto. Such information as is available at the present time from Federal and State sources has been collected and compiled by the Denver Regional Office staff of the Federal Power Commission under the direction of the Compact Commission.

From an analysis of the available information, it is the concensus of the Compact Commission:

1. That adequate factual data necessary to the drafting of a compact between the States of Montana and Wyoming are not available at the present time; however, studies now being carried on by the Bureau of Reclamation, U. S. Army Engineers, Forest Service, Indian Service, and other Federal agencies will produce a considerable amount of additional data, which will be useful for this purpose. Information which is presently inadequate or entirely lacking is as follows:

SEP 1939

(a) Existing diversions for irrigation;

(b) Priorities of irrigation appropriations and rights;

(c) Acreages presently being irrigated and which are irrigable from existing works;

(d) Net water duty on irrigated lands;

(e) Crops grown on irrigated lands;

(f) Potentially irrigable lands and their water requirements;

(g) Stream flow data on minor tributaries;

(h) Location and cost of additional storage;

(i) Soil surveys;

(j) Studies of soil erosion, and silting of reservoirs;

2. That apparently the annual run-off of the Yellowstone River basin is sufficient to meet all existing and potential consumptive uses if and when a comprehensive plan of storage has been developed and put into effect;

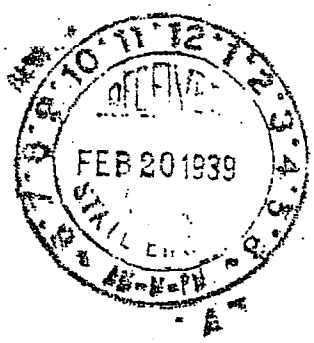
3. That the Indian rights, under various treaties, to the waters of the Wind, Big Horn, and Tongue Rivers for irrigation purposes have not been definitely determined. These rights likely will be more definitely defined by a decision of the Supreme Court of the United States in connection with litigation now pending before that tribunal;

4. That approximately 740 square miles of the drainage basin of the Yellowstone River lies within the State of North Dakota; therefore it appears

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desirable that the Congress of the United States amend its authorization for a compact with reference to the waters of the Yellowstone River to include the State of North Dakota as a signatory thereto;

5. That, because existing water supplies as presently developed are inadequate to fully meet demands for irrigation and other uses in critically dry years, there is imminent danger that irrigators in certain areas will resort to costly and protracted litigation in order to protect their rights; therefore, it is essential that additional storage be constructed at strategic points at the earliest possible date in order to relieve this situation; and that the respective State Compact Commissions be given adequate authority and funds with which to proceed with the collection of data necessary to the drafting of a Compact;



6. That, pending the negotiation of a formal compact and without prejudice to existing water rights, the representatives of the States of Montana and Wyoming agree to cooperate to the fullest extent in securing such administration of rights in their respective states as will tend to alleviate water shortages during dry years;

7. That, in view of the size of the task now facing the Compact Commission, it is the Commission's opinion

and recommendation that the Congress of the United States should extend indefinitely the time limit within which this compact may be consummated.

Respectfully submitted,

Representing the State of Montana:

E. B. Donohue

Rockwood Brown

Rockwood Brown

J. D. Scanlan

J. D. Scanlan

B. B. Armstrong

B. B. Armstrong

Representing the State of Wyoming:

John D. Quinn

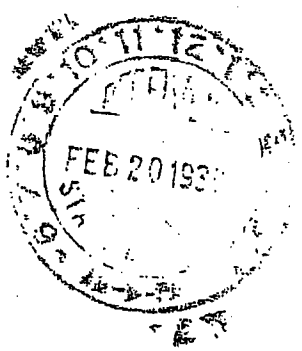
L. F. Thornton

L. F. Thornton

J. R. Ellis

Will G. Metz

Clyde L. Seavey,
Representing the United States



Dated Feb. 25, 1939

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Preliminary Report on Yellowstone River Basin, Federal Power Commission, 1940

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PRELIMINARY REPORT

ON

YELLOWSTONE RIVER BASIN

COMPILATION OF FACTUAL DATA

FOR USE OF

THE YELLOWSTONE RIVER COMPACT COMMISSION

FEDERAL POWER COMMISSION

BUREAU OF ENGINEERING

DENVER REGIONAL OFFICE

DECEMBER 1940

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Preliminary Report

on

YELLOWSTONE RIVER BASIN

Compilation of Factual Data Relating to the Basin
For Use of the Yellowstone River Compact Commission

COPY NO. 46

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Federal Power Commission
Bureau of Engineering
Denver Regional Office

December 1940

Preliminary Report

on

YELLOWSTONE RIVER BASIN

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INTRODUCTION

1. Purpose of the Report

The purpose of this report is to compile all the pertinent information that has been collected by various state and Federal agencies on the physical characteristics, water resources, and water uses of the Yellowstone River Basin, and to present it in a form that will be readily useable by the Yellowstone River Compact Commission.

2. Scope of the Report

The report is primarily a compilation of factual data that have been collected by other agencies. An attempt has been made to cover the entire range of the subject in a concise and general manner, and to omit the bulk of details that have been published elsewhere. The findings of other reports have been summarized, and care has been taken to support each figure and statement of opinion by reference to the original source. The report is preliminary in that it arrives at no conclusions and makes no recommendations. A final report on this subject must await the completion of surveys now in progress.

The report consists of two main sections, five appendices, and accompanying maps and figures. Section I contains general information on the entire Yellowstone River Basin and data that are common to the seven sub-basins into which, for the purpose of this report, the main basin has been divided. Data pertaining to each of the seven sub-basins are

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presented separately and in detail in Section II.

3. Sources of Information

Most of the information contained in this report was obtained from special reports prepared under the sponsorship of Compact Commission representatives of the states of Wyoming, Montana, North Dakota, and the U. S. Office of Indian Affairs, and from published and special reports of the Corps of Engineers, U. S. Army. The sources referred to most often in this report are described below, followed by a complete bibliography:

Water Resources of the Yellowstone River Basin in Wyoming, September 1938. This report was prepared by workers on WPA Project 65-83-107 under the direction of H. T. Person, Consulting Engineer. It was submitted to the Wyoming State Engineer in October 1938. It is comprehensive and detailed, but has not been approved by the Wyoming members of the Compact Commission as accurately describing the Wyoming portion of the basin. It is generally referred to in the text as the "Wyoming Report."

Memorandum Report by the Montana Water Conservation Board, September 25, 1938. This report was prepared in response to a letter dated August 1, 1938, from the Federal Power Commission, requesting general information on the water resources and water uses of the Montana portion of the basin. It is incomplete in coverage and very limited in detail. It is often referred to in the text as the "Montana Report."

Report by the Montana Water Conservation Board, October 10, 1940. This report is referred to in the text as the "Montana Progress Report", as it was submitted as a progress report at the meeting of the

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Compact Commission held in Billings on October 10, 1940. It contains additional information on existing and potential reservoirs and irrigation projects in Montana.

Yellowstone River, Wyoming, Montana, and North Dakota - House Document No. 256, 73d Congress, 2d Session. This report was prepared by the Corps of Engineers, U. S. Army, to present the findings of the comprehensive survey of the Yellowstone Basin which it made under the provisions of House Document No. 308, 69th Congress, 1st Session. The survey began in the fall of 1928, and the District Engineer submitted his report on March 31, 1932. This survey is the most complete and comprehensive that has yet been made of the Yellowstone Basin. The report is referred to in the text as the "308 Report"; or, as "H.D. 256."

"Appendix F" of the Progress Report of the National Resources Planning Board. The progress report was attached to the minutes of the meeting of Upper and Middle Missouri Drainage Basin Sub-committees "A" and "B", which was held in Denver, Colorado, on August 18 and 19, 1939. Appendix F of the progress report, which is entitled "Water Use Studies of Yellowstone Basin and Middle Missouri Basin", was prepared by the Corps of Engineers, U. S. Army. It contains data obtained from a reconnaissance survey of existing irrigation projects made in the spring of 1939, and other information obtained by the Corps of Engineers since the 308 Report was prepared, supplemented by data furnished by various state and Federal agencies. The report is in many respects a revision of the irrigation section of the 308 Report. It is sometimes referred to in the text as "Appendix F."

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4. Summary of the Progress of the Compact Commission to date

On August 2, 1937, an Act of Congress (50 Stat. 551) was approved, granting the consent of the Congress to the states of Montana and Wyoming to negotiate and enter into a compact providing for an equitable division of the waters of the Yellowstone River Basin. The President appointed Mr. Clyde L. Seavey, member of the Federal Power Commission, to represent the United States. The Governors of the states of Montana and Wyoming, respectively, appointed the following representatives:

Montana:

Mr. E. B. Donohue, Chairman, Helena, Montana
Mr. Rockwood Brown, Billings, Montana
Mr. J. D. Scanlan, Miles City, Montana
Mr. B. B. Armstrong, Livingston, Montana

Wyoming:

Mr. John D. Quinn, Chairman, Cheyenne, Wyoming
Mr. L. F. Thornton, Thermopolis, Wyoming
Mr. J. R. Ellis, Basin, Wyoming
Mr. Will G. Metz, Cheyenne, Wyoming

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The first meeting of the Compact Commission was held in Billings, Montana, on May 5, 1938, for the purpose of determining what information was needed for drafting the compact and how it might best be obtained. The second meeting was held in Thermopolis, Wyoming, on November 21 and 22, 1938. At the second meeting a report embodying the material that had been collected up to that time was submitted by the Federal Power Commission, and a progress report(1) to the Governors of the states of Montana and Wyoming and to the Congress of the United States was drafted. On June 15, 1940, the President approved a bill (S. 1759) which extended the time for the drafting of the compact to June 1, 1943, and included North

(1) A copy of the progress report is contained in Appendix V.

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Dakota as a party thereto. The last meeting of the Compact Commission was held in Billings on October 10, 1940.

The present (December 1940) members of the Compact Commission are:

Montana:
Mr. E. B. Donohue, Chairman, Helena, Montana
Mr. Rockwood Brown, Billings, Montana
Mr. Wesley A. D'Ewart, Wilsall, Montana
Mr. E. B. Winter, Miles City, Montana

Wyoming:
Mr. L. C. Bishop, Chairman, Cheyenne, Wyoming
Mr. L. F. Thornton, Thermopolis, Wyoming
Mr. Will G. Metz, Buffalo, Wyoming
Mr. David Anderson, Riverton, Wyoming
Mr. John Gonin, Lander, Wyoming
Mr. Ernest Goppert, Cody, Wyoming
Mr. R. E. McNally, Sheridan, Wyoming
Mr. Ray Bower, Worland, Wyoming

North Dakota:
Mr. Frank P. Whitney, Dickinson, North Dakota

United States:
Mr. Clyde L. Seavey, Member of Federal Power Commission, Washington, D. C.

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5. Surveys Now in Progress

The U. S. Bureau of Reclamation is now making a survey of the irrigated and irrigable areas in the Big Horn Basin and in portions of the Yellowstone Basin above Billings, Montana. It is understood that the survey may be extended to cover the entire Yellowstone Basin. The report on the survey is expected to be released within about one year.

The Corps of Engineers, War Department, recently completed a survey of reservoir sites in the basin. The District Engineer has submitted his report to the Chief of Engineers, and it will probably be made public at an early date.

The Montana Water Conservation Board and the Montana State

College are jointly sponsoring a survey of irrigated areas and water-right priorities in the Montana portion of the basin. It is understood that this survey, which is expected to provide more complete information on the present uses of water in Montana, will be finished within a year.

The U. S. Indian Service is making a study of water use in the Big Horn Basin. The date of release of this report is indefinite.

The U. S. Bureau of the Census has just completed its decennial census of irrigation. The report of this census, which will be available in 1941, should contain data of value to the Compact Commission.

0521

Preliminary Report

on

YELLOWSTONE RIVER BASIN

Section I

GENERAL, ENTIRE YELLOWSTONE RIVER BASIN

A. Physical Characteristics
B. Occupancy and Economy
C. Climate and Hydrology
D. Water Use and Control
E. Water Laws and Their Administration
F. Existing Water Rights
G. Interstate Compacts

Federal Power Commission
Bureau of Engineering
Denver Regional Office

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9

A. PHYSICAL CHARACTERISTICS OF THE BASIN

1. General Description

The Yellowstone River Basin is a pear-shaped area extending from the continental divide in northern Wyoming northeastward to the confluence of the Missouri and Yellowstone Rivers near the Montana-North Dakota boundary line (see map 1). Its area of 70,400 square miles has a length of about 440 miles and a maximum width of about 310 miles. To the north and east lies the Upper Missouri River Basin; to the south, the upper Platte and Colorado River Basins; and to the west, the rugged headwaters of the Snake River.

The waters of the Yellowstone River rise in the Absaroka Range and the Wind River Range of the Rocky Mountains, and in the Big Horn Mountains to form several large streams which eventually find their way to the main stem in Montana. The northern portion of the Absaroka Range is drained by the Yellowstone, Boulder, Stillwater, Clark Fork, and Shoshone Rivers. The southeastern slope of the Absaroka Range and the eastern slope of the Wind River Range are drained by the Greybull, the Wind, and the Popo Agie Rivers, which, with the Shoshone, form the principal drainage of the Big Horn, the major tributary of the Yellowstone. The Big Horn Mountains, in North Central Wyoming, are drained on the west by Shell and Nowood Creeks and the Little Horn River, and on the east by the Tongue and the Powder Rivers.

The main stem of the Yellowstone River rises south of Yellowstone Park, flows north through Yellowstone Lake to Livingston, Montana,

0523

where it turns northeast and follows closely the northern boundary of the basin to its confluence with the Missouri. All of its major tributaries enter from the south and below the turn at Livingston, Montana. Map 1 outlines the boundaries of the Yellowstone River Basin and its tributaries.

2. Topography

The elevation of the basin ranges from 2,000 feet near the mouth of the main stem to 13,000 feet in the mountains surrounding Yellowstone Park. On the west and the south the basin is bound by the mountains of the Absaroka and Wind River Ranges; and near the center of the basin, the isolated Big Horn Mountains rise to 12,000 feet or more. After leaving the foothills the narrow, steep canyons of the mountains broaden into wide, flat valleys several miles in width and flanked by sharply-rising benches. In the lower elevations, the interstream divides are low, broad, and smoothly rolling. To the north and east, the basin broadens out to form part of the northern Great Plains. Although the plains are generally smooth, they are considerably dissected by a relief of mesas and isolated buttes that often rise 500 to 1,500 feet above the surrounding plains.

0524

The following table shows the average gradient for each of the principal streams (see figure 1 for profiles.)

Table 1

Slope of Yellowstone River and Principal Tributaries

Stream	Elevation at Headwaters (feet)	Elevation at Mouth (feet)	Length (miles)	Average Slope (feet/mile)
Yellowstone, Main Stem	10,800	1,858	671	13.3
Clark Fork	6,960*	3,225	136*	27.5
Big Horn (to headwaters of Wind River)	9,600	2,666	461	15.0
Tongue	9,400	2,310	265	26.7
Powder (to headwaters of North Fork)	9,410	2,200	437	16.5

Source: Corps of Engineers, War Department, 308 Report (H.D. 256, Yellowstone River Basin), page 27.

*Elevation at headwaters not available; elevation and length shown are for a point approximately 15 miles downstream from the headwaters.

3. Soils and Vegetal Cover

Detailed soil surveys have been made only for a small portion of the basin. The U. S. Department of Agriculture has published soil surveys covering the Billings area and the Lower Yellowstone Valley area in Montana, and the Basin area and the Shoshone area in Wyoming. Various other agencies have made surveys of isolated tracts as a part of investigations of the feasibility of proposed irrigation projects. The following information was taken from the Corps of Engineers' 308 Report and the "Preliminary Examination Report - Yellowstone River and Its Tributaries" of the Field Flood Control Coordinating Committee of the U. S. Department of Agriculture:

Practically all the soils of the broad river valleys are alluvial. Although they were all derived by similar processes from

0525

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shale and sandstone, there is a considerable variation in maturity from place to place, especially from stream to stream. Generally, the more mature soils are found on the higher portions of alluvial terraces back from the streams.

On the great plains of the basin heavy-textured loams predominate. These belong to the gray and brown pedocal groups, and are usually underlain by mineral deposits, especially lime, at relatively shallow depths. Because of the dry climate, the soils have never supported a sufficiently heavy vegetal cover for an appreciable quantity of organic matter and humus to accumulate. Alkali, mainly the white variety, is prevalent throughout the basin, but usually it is not sufficiently concentrated to be detrimental to agriculture.

On the higher, forest-covered portions of the watershed immature soils predominate. Above timberline, and also on large areas below timberline, soils black with organic matter to a depth of six inches have developed under a grass cover.

0526

The type of vegetation varies rather closely with precipitation. The semi-arid plains support a thin cover of sage brush and short grass, and, to a lesser extent, shadscale and saltbrush. The mountains and higher valley slopes are covered by forests and mountain bunchgrass.

4. Drainage Areas

The total drainage area of the Yellowstone River Basin is about 70,400 square miles, of which 32,960 square miles are in Wyoming, 36,700 square miles in Montana, and 740 square miles in North Dakota.

Table 2 shows the drainage area in square miles of the main stem and principal tributary basins.

Table 2

Drainage Area, by Sub-Basins, of the Yellowstone River Basin

Sub-Basin	Drainage Area (square miles)			
	Wyoming (1)	Montana (3)	North Dakota (2)	Total (2)
Yellowstone (main stem)	2,162	22,852	740	25,754
Clark Fork	1,184	1,664	0	2,848
Big Horn	18,259	4,683	0	22,942
Tongue	1,645	3,796	0	5,441
Powder	9,710	3,705	0	13,415
Total	32,960	36,700	740	70,400

(1) H. T. Person - Water Resources of Yellowstone River Basin, Wyoming, September 1938.

(2) Corps of Engineers, War Department, 308 Report (H.D. 256, Yellowstone River Basin), page 26.

(3) Developed from total area shown in 308 Report, and Wyoming area shown in H. T. Person report.

0527

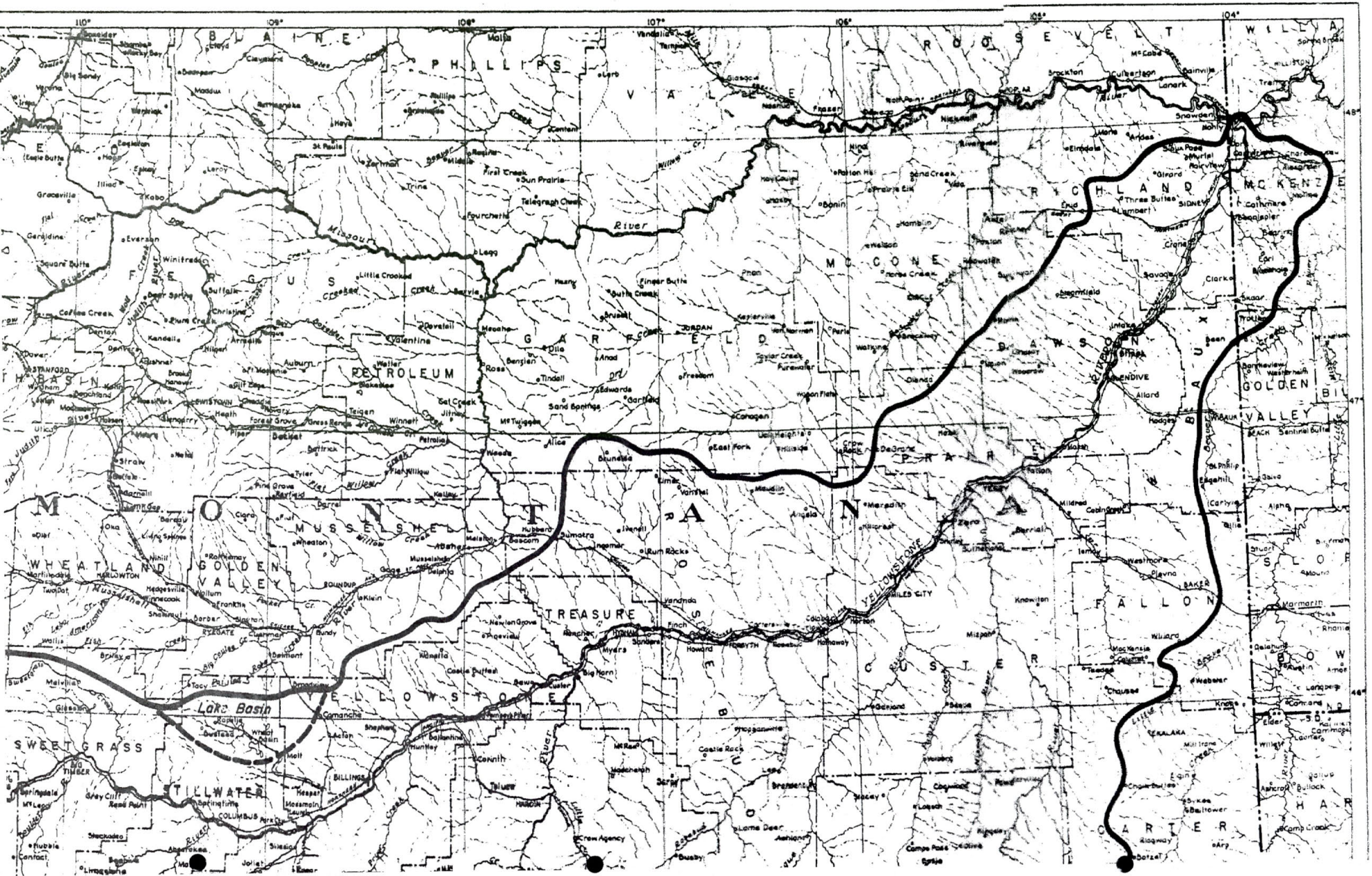
SEE FULL MAP ATTACHED

FEDERAL POWER COMMISSION
BUREAU OF ENGINEERING — DENVER REGIONAL OFFICE

THE YELLOWSTONE RIVER BASIN

GENERAL MAP

MAP NO. 1



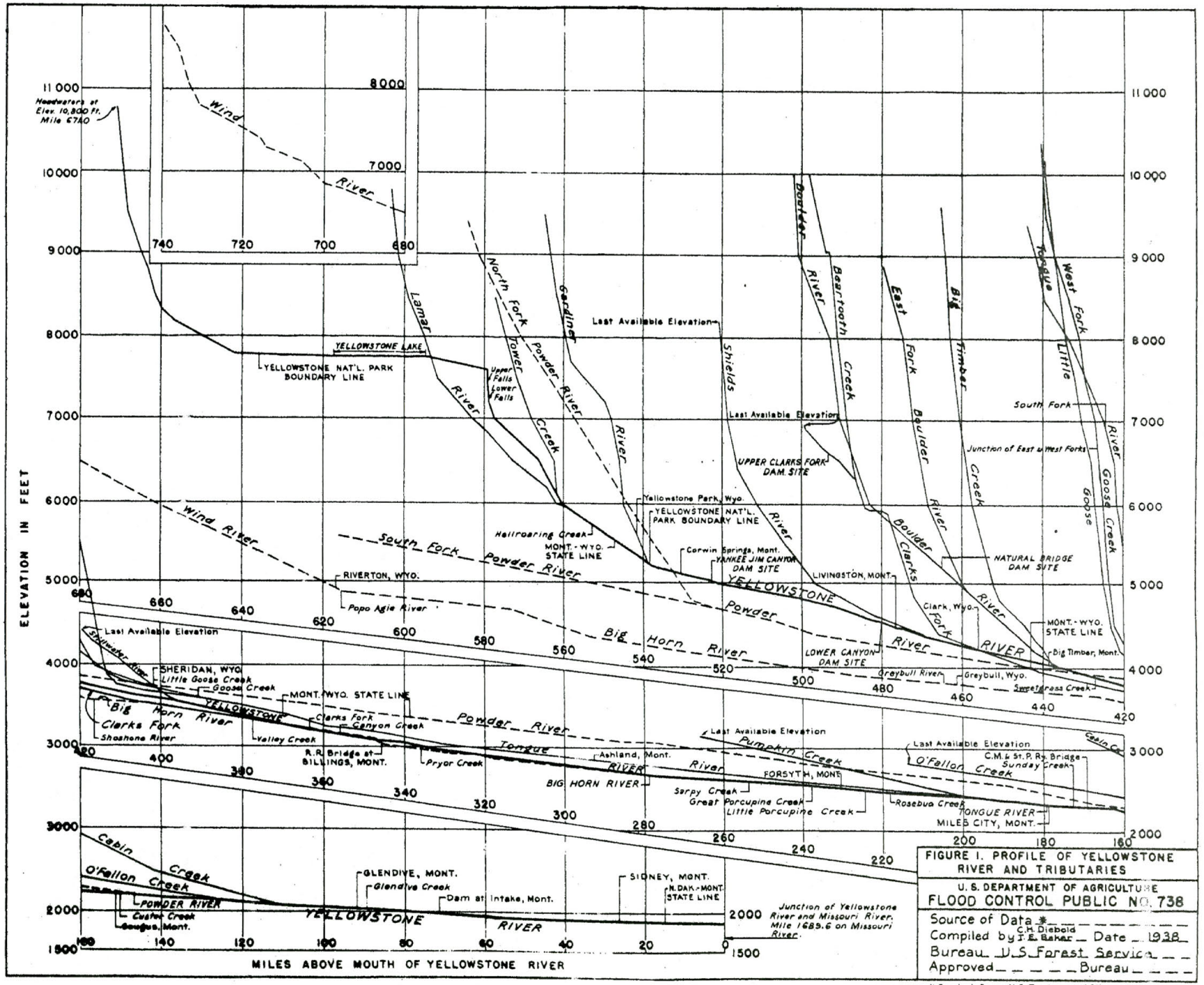


FIGURE 1. PROFILE OF YELLOWSTONE RIVER AND TRIBUTARIES

U. S. DEPARTMENT OF AGRICULTURE
FLOOD CONTROL PUBLIC NO. 738

Source of Data * _____
Compiled by C.M. Diebold I.E. Baker Date 1938
Bureau U.S. Forest Service
Approved _____ Bureau _____

*Copied from U.S. Engineer Office, Kansas City, Mo.

FIGURE NO. 1

B. OCCUPANCY AND ECONOMY

1. Public Lands in the Basin

Approximately one-third of the area of the basin is in public lands, which include three Indian reservations, seven national forests, one national park, five grazing districts, one national cemetery, one national monument, and one Federal experiment station. Table 4 shows, by counties, the number of acres in Indian reservations, national forest reserves, grazing districts, and unreserved public land. It will be noted that the county lines of the 26 counties of table 4 do not coincide exactly with the boundary of the basin. Map 2 and figure 2 show in detail the locations of reserved public land.

Indian Reservations

There are 4,832,411 acres in the three Indian reservations(1), distributed to sub-basins as shown in the following tabulation:

Land in Indian Reservations, by Sub-basins

(Acres)

Name of Reservation	Main Stem	Big Horn	Tongue	Total
Wind River	None	2,268,073	None	2,268,073
Crow	649,321	1,470,740	None	2,120,061
Tongue River	276,070	2,600	165,607	444,277
Total	925,391	3,741,413	165,607	4,832,411

Source: W. S. Hanna, Supervising Engineer, U. S. Indian Irrigation Service - Letter dated May 23, 1939.

The Wind River Indian Reservation, formerly known as the Shoshone Indian Reservation, lies along the Wind River in Fremont and Hot Springs

(1) Information on Indian reservations was furnished by the Office of Indian Affairs, particularly by Mr. W. S. Hanna, Supervising Engineer, U. S. Indian Irrigation Service, in a letter dated May 23, 1939 and memorandum reports dated January 23, 1939 and February 16, 1939.

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Counties, Wyoming, and was established by treaty with the Shoshone Indians in 1868. The original area of the reservation was approximately 2,260,000 acres, but this has been reduced to about 830,000 acres by cession treaties of 1872 and 1904, the latter providing for the development of irrigation for Indians on the diminished portion of the reservation with the proceeds from the sale of lands on the ceded portions.

The ceded portion, lying north of the Wind River, contains about 1,430,000 acres, of which about 200,000 acres have been deeded to others. The remaining area is leased to white stock operators and contributes materially to tribal revenue. In the southeastern part of the reservation about 45,000 acres are being irrigated under three large irrigation systems. The U. S. Bureau of Reclamation operates one of these systems, the Riverton Project, and plans eventually to increase its irrigated area from the 25,000 acres now being irrigated to 100,000.

The Indian population is concentrated on the diminished portion lying between the Wind and Popo Agie Rivers. Agriculture has been developed under irrigation systems constructed by the Indian Irrigation Service, a division of the Office of Indian Affairs. Approximately 14,000 acres are now being irrigated under six government canals. In addition, about 12,000 acres are being irrigated from about 100 private ditches within the diminished portion of the reservation.

Below is a summary of the irrigation canals and reservoirs under the six government irrigation systems, known as the "Wind River Irrigation Project."

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Irrigation Canals and Reservoirs on the Wind River Irrigation Project

Canals

Source of Supply	Number of Diversions	Aggregate Canal Capacity (c.f.s.)	Ultimate Area Under Ditches (acres)
Big Wind River	8	875(1)	39,620(2)
Little Wind River	5	1,050	45,500

Storage Reservoirs

Name	Source of Supply	Location	Capacity (acre-feet)
Ray Lake Reservoir	S. Fk. Little Wind	T1S R1W	7,200
Washakie Reservoir	S. Fk. Little Wind	T1S R2W	8,000

(1) Stream flow not equal during entire season to diversion capacity on tributary streams.
(2) Includes 15,013 acres under Le Clair-Riverton Canal which government does not operate but shares in the cost of operation and maintenance in proportion to the 3,230 acres of Indian trust patent land served by this system.

The Crow Indian Reservation is in southeastern Montana, and was established by treaty with the Crow Tribe in 1868. As originally established, the reservation contained about 8 million acres, but has been reduced to a present area of 2,120,000 acres by agreements of 1880, 1890, and 1904. The greater portion lies in Yellowstone and Big Horn Counties, with smaller tracts of ceded lands in Treasure, Sweetgrass, and Stillwater Counties.

Agricultural operations are devoted mainly to hay, small grains, and sugar beets, although corn, peas, small fruit, and potatoes can be grown successfully. Dry farming is very limited on the reservation, as crop failure, because of drought, is the rule rather than the exception under this method.

Thirteen irrigation units built under the supervision of the

0532

Indian Irrigation Service include a total irrigable area of 53,000 acres. At present about 27,000 acres are being irrigated, and it is estimated that 63,000 acres can be irrigated by extension of present systems. A summary of the present irrigation systems is given below:

Irrigation Canals on the Crow Indian Reservation

Source of Supply (Incl. Tributaries)	Number of Diversions	Aggregate Canal Capacity (c.f.s.)	Present Area Under Ditches (acres)
Pryor Creek	3	30	3,889
Big Horn River(1)	3	1,170	45,056
Little Horn River(2)	5	510	14,860
Lodgegrass Creek	3	(3)587	4,791
Acreage under government control			53,462
Total miles of canals and laterals			323

(1) Includes the privately-owned Two Leggin Canal which irrigates a total of 20,000 acres. U. S. has purchased carriage right in this canal for approximately 5,642 acres of Indian land.
(2) Includes the privately-owned Bozeman Trail Canal which irrigates a total of 2,738 acres. U. S. has purchased carriage right in this canal for 1,961 acres of Indian land.
(3) Includes 350 c.f.s. capacity of feeder canal to Willow Creek Reservoir.

0533

The ultimate area that can be irrigated by extension of each of the 13 existing systems is given below:

Name of Ditch	Capacity (c.f.s.)	Ultimate Area (acres)
Big Horn	700	28,714
Two Leggin	400	5,642
Soap Creek	50	1,814
Upper Little Horn No. 2	115	3,286
Bozeman Trail	70	1,961
Forty Mile	30	1,060
Reno	85	3,612
Agency	210	6,134
Lodgegrass No. 1	200	4,874
Lodgegrass No. 2	37	1,828
Pryor Creek	20	3,102
Lost Creek	10	716
Coburn	10	612
Total	1,937	63,355

There are no storage reservoirs on this reservation at present. The Willow Creek Reservoir, located on a tributary of Lodgegrass Creek, is under construction and will have a capacity of 23,000 acre-feet.

The Tongue River Indian Reservation, sometimes called the Northern Cheyenne Indian Reservation, lies east of and adjacent to the Crow Indian Reservation in Big Horn and Rosebud Counties, Montana. It was established by Executive Order in 1884. In 1910, the boundaries were modified and more definitely described to include 444,277 acres. The Indians are of the Northern Band of the Cheyenne Tribe, and were estimated to number about 1,600 in 1938.

The reservation lands are almost wholly Indian-owned and agricultural operations are limited to the production of feed for livestock, which is the principal industry. Mountain areas generally produce sufficient grass for forage purposes and permit production of small quantities of hay necessary to carry the stock through the winter.

0534

Not more than 300 acres are now being irrigated on the reservation. In 1905, the United States began construction of the Tongue River Irrigation Project to divert water from the Tongue River to irrigate 7,000 acres from a canal 25 miles long, following close to the west bank. Only 6.8 miles of canal, commanding 1,200 acres, were completed. The original plan to cover the larger area was abandoned because of difficult and costly construction. Not more than 600 acres have ever been irrigated in any one year under this project, and, at present, only 150 acres are being irrigated. Numerous attempts have been made by individuals to develop small irrigated tracts along reservation streams, but, in general, these have not been successful, primarily because of the inadequacy of the water supply during the summer season. Private systems, at present, cover

not more than 150 acres.

Present plans are to develop from 1,000 to 1,500 acres in 13 or 14 isolated pumping projects along the west bank of the Tongue River. These projects have already been authorized for construction. A contract whereby the United States will acquire 7,500 acre-feet of storage capacity in the recently constructed Tongue River Reservoir for irrigation on the reservation is awaiting final Congressional sanction.

National Forests

Seven national forests with a total area of 6,038,121 acres occupy 13.4 percent of the Yellowstone River Basin. The area of each forest in each sub-basin is shown in table 3 below:

Table 3

Land in National Forests
By Sub-Basins

(Acres)

Name of Forest	Main Stem	Clark Fork	Big Horn	Tongue	Powder	Total
Shoshone(1)	0	506,240	1,083,520	0	0	1,589,760
Washakie(1)	0	0	835,840	0	0	835,840
Big Horn(1)	0	0	556,739	293,120	264,115	1,113,974
Teton(2)	211,410	0	0	0	0	211,410
Custer(3)	282,870	106,014	79,462	469,477	37,478	975,301
Absaroka(3)	1,166,372	68,500	0	0	0	1,234,872
Gallatin(3)	76,964	0	0	0	0	76,964
Total	1,737,616	680,754	2,555,561	762,597	301,593	(4)6,038,121

(1) Allen S. Peck, Regional Forester, Rocky Mountain Region - Letter dated October 10, 1938.
(2) W. W. Blakeslee, Acting Regional Forester, Inter-mountain Region - Letter dated September 28, 1938.
(3) Evan W. Kelly, Regional Forester, Northern Region - Letter dated October 26, 1938.
(4) Includes 332,249 acres of alienated land within national forest boundaries.

National Parks

Yellowstone National Park, the only national park in the basin, is in the northwestern corner of Wyoming, with small areas extending into Montana, Idaho, and Utah. It has an area of 1,902,720 acres,

0535

1,196,800 of which are in the Yellowstone Basin - all on the main stem. The park is a plateau about 8,000 feet high, almost completely surrounded by higher peaks. Congressional authorization for the drafting of an interstate compact excludes from consideration therein any waters within or tributary to this park.

Grazing Districts

The Taylor Grazing Act of 1934, and as amended in 1936, provides for the establishment of grazing districts from certain vacant, unappropriated and unreserved public lands. Five of these districts, three in Montana and two in Wyoming, lie, entirely or in part, within the boundaries of the Yellowstone River Basin and occupy about 7 percent.of the basin area.

Miscellaneous Public Lands

Small tracts of public land are occupied by Custer Battlefield, a national cemetery near Hardin, Montana, by Shoshone Cavern, a national monument near Cody, Wyoming, and by Fort Keogh Military Reservation, at Miles City, Montana, now used by the U. S. Range Livestock Experiment Station. Unreserved public lands occupy about 300,000 acres of the basin.

0536

2. Population

The total population of the Yellowstone River Basin(1) in 1930, as determined from publications of the U. S. Bureau of the Census, was 192,320. The following statement indicates the relative importance of the population of each component state section of the basin:

(1) The boundary lines of the minor civil divisions (for which the population was published) do not coincide exactly with the Yellowstone River Basin boundary.

Population of Yellowstone River Basin
By State Sections

State	Number of Persons	Percentage of Basin's Total Population	Total State Population	Percentage of State Population in Basin
Wyoming	70,425	36.6	225,565	31.2
Montana	119,523	62.2	537,606	22.2
North Dakota	2,372	1.2	680,845	.3
Total	192,320	100.0	1,444,016	13.3

Figure 3 shows the distribution, by sub-basins, of the total population of the basin. The trend of population from 1910 to 1930 is shown by figure 4. The distribution, classified as to urban, rural non-farm, and rural farm, is given in figure 5. Map 3 shows in detail the distribution of the population throughout the basin, and map 4, the minor civil divisions from which all population figures were developed.

The seven cities of the basin having a 1930 population of 2,500 or more are listed below:

Town or City	Population 1930
Billings, Montana	16,380
Sheridan, Wyoming	8,536
Miles City, Montana	7,175
Livingston, Montana	6,391
Glendive, Montana	4,629
Red Lodge, Montana	3,026
Laurel, Montana	2,558

Source: U. S. Bureau of the Census.

Although the population is predominately white, there are in the basin some 9,500 colored or non-white residents, mostly Indian. The Indian population, amounting to 5 percent of the total, and distributed about equally between Wyoming and Montana, is concentrated in the Big Horn and main stem basins.

0537

3. Agricultural Development

Agriculture, including stock raising, is the predominant occupation in the basin. In 1929 about three-fourths of the total income of the basin was derived from the sale of livestock and agricultural products. Prior to 1900 stock raising was the chief industry, and all agriculture was devoted almost entirely to its support. Since the turn of the century the intensive development of irrigation facilities has stimulated crop production to a growth that has placed it parallel in importance with stock raising. Table 7(1) shows the income of the basin derived from crops and from livestock. It will be noted that crops accounted for 40 percent of the 1929 agricultural income of the entire basin, but had not then reached the relative importance in Wyoming that they had in Montana and North Dakota.

Although about 85 percent of the land is devoted to hay and small grains, agriculture is rather well diversified considering the limitations placed upon it by climatic conditions. Especially is this true of irrigated crops, from which about half the total crop income is derived. The number of acres of each of the principal crops harvested in 1929 is shown below:

0538

(1) Tables 7-12 are U. S. Bureau of the Census figures. The 1930 Census (covering, in general, the year 1929) has a broader coverage and is in more detail than the 1935 Census. Table 8 presents data by sub-basins, which were compiled from tables of the Census of 1930 giving special data by minor civil divisions. In general, the county is the smallest unit for which data are given. Therefore, tables 7 and 9-12 present data for the 25 counties that most nearly represent the Yellowstone River Basin.

Principal Crops - 1929
(Number of Acres Harvested)

Crop	Irrigated Land	Dry Land	Total
Wheat (threshed)	70,000	1,314,000	1,384,000
Flax (threshed)	2,000	171,000	173,000
Barley (threshed)	50,000	115,000	165,000
Oats (threshed)	50,000	102,000	152,000
Hay	363,000	544,000	907,000
Beans (grown alone)	62,000	8,000	70,000
Alfalfa Seed	7,000	58,000	65,000
Sugar Beets	42,000	0	42,000
Potatoes	5,000	5,000	10,000
All Others	26,000	168,000	194,000
Total	677,000	2,485,000	3,162,000

Source: U. S. Bureau of the Census, Census of Agriculture, 1930.

Although dry farming is practiced to a limited extent, irrigation is the backbone of agriculture. Of the 3,162,000 acres harvested in 1929, only 20 percent was irrigated, but the irrigated land produced 45 percent of the total crop value (see table 10). The average value of crops harvested from irrigated land in 1929 was $28.12 per acre, as compared with $9.44 for dry land. It has been estimated that one acre of irrigated farm land will stabilize 20 acres of range. The stabilizing effect of irrigation in years of drought and depression is strikingly illustrated by table 11. This table shows the number of acres of irrigated and dry land harvested for crops in the normal year 1929 and in the extremely dry year 1934. It will be noted that, while the number of acres harvested from dry land fell to one-fourth the normal amount, the number harvested from irrigated land dropped only one percent. The value of irrigation in 1934 to the stock industry of the basin is reflected in table 12, which shows that the total number of cattle and sheep in the

0539

basin remained practically stationary over the five-year period. This fact is extremely significant if it will be remembered that in 1934, in the region immediately east of the basin where irrigation is not practiced, stockmen were forced to sell even their breeding stock for lack of feed.

The value of farm land and buildings (see tables 8 and 9) was $228,000,000 in 1930. By 1935 the value had been reduced by 24 percent to $174,000,000, Montana having suffered a greater decline in values than Wyoming and North Dakota. The investment in irrigation works in 1930, as estimated by the Bureau of the Census, was $32,000,000, of which $19,000,000 was invested in Wyoming, and $13,000,000 in Montana. No estimate was given for the investment in irrigation works serving the 5,000 acres of irrigated land in North Dakota.

4. Industrial Development

Manufacturing and mining, as shown in table 6, account for about 14 and 13 percent, respectively, of the total income of the basic income-producing industries. The basin's coal reserves are considerable, and coal is mined in the Montana and Wyoming sections. The Montana section contains, in the Baker-Glendive natural gas field, one of the most important gas-producing regions in the state; and the Wyoming section contains, in the Salt Creek oil field (Natrona County), an outstanding oil-producing area. Manufacturing is confined largely to oil refining and to sugar beet and other food-processing industries.

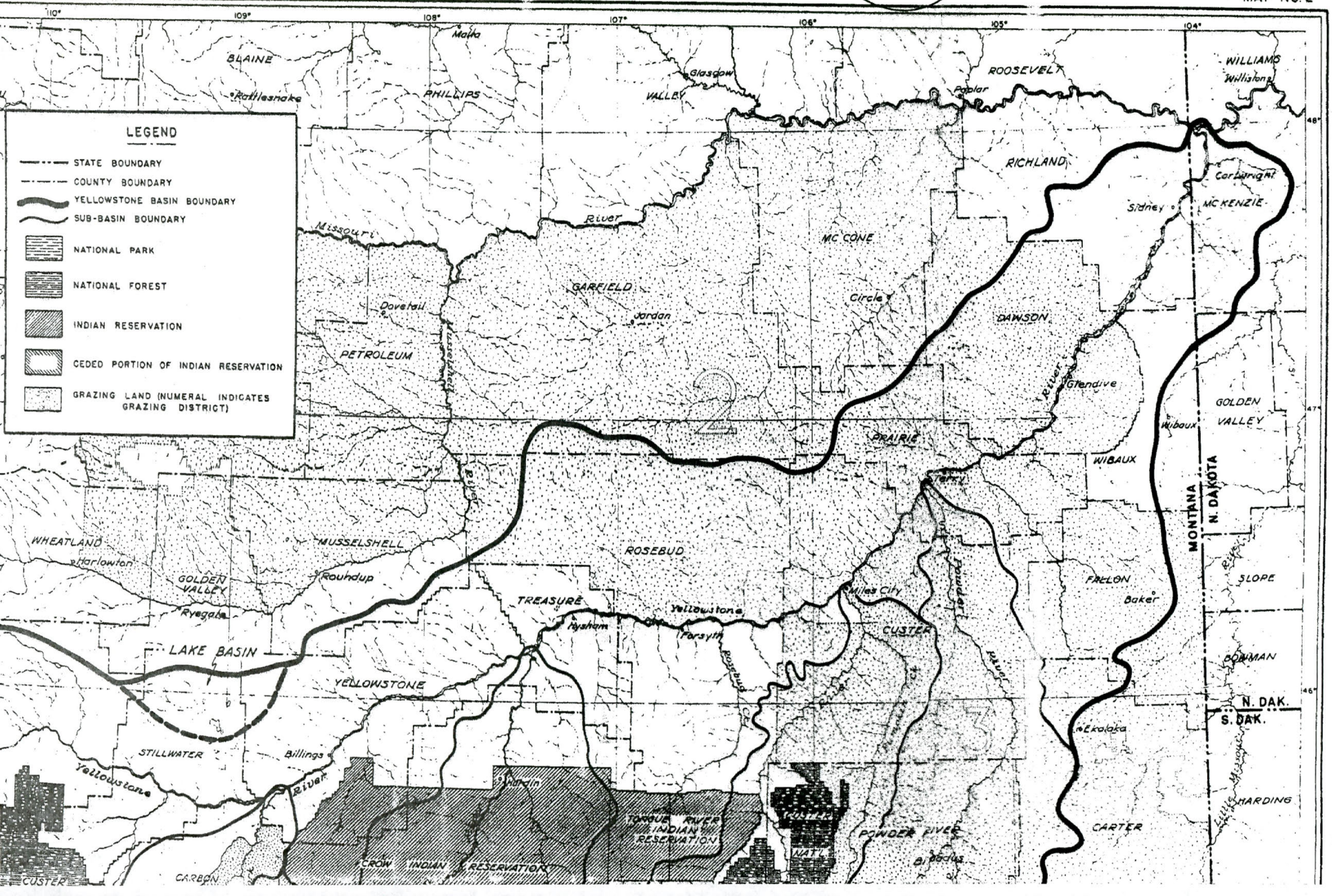
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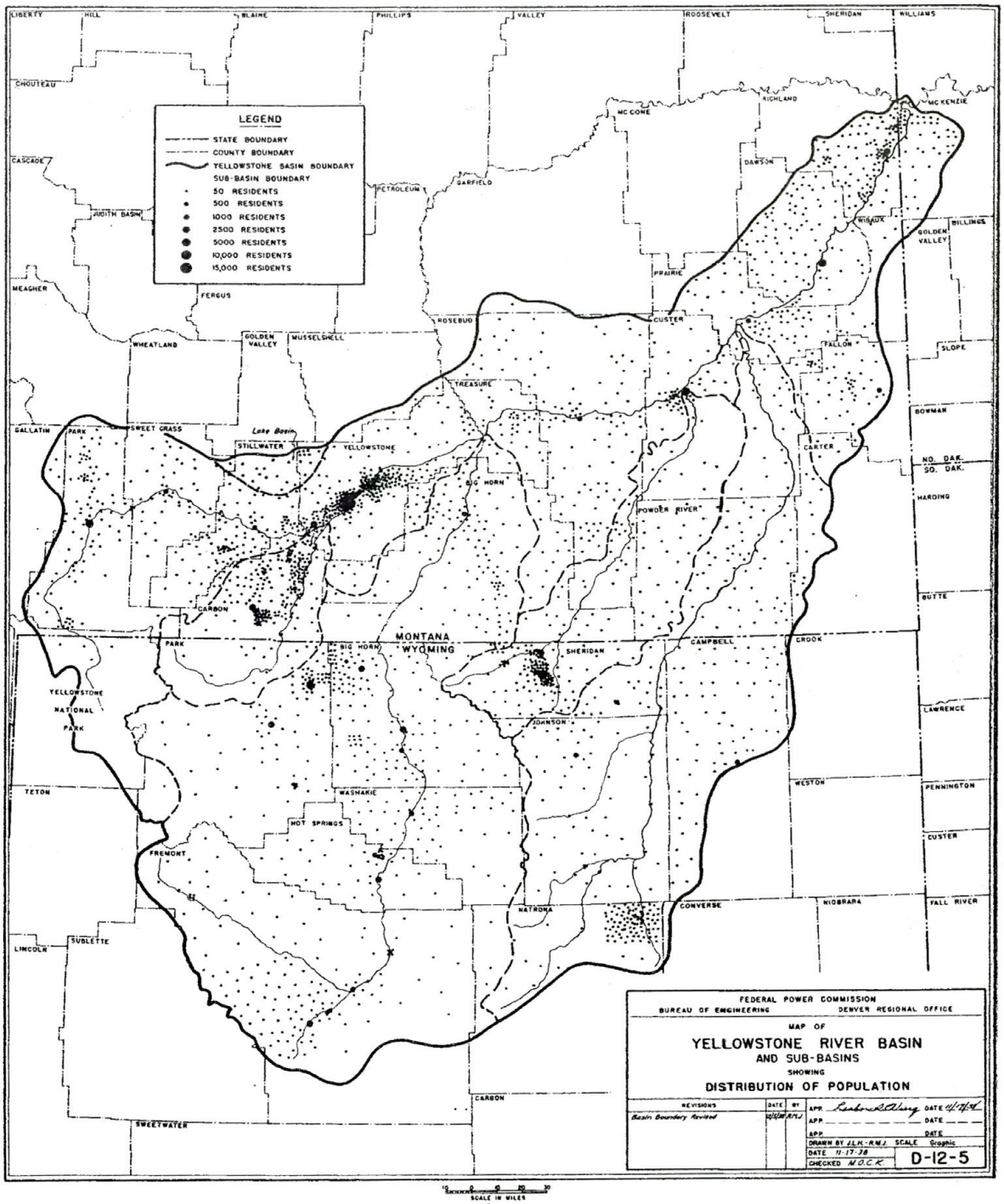
SEE FULL MAP ATTACHED

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MAP NO. 2



MAP NO. 3


LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
YELLOWSTONE BASIN BOUNDARY
SUB-BASIN BOUNDARY
50 RESIDENTS
500 RESIDENTS
1000 RESIDENTS
2500 RESIDENTS
5000 RESIDENTS
10,000 RESIDENTS
15,000 RESIDENTS
LIBERTY
HILL
BLAINE
PHILLIPS
VALLEY
ROOSEVELT
SHERIDAN
WILLIAMS
CHOUTEAU
MC CONE
RICHLAND
MC KENZIE
CASCADE
DAWSON
PETROLEUM
GARFIELD
JUDITH BASIN
WIBAUX
BILLINGS
GOLDEN VALLEY
MEAGHER
PRAIRIE
FERGUS
ROSEBUD
CUSTER
WHEATLAND
GOLDEN VALLEY
MUSSELSHELL
FALLON
SLOPE
TREASURE
BOWMAN
GALLATIN
PARK
SWEET GRASS
Lake Basin
STILLWATER
YELLOWSTONE
CARTER
NO. DAK.
SO. DAK.
BIG HORN
HARDING
POWDER RIVER
BUTTE
CARBON
MONTANA
WYOMING
PARK
BIG HORN
SHERIDAN
CAMPBELL
CROOK
YELLOWSTONE NATIONAL PARK
JOHNSON
LAWRENCE
WESTON
PENNINGTON
TETON
WASHAKIE
HOT SPRINGS
CUSTER
FREMONT
NATRONA
CONVERSE
NIOBRARA
FALL RIVER
LINCOLN
SUBLETTE
CARBON
SWEETWATER
SCALE IN MILES
FEDERAL POWER COMMISSION
BUREAU OF ENGINEERING
DENVER REGIONAL OFFICE
MAP OF
YELLOWSTONE RIVER BASIN
AND SUB-BASINS
SHOWING
DISTRIBUTION OF POPULATION
REVISIONS
DATE
BY
Basin Boundary Revised
APP.
DATE 11/7/58
APP.
DATE
APP.
DATE
DRAWN BY JLK-RMJ
SCALE Graphic
DATE 11-17-58
CHECKED M.O.C.K
D-12-5

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FEDERAL POWER COMMISSION
BUREAU OF ENGINEERING — DENVER REGIONAL OFFICE

MAP OF

YELLOWSTONE RIVER BASIN
AND SUB-BASINS

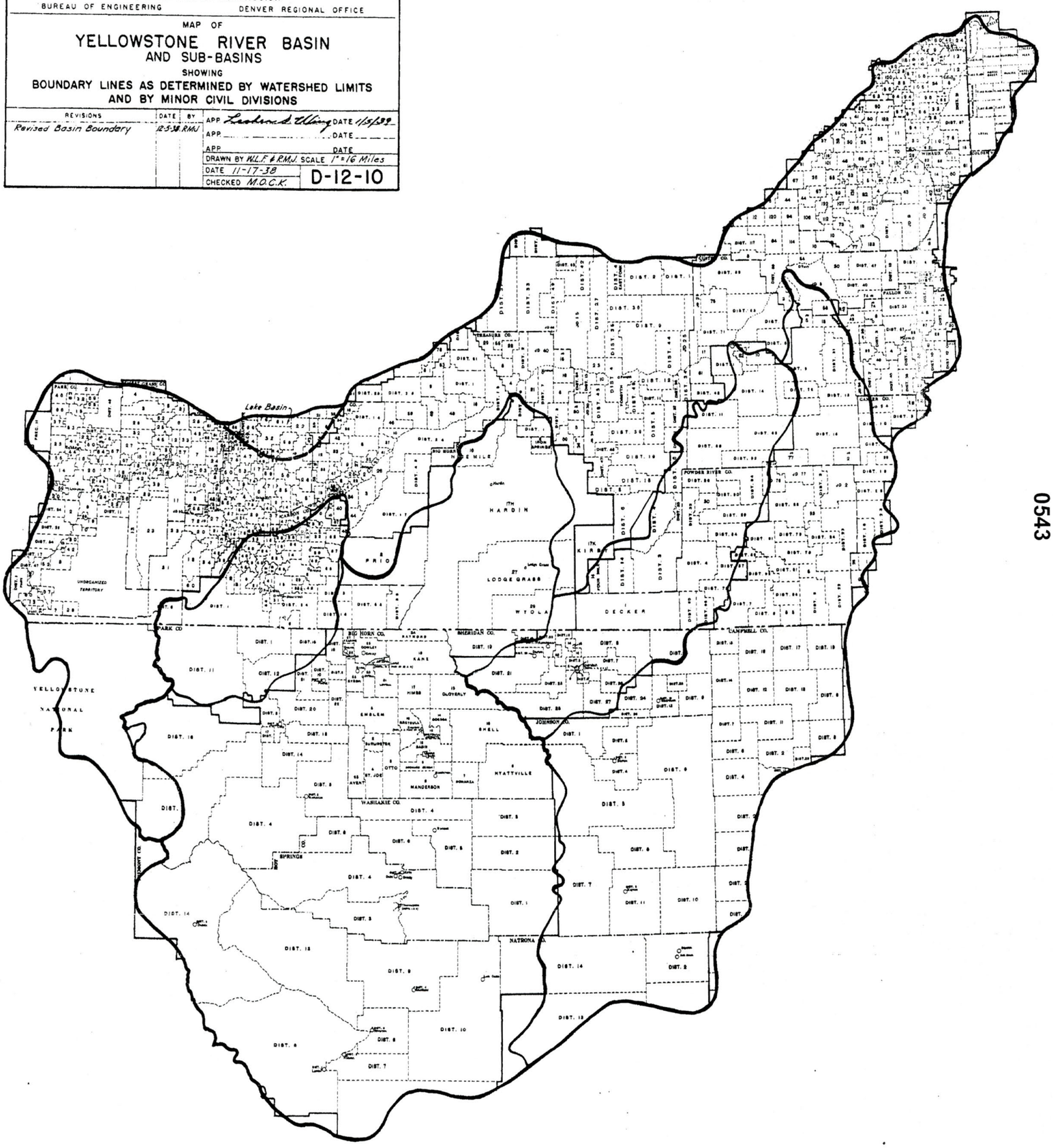
SHOWING

BOUNDARY LINES AS DETERMINED BY WATERSHED LIMITS
AND BY MINOR CIVIL DIVISIONS

REVISIONS	DATE	BY
Revised Basin Boundary	12-5-38	R.M.J.

APP Frederick L. Ellis DATE 11/5/38
APP ..... DATE .....
APP ..... DATE .....
DRAWN BY W.L.F. & R.M.J. SCALE 1" = 16 Miles
DATE 11-17-38
CHECKED M.O.C.K.

D-12-10



0543

0544

LEGEND

Privately Owned Lands. Figure Indicates Percent Of Total County Area.

Publicly Owned Forest Lands. Figure Indicates Percent Of Total County Area.

Publicly Owned Indian Reservations. Figure Indicates Percent Of Total County Area.

Publicly Owned Unreserved Lands. Figure Indicates Percent Of Total County Area.

Publicly Owned Unreserved Lands Withdrawn For Grazing Purposes In Accordance With The Taylor Grazing Act. Figure Indicates Percent Of Total County Area.

CARBON 1,320,960 — County Name. Figure Indicates Total County Area In Acres.

(865,680) — Figures In Parenthesis Indicate Portion Of County Acreage Within Basin.

GALLATIN (134,400) — Indicates Basin Acreage In Counties Not Shown On This Map.

MONTANA

NORTH DAKOTA

WYOMING

RICHLAND 1,345,920 (678,400)

MC KENZIE 1,822,080 (425,600)

DAWSON 1,309,760 (1,228,800)

GOLDEN VALLEY (48,000)

WIBAUX 465,920 (345,600)

GARFIELD (108,800)

PRAIRIE 1,114,880 (899,200)

Note 'A'

MUSSELSHELL (70,400)

ROSEBUD 3,195,520 (3,184,000)

CUSTER 2,394,240 (2,377,600)

FALLON 1,029,120 (668,800)

TREASURE 614,400

GALLATIN (134,400)

PARK 1,685,120 (1,670,400)

SWEETGRASS 1,176,960 (1,040,000)

YELLOWSTONE 1,668,480 (1,651,200)

STILLWATER 1,137,280 (865,680 Approx.)

BIG HORN 3,178,240

CARTER 2,162,000 (518,800)

POWDER RIVER 2,135,680

CARBON 1,320,960

PARK 3,316,480

YELLOWSTONE 1,902,720 (1,796,800)

NATIONAL PARK

BIG HORN 1,990,400

SHERIDAN 1,847,360

CAMPBELL 1,047,040 (1,840,000)

JOHNSON 2,664,960

WASHAKIE 1,434,240

HOT SPRINGS 1,296,000

FREMONT 5,904,000 (4,617,600)

NATRONA 3,406,080 (1,472,000)

Note 'B'

Note 'A'
Other miscellaneous basin acreage in Montana = 32,000 A.

Note 'B'
Other miscellaneous basin acreage in Wyoming = 70,400 A.

FEDERAL POWER COMMISSION

YELLOWSTONE RIVER BASIN

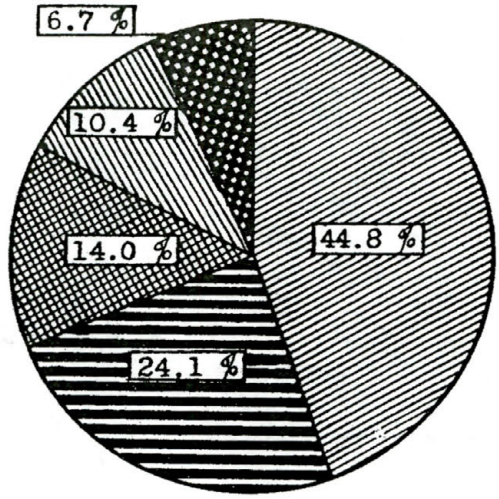
MAP SHOWING BY COUNTIES
PERCENT OF LANDS PUBLICLY AND PRIVATELY OWNED

D-12-3 Basin Boundary Revised 12-5-58

September 30, 1938

Figure 3.

Distribution by Sub-Basins of the Total Population of the Yellowstone River Basin - 1930.



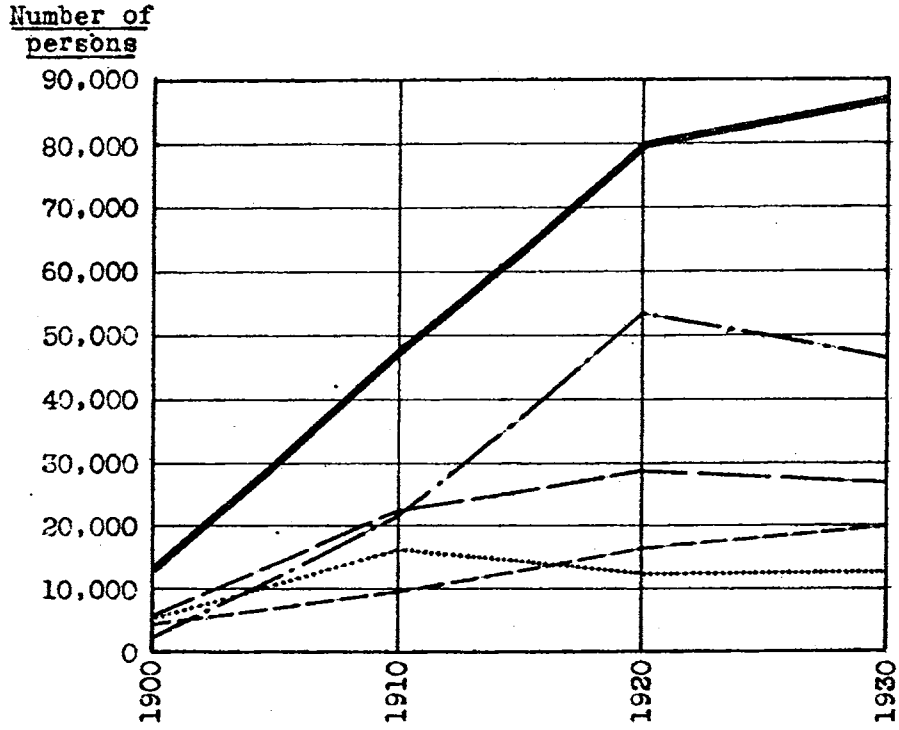
Basin	Total population - 1930	
	Persons	Percentage of total
Yellowstone River basin	192,320	100.0
Main stem basin	86,221	44.8
Clark Fork River basin	12,885	6.7
Big Horn River basin	46,319	24.1
Tongue River basin	26,945	14.0
Powder River basin	19,950	10.4

Authority: U. S. Bureau of the Census.

0545

Figure 4.

Trends of Population Development in the Yellowstone River Basin - 1900 to 1930, Inclusive.



Basin	Total population			
	1930#	1920*	1910*	1900*
Yellowstone River basin	192,320	196,786	117,248	31,481
Main stem basin	86,221	79,488	47,527	13,013
Clark Fork River basin	12,885	12,248	16,044	5,693
Big Horn River basin	46,319	53,684	21,881	2,460
Tongue River basin	26,945	28,895	22,289	5,808
Powder River basin	19,950	16,471	9,507	4,507
Percentage distribution				
Yellowstone River basin	100.0	100.0	100.0	100.0
Main stem basin	44.8	40.4	40.5	41.3
Clark Fork River basin	6.7	9.3	13.7	18.1
Big Horn River basin	24.1	27.3	18.7	7.8
Tongue River basin	14.0	14.7	19.0	18.5
Powder River basin	10.4	8.3	8.1	14.3

Population for 1930 is based upon published reports of the U. S. Bureau of the Census.

* Population for 1920, 1910, and 1900 is based in part upon such published reports, from which estimates have been made.

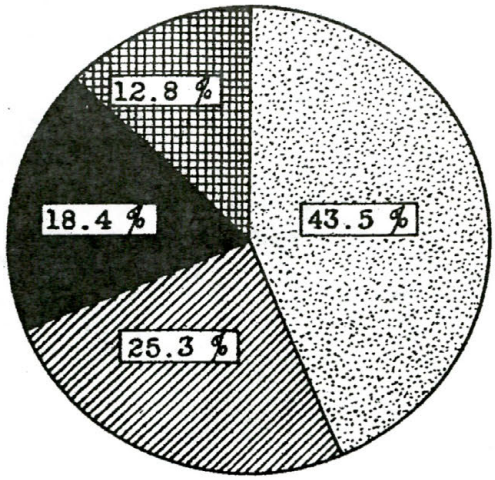
Authority: U. S. Bureau of the Census

Yellowstone basin
Main stem basin
Clark Fork basin
Big Horn basin
Tongue basin
Powder basin

0546

Figure 5.

Urban, Rural Non-Farm, and Rural Farm Population of the Yellowstone River Basin - 1930.



Classification	Persons	Percentage of total
Urban*	48,695	25.3
Rural non-farm		
Small incorporated places#	35,440	18.4
Other rural non-farm	24,555	12.8
Rural farm	83,630	43.5
Total population -	192,320	100.0

* Incorporated places having 2,500 or more inhabitants.
\# " " " less than 2,500 inhabitants.

Authority: U. S. Bureau of the Census.

0547

PUBLIC LANDS IN THE YELLOWSTONE RIVER BASIN*
(By Counties)

(Acres)

State and County	Public Land Reserved for: Indian Reservations (1)	National Forests (2)	Grazing Districts (3)	Unreserved Public Land (3)	Total Public Land	Total Private Land	Total Land in County
Wyoming							
Big Horn	None	356,259	806,616	None	1,162,875	827,525	1,990,400
Campbell	None	None	None	125,149	125,149	2,921,891	3,047,040
Fremont	2,002,696	964,484	1,510,697	480,514	4,958,391	946,609	5,905,000
Hot Springs	265,377	53,355	212,794	151,423	682,949	613,051	1,296,000
Johnson	None	327,312	None	343,192	670,504	1,994,456	2,664,960
Natrona	None	None	103,800	718,900	822,700	2,583,380	3,406,080
Park	None	1,687,058	140,616	223,947	2,051,621	1,264,859	3,316,480
Sheridan	None	395,444	None	26,189	421,633	1,225,727	1,647,360
Washakie	None	34,773	86,156	644,588	765,517	668,723	1,434,240
Total for Wyoming	2,268,073	3,818,685	2,860,679	2,713,902	11,661,339	13,046,221	24,707,560
Montana							
Big Horn	2,025,774	None	None	26,999	2,052,773	1,125,467	3,178,240
Carbon	None	317,635	144,887	68,918	531,440	789,520	1,320,960
Carter	None	88,566	369,996	None	458,562	1,701,438	2,160,000
Custer	None	None	172,842	None	172,842	2,221,398	2,394,240
Dawson	None	None	81,527	None	81,527	1,428,233	1,509,760
Fallon	None	None	34,328	None	34,328	994,792	1,029,120
Park	None	781,626	None	20,345	801,971	883,149	1,685,120
Powder River	None	333,327	108,934	6,220	448,481	1,687,199	2,135,680
Prairie	None	None	42,540	None	42,540	1,072,340	1,114,880
Richland	None	None	None	40,242	40,242	1,305,678	1,345,920
Rosebud	240,807	96,308	111,075	78,501	526,691	2,668,829	3,195,520
Stillwater	305	187,770	None	6,760	194,835	942,445	1,137,280
Sweetgrass	260	270,519	None	12,599	283,378	893,582	1,176,960
Treasure	76,012	None	None	20,360	96,372	518,028	614,400
Wibaux	None	None	None	22,071	22,071	543,049	565,120
Yellowstone	221,180	None	None	10,517	231,697	1,436,783	1,668,480
Total for Montana	2,564,338	2,075,751	1,066,129	313,532	6,019,750	20,211,930	26,231,680
North Dakota							
McKenzie	None	None	None	50,320	50,320	1,771,760	1,822,080
Total 26 Counties	4,832,411	5,894,436	3,926,808	3,077,754	17,731,409	35,029,911	52,761,320 (4)
Percent of Total	9.2	11.2	7.4	5.8	33.6	66.4	100.0

(1) Robert Yellowtail, Superintendent, Crow Indian Reservation - letter dated November 4, 1937

C. H. Jennings, Superintendent, Tongue River Indian Reservation - letter dated November 5, 1937

F. R. Stone, Superintendent, Wind River Indian Reservation - letter dated November 9, 1937

(2) J. A. Brownlee, Assistant Regional Forester, Rocky Mountain Region - letter dated November 1, 1937

J. P. Martin, Regional Engineer, Intermountain Region - letter dated November 4, 1937

F. E. Thieme, Assistant Regional Forester, Northern District - letter dated November 6, 1937

(3) General Land Office - letter dated October 6, 1937

(4) County lines do not coincide with basin boundary. Area of Yellowstone River Basin is 45,060,000 acres.

* Does not include Yellowstone National Park, 1,196,800 acres of which are in the basin.

Table 5

URBAN, RURAL NON-FARM AND RURAL FARM POPULATION OF THE YELLOWSTONE RIVER BASIN - 1930

Basin and State	Total	Urban	Rural non-farm		Rural farm*	Percentage distribution				
			Incorporated places having less than 2500 residents	Other rural non-farm*		Total	Urban	Rural non-farm: Incorporated places having less than 2500 residents	Rural non-farm: Other rural non-farm*	Rural farm*
Yellowstone Basin	192,320	48,695	35,440	24,555	83,630	100.0	100.0	100.0	100.0	100.0
Main stem	86,221	29,958	9,772	7,661	38,830	44.8	61.5	27.6	31.2	46.4
Clark Fork	12,885	3,026	1,844	2,015	6,000	6.7	6.2	5.2	8.2	7.2
Big Horn	46,319	--	19,513	6,308	20,498	24.1	--	55.1	25.7	24.5
Tongue	26,945	15,711	503	3,887	6,844	14.0	32.3	1.4	15.8	8.2
Powder	19,950	--	3,808	4,684	11,458	10.4	--	10.7	19.1	13.7
Yellowstone Basin	192,320	48,695	35,440	24,555	83,630	100.0	100.0	100.0	100.0	100.0
Main stem										
Montana	83,576	29,958	9,321	7,408	36,889	43.5	61.5	26.3	30.2	44.1
Wyoming	273	--	--	214	59	.1	--	--	.9	.1
North Dakota	2,372	--	451	39	1,882	1.2	--	1.3	.2	2.3
Clark Fork										
Montana	12,291	3,026	1,844	1,690	5,731	6.4	6.2	5.2	6.9	6.8
Wyoming	594	--	--	325	269	.3	--	--	1.3	.3
Big Horn										
Montana	7,373	--	1,542	1,111	4,720	3.8	--	4.4	4.5	5.6
Wyoming	38,946	--	17,971	5,197	15,778	20.3	--	50.7	21.2	18.9
Tongue										
Montana	11,811	7,175	--	1,230	3,406	6.1	14.8	--	5.0	4.1
Wyoming	15,134	8,536	503	2,657	3,438	7.9	17.5	1.4	10.8	4.1
Powder										
Montana	4,472	--	--	722	3,750	2.3	--	--	2.9	4.5
Wyoming	15,478	--	3,808	3,962	7,708	8.1	--	10.7	16.1	9.2
Summary by States										
Yellowstone Basin	192,320	48,695	35,440	24,555	83,630	100.0	100.0	100.0	100.0	100.0
Montana	119,523	40,159	12,707	12,161	54,496	62.2	82.5	35.8	49.5	65.2
Wyoming	70,425	8,536	22,282	12,355	27,252	36.6	17.5	62.9	50.3	32.6
North Dakota	2,372	--	451	39	1,882	1.2	--	1.3	.2	2.2

* Estimated.

Authority: U. S. Bureau of the Census.

Table 6

INCOME OF THE YELLOWSTONE RIVER BASIN IN 1929 FROM AGRICULTURE, MANUFACTURING AND MINING

(Thousands of Dollars)

State and County	Agriculture(1)	Mining(2)	Manufacturing(3)	Total
Wyoming				
Big Horn	3,616	90	2,985	6,691
Campbell	3,463	1,238	295*	4,996
Fremont	2,802	202	398	3,402
Hot Springs	1,270	1,803	57	3,130
Johnson	2,704	28	103	2,835
Park	3,134	1,836	170	5,140
Sheridan	3,533	1,530	1,561	6,624
Washakie	2,830	35	608*	3,473
Total, Wyoming	23,352	6,762	6,177	36,291
Montana				
Big Horn	4,746	-	97*	4,843
Carbon	3,652	2,450	287	6,389
Carter	1,972	-	51*	2,023
Custer	2,163	52*	856	3,071
Dawson	2,495	11	226*	2,732
Fallon	1,948	164	66*	2,178
Park	2,594	627	1,018	4,239
Powder River	2,604	-	17*	2,621
Prairie	1,379	-	12*	1,391
Richland	3,591	113*	537	4,241
Rosebud	2,906	1,830	48*	4,784
Stillwater	2,891	104	70	3,065
Sweetgrass	2,052	-	27	2,079
Treasure	801	-	10*	811
Wibaux	1,255	-	17*	1,272
Yellowstone	5,774	22*	3,401	9,197
Total, Montana	42,823	5,373	6,740	54,936
North Dakota				
McKenzie	4,308	5	33*	4,346
Total for 25 Counties	70,483	12,140	12,950	95,573
Percentage Distribution:				
Entire Basin	73.7%	12.7%	13.6%	100%
Wyoming	64.4	18.6	17.0	100
Montana	77.9	9.8	12.3	100
North Dakota	99.1	0.1	0.8	100

Source: (1) U. S. Bureau of the Census, Census of Agriculture, 1930.
(2) U. S. Bureau of Foreign and Domestic Commerce, Manufacturing Market Statistics, 1932.
(3) Value added by manufacturing. From: U. S. Bureau of the Census, Census of Manufactures, 1930.

*Estimated

Table 7

AGRICULTURAL INCOME OF THE YELLOWSTONE RIVER BASIN - 1929

Value of Products Sold or Traded

(Thousands of Dollars)

State and County	Crops	Livestock and Livestock Products	Other Farm Products	Total
Wyoming				
Big Horn	1,678	1,641	297	3,616
Campbell	683	2,472	308	3,463
Fremont	436	2,161	205	2,802
Hot Springs	139	1,058	73	1,270
Johnson	295	2,250	159	2,704
Park	1,344	1,581	209	3,134
Sheridan	848	2,449	236	3,533
Washakie	950	1,767	113	2,830
Total, Wyo.	6,373	15,379	1,600	23,352
Montana				
Big Horn	1,531	2,960	255	4,746
Carbon	1,848	1,539	265	3,652
Carter	343	1,470	159	1,972
Custer	671	1,349	143	2,163
Dawson	1,376	895	224	2,495
Fallon	1,085	724	139	1,948
Park	564	1,831	199	2,594
Powder River	820	1,542	242	2,604
Prairie	725	549	105	1,379
Richland	2,105	1,171	315	3,591
Rosebud	913	1,781	212	2,906
Stillwater	1,167	1,473	251	2,891
Sweetgrass	235	1,684	133	2,052
Treasure	469	285	57	801
Wibaux	720	426	109	1,255
Yellowstone	3,654	1,700	420	5,774
Total, Mont.	18,216	21,379	3,228	42,823
North Dakota				
McKenzie	2,836	1,117	355	4,308
Total for 25 Counties	27,425	37,875	5,183	70,483
Percentage Distribution:				
Entire Basin	38.9%	53.7%	7.4%	100%
Wyoming	27.3	65.9	6.8	100
Montana	42.6	49.9	7.5	100
North Dakota	65.8	25.9	8.3	100

Source: U. S. Bureau of the Census, Census of Agriculture, 1930, Vol. III, County Table III.

Table 8

NUMBER, SIZE AND VALUE OF FARMS IN THE YELLOWSTONE RIVER BASIN - 1929

By Sub-basins and States

Sub-basin and State	Number of Farms	Land in Farms (1,000 Acres)	Crop Land Harvested (1,000 Acres)	Value of Farms (1,000 Dollars): Land and Buildings	Implements and Machinery	Total	Avg. Value of Farm (Dollars)	Avg. Size of Farm (Acres)	Avg. Value per Acre (Dollars)
Main Stem									
Wyoming	11	9	1	151	10	161	14,600	820	17.90
Montana	8,011	8,166	1,324	86,344	9,416	95,760	12,000	1,020	11.70
North Dakota	489	326	98	4,023	892	4,915	10,000	670	15.10
Total	8,511	8,501	1,423	90,518	10,318	100,836	11,800	1,000	11.90
Clark Fork									
Wyoming	59	77	7	1,071	68	1,139	19,300	1,310	14.80
Montana	1,113	403	116	11,833	1,163	12,996	11,700	360	32.20
Total	1,172	480	123	12,904	1,231	14,135	12,100	410	29.40
Big Horn									
Wyoming	3,079	2,222	245	33,371	3,645	37,016	12,000	720	16.70
Montana	869	1,353	129	9,642	1,194	10,836	12,500	1,560	8.00
Total	3,948	3,575	374	43,013	4,839	47,852	12,100	910	13.40
Tongue									
Wyoming	668	597	72	11,844	746	12,590	18,800	890	21.10
Montana	843	1,371	95	8,673	775	9,448	11,200	1,630	6.90
Total	1,511	1,968	167	20,517	1,521	22,038	14,600	1,300	11.20
Powder									
Wyoming	1,625	3,295	177	20,199	1,627	21,826	13,400	2,030	6.60
Montana	956	1,439	123	8,032	863	8,895	9,300	1,510	6.20
Total	2,584	4,734	300	28,231	2,490	30,721	11,900	1,830	6.50
Total, Yellowstone Basin	17,726	19,258	2,387	195,183	20,399	215,582	12,200	1,090	11.20
Wyoming	5,442	6,200	502	66,636	6,096	72,732	13,400	1,140	11.70
Montana	11,792	12,732	1,787	124,524	13,411	137,935	11,700	1,080	10.80
North Dakota	489	326	98	4,023	892	4,915	10,000	670	15.10

Source: U. S. Bureau of the Census, Census of Agriculture, 1930.

Table 9

NUMBER, AREA AND VALUE OF FARMS IN THE YELLOWSTONE RIVER BASIN

By States and Counties

State and County	No. of Farms (1929) All Farms	No. of Farms (1929) Irrigated Farms	Land in Farms (1929), 1,000 Acres All Farms	Land in Farms (1929), 1,000 Acres Irrigated Farms	Value of Farm Land and Buildings (1,000 Dollars) Jan. 1, 1935	Value of Farm Land and Buildings (1,000 Dollars) Apr. 1, 1930
Wyoming						
Big Horn	948	863	188	172	6,924	7,661
Campbell	1,310	2	2,561	22	10,617	12,499
Fremont	942	833	1,088	673	8,393	7,906
Hot Springs	229	171	276	195	2,625	2,937
Johnson	536	237	1,229	738	7,919	9,667
Park	688	652	472	437	8,333	8,823
Sheridan	926	465	990	496	12,884	16,532
Washakie	326	285	256	171	4,362	5,222
Total, Wyo.	5,905	3,508	7,060	2,904	61,155	71,247
Montana						
Big Horn	1,086	420	1,863	636	7,148	11,766
Carbon	1,170	746	464	248	8,852	12,482
Carter	848	12	1,099	29	5,371	5,885
Custer	715	116	1,367	211	5,843	6,923
Dawson	1,018	16	1,061	56	7,362	10,889
Fallon	650	-	741	-	4,524	7,119
Fork	656	462	701	558	6,354	10,210
Powder River	896	-	1,211	-	5,107	8,229
Prairie	559	3	722	8	4,203	5,953
Richland	1,341	247	906	72	7,700	11,957
Rosebud	940	94	1,536	213	6,572	8,772
Stillwater	962	283	863	200	5,637	10,685
Sweetgrass	532	260	716	436	6,399	7,388
Treasure	266	80	305	70	1,761	2,622
Wibaux	469	-	377	-	2,700	5,190
Yellowstone	1,748	1,102	1,019	239	13,841	18,464
Total, Mont.	13,856	3,841	14,951	2,976	100,374	144,533
North Dakota						
McKensie	1,738	89	1,211	21	12,011	12,654
Total for 25 Counties	21,499	7,438	23,222	5,901	173,540	228,434

Source: U.S.Bureau of the Census, Census of Agriculture, 1930, Vol. II County Tables I and III, and Irrigation Section. Census of Agriculture. 1935. County Table I.

Table 10

VALUE OF CROPS HARVESTED FROM DRY LAND AND FROM IRRIGATED LAND
YELLOWSTONE RIVER BASIN - 1929

By States and Counties

State and County	Land Harvested (1,000 Acres) Irrigated Land	Land Harvested (1,000 Acres) Dry Land	Land Harvested (1,000 Acres) Total	Value of Crops Harvested (1,000 Dollars) Irrigated Land	Value of Crops Harvested (1,000 Dollars) Dry Land	Value of Crops Harvested (1,000 Dollars) Total
Wyoming						
Big Horn	62	1	63	2,164	78	2,242
Campbell	-	158	158	2	1,451	1,453
Fremont	56	1	57	1,037	50	1,087
Hot Springs	16	1	17	323	21	344
Johnson	40	21	61	719	241	960
Park	73	-	73	2,176	56	2,232
Sheridan	54	54	108	1,136	786	1,922
Washakie	32	1	33	1,327	46	1,373
Total, Wyoming	333	237	570	8,884	2,729	11,613
Montana						
Big Horn	33	115	148	899	1,280	2,179
Carbon	65	56	121	2,049	783	2,832
Carter	1	106	107	14	946	960
Custer	12	91	103	285	901	1,186
Dawson	1	257	258	11	1,870	1,881
Fallon	-	172	172	-	1,456	1,456
Park	50	36	86	903	425	1,328
Powder River	-	111	111	-	1,649	1,649
Prairie	-	142	142	-	942	942
Richland	22	257	279	666	2,061	2,727
Rosebud	13	117	130	333	1,080	1,413
Stillwater	22	141	163	638	1,139	1,777
Sweetgrass	35	30	65	595	243	838
Treasure	8	34	42	234	361	595
Wibaux	-	109	109	-	945	945
Yellowstone	74	123	197	3,272	1,096	4,368
Total, Montana	336	1,897	2,233	9,899	17,177	27,076
North Dakota						
McKensie	8	351	359	252	3,549	3,801
Total for 25 Counties	677	2,485	3,162	19,035	23,455	42,490
Value per Acre of Crops Harvested	-	-	-	$28.12	$9.44	$13.44

Source: U. S. Bureau of the Census, Census of Agriculture, 1935, County Tables I and VI, and Irrigation Section, 1930.

Table 11

CROP LAND HARVESTED IN THE YELLOWSTONE RIVER BASIN IN 1929 AND 1934

(Thousands of Acres)

By States and Counties

State and County	Land Harvested in 1929 Irrigated Land	Land Harvested in 1929 Dry Land	Land Harvested in 1929 Total	Land Harvested in 1934 Irrigated Land	Land Harvested in 1934 Dry Land	Land Harvested in 1934 Total
Wyoming						
Big Horn	62	1	63	59	-	59
Campbell	-	158	158	-	45	45
Fremont	56	1	57	65	1	66
Hot Springs	16	1	17	17	1	18
Johnson	40	21	61	33	9	42
Park	73	-	73	70	1	71
Sheridan	54	54	108	50	24	74
Washakie	32	1	33	30	1	31
Total, Wyoming	333	237	570	324	82	406
Montana						
Big Horn	33	115	148	35	35	70
Carbon	65	56	121	65	31	96
Carter	1	106	107	-	7	7
Custer	12	91	103	11	3	14
Dawson	1	257	258	1	70	71
Fallon	-	172	172	-	15	15
Park	50	36	86	45	23	68
Powder River	-	111	111	-	11	11
Prairie	-	142	142	-	9	9
Richland	22	257	279	24	90	114
Rosebud	13	117	130	13	7	20
Stillwater	22	141	163	23	67	90
Sweetgrass	35	30	65	35	15	50
Treasure	8	34	42	8	3	11
Wibaux	-	109	109	-	47	47
Yellowstone	74	123	197	77	44	121
Total, Montana	336	1,897	2,233	337	477	814
North Dakota						
McKensie	8	351	359	10	116	126
Total for 25 Counties	677	2,485	3,162	671	675	1,346
Percent Decrease, 1934 from 1929				1%	73%	57%

Source: U. S. Bureau of the Census, Census of Agriculture 1930, County Tables I and X, and Irrigation Section.

Table 12

Number of Cattle and Sheep in 1930 and 1935
Yellowstone River Basin

State and County	Number of Cattle All Ages Jan. 1, 1935	Number of Cattle Over 3 Months Apr. 1, 1930	Number of Sheep All Ages Jan. 1, 1935	Number of Sheep All Ages Apr. 1, 1930
Wyoming				
Big Horn	27,846	20,896	129,021	151,669
Campbell	58,166	58,932	183,571	147,757
Fremont	50,494	27,150	250,718	217,847
Hot Springs	21,333	13,468	97,878	129,270
Johnson	50,800	39,040	212,159	214,749
Park	33,612	21,897	125,221	179,722
Sheridan	65,296	57,811	108,147	104,375
Washakie	16,769	12,636	179,588	143,446
Total, Wyo.	324,343	251,330	1,286,303	1,288,835
Montana				
Big Horn	50,406	40,384	37,688	101,772
Carbon	32,085	19,637	82,763	81,966
Carter	23,087	30,248	110,552	125,826
Custer	19,371	40,696	46,979	75,310
Dawson	17,808	18,779	32,817	50,169
Fallon	10,543	15,195	18,716	26,854
Park	26,729	21,455	101,520	104,203
Powder River	31,983	44,554	45,743	69,891
Prairie	7,542	13,078	31,147	44,193
Richland	24,321	18,736	75,089	31,639
Rosebud	31,815	31,189	98,804	156,145
Stillwater	34,330	21,977	73,940	75,050
Sweetgrass	31,437	22,704	114,880	146,636
Treasure	10,177	8,246	15,910	7,511
Wibaux	9,751	8,258	12,449	8,451
Yellowstone	40,133	19,975	123,142	50,791
Total, Mont.	401,518	375,191	1,027,139	1,156,407
North Dakota				
McKensie	39,075	33,968	24,138	21,521
Total for 25 Counties	764,936	660,489	2,337,580	2,466,763

Source: U. S. Bureau of the Census, Census of Agriculture, 1935, County Table II.

C. CLIMATE AND HYDROLOGY OF THE BASIN

1. Climate

The climate of the plains area is distinctly continental, and is characterized by abundant sunshine, low relative humidity, light rainfall (confined largely to the warmer half of the year), moderate wind movement, a large diurnal change in temperature, and pronounced extremes of temperature. Although the climate of the mountainous sections varies markedly from place to place, it is, in general, distinguished from that of the plains by increased precipitation, especially in the winter months, decreased temperature, decreased diurnal range, and increased relative humidity. Climatological data for twenty selected stations are given in tables 13 and 14. The location of weather stations is shown on map 6.

Temperature

The average annual temperature ranges from 32 degrees at Lake Yellowstone to 46 degrees at several plains stations. It will be noted from table 13 that the temperature range between the summer months and the winter months is much greater in the plains than in the mountain regions. The maximum and minimum temperatures recorded at Glendive are 117 and -48, and at Lake Yellowstone, 94 and -51. On the plains, temperatures of 100 degrees are not uncommon during the hottest season. Cold waves strike the basin an average of four times a winter, but, as a rule, do not last more than a few days at a time. Sunshine is abundant in all seasons.

The average length of growing season for the cultivated areas ranges from 110 days to 140 days, averaging, perhaps, 120 days. There is little cultivation in areas having a frost-free period of less than 100 days.

0552

Precipitation

The plains are semi-arid. Average annual precipitation (table 14) varies from about 7 inches in the heart of the Big Horn Basin to about 15 inches near the mouth of the Yellowstone River. Although 70 percent of the precipitation on the plains occurs during the warmer months, prolonged droughts, to which the basin is subject, make dry-farming precarious. Map 5 shows the mean annual precipitation over all areas of the basin. This map was adapted from one prepared by the Field Flood Control Coordinating Committee of the U. S. Department of Agriculture.

In general, precipitation increases with increase in elevation, although exposure and other topographic conditions often completely mask this relationship. Precipitation in the mountains is greater and more evenly distributed throughout the year than on the plains. Snowfall is moderately heavy and drifts into banks where it packs and remains well into the summer. The melting snow banks feed the streams which furnish water for irrigation in the valleys.

0553

2. General Stream Flow Characteristics

Nearly all of the water in the streams originates in the mountains. Except for a short time in the spring and for occasional flash floods in the warm season the water yield of the plains is negligible. Stream flow is low during the winter, when the streams are partly frozen, but increases when the snow begins to melt in the spring. The rise begins in March or April, reaches a peak usually in June, then gradually decreases until late summer or early fall. Spring rains cause a lesser peak on the lower Yellowstone and lower Big Horn during March or April. Occasionally, during the warmer season, peaks of short

duration are caused by local heavy showers or cloud bursts. After June, small streams that do not rise in the mountains are normally dry. Even the Tongue and Powder are practically dry in late summer.

Quite aside from the normal seasonal variation, there is a wide variation of stream flow from year to year for the same month. For example, the maximum recorded discharge of the Big Horn River at Hardin for the month of July is 1,370,000 acre-feet, nearly three times the minimum recorded discharge for the same month of 37,300 acre-feet. This extreme variation probably is not equaled by any major stream in the basin for any thirty-day period, but it is approached by all of them. Several factors contribute to the variation from year to year of stream flow during the summer months, of which the chief are the amount of snow on the upper water sheds and its time and rate of melting, the amount of precipitation on the entire basin, and the amount of water diverted for irrigation and stored in reservoirs. Water is diverted each year to irrigate about 900,000 acres and to fill about 850,000 acre-feet of reservoir capacity. Since the amount of water used in irrigation operations is more or less constant each year its effect on stream flow is relatively greater in dry years.

0554

3. Stream Flow Records

Practically all stream flow measurements are made by, or in cooperation with, the U. S. Geological Survey and published annually in the water supply papers of that agency ("Surface Water Supply of the United States - Part 6, Missouri River Basin."). Map 6 shows the location of all known stream gaging stations in the Yellowstone Basin. All records for the Yellowstone Basin, up to October 1931, reduced to run-off

in acre-feet, by months, are tabulated in Appendix II of H.D. 256 of the Corps of Engineers' 308 Report. Estimates have been made for many of the months for which complete records were not available. All records up to October 1936 for the Wyoming portion of the basin are given in "Water Resources of the Yellowstone River Basin in Wyoming" by H. T. Person. Although estimates of actual flow for months of no record are not made, the reconstructed run-off is estimated for some of the stations. The reconstructed run-off was computed from actual records by correcting for estimated depletions from irrigation operations. Records and estimates for certain stations for the period 1930 to 1938 were prepared by the Helena office of the U. S. Geological Survey, and were published as Appendix "G" of the Progress Report (1939) of the National Resources Planning Board.

Inasmuch as these reports on stream flow measurements and estimates are already available, complete records are not included in this report. Presentation of stream flow data is confined to a summary of the maximum, minimum, and mean run-off, by months, of the major streams of the basin and a statement of the monthly run-off at the state line for the entire period of record. This information is presented by sub-basins in Section II, and repeated, for some of the more important stations, in this section (table 16). There is also included in this section (table 15), a statement of the run-off of the Yellowstone at Intake, Montana, which is approximately representative of the run-off at the Montana-North Dakota state line. In addition to the mean run-off for the entire period of record, the mean run-off for the eight years from 1930 to 1937 is also given for all stations for which this record

0555

was available. This eight-year period is the most severe period of sustained drought of record, and probably represents the limiting water supply condition for basin planning.

Flow at the state line was considered the same as the flow at the gaging station or stations nearest the state line. It is believed that in all instances this assumption is substantially correct. The stations selected as representing the flow at the state line are listed below:

Montana-North Dakota		
Yellowstone River	- Table 15	Yellowstone at Intake
Wyoming-Montana		
Yellowstone River	- Table 27	Yellowstone at Corwin Springs
Clark Fork	- Table 31	Clark Fork at Chance
Big Horn River	- Table 34	Big Horn at Kane plus Shoshone at Byron
Little Horn River	- Table 39	Little Horn near Wyola
Tongue River	- Table 42	Tongue near Decker
Powder River	- Table 47	Powder at Moorhead
Little Powder River	No Record	

The flow at the above stations was estimated for some years by comparison with the flow at other stations on the same stream when a good correlation could be established.

0556

4. Storage Reservoirs

About 850,000 acre-feet of useful storage capacity has been developed in the basin, of which more than 650,000 acre-feet is in the Big Horn basin in Wyoming. This storage is used almost exclusively for irrigation. Water is stored during the winter months and during the spring floods, and released as needed during the mid and late irrigation season.

Table 17 lists the existing reservoirs of more than 500 acre-feet capacity, as reported in Appendix F of the Progress Report (1939)

of the National Resources Planning Board and in "Water Resources of the Yellowstone River Basin in Wyoming" (H. T. Person). These two sources do not agree as closely as might be expected. Many reservoirs are reported by one source and not by the other. The total developed capacity in the basin, as shown in table 17, is 847,997 acre-feet. In arriving at this total, the capacity of every reservoir listed in the above reports was included, and whenever the two sources disagreed, the figure as reported in Appendix F was used. The figures that are included in the total are marked by an asterisk. Complete information is not available for reservoirs of less than 500 acre-feet capacity, but it is believed that the aggregate capacity of such reservoirs is very small. The Montana Water Conservation Board reports(1) that it has recently constructed 58 small reservoirs having a combined capacity of 6,417 acre-feet. Potential reservoirs in the basin are discussed in Section II and in Appendix II. Map 7 shows the location of both the existing and the potential reservoirs.

0557

All reservoirs lose water through evaporation in proportion to the area of the exposed water surface. Other factors, such as, location, temperature, etc., affect the rate of evaporation, but it may be assumed that these contributing factors are reasonably uniform throughout the Yellowstone Basin. In Appendix X of H.D. 197 (Platte River 308 Report) the average annual evaporation from free-water surfaces in the North Platte River west of North Platte, Nebraska, is estimated to be 36 inches, of which 27 inches, or 75 percent, occurs between May 1 and October 1. These figures could probably be applied

(1) Montana "Progress Report" submitted at the meeting of the Compact Commission held in Billings, Montana, on October 10, 1940.

to reservoirs in the Yellowstone Basin without serious error. The surface area of a reservoir varies, often markedly, with the amount of water in storage, which complicates the computation of losses. The Corps of Engineers, in Appendix F of the Progress Report of the National Resources Planning Board, has attempted to simplify the problem of estimating reservoir losses by adopting a schedule of losses based upon annual storage. This schedule is given below:

Evaporation Losses on Annual Irrigation Storage

Reservoir Capacity (acre-feet of annual storage)	Seasonal Evaporation (percent of annual storage)
0 to 5,000	10
5,000 to 15,000	7
15,000 to 30,000	5
30,000 to 200,000	4

5. Ground Water

Several reports on ground water, published by the U. S. Geological Survey(1), covering a portion of the Yellowstone River Basin reveal that, although supplies ample for domestic use and stock watering can usually be found, the supply is not sufficient to affect the surface run-off. Although a few flowing wells are scattered throughout the basin, more commonly near the beds of large streams, there apparently is no possibility of utilizing underground waters to irrigate tracts larger than family gardens.

(1) No. P53. Geology and Water Resources of the Bighorn Basin, Wyoming.
No. W598. Geology and Ground Water Resources of North Dakota.
No. W599. Ground Water in Yellowstone and Treasure Counties, Montana.
No. W600. Geology and Ground Water Resources in Central and Southern Rosebud County, Montana.

0558

It sometimes happens that a large area under irrigation develops a water table which permits limited irrigation by pumping from wells. In some instances it has even been necessary to pump wells in order to prevent the irrigated land from becoming water logged. However, there is no indication that such a drainage condition will develop over any extensive area in the Yellowstone Basin, and it may be assumed that irrigation from underground pumping will not have a significant effect on stream diversions within the calculable future.

0559

FEDERAL POWER COMMISSION

BUREAU OF ENGINEERING — DENVER REGIONAL OFFICE

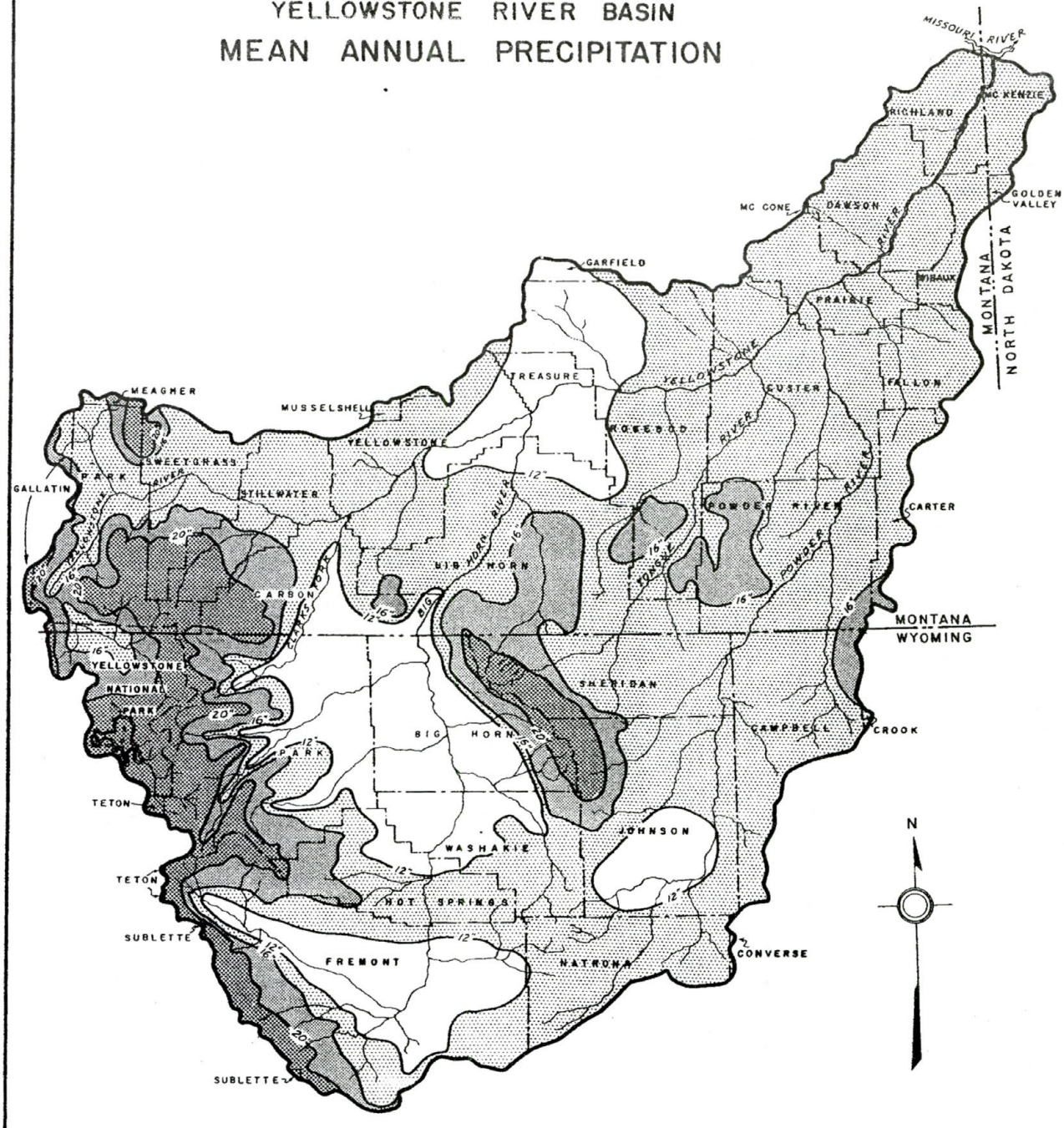
46

YELLOWSTONE RIVER COMPACT

MONTANA — WYOMING — NORTH DAKOTA

YELLOWSTONE RIVER BASIN

MEAN ANNUAL PRECIPITATION



Adapted From Map
Prepared By
U.S. Department Of Agriculture
Field Flood Control Coordinating Committee

Jan. 9, 1941

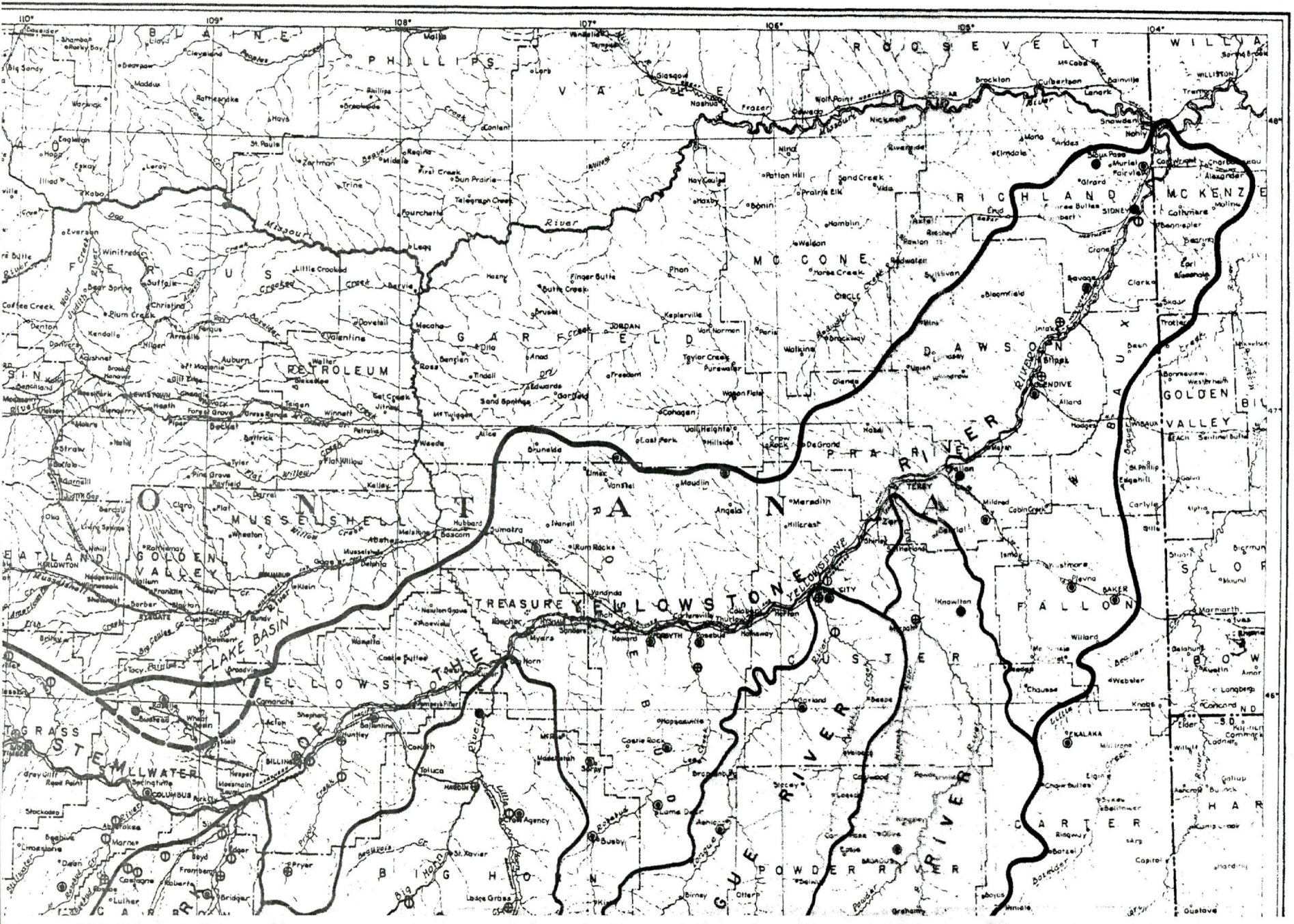
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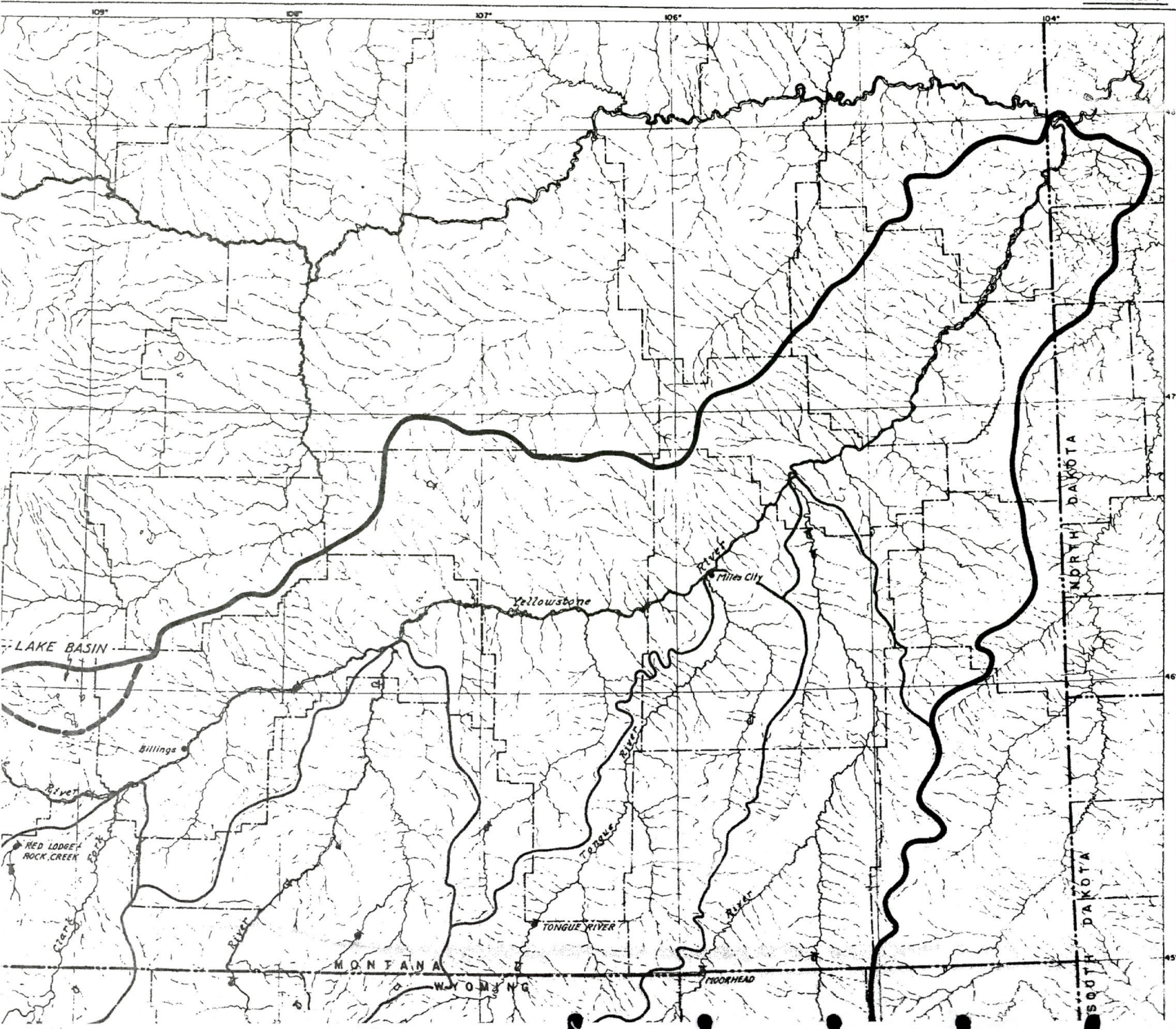
0560

SEE FULL MAP ATTACHED

MAP NO. 6

47


110°
109°
108°
107°
106°
105°
104°
BLAINE
PHILLIPS
VALLEY
ROOSEVELT
WILLIA
FERGUS
GARFIELD
MCCONE
RICHLAND
MCKENZE
PETROLEUM
JORDAN
DAWSON
GOLDEN VALLEY
MUSSELSHELL
PRAIRIE
FALLON
TREASURE
YELLOWSTONE
LAKE BASIN
STILLWATER
CARTER
POWDER RIVER
Missouri River
Yellowstone River
Musselshell River
Big Horn River
Powder River
Little Missouri River
Milk River
Judith River
Box Elder Creek
Big Dry Creek
Redwater River
Prairie Elk Creek
Sand Creek
Timber Creek
Big Porcupine Creek
Big Beaver Creek
Big Sandy
Havre
Malta
Glasgow
Wolf Point
Brockton
Culbertson
Lanark
Williston
Fairview
Sidney
Glendive
Terry
Miles City
Billings
Hardin
Forsyth
Baker
Ekalaka
Broadus
Jordan
Winnett
Roundup
Harlowton
Lewistown
Grass Range
Stanford
Great Falls
Lewistown
Columbus
Absarokee
Red Lodge
Crow Agency
Lame Deer
Ashland
Birney
Otter
Broadus
Ekalaka
Baker
Glendive
Sidney
Fairview
Williston
Havre
Malta
Glasgow
Wolf Point
Brockton
Culbertson
Lanark
Plentywood
Scobey
Opheim
Whitetail
Medicine Lake
Circle
Jordan
Winnett
Roundup
Harlowton
Lewistown
Grass Range
Stanford
Great Falls



SEE FULL MAP ATTACHED

Table 13

MEAN MONTHLY TEMPERATURE AND AVERAGE LENGTH OF GROWING SEASON

Line No.	Elevation Above Sea Level (Feet)	No. Years Record	Mean Monthly Temperature (Degrees F.) Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean Annual Temp. (Deg. F.)	Average Growing Season (Days)
1. Dome Lake, Wyo.	8820	21	15	16	21	29	37	47	54	52	44	34	25	16	33	55
2. Lake Yellowstone, Y.N.P.	7800	24	11	15	20	29	38	47	54	53	45	36	25	14	32	48
3. Yellowstone Park, Y.N.P.	6200	44	18	20	27	37	46	54	61	60	51	41	29	20	39	115
4. Dubois, Wyoming	6920	22	20	23	29	38	45	54	59	58	50	41	31	22	39	69
5. Shoshone Dam, Wyoming	5380	25	26	30	35	44	52	61	69	68	58	48	39	28	46	138
6. Lander, Wyoming	5370	39	19	22	32	42	51	60	68	66	56	44	31	19	42	123
7. Red Lodge, Mont.	5250	31	20	21	28	38	46	56	62	61	51	41	31	23	40	95
8. Buffalo, Wyoming	4650	25	22	25	34	43	51	61	68	67	56	46	35	25	44	112
9. Clark, Wyo.	4500	24	25	28	36	45	54	63	70	68	58	47	37	26	46	152
10. Livingston, Mont.	4480	28	25	28	35	44	52	60	68	67	57	48	36	29	46	127
11. Thermopolis, Wyo.	4350	26	18	24	34	45	54	64	71	69	58	46	34	21	45	116
12. Big Timber, Mont.	4100	25	25	28	34	45	54	62	69	68	57	48	36	28	46	118
13. Basin, Wyo.	3870	27	15	22	34	47	56	66	74	72	60	47	32	16	45	130
14. Sheridan, Wyo.	3790	35	19	22	31	43	52	61	68	66	56	44	32	22	43	125
15. Ekalaka, Mont.	3200	30	19	20	31	44	53	63	71	69	59	46	33	22	44	126
16. Billings, Mont.	3120	35	23	26	35	47	55	64	71	69	58	48	35	26	46	129
17. Crow Agency, Mont.	3040	47	19	22	34	46	55	65	72	69	59	47	34	24	45	134
18. Miles City, Mont.	2380	39	17	19	32	47	56	66	74	72	60	48	33	22	46	153
19. Glendive, Mont.	2090	39	13	15	28	46	56	66	73	70	59	47	31	19	44	131
20. Williston, N. D.	1880	52	7	10	24	43	53	63	69	67	56	44	27	14	40	127

Source: U. S. Weather Bureau, Climatic Summary of the United States, 1930.

Table 14

AVERAGE MONTHLY AND AVERAGE ANNUAL PRECIPITATION

Line No.	Elevation Above Sea Level (Feet)	Average Monthly Precipitation (Inches) Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average Annual Precipitation (Inches)	Period of Record
1. Dome Lake, Wyoming	8820	1.5	1.3	2.5	3.8	3.2	2.5	2.0	1.8	2.0	2.4	1.9	1.6	26.4	1908-1930
2. Lake Yellowstone, Y.N.P.	7800	2.4	1.7	2.2	1.5	2.2	2.0	1.6	1.5	1.5	1.7	1.5	1.7	21.5	1904-1930
3. Yellowstone Park, Y.N.P.	6200	1.6	1.3	1.7	1.3	2.0	1.7	1.3	1.2	1.2	1.4	1.4	1.4	17.4	1889-1930
4. Dubois, Wyoming	6920	.5	.5	.6	.9	1.3	1.1	.8	.9	1.0	.8	.4	.4	9.1	1905-1930
5. Shoshone Dam, Wyoming	5380	.4	.3	.6	.9	1.9	1.3	1.2	1.0	1.1	.8	.5	.5	10.6	1905-1930
6. Lander Wyoming	5370	.5	.7	1.3	2.2	2.4	1.1	.8	.6	1.1	1.6	.7	.8	13.8	1892-1930
7. Red Lodge, Montana	5250	.8	.8	1.5	2.5	3.7	2.3	1.4	1.2	2.3	1.7	1.0	.7	19.8	1903-1930
8. Buffalo, Wyoming	4650	.5	.5	.8	1.5	2.4	2.0	1.2	1.1	1.1	.8	.5	.5	12.8	(1)
9. Clark, Wyoming	4500	.5	.4	.8	1.0	1.9	1.3	1.2	.9	1.1	.9	.8	.5	11.2	1905-1930
10. Livingston, Montana	4480	.6	.6	.9	1.4	3.1	2.0	1.5	1.1	1.6	1.2	.9	.6	15.4	(2)
11. Thermopolis, Wyoming	4350	.4	.4	1.0	2.2	2.7	1.4	1.1	.8	1.4	1.2	.4	.5	13.6	1900-1930
12. Big Timber, Montana	4100	.7	.5	1.0	1.3	2.6	2.0	1.5	1.2	1.6	1.4	.9	.6	15.3	(3)
13. Basin, Wyoming	3870	.4	.4	.6	.8	1.1	.8	.5	.4	.7	.6	.3	.4	7.0	1898-1930
14. Sheridan, Wyoming	3790	.9	.7	1.2	1.9	2.6	1.9	1.2	.8	1.4	1.1	.7	.6	15.2	1895-1930
15. Ekalaka, Montana	3200	.4	.4	.6	1.0	2.3	3.0	1.8	1.4	1.3	.8	.3	.3	13.7	1905-1930
16. Billings, Montana	3120	.7	.4	.8	1.2	2.5	2.2	1.3	1.0	1.2	1.2	.8	.5	13.8	(4)
17. Crow Agency, Montana	3040	.8	.7	1.0	1.4	2.5	2.5	1.4	.9	1.2	1.3	.9	.7	15.1	(5)
18. Miles City, Montana	2380	.6	.5	.8	1.0	2.2	2.7	1.6	1.0	1.0	.9	.6	.5	13.5	1877-1930
19. Glendive, Montana	2090	.5	.5	.9	1.1	2.3	3.4	1.8	1.3	1.3	.8	.5	.6	15.0	1889-1930
20. Williston, North Dakota	1880	.5	.4	.7	1.2	2.0	3.4	1.9	1.5	1.1	.8	.6	.6	14.7	1879-1930

Source: U. S. Weather Bureau, Climatic Summary of the United States, 1930.
(1) Buffalo: 1886-1894; 1899-1911; 1915-1930.
(2) Livingston: 1896-1910; 1915-1920; 1922-1930.
(3) Big Timber: 1895-1897; 1909-1930.
(4) Billings: 1894-1899; 1905-1930.
(5) Crow Agency: 1879-1914; 1917-1930.

Table 15

YELLOWSTONE RIVER AT INTAKE,* MONTANA

Run-off in 1,000 Acre-feet

Drainage Area: 67,901 Square Miles — Miles Above Mouth of Yellowstone River: 71.8

Year Ending Sept. 30:	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual Total
1904	422	342b	350	350	328	350	829b	1660	3270	2060	797	492	11,200
1905	363b	298a	307b	277a	250a	369b	260	594	2850	1800	683	331	8,380
1906	364	315b	314a	307a	333a	461a	637	1540	2470	1620	947	525	9,830
1907	345	331	307a	277a	250a	461a	413	1270	3170	3940	1480	690	12,900
1908	505	363	307b	307a	259a	369a	476b	1310	3620	2750	1010	513	11,800
1909	584	417b	400a	307a	278a	307a	335	861	4420	3090	1030	720	12,700
1910	470	370b	357a	338	278	1160	593	1760	1920	953	497	432	9,130
1911	358	328	277	215	222	570	351	787	3320	1690	953	589	9,160
1912	411	283	246	246a	222a	738	1340	1300	3250	2790	1260	797	12,900
1913	836	562	304	312	253	601	1040	1370	3520	1760	1150	489	12,200
1914	461	377	330	307a	283a	491	555	1810	3170	1320	554	379	10,000
1915	479	387	234	192	173	341	511	1020	2710	2120	1090	768	10,000
1916	701	339	398	369a	345a	1230b	553	1070	2760	2910	928	404	12,000
1917	460	409	354	307a	250a	615a	1310b	1620	3680	3390	824	595	13,800
1918	467	396	405	369a	333a	1080b	690	1190	4600	2370	781	523	12,900
1919	614	460	453	306	267	646	631	818	690	204	217	224	5,530
1920	303	440	389	363	288a	307a	564	1470	3180	2310	670	405	10,700
1921	386	390	400a	339a	333a	542	342	990	3840	1100	358	249	9,270
1922	229	232b	274b	277a	250a	646b	541	1090	2930	1120	599	342	8,530
1923	298	314	275	292b	278b	486b	569	1070	2650	1850	787	517	9,390
1924	1790	720	536	652	834	1020	2330	2150	2850	1680	486	380	15,400
1925	581	472	389	806	855	1130	797	1530	2930	2090	732	509	12,800
1926	627	541	496	520	519	627	666	1790	1560	1140	528	514	9,530
1927	544	440	503	409	490	713	537	1740	3880	2400	1200	774	13,600
1928	594	587	430b	307a	288a	799b	511	2340	2390	2770	781	483	12,300
1929	485	450	343	365	316	1480	952	1460	2780	1460	504	499	11,100
1930	480	371	357	281	661	781	631	916	1560	910	867	547	8,360
1931	646	483	375	282	298	320	352	769	1810	291	295	162	6,080
1932	339	253	180	201	196	422	526	1540	2560	1510	405	431	8,560
1933	412	333	202	221	187	738	437	1210	2840	836	414	450	8,280
1934	340	345	207	275	260	348	425	780	728	226	154	142	4,231
1935	294	250	193	170	246	323	325	600	2473	1491	345	199	6,908
1936	259	269	228	200	155	681	495	1195	1898	625	359	207	6,572
1937	321	328	214	128	158	418	405	805	2369	1381	230	202	6,958
1938	376	270	190	268	189	574	370	965	2940	1910	481	378	8,910
Maximum	1790	720	536	806	855	1480	2330	2340	4600	3940	1480	797	15,400
Minimum	229	232	180	128	155	307	260	594	690	204	154	142	4,231
Mean - 35 yrs.	490	385	329	318	319	633	637	1268	2788	1768	697	453	10,055
Mean - 1930-37	386	329	244	220	270	504	446	977	2030	909	384	292	6,994

a - Estimated
b - Partially estimated

* Record from Oct. 1904 to Dec. 1911 and from Oct. 1931 to March, 1934 is that of the Yellowstone River at Glendive. Flow considered the same, except for the diversion of the Lower Yellowstone Project.

Table 16

MAXIMUM, MINIMUM, AND MEAN RUN-OFF OF THE MAJOR STREAM IN EACH SUB-BASIN

(1,000 Acre Feet)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Yellowstone River at Intake and Glendive, Montana(1)													
Drainage Area: 67,901 sq. mi.												Period: Oct. 1903 - Sept. 1938	
Maximum	1790	720	536	806	855	1480	2330	2340	4600	3940	1480	797	15,400
Minimum	229	232	180	128	155	307	260	594	690	204	154	142	4,231
Mean 1903-1938	490	385	329	318	319	633	637	1268	2788	1768	697	453	10,055
Mean 1930-1937	386	329	244	220	270	504	446	977	2030	909	384	292	6,994
Yellowstone River at Corwin Springs, Montana(1)													
Drainage Area: 2,599 sq. mi.												Period: Oct. 1910 - Sept. 1937	
Maximum	144.0	123.0	86.1	75.5	68.0	75.6	155.0	836	1110	769	333	170.0	3,060
Minimum	57.4	42.2	33.9	27.6	22.8	25.3	34.3	189	253	125	81	60.5	1,380
Mean 1910-1937	94.4	71.8	62.2	55.4	49.3	58.6	89.4	344	641	397	189	112.9	2,166
Mean 1930-1937	73.0	55.0	48.5	42.5	37.2	44.0	84.7	330	526	279	141	84.2	1,746
Clark Fork at Edgar and Fromberg, Montana(1) Period: June 1905 - Dec. 1913; Aug. 1921 - July 1933; Feb. 1934 - Sept. 1937													
Drainage Area: 2,050 sq. mi.													
Maximum	56.8	46.2	34.4	30.7	31.1	40.2	63.1	343	502	380	117.0	52.8	1,210
Minimum	18.8	17.3	13.4	13.4	6.8	14.1	15.6	56	156	20	13.1	14.5	505
Mean 1905-1937(3)	30.8	26.3	22.4	20.9	18.7	23.7	32.6	136	269	150	54.2	30.9	832
Mean 1930-1937	31.1	24.1	19.8	18.9	16.3	21.4	32.0	122	223	78	30.1	21.7	-
Big Horn River at Hardin and St. Xavier, Montana(1)													
Drainage Area: 20,700 sq. mi.												Period: June 1904 - May 1925; Aug. 1928 - Sept. 1937	
Maximum	584	291	209	167	142	658	821	972	1480	1370	548	320	5,830
Minimum	92	72	62	58	45	86	86	173	(4)135	37	69	(4)75	(4)1,300
Mean 1904-1937(3)	164	132	109	93	87	202	196	394	927	570	240	158	3,238
Mean 1930-1937	137	119	95	81	72	131	131	328	738	322	188	119	2,462
Little Horn River near Crow Agency, Montana(1)													
Drainage Area: 1,157 sq. mi.												Period: Oct. 1904 - Sept. 1906; Apr. 1912 - Sept. 1924; Aug. 1928-Nov.1933	
Maximum	52.9	33.7	*14.1	*17.8	*21.6	*65.8	115.0	66.4	78.6	49.6	16.9	22.7	486
Minimum	3.6	3.1	*3.1	*3.1	*2.8	*7.4	7.0	14.4	7.4	(5)3.1	1.7	2.3	110
Mean	12.0	10.4	*9.2	*8.1	*8.5	*24.8	31.1	39.6	49.7	18.9	8.6	7.9	224
*Estimated													
Tongue River near Miles City, Montana(2)(6)													
Drainage Area: 5,440 sq. mi.												Period: Oct. 1929 - Sept. 1938	
Maximum	19.9	19.0	16.0	11.7	20.4	46.6	36.0	120.0	150.0	47.1	3.7	2.0	392
Minimum	0.5	3.0	5.0	5.8	7.0	9.0	10.0	16.0	2.0	0.1	0.0	0.0	103
Mean	9.4	9.9	8.8	8.9	11.6	20.6	20.2	57.9	71.7	13.0	1.3	0.8	237
Powder River near Mizpah, Montana(2)(7)													
Drainage Area: 12,821 sq. mi.												Period: Oct. 1929 - Sept. 1938	
Maximum	21.5	14.6	13.0	14.0	127.0	125.0	60.0	200.0	150.0	175.0	45.4	21.8	524
Minimum	4.0	6.0	4.0	4.0	1.6	14.0	16.0	6.0	20.0	6.0	2.0	0.2	141
Mean	10.3	10.1	8.2	8.0	24.6	50.0	37.6	67.7	89.5	46.0	16.0	8.3	376

Little Powder River: No record

(1) Source: Appendix II, H.D. 256 of the 308 Report through 1931, U.S.G.S. Water-supply papers since 1931.
(2) Source: Appendix "G", Progress Report of National Resources Planning Board. Prepared by the Helena Office of the U. S. Geological Survey.
(3) Broken record as noted at head of table.
(4) Estimated for 1934 by comparison with the Big Horn at Kane and the Shoshone at Byron.
(5) Measured in 1931. An extended record for July 1906 indicates a run-off of 1,840 acre-feet for that month.
(6) Run-off estimated by comparison with the Tongue River near Decker and the Powder River at Moorhead Dec. 1929 to Feb. 1930 and Nov. 1932 to March 1938.
(7) Run-off estimated by comparison with the Powder River at Moorhead December 1929 and January 1930, January to March 1932 and April 1933 to March 1938. Run-off for Powder River near Locate used April to September 1938.

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COMPARISON OF ESTIMATES OF DEVELOPED STORAGE IN THE YELLOWSTONE RIVER BASIN

(Reservoirs of More Than 500 Acre-Feet Capacity)

Name of Reservoir	Location Section	Township	Range	Source of Water Supply	Capacity in Acre-feet Appendix F(1)	Wyoming Report(2)
Main Stem and Minor Tributaries						
Lake Adam				Sweetgrass Creek	6,000*	-
Lake Walvoord				Sweetgrass Creek	12,000*	-
Total, Main Stem					18,000	
Clark Fork						
Glacial Lake				Rock Creek	5,500*	-
Cooney				Red Lodge Creek	27,340*	-
Lagoon Lake	11	56N	106W	Reef Creek	-	1,320*
Luce	5	55N	103W	Clark Fork	-	2,130*
Paint Creek	34	56N	103W	Paint Creek	-	1,700*
Total, Clark Fork					37,990	
Big Horn River						
Shoshone River						
Beck Lake	6	52N	101W	S. F. Shoshone River	-	930*
L. Thompson	26	52N	100W	Sage Creek	-	1,960*
Newton	26	50N	102W	Trail Creek	-	4,530*
Perkins & Kinney	22	50N	102W	Sage Creek	-	1,260*
Ralston	35	55N	100W	Shoshone River	-	2,100*
Shoshone	7	52N	102W	Shoshone River	386,600*	456,570
Stonebridge	31	52N	104W	Whit Creek	-	640*
Greybull River						
Upper Sunshine	12	47N	102W	Greybull & Sunshine Cr.	43,500*	49,500
Wind River						
Bull Lake	30	3N	2W	Bull Lake Creek	150,000*	150,000
Chimney Butte**	19	3N	1E	Wind River	-	31,690**
Pilot Butte	23	3N	1E	Wind River	30,000*	30,000
Tepot	30	5N	2W	Dry Creek	-	1,580*
Popo Agie River						
Shoshone Lake				Shoshone Creek	2,380*	-
Washakie	16	1S	2W	S. F. Little Wind	8,000*	-
North Fork Sage Creek	14	2N	3W	N. F. Sage Creek	-	550*
Christiana Lake	8	30N	101W	Little Popo Agie	1,800*	-
Ray Lake	24	2S	1W	S. F. Little Wind	7,000*	7,360
Minor Tributaries						
Dempsey No. 1	1	43N	95W	Owl Creek	-	1,140*
Dempsey No. 2	1	43N	95W	Owl Creek	-	3,200*
Lake Adelaide	36	53N	88W	Shell Creek	1,410*	3,190
Shell Lake	17	52N	87W	Shell Creek	-	530*
Bethurem	31	55N	93W	Crystal Creek	-	640*
Bonneville	36	39N	94W	Badwater Creek	-	510*
Debatable	27	7N	1W	Muddy Creek	-	530*
Muskrat No. 1	31	36N	93W	Conant Creek	-	1,160*
Prairie	16	6N	1W	Muddy Creek	-	580*
Thorpe	13	44N	95W	Dry Draw	-	8,130*
Total, Big Horn					660,660	
Little Horn River						
Willow Creek				Willow Creek	22,800*	-
Tongue River						
Big Horn	27	53N	86W	Cross Creek	2,620*	2,624
Park	16	53N	86W	E.F. Big Goose Creek	8,000*	7,347
Dome Lake	2	53N	87W	W.F. Big Goose Creek	2,400*	1,319
Tongue River		7½S	41E	Tongue River	60,000*	-
Total, Tongue					73,020	
Powder River						
Lower Salt Creek	36	41N	79W	Salt Creek	-	2,708*
Cloud Peak	16	51N	85W	S.F. Piney Creek	2,720*	2,390
Gantz	15	38N	85W	Cottonwood Creek	-	910*
Kearney Lake	30	52N	85W	S.F. Piney Creek	1,800*	1,845
Lake DeSmet	6	52N	82W	Piney Creek	26,000*	25,000
Moore	23	52N	82W	Boxelder Creek	-	875*
Total, Powder					35,013	
Little Powder River						
Rawhide	34	52N	72W	Rawhide Creek	-	514*
Total, Yellowstone Basin					847,997	

* These figures are included in the total shown for the entire Yellowstone basin.
** This reservoir apparently does not exist.
(1) Useful capacity according to Appendix F of the Progress Report (1939) of the National Resources Planning Board.
(2) Total capacity according to "Water Resources of Yellowstone River Basin in Wyoming", by H. T. Person, September 1938.

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D. WATER USE AND CONTROL

1. Irrigation

Irrigation is at present the most important use to which water is put in the Yellowstone River Basin. As has been pointed out in Section I-B, irrigation is the backbone of agriculture, and agriculture, in turn, supports the livestock industry. There are at present about 900,000 acres under irrigation. In 1929 produce valued at $19,000,000 was harvested from the 677,000 acres of irrigated land devoted to crops. About $32,000,000(1) has been invested in irrigation works alone. The Corps of Engineers' 308 Report states that the value of the different types of farm land ranges from $20.00 to $250.00 per acre for irrigated land, from $5.00 to $50.00 for dry-farm land, and from $2.00 to $15.00 for grazing land.

Irrigated Lands in the Basin

Definition. All lands are not subjected to the same degree of irrigation. Lands having a good water right receive, in general, more water than those having a poor right. Some land is flood-irrigated once in every one to five years from the overflow caused by temporary dams hastily constructed across normally dry water courses. Other land is subjected to systematic and intensive irrigation through an elaborate system of canals and ditches diverting from a source whose dependability has been assured. Opinions differ as to the lands that should be classed as irrigated, a fact that, to some extent, accounts for the differences in irrigated areas in the basin, as estimated by various agencies. In the tables of this report "Irrigated Area", as estimated by various authorities, is

(1) U. S. Bureau of the Census, Irrigation Section, 1930.

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believed to mean the area in a basin which is systematically irrigated from a system of canals, usually referred to as a project.

The terms "Irrigable Area under Present System", "Irrigable Area by Extension of Project", and "Irrigable Area in Potential Project" are often used hereafter in this report. "Irrigable Area under Present System" means the area which can be irrigated by the project in its present state of development; "Irrigable Area by Extension of Project", the additional area which it is feasible to irrigate by extending or enlarging the existing system; and "Irrigable Area in Potential Project", the area in proposed projects which it is considered feasible to irrigate. "Ultimate Irrigable Area" of a basin, sometimes mentioned in this report, refers to the total area that will be under irrigation in the basin when the basin is completely developed, and represents the sum of "Irrigable Area under Present Systems", "Irrigable Area by Extension of Projects" and "Irrigable Area in (feasible) Potential Projects."

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The ultimate irrigable area of any basin is generally limited by one of the three following conditions: (1) The amount of arable land; (2) The water supply; (3) The cost of conveying the water to the arable land.

If the amount of arable land is the controlling factor, the ultimate irrigable area of the basin can be determined fairly closely. Thus, in the higher reaches, the valleys are narrow, and the arable land lies in small plots which makes the determination of the irrigable area relatively simple. In the main stem basin in Wyoming and along many of the lesser mountain streams, there, apparently, is no land that can be cultivated.

If the water supply is the limiting factor, the ultimate irrigable

area can be determined within reasonable limits, but the determination must be conditioned upon possible future changes in the water supply by storage or by interstream diversions. The ultimate irrigable area of the Greybull Basin, of the Tongue Basin, and of many minor basins is limited by the direct water supply.

If the cost of conveying the water to the land is the limiting factor, the ultimate area which it is feasible to irrigate is a matter of judgment, and is subject to change with changing economic conditions, and, hence, cannot be determined with finality. It is in the basins where this factor controls that the various estimates differ most. Along the Big Horn and along the Yellowstone in Montana, there are large tracts of arable land and an ample supply of water, but irrigation of much of the land is prohibited by the excessive cost of long canals or of high-lift pumping.

Estimates of the irrigated and irrigable areas in the basin differ. The number of acres that are irrigable from present systems seems to be rather definitely known, but estimates as to how much of this is actually irrigated vary widely. There is also considerable difference of opinion as to the area that it is feasible or economically sound to irrigate by the extension of present systems and the construction of new projects. Many potential projects that are considered feasible by one agency are rejected by others as being impracticable.

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Table 18 compares, by sub-basins, estimated irrigated and irrigable areas from the following three sources:

1. Appendix F of the Progress Report of the National Resources Planning Board - prepared in 1939 by the Corps of Engineers, War Department.

2. U. S. Bureau of the Census, Irrigation Section for 1930.

3. "Water Resources of the Yellowstone River Basin in Wyoming" - H. T. Person.

The field survey sheets used by the Corps of Engineers in the preparation of Appendix F were loaned to the Federal Power Commission and were used in grouping the projects as to source of water supply. The irrigated area given in Appendix F is the average area actually irrigated during the period 1930 to 1938.

The figures listed for the U. S. Bureau of the Census were taken from the regular reports publishing the results of the census of 1930. The irrigated area shown is the area irrigated during the 1929 growing season.

The figures listed under the heading "Wyoming Report" were taken from "Water Resources of the Yellowstone River Basin in Wyoming" which was prepared under the direction of H. T. Person and submitted to the Wyoming State Engineer in October 1938. The estimates for the irrigated area, as given in this report, appear to have been taken from water right filings in the State Engineer's office. The total of 782,120 acres is evidently composed of the 700,130 acres having adjudicated water rights, plus an additional 81,990 acres being irrigated under permits in good standing (see Section F-2). Since it is doubtful that all the land having adjudicated rights is actually irrigated in any one year, this figure is probably not comparable to the other two estimates of irrigated areas.

A report submitted by the Montana State Water Conservation Board in September 1938 lists the following estimates of the irrigated area in Montana:

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U. S. Army Engineers (H.D. 256)	561,643 acres
U. S. Dept. Agr. Econ. Bureau	336,198 acres
State Board of Equalization	434,651 acres
Montana Irrigation Commission (1920)	668,500 acres
R. B. Tootell Inventory	318,558 acres
Montana State Planning Board	472,000 acres
U. S. Census Bureau (1935)	336,198 acres

The report does not offer an independent estimate of the irrigable area in the basin, but lists the projects that were apparently omitted from the 308 Report (H.D. 256). Many of the projects listed were later incorporated in Appendix F of the Progress Report of the National Resources Planning Board. All of the projects listed in the Montana report are included in Appendix I, table 2, of this report.

A letter from the North Dakota State Water Conservation Commission, dated June 7, 1940, reports the following irrigable areas in North Dakota:

Name of Project	Irrigated Area	Irrigable Area Under Present System	Ultimate Irrigable Area
Main Stem	14,650	21,030	23,680
Sioux Irrigation Dist.	650	1,030	1,030
Lower Yellowstone Project	14,000	20,000	20,000
Cartwright Irrig. District	0	0	840
Yellowstone Pump. Irr. Dist.	0	0	1,810
Tributaries	98	108	108
Frank Lassey Ditch	10	20	20
Jackson Brothers Ditch	88	88	88
Total, North Dakota	14,748	21,138	23,788

The U. S. Bureau of Reclamation is conducting a survey of irrigable areas in the Big Horn River Basin and in portions of the Yellowstone Basin above the Big Horn River. The report of this survey, which is scheduled for completion in 1941, should prove to be of great value to this investigation.

Table 19 is a further breakdown of the estimates reported by the

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Corps of Engineers and shown in table 18. Because the only detailed data covering the entire basin, which are available in this office, are those furnished by the Corps of Engineers, these data are used in developing this report. Where comparable data have been furnished by another agency, they are presented for comparison. Data on irrigated and irrigable areas and on water shortages are given in detail in Section II for each existing project in the basin. A description of each major project is contained in Appendix III of the 308 Report (H.D. 256). Map 8, showing the approximate location of existing and potential irrigation projects, was developed from the best available information of this nature.

The potential irrigation projects listed in table 20 are those projects which were included in the water use studies of Appendix F of the Progress Report of the National Resources Planning Board. The area in these projects is included in the "ultimate irrigable area" as estimated in Appendix F and listed in tables 18 and 19 of this report. Other potential projects were mentioned in Appendix F, but were excluded from the water use studies for one or more of the following reasons:

A. An alternate to a listed potential project, or included in a listed project.

B. Infeasible on account of insufficient water supply or other physical cause.

C. Infeasible economically.

D. Data insufficient for appraisal of project. (Some of these may prove to be alternates.)

Appendix I of this report contains a list of all the proposed projects of which this office has any knowledge. Since most of the smaller streams in the basin are over-appropriated at present, additional areas that are brought under irrigation in the future will be, to a great extent,

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dependent upon new storage. For a list of potential storage reservoirs, see Appendix II (see map 7 for location).

Definition of Terms Relating to Irrigation Practice

Terms relating to irrigation practice are often loosely used and, when not adequately defined, are subject to misinterpretation. In this report "Water Duty at Headgate" or simply "Water Duty" will mean the gross diversion from stream per acre irrigated. "Water Duty at Farm" will mean the amount of water per acre actually applied to the land. Canal and lateral losses and waste returns make up the difference between "Water Duty at Headgate" and "Water Duty at Farm." "Return Flow" is the amount of the gross water diversion that ultimately finds its way back to a stream. "Stream Depletion", as used in this report, is the difference between "Water Duty at Headgate" and "Return Flow." "Consumptive Use" is the amount of water lost from irrigated land through evaporation and transpiration.

Water Duty

Many factors affect water duty, and they are so intricately interrelated that it is impossible to determine the relative effects of each. Many formulae have been offered purporting to express water duty as a function of several of the numerous factors which affect it. Although many of these formulae are products of valuable research, they fall short of their aim. One of the greatest obstacles to the determination of the relative effects of the physical factors affecting water duty is the human factor of the irrigator. The irrigation which a crop receives depends upon the industry, skill, and efficiency of the irrigator, as well as upon the needs of the crop. Also, it is quite natural for irrigators to use water lavishly when it is plentiful or when there is fear that soon it will be scarce. Nevertheless, physical factors are dominant in determining water duty, and, therefore, the more important of these are discussed below.

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Precipitation is the most important factor affecting water duty, as is evident from the fact that irrigation is not generally practiced where the annual precipitation exceeds 20 inches, unless the distribution is unfavorable. A scatter diagram (not printed) showing water duty at the farm plotted against precipitation during the growing season, by years, for six U. S. Bureau of Reclamation(1) projects - four in the Yellowstone Basin and two just outside the basin - indicates roughly but definitely a decrease in water duty with increase in precipitation, the relationship being approximately straight-lined. The relationship between water duty and precipitation, however, is not as close as might be expected. In general, projects having relatively heavy precipitation during the growing season have a lower water duty than projects having relatively light precipitation, but, for certain projects, water duty from year to year appears to be almost independent of rainfall. This is perhaps due to the fact that the rainfall during the actual irrigation season is often too light to interrupt the systematic irrigation practice. Then, too, a rather large total rainfall for a season might occur in numerous showers, each of which is too light to benefit the crop. Of the irrigable area of the Yellowstone Basin, the heart of the Big Horn Basin receives the least precipitation, and, if this factor were the sole criterion, might reasonably be expected to require the most water. The irrigable areas receiving the greatest precipitation, and which might be expected to require the least water, are those occupying the higher elevations and perhaps those farthest east, near the North Dakota state line. However, precipitation

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(1) "Use of Water on Federal Irrigation Projects" by E. B. Debler. Printed in Volume 94 of the Transaction of the American Society of Civil Engineers.

does not alone determine water duty, and the precipitation does not vary enough over the irrigable areas to cause an extreme range of water duty in the Yellowstone Basin.

Type of soil. The report of E. B. Debler, "Use of Water on Federal Irrigation Projects", printed in Volume 94 of the Transactions of the American Society of Civil Engineers, gives pertinent data on 24 irrigation projects of the U. S. Bureau of Reclamation, scattered throughout the western United States. The mean annual water requirements ("water duty at the farm", plus precipitation) for the 24 projects of the Debler report, classified as to type of soil, are:

Average of 5 light soils - 3.72 acre-feet
Average of 11 medium soils - 3.21 acre-feet
Average of 7 heavy soils - 2.36 acre-feet

So great a difference is probably highly significant and indicates that, under the same general climatic conditions, such as exist in the Yellowstone Basin, the type of soil is perhaps the dominant factor in the variation of water use. Too little is known of the soils in the basin to permit general conclusions as to water duty in the several sub-basins. The influence of soil texture on the water duty of a given project can be determined only after detailed soil surveys are made.

0575

Canals and laterals. Canal and lateral losses increase with the length of the conduit and the porosity of the soil, and, therefore, vary widely on different projects. For the 24 projects of the Debler report canal and lateral losses range from 13 to 48 percent of the total diversions, and average 34 percent. Hence, it is evident that, for certain projects, the length of the canal system might easily outweigh all other factors that determine water duty. High cost usually prohibits correction by lining the canals. Projects having short canals are usually cheaper

and were developed first. Projects built in the future may, in general, be expected to have longer canals and, therefore, greater losses than those already constructed.

The method and efficiency of irrigation might be considered a human factor, rather than a physical factor, were they not effected by the generally recognized methods of irrigation practice. Both flood and furrow irrigation, depending upon the type of crop, are practiced in the Yellowstone Basin. Sub-surface irrigation is too expensive to be practical in this region. Flood irrigation is applied to small grains, hay, and pasture lands. It requires more water and results in a greater waste than does furrow irrigation. However, since hay and pasture lands can withstand drought without serious deterioration better than other crops, they are sometimes neglected if the water on a farm must be rationed. Sections devoted exclusively to hay and pasture and having an abundant supply of water can be expected to have a use of water greater than that of other sections.

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Type of crop. Water duty varies both in total amount and in seasonal distribution with the kind of crop and its yield. Many attempts, by controlled laboratory experiment, have been made to determine the amount of water used by various crops. An article, "Determination of the Duty of Water by Analytical Experiment" by W. C. Hammatt, printed in Volume 83 of the Transactions of the American Society of Civil Engineers, presents a table, attributed to Samuel Fortier, showing the transpiration use of plants as determined by various investigators throughout the world. An abridged rearrangement of this table is presented below.

Transpiration for Various Standard Crops
(Pounds of Water per Pound of Dry Matter)

Investigator	Wheat	Oats	Barley	Corn	Rye	Peas	Potatoes	Alfalfa
Sorauer(1)	708	600	490	-	-	-	-	-
Hellriegel(1)	339	401	297	-	377	292	-	-
Von Seelhorst(1)	333	-	365	-	469	-	281	-
Leather(2)	544	469	468	337	-	563	-	-
Briggs & Shants(3)	507	614	539	369	724	800	448	1,068
Lawes(4)	235	-	260	-	-	235	-	-
King(3)	-	514	388	348	-	477	423	-

(1) Germany (3) United States
(2) India (4) England

The fact that the variation between irrigators is greater than the variation between type of drop (which tends to indicate that water use varies with the investigator or irrigator more than with the kind of plant) cannot be dismissed as entirely insignificant. Nevertheless, it is a well-known fact that some crops require more water than others, and that some crops require early water and others late water. If this fact is considered in determining the "beneficial use" of irrigation water, it will undoubtedly reflect to the advantage of the entire basin. Sugar beets, especially, demand late water, and irrigators in areas devoted primarily to sugar beets might advantageously sacrifice early water to the hay and pasture areas in return for a more dependable supply in late summer.

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Temperature and humidity directly affect water duty by controlling the rate of evaporation. Also, temperature is a fairly accurate measure of the amount of solar radiation received, which, in turn, is a controlling factor in plant growth. The areas in the basin having higher summer temperatures might reasonably be expected to have higher water duty.

It is evident, from the above discussion, that the water duty in any area must be estimated by comparison with actual experience in similar

areas, with due regard to variations in physical factors. The only actual records known to be available are those for four projects of the U. S. Bureau of Reclamation. Data on water use on these projects are presented below. Immediately following the presentation of the actual records, estimates of water duty according to various authorities are discussed.

Average "Water Duty at Farm" - U.S.B.R. Projects

(Acre-feet per acre)

Project	April	May	June	July	Aug.	Sept.	Oct.	Total
Lower Yellowstone	.00	.07	.30	.51	.35	.11	.00	1.34
Huntley	.00	.12	.28	.51	.37	.11	.00	1.39
Shoshone Project								
Frannie Division	.02	.29	.56	.63	.46	.19	.04	2.19
Garland Division	.05	.30	.57	.71	.50	.21	.03	2.38
Riverton	.00	.20	.70	.96	.47	.27	.01	2.62
Average	.01	.20	.48	.66	.43	.18	.02	1.98
Percent of Annual	1	10	24	33	22	9	1	100

Average "Water Duty at Farm" Plus Precipitation - U.S.B.R. Projects

(Acre-feet per acre)

Project	April	May	June	July	Aug.	Sept.	Oct.	Total
Lower Yellowstone	.08	.20	.54	.68	.48	.22	.08	2.28
Huntley	.09	.30	.47	.62	.44	.25	.09	2.26
Shoshone Project								
Frannie Division	.06	.40	.64	.69	.49	.26	.08	2.62
Garland Division	.09	.38	.65	.78	.54	.29	.06	2.79
Riverton	.10	.36	.76	1.06	.57	.32	.09	3.26
Average	.07	.33	.61	.77	.50	.27	.08	2.64
Percent of Annual	3	12	23	29	19	11	3	100

Source: "Use of Water on Federal Irrigation Projects", by E. B. Debler, and Project Histories of the Riverton Project.

The period covered is from 1912 to 1926, except for the Riverton Project, where the period is from 1929 to 1937. Broken and less accurate data since 1926 indicate that the average total "water duty at farm" should be increased from 1.98 acre-feet to 2.25 acre-feet, and that the average total "water duty at farm" plus precipitation should be increases from 2.64 acre-feet to 2.80 acre-feet per acre. Since canal and lateral losses for

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these projects range from 36 to 44 percent of diversion, this would result in an average "water duty at the headgate" of about 3.5 acre-feet per acre. The maximum and minimum "water duty at the farm" is given for each project in the following tabulation:

Maximum and Minimum Water Duty at Farm

(Acre-feet per acre)

Project	Maximum		Minimum	
	Amount	Year	Amount	Year
Lower Yellowstone	2.51	1931	0.87	1920
Huntley	3.13	1934	0.96	1922
Shoshone Project				
Frannie Division	4.90	1936	1.72	1926
Garland Division	4.06	1936	2.08	1913
Willwood Division	2.71	1934	2.00	1932
Riverton	3.31	1934	2.08	1937

Source: "Use of Water on Federal Irrigation Projects", by E. B. Debler, and Project Histories.

It should be pointed out that the use of water on these projects has never been curtailed because of a water shortage.

In the Wyoming report, "Water Resources in the Yellowstone River Basin in Wyoming", streamflow was reconstructed by assuming a stream depletion of 1.5 acre-feet per irrigated acre per year. It was assumed that 2.5 acre-feet were diverted, 1.0 acre-foot of which was return flow. Stream depletions were estimated to be distributed throughout the growing season as follows:

May	15% or	.23 acre-feet
June	35% or	.52 acre-feet
July	35% or	.52 acre-feet
August	10% or	.15 acre-feet
September	5% or	.08 acre-feet
Total	100% or	1.50 acre-feet

It was emphasized in the report that these estimates were for past use, and that the correction was not applied to areas devoted primarily to crops requiring a great amount of late water. Because of the

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increasing trend in crops requiring more water, the estimated future depleted run-off was found by assuming the following depletion:

Upper Big Horn Basin . . . . . 1.6 acre-feet
Lower Big Horn Basin . . . . . 1.8 acre-feet
Little Horn Basin . . . . . 1.5 acre-feet

In H.D. 256 of the 308 Report, Appendix IV, which treats of potential irrigation projects, goes into considerable detail on water duty on the Shoshone Project extension. A tabulation of the estimates arrived at is given below:

Irrigation Requirements for Shoshone Project and Extensions

(Acre-feet per acre)

Division	Estimated Duty at Farm	Estimated Consumptive Use*
Garland and Willwood	2.38	1.83
Frannie	2.44	-
Heart Mountain	2.25	1.70
Chapman Bench	2.80	-
Oregon Basin above Reservoir	2.25	1.70
Below Oregon Basin Reservoir	2.40	1.70
Greybull District	2.90	**1.90

Source: Appendix IV, H.D. 256.

* "Consumptive use" is not defined in the report.

** Exclusive of loss from some 12,000 acres of seeped river bottom.

The duty of water for most of the other potential developments is estimated in Appendix IV with little comment. The estimates are tabulated below:

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Estimated Duty of Water on Potential Irrigation Projects

(Acre-feet per acre)

Proposed Project	Location	Duty of Water Diverted	Duty of Water At Farm
Middle Yellowstone	Lower Yellowstone	2.3	1.4
Powder River	Lower Powder River	2.7	1.5
Sussex	Upper Powder River	2.7	1.8
Tensleep and Bonanza	Nowood Creek	2.5	2.0
Paintrock	Nowood Creek	2.5	2.0
Buffalo Basin	Gooseberry Creek	2.4	2.0
Big Horn	Lower Big Horn	3.34	2.0
Clark Fork	Clark Fork	3.1	1.89
Clark Fork alternate scheme	Clark Fork	4.0	2.00
Chapman Bench	Clark Fork	3.5	-
Lander Valley	Popo Agie River	4.25	-
Parkman Irrigation District	Tongue River	3.0	-
Johnson County	Crazy Woman Creek	3.0	-
North Wyoming Land Company	Crazy Woman Creek	3.0	-
Brackett Creek	Upper Yellowstone	2.9	1.5
Joliet & White Horse Bench	Upper Yellowstone	2.5	1.5
Tongue River Canyon	Tongue River	3.33	2.0

Source: Appendix IV, H.D. 256.

In the Platte River 308 Report (H.D. 197), consumptive use and return flow are discussed in Appendix X. This appendix gives, in tabular form, the consumptive use of different crops as found by various investigations. This table, which has been abridged and rearranged, is given below. The meaning of "consumptive use", as used in this table, is not perfectly clear, but it is believed to mean the amount of water (including that supplied by precipitation) actually lost from an acre of crop through evaporation and transpiration. This figure may be expected to vary with crop yield.

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Summary of the "Consumptive Use" of Various Crops

(Acre-feet per acre)

	Poudre Valley Colorado(1)	Cache Valley Utah(2)	Utah Experiment Station(3)	Snake River Valley Idaho(4)
Alfalfa	3.7	3.3	4.6	1.2
Sugar Beets	3.0	2.5	2.4	-
Potatoes	3.3	2.2	2.2	1.6
Corn	-	2.5	2.2	1.3
Wheat	2.1	2.4	2.5	1.2
Barley	2.3	-	-	1.6
Oats	1.4	2.5	3.1	1.5
Beans	-	-	-	1.2
Peas	-	-	-	1.4

Source: Appendix X, H.D. 197.

(1) U. S. Dept. of Agriculture Bul. 1026, by R. G. Hemphill.
(2) Utah Agricultural College Bul. No. 173, by F. S. Harris.
(3) Utah Agricultural College Bul. No. 117, by Widsoe and Merrill.
(4) M. R. Lewis.

In making return flow studies, the report adopted the following values for consumptive use as applicable to the North Platte Valley:

Alfalfa	3.4
Sugar Beets	2.6
Potatoes	2.3
Cereals	2.1
Miscellaneous	2.6

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Appendix "F" of the Progress Report of the National Resources Planning Board, which was prepared for the Board by the Corps of Engineers, War Department, estimates the average water duty in the Yellowstone Basin as 3.5 acre-feet gross diversion per acre. This estimate is supported by the following statement: "This is a compromise between earlier estimated duties for various proposed projects and the actual diversions and claims of irrigators on existing projects, and is in accord with prevailing duty estimated by the U. S. Bureau of Reclamation for ultimate development of its projects." The seasonal distribution of diversions is estimated to be

as follows:

April	5%	or 0.18 acre-feet per acre
May	12%	or 0.42 acre-feet per acre
June	20%	or 0.70 acre-feet per acre
July	24%	or 0.84 acre-feet per acre
August	24%	or 0.84 acre-feet per acre
September	12%	or 0.42 acre-feet per acre
October	3%	or 0.10 acre-feet per acre
Total	100%	3.50 acre-feet per acre

Return flow is estimated to average not less than 40 percent of the gross diversion. The time of return flow was assumed to conform to the following general return formula:

15 % of diversion for any month during the same month
15 % of diversion for any month during the first month following
5 % of diversion for any month during the second month following
1 % of diversion for any month during the third month following
0.5% of diversion for any month during each of the next eight months following

According to this formula the entire return flow, amounting to 40 percent of gross diversion, returns to the stream within 12 months of the date of diversion. Combinations of the above diversion and return flow schedules result in the following net effects on stream flow:

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Table 21

Net Effect of Irrigation on Streamflow

Month	Acre-feet per Acre: Gross Diversion	Returns	Net Effect on Stream Flow
January	0.00	0.02	0.02
February	0.00	0.018	0.018
March	0.00	0.018	0.018
April	0.18	0.05	-0.13
May	0.42	0.10	-0.32
June	0.70	0.19	-0.51
July	0.84	0.26	-0.58
August	0.84	0.29	-0.55
September	0.42	0.24	-0.18
October	0.10	0.13	0.03
November	0.00	0.059	0.059
December	0.00	0.025	0.025
Season	3.50	1.40	-2.10

Source: Appendix "F" of the Progress Report of the National Resources Planning Board, 1939.

Other estimates. The history of irrigation in the Yellowstone River Basin records a perplexing array of estimates of the use of water, since no writer on the subject can long evade the necessity of adopting a figure for water duty. It would be impracticable to attempt to give even a partial list of these estimates in this report. It may be safely assumed, however, that the recent estimates quoted in the preceding paragraphs were made only after careful consideration had been given to previous estimates. The only attempt to fix by law the amount of water which may be applied to the land is the ruling in Wyoming which limits diversion to one cubic foot per second to every 70 acres.

Return Flow

Return flow is that portion of the gross diversion which ultimately finds its way back to some stream. It is the difference between gross diversion and stream depletion. Seepage from canals and laterals, farm waste and farm percolation losses are the chief sources of return flow.

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Return flow varies widely from project to project, both in amount and in time of return. In general, the amount of return flow depends upon the amount of water diverted, and, consequently, any factor which affects water duty at the headgate must also affect return flow. The type of subsoil has a marked effect on return flow both as to total amount and to time of return. A loose, porous sub-boil is conducive to great losses which are quickly returned to the stream. A heavy textured sub-soil reduces seepage and percolation losses and delays their return. Seeped areas, inasmuch as they increase stream depletion by offering surfaces of evaporation, decrease return flow. Because it takes several years to build up the water table under irrigated areas, return flow is relatively low the first few years a project is under irrigation, and increases with the age

of the project until a normal return is reached.

Records of return flow in the region are very meager. The many sources of error connected with the measurement of return flow render accurate determination almost impossible. The most valuable known information on the subject is contained in a report, "The Consumptive Use of Water on the Garland Division, Shoshone Project", by H. H. Johnson, discussing the results of an investigation conducted by the U. S. Bureau of Reclamation on the Garland Division in 1923. It was found that, of the net diversion of 118,704 acre-feet, 63,037 acre-feet were returned to the stream, leaving a gross stream depletion of 55,667. (This indicates a depletion of 1.83 acre-feet per acre for the 30,468 acres irrigated.)

The Wyoming Report, the "308" Report, and "Appendix F" estimate return flow at 40 percent of gross diversions. Jerome G. Locke, in "Preliminary Report on the Complete Development of the Yellowstone Drainage Basin", quotes the Montana Planning Board as assuming return flow as 50 percent of gross diversions, with which he concurs. It appears, from the preceding paragraph, that return flow on the Garland Division amounted (in 1923) to about 53 percent of "net" diversions (gross diversion less canal waste).

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Apparently, the nature of the sub-soil is the dominant factor controlling the seasonal distribution of return flow. The table below shows the monthly percentages of the annual return flow on four projects as given in Appendix X of the Platte River "308 Report", to which has been added for comparison the seasonal distribution as estimated in "Appendix F" of the Progress Report of the National Resources Planning Board.

Monthly Distribution of Return Flow

(Percent of Annual Return Flow)

Month	Garland Division, Shoshone Project(1)	Boise Project, Idaho(2)	Casper-Alcova Project(3)	North Platte Basin(4)	Appendix "F"
January	1.9	4.2	6	6.1	1.4
February	1.4	3.8	5	5.7	1.3
March	1.5	3.4	5	5.6	1.3
April	1.5	3.1	5	5.5	3.6
May	7.6	8.0	7	8.0	7.1
June	16.0	13.8	11	9.6	13.6
July	20.9	13.4	12	9.6	18.6
August	20.4	14.1	12	11.5	20.7
September	14.9	14.9	12	11.9	17.1
October	7.9	9.9	10	10.4	9.3
November	3.3	6.1	8	8.6	4.2
December	2.7	5.3	7	7.5	1.8
Total	100.0	100.0	100	100.0	100.0

(1) "The Consumptive Use of Water on the Garland Division, Shoshone Project", by H. H. Johnson.
(2) Report on drainage investigation, Boise Project, 1916 and 1917, by D. J. Paul and W. G. Steward.
(3) Rate adopted by U. S. Bureau of Reclamation as applicable to the Casper-Alcova Project (Kendrick Project, Wyoming).
(4) As computed by Corps of Engineers, War Department, Appendix X, H.D. 197, Platte River Report.

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Effect of Irrigation on Streamflow

The total effect of irrigation operations on streamflow may be determined from the combined effect of gross diversion, return flow and reservoir operations. A schedule of the effect of the first two factors, as developed in "Appendix F", is shown by table 21. This schedule, which was prepared by the Corps of Engineers, is intended to reflect average conditions throughout the basin. The effect of reservoir operations depends upon the capacity available for storage, and must be computed separately for each stream. Since reservoirs are operated to correct the deficiencies of the natural stream, their general effect is to decrease the flood peaks in early summer and increase the flow in late summer, thereby causing a more even flow throughout the irrigation season.

Evaporation loss from storage reservoirs must be added to the depletion resulting from irrigation proper, in order to obtain the total stream depletion resulting from irrigation. Thus, the net effect of irrigation on streamflow results in a decrease in total annual discharge through depletion, and a re-distribution of seasonal flow arising from the regulating effect of storage and diversion operations and the subsequent return flow schedule.

2. Power Development

Generating facilities are operated by 17 public utility systems, the National Park Service, the Bureau of Reclamation, and five industrial companies. The industrial companies generate energy for their own use, and their capacity is, in general, not available to the utility load in the area. Pertinent information on existing power plants in the region is given in table 22, and map 9 shows the location of these plants. It will be noted, from the summary below, that, although only one-third of the basin's capacity is in hydroelectric plants, they account for nearly one-half the total energy generated in the basin.

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	Generator Capacity		Net Generation, 1939*	
	Kw	Percent	1,000 Kwh	Percent
Hydro	19,348	29	72,299	49
Steam	45,602	67	70,930	48
Internal Combustion	2,326	4	3,796	3
Total	67,276	100	147,025	100

* 1939 generation, except as noted on table 22.

Although there are interconnections with the main system of the Montana Power Company to the northwest and with the Williston Division of the Montana-Dakota Utilities Company to the northeast, energy interchanges with these systems outside the basin are relatively small. In 1938

interchanges amounted to a net importation into the Yellowstone Basin of 4,400,000 kwh from the main system of the Montana Power Company and 1,100,000 kwh from the Williston Division of the Montana-Dakota Utilities Company. However, the Stanolind Oil and Gas Company exports (to the Casper area, outside the basin) about 15 to 20 million kilowatt-hours annually.

In 1939 the Federal Power Commission made a survey of the potential power markets in and near the Yellowstone Basin, and estimated the future power requirements of the region through the year 1955. Table 23 presents a summary of that portion of the load, in the region studied, that is approximately within the limits of the Yellowstone Basin itself. It will be noted that the energy requirements of the basin are expected to increase from 102 million kilowatt-hours in 1938 to about 183 million in 1955.

Table 23

Classified Energy Sales and Energy Requirements of Public Utility Systems in the Yellowstone Basin

(1,000 kwh)

Customer Classification	Actual Records		Forecasts(1)		
	1929	1938	1945	1950	1955
Residential and Farm	10,070	19,110	31,330	38,490	44,730
Commercial and Industrial	39,320	45,780	60,040	67,680	73,610
Government and Municipal	6,780	8,700	10,990	12,270	13,350
Total Sales to Utlimate Consumers(2)	56,170	73,590	102,360	118,440	131,690
Corresponding Energy Requirements(3)	78,120	102,440	142,150	164,410	182,680

Source: "Power Market Survey - Yellowstone River Basin", Federal Power Commission, October 1939.

(1) Estimates do not include energy requirements of the potential irrigation pumping projects listed in table 24.
(2) Does not include sales of small isolated systems.
(3) Includes energy requirements of small isolated systems.

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This estimate does not include the energy requirements of pumping plants of potential irrigation projects. This possible market was investigated, and, from the list of potential pumping projects which have been proposed, 17 in the Yellowstone Basin were selected as being capable, under favorable circumstances, of meeting power charges. These 17 projects (listed in table 24) would provide a market for an additional 16 million kilowatt-hours of electric energy. Markets adjacent to the Yellowstone Basin were also investigated, but it was found that the only two probable markets of any magnitude - the proposed irrigation pumping projects along the Missouri River and the mining industry in the Butte-Great Falls area of Montana - could be adequately, and possibly more economically, supplied from the Fort Peck Project and undeveloped hydroelectric resources of western Montana.

Table 25 gives pertinent data on the 34 water power plants (some of which are direct drive) in the Yellowstone Basin. This list was compiled by the Federal Power Commission in 1938 and is believed to be complete.

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The future development of hydroelectric power appears to be limited by the absence of an adequate market and the abundance of cheap fuel, rather than by a lack of favorable water power sites. Appendix III presents pertinent information on hydroelectric developments which have been proposed. The Corps of Engineers' 308 Report tabulates 26 water power plants, at which, it was estimated, prime power could be produced for less than 8 mills per kilowatt-hour. These plants are listed in table 1 of Appendix III.

3. Navigation

Navigation of the Yellowstone River was rather extensive during the decade prior to the completion, in 1882, of the Northern Pacific

Railroad between Bismarck, North Dakota and Billings, Montana. Apparently, navigation was too difficult to permit water-borne commerce to compete with this improved means of transportation, for, immediately after the completion of the railroad, river traffic dropped markedly, and thereafter diminished gradually until 1910, when the construction of the diversion dam at Intake, Montana closed the river to traffic above that point. Today, the actual head of navigation is the dam at Intake.

Past Navigation

The Corps of Engineers, in its 308 Report, includes the following on page 157:

> "During the period 1882 to 1884, boats were operated on the Yellowstone River from the mouth of the stream to Billings, Mont. (mile 346). The principal steamers that were operated on the Yellowstone River according to the information now available were the 'Far West', the 'Eclipse', the 'Josephine', and the 'Bachelor'. It appears that the navigation season was limited to the period during which the river maintained a fairly dependable stage, and in general lasted only from May to September of each year. Existing records also indicate that steamers during this period navigated the Big Horn River as far as Fort Custer, Mont. (at the mouth of the Little Horn River, 40 miles above its confluence with the Yellowstone). In 1882 the Northern Pacific Railroad was completed between Bismarck, N. D., and Billings, Mont. After the construction of the railroad, navigation on the upper reaches of the river was gradually abandoned. Between Glendive and the mouth of the river, however, there continued to be a small amount of river commerce until 1910, when through navigation was interrupted by completion of the dam at Intake."

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The following items were obtained from works found in the Library of Historical Society of Montana, at Helena:

The Bozeman Times - June 15, 1875:

> "According to the Bismarck Tribune of the 26th, the Josephine started up the Yellowstone River on the 23rd ulto., with Forsyth and Grant and party - time to Big Horn and back estimated at three weeks.
>
> "We are advised that the main object of the Pease Expedition is the location of a town and colony at the head of navigation of the Yellowstone probably at the Big Horn."

The Bozeman Times - June 22, 1875:

> Reprint of an extra issued June 15: "A messenger, just arrived at Bozeman from the Yellowstone valley, brings the gratifying news that the steamer Josephine has reached the mouth of

Clark's Fork 75 miles above the mouth of the Big Horn, and ascended that stream a few miles. She met with no obstruction on the way - easily getting over Wolf Rapids - and will probably ascend the Yellowstone to the site of the old Crow Mission, or within 35 miles of Bozeman. * * * The officers of the Josephine are reported to have pronounced the Yellowstone a better river to navigate than the Upper Missouri."

War Department - Report of an Expedition up the Yellowstone River - Made in 1875 by Lieutenant Colonel James W. Forsyth and Lieutenant Colonel F. D. Grant - Government Printing Office, 1875.

Forsyth's Report:

"The steamboat selected for the expedition was the Josephine, Captain Marsh commanding. She is one of the best boats engaged in the Upper Missouri trade, being 180 feet in length, 31 feet in breadth, with a depth of hold of 4 feet, and is registered at 300 tons burden. She had no freight on board and was manned by 12 officers and 31 men. * * * "

Big Horn River:

"We steamed up this river for a distance of 12 miles, found it quite crooked, with a narrow valley, and were obliged to return on account of the water becoming distributed over so wide a space that the main channel did not afford sufficient depth of water for us to continue our course. The current of the Big Horn was about as strong as that of the Yellowstone, water muddy, and at the mouth it was about 150 yards wide."

Grant Report - The Yellowstone River:

"In low water the stream is navigable with ease as far up as Rompey's Pillar, about thirty miles above the mouth of the Big Horn River, there being but one place from its mouth to this point that would have to be fixed to improve its navigation. A couple of boulders would have to be removed from near the mouth of the Powder River. * * * The only other obstacles in the way are the different rapids. Most of these a steamboat can run over without any trouble. Some are almost too rapid, and these can be cordelled without any trouble. To cordelle is to tie a long rope around a tree or stump on shore and the other end wrapped around the capstan of the boat, which is turned by steam, and then the boat is pulled along. The water of the Yellowstone is deeper than that of the Missouri above the mouth of the Yellowstone, and could be navigated more months in the year than the Missouri can be."

Leeson, in "History of Montana", states that importation by the Yellowstone River amounted to 4,210 tons in 1881, but dropped to 960 tons in 1882, after completion of the railroad to Billings.

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Present Navigation

The Corps of Engineers' 308 Report contains the following concerning present navigation on the Yellowstone River:

"Since the construction of the diversion dam at Intake there has been practically no commercial navigation on the Yellowstone. During recent years the Northland Seed Company of Sidney, Montana, has operated a small boat between Sidney (mile 26.6) and the mouth of the river for the purpose of transporting alfalfa seed and other agricultural products. This boat has a draft of only about 18 inches and requires a vertical clearance of approximately 18 feet. It is 63 feet long; the beam is 16 feet. The boat is powered by an internal combustion motor and has a registered capacity of approximately 33 tons. During the calendar year 1929 this boat handled a total of approximately 60,000 pounds of produce. There are no large pleasure boats of any kind on the Yellowstone at this time, nor have such craft ever been used to any considerable extent. * * * "

"In view of the temporary abandonment of that section of the river above Intake for all purposes of river commerce, and in recognition of the practical head of navigation as determined by the obstruction at Intake, the Engineer Department has withdrawn active supervision over that section of the river above Intake, Mont. That section of the Yellowstone River below Intake (mile 71.8) has the status of a navigable waterway of the United States and requires active supervision by the War Department under the provisions of section 9 of the Act of March 3, 1899."

"The people of Montana have no interest at this time in the development of the Yellowstone River for navigation. The present status of development of the Yellowstone Basin indicates that existing transportation facilities will be adequate to all needs for the next decade, or longer."

"There are at this time no industries within the Yellowstone Basin which require the utilization of the Yellowstone River as a navigable waterway. However, the presence of coal and ores suggests a possibility of the ultimate exploitation of these mineral resources on a scale which might justify the utilization of the Yellowstone River for the purpose of navigation."

There are two bridges across the Yellowstone below the dam at Intake. One is a railroad bridge near Fairview, Montana, with a vertical clearance at high water of 50 feet and a horizontal clearance of 200 feet. The other, a highway bridge near Sidney, Montana, has a vertical clearance of 20.5 feet and a horizontal clearance of 250 feet. A number of bridges span the river above the Intake dam. Since the Army has abandoned

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supervision of the river above the dam, the bridges, presumably, were not designed with the view of providing clearance for navigation.

4. Flood Control

The only comprehensive investigation of flood damage and flood control yet made in the Yellowstone Basin is that of the Corps of Engineers in connection with their "308 Report". It was found that 225,300 acres, constituting 0.5 percent of the basin land, is subject to overflow. The total damage for the 50-year period from 1882 to 1931 was estimated at $5,200,000 or 46 cents per acre per year. The five most seriously affected municipalities (Sheridan, Greybull, Thermopolis, Miles City, and Forsyth) suffered damages estimated at $763,000 during the 32-year period from 1900 to 1931. Damage to other municipalities for this period was estimated at not more than $100,000. The investigation was unable to develop a scheme for diminishing flood peaks at a cost commensurate with the damage suffered, Local control could be effected by a system of levies for the five cities mentioned above, but, except for Forsyth, the annual cost would exceed the average annual damage.

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Areas Subject to Flooding

Concerning the causes of floods and the area affected, the 308 Report states:

> "The topography and character of the soil are conducive to excessive run-off only in the upper basin. Large areas of the lower reaches of the river contribute only moderate run-off, due to flatter slopes and lighter soils, Meteorological conditions are not conducive to heavy run-off over large areas; great general storms, covering a large part of the basin, are of rare occurrence. All parts of the basin are subject to short and sometimes very destructive periods of overflow, due to cloudbursts. The primary causes of flood conditions are heavy general rains, local cloudbursts, warm winds (Chinook winds) that cause the rapid melting of the snow blanket and ice jams. Heavy rains over large areas usually occur in May and June, coinciding with the high run-off, resulting from melting snows in the mountains, thus producing high stages throughout the basin.

Cloudbursts may occur at nearly any point in the basin and during any season of the year, other than winter months. These torrential rains with subsequent excessive run-off, frequently cause flood damages in localized areas. Chinook winds are warm, dry, westerly, or northerly winds occurring on the eastern slopes of the mountains of the upper Missouri Basin.

"The Yellowstone River is affected by ice jams during spring months; these form the principal menace at several of the more important towns. In the southern, or upper part, of the basin the spring break-up is at an earlier date than farther north or down-stream. Chinook winds are often an important factor in the early spring break-up in the upper basin, producing conditions that are conducive to the formation of ice jams.

"The valley of the Yellowstone is narrow from the headwaters to a point a short distance above Billings, Mont. Consequently, the overflow area is of small extent. Below Billings, the valley broadens out and the area subject to flooding is considerably increased. However, at the present time the valley is less developed in proportion to the inundated area (with actual damages correspondingly smaller) than many other sections of the Missouri River Basin. The ordinary spring overflows are not regarded as typically destructive of crops, buildings, and farm lands. However, the erosion caused by high water is of considerable local importance at many points. The extreme range of June freshets on the lower Yellowstone is about 12 feet. The ordinary range is from 8 to 10 feet. In periods of ice engorgement, the water may rise 15 or 20 feet above the ordinary high-water stage.

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"One of the most frequent causes of damage, is a tendency of the stream to leave its usual channel and cut a new course across the adjacent lands. Almost the entire Yellowstone Valley, from the vicinity of Billings, Mont., to the mouth, is subject to such damage, as well as the lower portions of the larger tributaries. The greater part of the damage ordinarily occurs at constricted sections, such as irrigation dams and headworks, bridges, and along the railroad tracks paralleling the streams. The Big Horn Valley is narrow, for the most part, from the headwaters to the vicinity of Riverton, Wyo.; and throughout the Big Horn Canyon (length about 55 miles) just above Hardin, Mont. The remainder of the valley is rather broad and subject to frequent minor overflows, but the amount of damage, considering the great area, is comparatively small.

"The Tongue and Powder River Valleys, particularly the latter, are wide throughout most of their lengths, and the banks are generally low. Overflows cover considerable areas; but the valleys are sparsely settled, and the damages are small."

Flood Damage

"Partial records of flood damages in agricultural areas are available since 1882. The data are summarized in the following table:

Flood Damages - Agricultural Areas

River	Flood Year	Damages: Crops and Livestock	Farm Lands, Buildings, Irrigation Structures	Bridges, Highways	Railroads	Total
Yellowstone:						
June.....	1882	$ 10,000	$ 10,000	$ -	$ -	$ 20,000
April.....	1899	5,000	10,000	5,000	15,000	35,000
June.....	1908	7,000	5,000	-	15,000	27,000
June.....	1918	460,000	500,000	250,000	1,000,000	2,210,000
June.....	1921	12,000	5,000	3,000	35,000	55,000
March.....	1929	2,000	8,000	-	-	10,000
Big Horn:						
June.....	1908	8,000	5,000	2,000	-	15,000
June.....	1912	9,000	4,000	2,000	10,000	25,000
June.....	1917	12,000	5,000	-	10,000	27,000
June.....	1921	7,000	5,000	3,000	5,000	20,000
July.....	1923	110,000	150,000	40,000	1,500,000	1,800,000
September..	1923	8,000	15,000	7,000	20,000	50,000
March.....	1929	10,000	20,000	30,000	35,000	95,000
Tongue:						
September..	1923	4,000	240,000	4,000	5,000	253,000
March.....	1929	2,000	40,000	5,000	3,000	50,000
June.....	1929	11,000	20,000	9,000	5,000	45,000
Powder:						
September..	1923	65,000	65,000	45,000	125,000	300,000
March.....	1924	7,000	45,000	8,000	-	60,000
June.....	1929	30,000	25,000	40,000	5,000	100,000
Total..		$779,000	$1,177,000	$453,000	$2,788,000	$5,197,000

Control by Storage Reservoirs

The result of an investigation of the possibilities controlling floods by storage in three reservoirs is contained in the quotation below:

"Flood control, by means of storage or detention reservoirs, can be economically obtained, provided reservoir sites of reasonable cost and proper capacity are available; and provided further, that the area to be protected is not at too great a distance from the storage sites. A large number of potential reservoir sites are available on the main stem of the Yellowstone above Billings, Mont., and on the principal tributaries, all of which have been given consideration during the progress of the report, in regard to power, irrigation, flood control, and navigation benefits to the Mississippi and Missouri Rivers, or a combination of these potentialities.

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"Of the many reservoirs under consideration, the potential Lower Canyon Reservoir on the upper Yellowstone, and a combination of potential reservoirs on the Big Horn River, appear to be favorably situated, for the purpose of controlling a general flood, affecting the main Yellowstone Valley. Sites are available on the Tongue and Powder Rivers, but these would have been of little value in controlling general floods such as those of 1918 and 1921. A reservoir on the upper Powder River would have reduced to some extent the crest of the 1923 flood, but the money value of such reduction would have been small.

"Detailed studies of reservoir operation and cost indicate that the Lower Canyon Reservoir (Yellowstone River), and Upper Big Horn and Cave Canyon Reservoir (Big Horn River), would form the most desirable combination. The Lower Canyon Reservoir on the Yellowstone, approximately 4 miles upstream from the town of Livingston, Mont., would have a storage capacity of 700,000 acre-feet, and it is estimated that it would cost $16,500,000. The Upper Big Horn Reservoir on the Big Horn River, about 10 miles north of the town of Kane, Wyo., would have a storage capacity of 479,000 acre-feet. Its estimated cost is $2,634,000. The Cave Canyon Reservoir on the Big Horn River, approximately one mile north of the railroad station at Himes, Wyo., would have a capacity of 393,000 acre-feet, at an estimated cost of $4,800,000."

Benefits Versus Cost of Flood Control Reservoirs

The following extract from the 308 Report summarizes the relative benefits and costs of flood control reservoir projects investigated therein:

"The total estimated damage that would have been eliminated by the reservoir operation over the 50-year period (1882-1931) would have been $2,769,500.

Estimated Damage Eliminated by Reservoir Operation

Flood Date	Agricultural	Municipal	Total
1882.....	$ 20,000	$ -	$ 20,000
1908.....	42,500	-	42,500
1917.....	27,000	-	27,000
1918.....	2,210,000	285,000	2,495,000
1921.....	50,000	-	50,000
1923 (July).....	100,000	-	100,000
1923 (September)...	25,000	10,000	35,000
Total.....	$2,474,500	$295,000	$2,769,500

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"The average annual benefit would have been $55,390. This amount, if capitalized at 5 percent, indicates a total justifiable expenditure of $1,107,800. However, protection at Forsyth, Mont., can be obtained at a cost somewhat less than the amount of capitalized damages. Therefore the amount that could be contributed by local flood-control interests would be reduced to $1,075,000. The estimated total costs of the three reservoirs for local flood-control purposes are as follows: Lower Canyon, $16,500,000; Upper Big Horn, $2,634,000; Cave Canyon, $4,800,000; or a total of $23,934,000. The adjusted capitalized benefit ($1,075,000) is only 4.5 percent of the total cost of the plan. Consequently, the three-reservoir scheme for local flood control, is not economically feasible.

"If no factor of safety is desired over the storage requirements of the 1918 flood only the costs of the Lower Canyon and Upper Big Horn Reservoirs need be considered. In this case the total cost of the project would be $19,134,000, and the adjusted capitalized benefit ($1,075,000) would be about 5.6 percent of the cost."

5. Industrial Use, Municipal Water Supply and Sewage Disposal

Very little information is available on industrial and municipal uses. A report by the Montana Water Conservation Board, dated September 25, 1938, estimates that the total amount of water diverted from the Yellowstone River by 26 municipal water supply systems in that state is equivalent to 20 second-feet continuous flow. The report estimates the return flow to be about equal to the diversion, thus resulting in a negligible net stream depletion. The municipal systems, having a more pressing demand for water, may exercise the right of Eminent Domain to secure an ample supply of potable water. The following quotation on stream pollution is extracted from the Montana report mentioned above:

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"The Yellowstone River and its tributaries drain practically all of the area of twelve counties, the population of which as given by the United States Bureau of the Census for 1930 was 112,645. Starting with Gardiner, which is at the closest point to the head waters of this river, and extending through Sidney, which is at the lowest point in the state, we find domestic sewage reaching the stream directly from thirteen communities in which sewer systems are built. In a few of these the sewage is given some form of primary treatment.

"Industrial wastes reach the stream at various points. These are from mining and milling activities in the mountainous areas and from beet sugar factories, oil refineries and such other industries as may be found in agricultural communities. Because of the extensive irrigation in various sections, it has been observed that the alkalinity of the water increases throughout the course of the stream, although this may not be classed as a pollution problem. Odors and tastes are accentuated in a restricted area in Yellowstone County, possibly because of a considerable amount of ground water seepage to the stream. This point is to be studied intensively by the State Board of Health this coming winter.

"While the population in the total area tributary to the Yellowstone River is not extensive, there are in certain restricted places acute pollution problems. These will doubtless be solved only through the building of proper waste treatment plants."

6. Miscellaneous Purpose Small Reservoirs

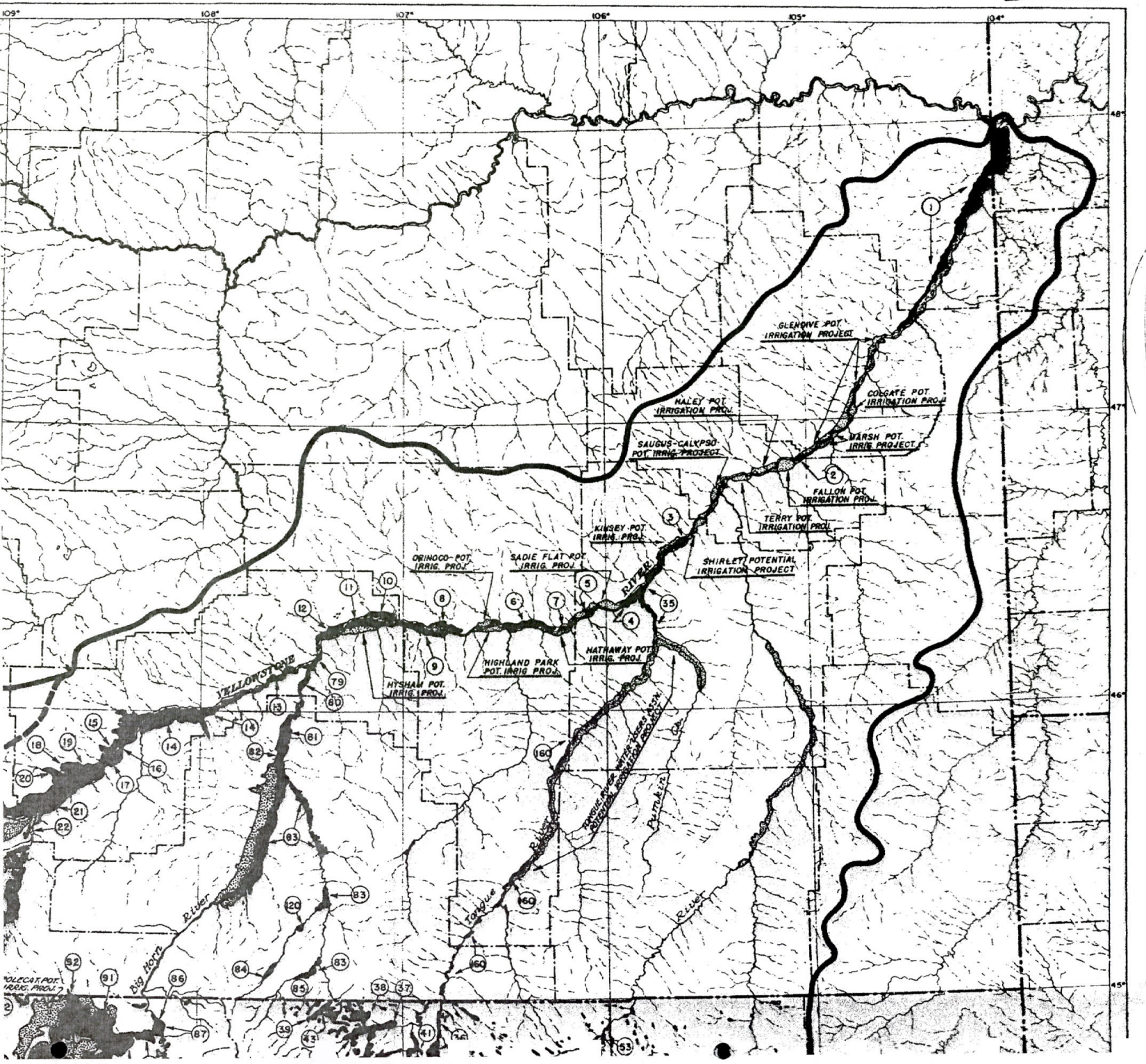
Appendix "F" of the Progress Report of the National Resources Planning Committee states that several thousand small reservoirs are being constructed in the Yellowstone Basin and Middle Missouri Basin for such purposes as water conservation, stock watering, recreation, wild life refuges, and flood irrigation. It estimates the total capacity of such reservoirs in the Yellowstone Basin at 163,140 acre-feet, distributed by states as follows:

North Dakota.....	240 acre-feet
Montana.....	83,900 acre-feet
Wyoming.....	79,000 acre-feet

It is further estimated that the net stream depletion resulting from operation of these reservoirs would amount to 30 percent of their capacity, or 48,900 acre-feet per year.

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MAP NO. 8 85



SEE FULL MAP ATTACHED

INDEX TO EXISTING IRRIGATION PROJECTS

SHOWN ON MAP NO. 8

No.	Name
1.	Lower Yellowstone Irrig. Proj.
2.	Glendive-Fallon Irrig. Dist.
3.	Buffalo Rapids Irrig. Dist.
4.	Fort Keogh Proj.
5.	Sheffield Proj.
6.	Cartersville Irrig. Dist.
7.	Hathaway Proj.
8.	Hammond Irrig. Dist.
9.	Yellowstone Irrig. Dist.
10.	North Sanders Irrig. Dist.
11.	Boxelder Irrig. Dist.
12.	Rancher Ditch Co.
13.	Waco-Custer Ditch Co.
14.	Huntley Irrig. Proj.
15.	Billings Bench Water Assn.
16.	Coulson Ditch
17.	Lockwood Irrig. Dist.
18.	Cove Irrig. Dist.
19.	Big Ditch Co.
20.	Canyon Creek Ditch Co.
21.	Danford Irrig. Dist.
22.	Whitehorse Ditch
23.	Columbus Irrig. Dist.
24.	Big Timber Proj.
25.	Dry Creek Canal
26.	Post Kellogg Ditch
27.	Hunters Hot Springs Canal
28.	Larsen Ditch
29.	Yellowstone Valley Land & Irrig. Co.
30.	Armstrong Ditch
31.	Red Lodge-Rosebud Irrig. Dist.
32.	Paint Creek Ditch & Res. Co.
33.	Sirrine Ditch
34.	Clark Fork Irrig. Dist.
35.	Tongue & Yellowstone Irrig. Proj.
36.	Prairie Dog Water Supply Co.
37.	Tongue River No. 1 Ditch
38.	Hanover Ditch
39.	Tongue River Ditch Co.
40.	Wyoming & Five Mile Ditch
41.	Suburban Homes Co.
42.	Stewart Ditch
43.	So. Side Tongue River & Dayton Ditch
44.	Highline Ditch
45.	Dome Lake Canal Co.
46.	Patrick Land & Livestock Co.
47.	Big Goose & Beaver Ditch Co.
48.	Peralata Ditch
49.	Piney & Cruse Creek Ditch Co.
50.	Mead Ditch
51.	Piney Divide Ditch Co.
52.	Last Chance Ditch Co.
53.	Kendrick Ditch
54.	Pratt & Ferris Ditch
55.	Big Bonanza Ditch
56.	Hallie Ditch
57.	Redman Ditch
58.	Lake DeSmet Ditch Co.
59.	Colorado Colony Ditch Co.
60.	Clear Creek Land & Ditch Co.
61.	Crown Ditch
62.	Six Mile Ditch
63.	Johnson & Holt Ditch
64.	Four Lakes & French Creek Ditch & Flume Co.
65.	Blue Gap Ditch
66.	Cook Ditch
67.	John R. Smith Ditch
68.	Mitchell & Long Ditch
69.	Devoe No. 1 Ditch
70.	Devoe No. 2 Ditch
71.	Teddy Miller Ditch
72.	Moreton Ditch
73.	Sahara Ditch
74.	Willow Creek Ditch Co.
75.	Vruwink Ditch
76.	Boughton Ditch
77.	Big Four Ditch
78.	Buffalo Creek Livestock Co.
79.	Big Horn-Tullock Irrig. Dist.
80.	Victory Irrig. Dist.
81.	Big Horn-Low Line Ditch Co.
82.	Two Leggin Water Users Assn.

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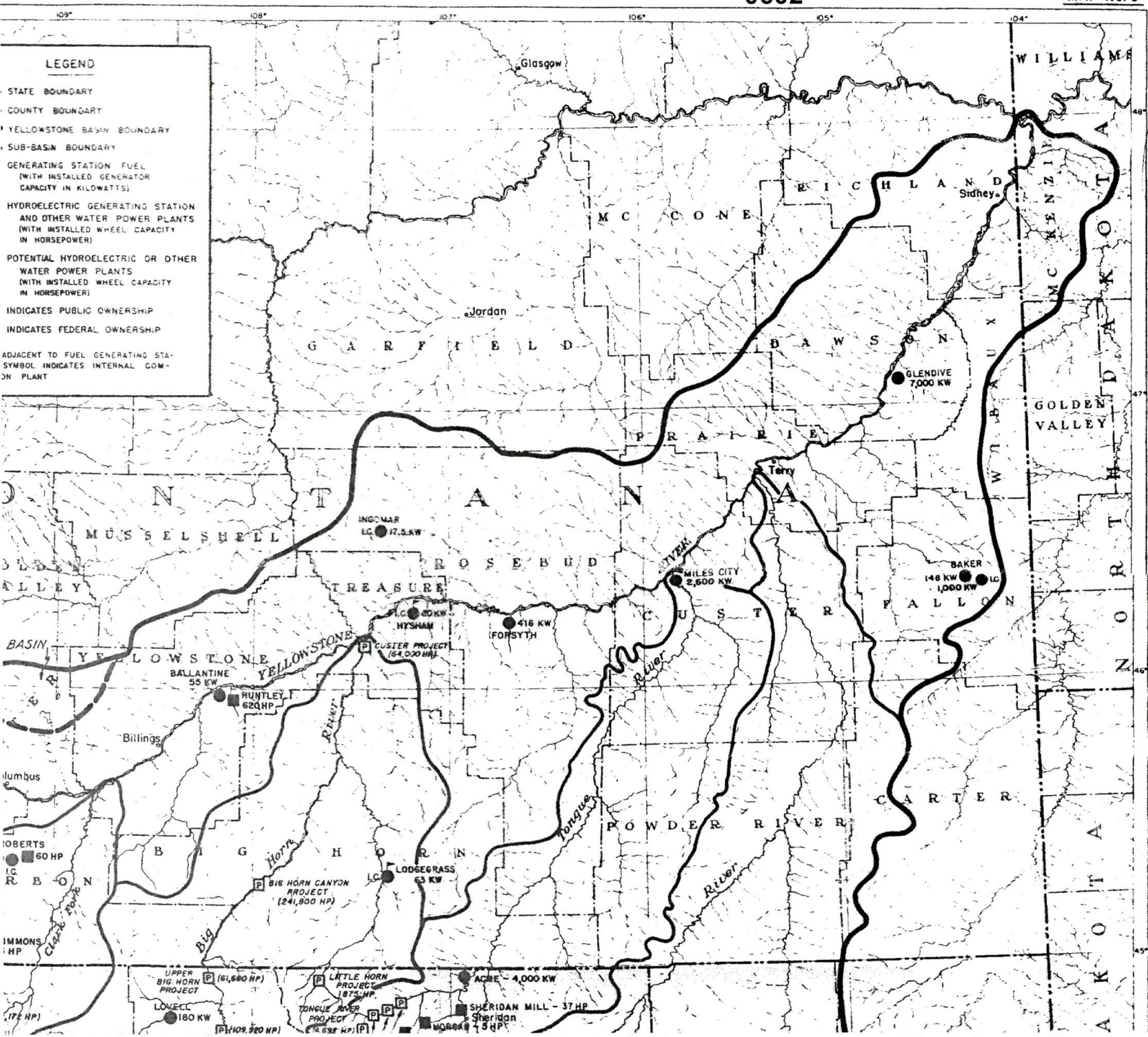
No.	Name
83.	Crow Indian Proj.
84.	Steven's Ditch
85.	Jones Ditch
86.	Big Forks Ditch
87.	Independent Ditch
88.	Hunt & Godfrey Canal
89.	Lovell Canal
90.	Globe Canal
91.	Sidon Irrig. Dist.
92.	Shoshone Proj.
93.	Cody Canal Irrig. Dist.
93a.	Hammitt Canal
94.	Shell Canal
95.	Whaley Ditch
96.	Gould Ditch
97.	Wood & Burnett Ditch
98.	J. F. W. Ditch
99.	Perkins Ditch
100.	Beck and Allen Ditch
101.	Farmers Canal
102.	Bench Canal
103.	Avent Ditch
104.	Sandstone Ditch
105.	Grout Ditch
106.	Croxall & Brown Ditch
107.	Tatman Canal
108.	German Ditch
109.	Dyer Ditch
110.	Butte Ditch
111.	Greybull Ditch
112.	Sunshine Basin Ditch
113.	White or Pease Ditch
114.	Tillard Canal
115.	Big Horn Canal Assn.
116.	Highland Ditch
117.	Anita Ditch
118.	Van Alstine Walker Ditch
119.	Harmony Ditch
120.	Lodge Grass No. 2 Ditch
121.	Fritz Ditch

No.	Name
122.	Lower Hanover Canal
123.	Hanover Irrig. Dist.
124.	Bluff Irrig. Co.
125.	Blake Denton Proj.
126.	Sunnyside Ditch
127.	Holly & Nicholls Ditch
128.	Kirby Ditch
129.	Dempsey Canal Co.
130.	Southside Canal
131.	DeWitt Ditch
132.	Baylor & Purvis Ditch
133.	Mountain View Ditch
134.	Southside Irrig. Canal
135.	Morrison & McConaughy Ditch
136.	Woodward & Johnson Ditch
137.	Becker Ditch
138.	Lost Cabin Water Works Ditch
139.	Riverton Valley Irrig. Dist.
140.	LeClair-Riverton Irrig. Dist.
141.	Riverton Proj.
142.	Wind River Indian Proj.
143.	Sam P. Large Ditch
144.	Rogers & Gregg Ditch
145.	Dutch Flat Ditch Co.
146.	Nicoll & Table Mt. Ditch Co.
147.	Enterprise Ditch
148.	Gaylor & Warnock Ditch
149.	St. John Ditch
150.	Peterson Ditch
151.	Lunn Williams & Sharp Ditch
152.	Red Butte Ditch
153.	Cemetery Ditch
154.	Harting & Sharp Ditch
155.	North Fork Ditch
156.	Harris & Myers Ditch
157.	Big Cottonwood Ditch
158.	Diamond A Ditch
159.	Duncan Ditch
160.	Tongue River Proj.

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MAP NO. 9



SEE FULL MAP ATTACHED

Table 18

COMPARISON OF ESTIMATES OF IRRIGATED AND IRRIGABLE AREAS IN THE YELLOWSTONE RIVER BASIN

(Acres)

Line No.		Irrigated Area: Appendix "F" 1930 - 1938	Irrigated Area: Wyoming Report	Irrigated Area: Census 1929	Irrigable Area Under Present Systems: Appendix "F"	Irrigable Area Under Present Systems: Wyoming Report	Irrigable Area Under Present Systems: Census	Ultimate Irrigable Area, Complete Development of Basin: Appendix "F"	Ultimate Irrigable Area, Complete Development of Basin: Wyoming Report
1.	Yellowstone, Main Stem	306,475		(1)290,474	370,285		(1)415,998	738,515	
2.	Main Stem, direct	176,810			231,530			576,860	
3.	North Dakota	5,000		(2)	(3)		(2)	(3)	
4.	Montana	171,810		162,312	231,530		236,401	576,860	
5.	Wyoming	0	0	0	0	0	0	0	
6.	Minor Tributaries	129,665			138,755			161,655	
7.	North Dakota	0		(2)	0		(2)	0	
8.	Montana	129,665		128,162	138,755		179,597	138,755	
9.	Wyoming	0	0	0	0	0	0	0	0
10.	Clark Fork River	73,300		92,968	85,500		111,583	148,500	
11.	Montana	62,850		86,310	69,680		100,548	119,120	
12.	Wyoming	10,450	20,190	6,658	15,820	23,430	11,035	29,380	61,430
13.	Big Horn River	397,440		361,926	568,770		552,748	1,121,320	
14.	Total, Montana	53,555		43,319	80,740		77,447	173,110	
15.	Total, Wyoming	343,885	503,550	318,607	488,030	596,465	475,301	948,210	1,248,265
16.	Little Horn	13,780		-	20,990		-	42,460	
17.	Montana	12,180		(4)	19,390		(4)	33,360	
18.	Wyoming	1,600	7,800	1,637	1,600	7,800	2,705	9,100	14,800
19.	Big Horn in Wyoming	342,285	495,750	316,970	486,430	588,665	472,596	939,110	1,233,465
20.	Main Stem, direct	48,900	46,630	45,379	61,380	60,510	52,318	88,560	107,010
21.	Wind River	52,175	57,900	51,789	89,825	89,145	116,788	254,855	269,145
22.	Popo Agie River	40,470	73,100	21,131	62,960	86,190	26,189	163,755	196,190
23.	No Wood Creek	11,900	31,800	15,254	17,250	32,690	19,778	50,550	69,690
24.	Greybull River	58,800	85,450	52,138	71,370	88,875	65,331	78,370	167,375
25.	Shell Creek	8,750	15,900	7,110	13,500	19,200	13,795	13,500	29,700
26.	Shoshone River	98,500	112,030	95,636	129,955	137,030	142,902	200,330	259,030
27.	Minor Tributaries	22,790	72,940	28,533	40,190	75,025	35,495	89,190	135,325
28.	Tongue River	53,305		65,498	57,605		73,950	86,155	
29.	Montana	13,840		13,303	14,940		18,497	38,390	
30.	Wyoming	39,465	95,650	52,195	42,665	95,650	55,453	47,765	125,650
31.	Tongue & Minor Tribs.	12,055	-	16,740	12,055	-	18,569	14,705	-
32.	Goose Creek	27,410	-	35,455	30,610	-	36,884	33,060	-
33.	Powder River	63,785		50,279	75,480		56,411	122,705	
34.	Montana	380		1,144	380		1,217	13,030	
35.	Wyoming	63,405	156,500	49,135	75,100	156,500	55,194	109,675	216,500
36.	Upper Powder	11,815	42,540	11,240	16,240	42,540	15,088	32,315	70,540
37.	Crazy Woman Creek	11,360	35,180	*2,600	12,200	35,180	4,146	12,400	40,180
38.	Clear Creek	40,230	78,780	**35,295	46,660	78,780	35,960	64,960	105,780
39.	Little Powder River	0			0			2,300	
40.	Montana	0		(5)	0		(5)	0	
41.	Wyoming	0	6,230	(6)	0	6,230	(6)	2,300	13,730
42.	Total, Yellowstone Basin	894,305		(1)861,145	1,157,640		(1)1,210,690	2,219,495	
43.	North Dakota	5,000		(2)	(3)		(2)	(3)	
44.	Montana	432,100		434,550	536,025		613,707	1,082,165	
45.	Wyoming	457,205	782,120	426,595	621,615	878,275	596,983	1,137,330	1,665,575

Sources: See Text.

* This area was given as 21,965 acres in census for 1919.

** This area was given as 50,648 acres in census for 1919.

(1) Does not include area (believed to be relatively small) in North Dakota.

(2) Area in North Dakota not given.

(3) Area (believed to be relatively small) in North Dakota is included in figure for Montana.

(4) Not given separately. Included in line 14.

(5) Not given separately. Area (if any) included in line 34.

(6) Not given separately. Area (if any) included in line 36.

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Table 19

IRRIGATED AND IRRIGABLE AREA IN THE YELLOWSTONE RIVER BASIN

(Acres)

	Average Area Irrigated 1930 - 1938	Irrigable Area Present Systems	Ultimate Irrigable Area
Main Stem of Yellowstone	306,475	370,285	738,515
Total, Main Stem	176,810	231,530	576,860
Total, Tributaries	129,665	138,755	161,655
Above Clark Fork	200,255	223,825	504,075
Main Stem	73,960	91,560	351,510
Tributaries	126,295	132,265	152,565
Clark Fork to Big Horn	42,360	48,830	58,200
Main Stem	40,590	43,940	53,110
Tributaries	1,770	4,890	5,090
Big Horn to Tongue	27,530	38,630	61,420
Main Stem	25,930	37,030	57,420
Tributaries	1,600	1,600	4,000
Tongue to Powder	180	180	56,000
Main Stem	180	180	56,000
Tributaries	-	0	0
Below Powder	36,150	58,820	58,820
Main Stem	36,150	58,820	58,820
Tributaries	-	0	0
Clark Fork River	73,300	85,500	148,500
Montana	62,850	69,680	119,120
Main Stem	33,810	34,060	83,500
Tributaries	29,040	35,620	35,620
Wyoming	10,450	15,820	29,380
Big Horn River	383,660	547,780	1,078,860
Montana	41,375	61,350	139,750
Main Stem	40,525	59,400	135,600
Tributaries	850	1,950	4,150
Wyoming	342,285	486,430	939,110
Main Stem, direct	48,900	61,380	88,560
Wind River	52,175	89,825	254,855
Popo Agie River	40,470	62,960	163,755
No Wood Creek	11,900	17,250	50,550
Greybull River	58,800	71,370	78,370
Shell Creek	8,750	13,500	13,500
Shoshone River	98,500	129,955	200,330
Minor Tributaries	22,790	40,190	89,190
Little Horn River	13,780	20,990	42,460
Montana	12,180	19,390	33,360
Main Stem	8,410	14,740	24,060
Tributaries	3,770	4,650	9,300
Wyoming	1,600	1,600	9,100
Tongue River	53,305	57,605	86,155
Montana	13,840	14,940	38,390
Main Stem	13,840	14,940	35,190*
Tributaries	0	0	3,200
Wyoming	39,465	42,665	47,765
Main Stem	11,345	11,345	13,995
Goose Creek	27,410	30,610	33,060
Prairiedog Creek	710	710	710
Powder River	63,785	75,480	122,705
Montana	380	380	13,030
Main Stem	380	380	13,030
Tributaries	0	0	0
Wyoming	63,405	75,100	109,675
Upper Powder	11,815	16,240	32,315
Crazy Woman Creek	11,360	12,200	12,400
Clear Creek	40,230	46,660	64,960
Little Powder River	0	0	2,300
Montana	0	0	0
Main Stem	0	0	0
Tributaries	0	0	0
Wyoming	0	0	2,300
Total, Entire Yellowstone Basin	894,305	1,157,640	2,219,495
Montana	437,100**	536,025	1,082,165
Main Stems, direct	273,775**	355,050	868,240
Tributaries	163,325	180,975	213,925
Wyoming	457,205	621,615	1,137,330

Source: Appendix "F" of the Progress Report (1939) of the Upper and Middle Missouri Drainage Basin Sub-committees "A" and "B" of the National Resources Planning Board, and the field survey sheets from which it was prepared.

* Limited by capacity of Tongue River Reservoir.

** Includes 5,000 acres in North Dakota. See footnotes (2) and (3) Table 18.

Table 20

SELECTED POTENTIAL IRRIGATION PROJECTS*

Stream and Project	Source of Water Supply	Irrigable Acreage
Yellowstone Above Clark Fork		251,400
Brackett Creek Project	Brackett Creek	9,800
Lake Basin Project(1)	Yellowstone River	239,200
Miscellaneous	Porcupine Creek	2,400
Clark Fork		60,800
Clark Fork Project	Clark Fork	60,800
Big Horn River		323,655
Wind River		86,680
Fremont Canal Project	Wind River	64,000
Wind River Canal Project	Wind River	22,680
Popo Agie River		88,195
Lander Valley Project		9,275
Louis Lake Project		78,920
No Wood Creek		30,600
Tensleep and Bonanza Project	Tensleep Creek	15,000
Paintrock Creek Project	Paintrock Creek	15,600
Minor Tributaries		47,500
Buffalo Basin Project(2)	Greybull and Wood Rivers	47,500
Main Stem		70,680
Riverside Canal Project	Big Horn River	6,930
Tremont Canal Project	Big Horn River	16,250
Big Horn Project	Big Horn River	47,500
Little Horn River		5,470
Parkman Irrigation District(3)	Tongue River	5,470
Tongue River		22,200
Tongue River Water Users' Assn.	Tongue River	19,000
Miscellaneous	Pumpkin Creek	3,200
Powder River		41,325
Red Fork Irrigation District	Red Fork of Powder	14,875
North Wyoming Land Co. Proj.	Crazy Woman Creek	13,800
Powder River Project	Powder River	12,650
Little Powder River		2,300
Cottonwood Project	Little Powder River	2,300
Total Yellowstone Basin		707,150

* Projects included in the water use studies of Appendix F of the Progress Report (1939) of the National Resources Planning Board.

(1) Lands in Lake Basin. Water duty 1.8 acre-feet per acre with no return flow.

(2) Lands in Dry Cottonwood Creek and Gooseberry Creek Basins. Return flow to these streams.

(3) Lands in Little Horn Basin. Return flow to Little Horn.

ELECTRIC GENERATING PLANTS IN THE YELLOWSTONE RIVER BASIN

(As of December 31, 1940)

Owner or Operator	Location	Installed Capacity Kw(1)	1939 Net Generation, 1000 Kwh	Installed Capacity by Units: Unit Number	Rating, Kw	Year Installed
Steam-electric Plants						
Montana-Dakota Utilities Company	Glendive, Montana	7,000	7,566	3	5,000	1940
				4	2,000	1926
	Miles City, Montana	2,600	6,684	1	2,000	1927
				2	600	1938
Mountain States Power Company	Forsyth, Montana	416	**3	1	200	1920
				2	120	1922
				3	96	1925
	Buffalo, Wyoming	300	**9	1	300	1928
	Riverton, Wyoming	200	3	1	120	1915
				2	80	1915
	Lovell, Wyoming	180	0	1	120	1918
				2	60	1918
	Baker, Montana	148	**0	1	100	1914
				2	48	1923
Sheridan County Electric Company	Acme, Wyoming	4,000	10,545	1-2	1,000	1910
Stanolind Oil and Gas Company(2)	Salt Creek	25,000	37,059	1-2	12,500	1924
Standard Oil Company(2)	Greybull, Wyoming	500	*1,600	1	500	1923
Holly Sugar Company(2)	Sidney, Montana	1,200	*2,496	1-2	600	1925
	Sheridan, Wyoming	750	*1,091	1	750	1932
	Worland, Wyoming	250	*700	1	250	1923
	Hardin, Montana	1,000	*1,773	1	1,000	1937
Great Western Sugar Company(2)	Billings, Montana	1,608	*1,207	1	108	1924
				2	1,500	1933
	Lovell, Wyoming	400	*126	1-2	200	1936
Russell-Miller Milling Company(2)	Billings, Montana	50	*8	1	50	1909
Total, Public Utilities		14,844	24,810			
Total, Industrial		30,758	46,120			
Total, Steam-electric		45,602	70,930			
Internal Combustion Plants						
Project Electric Plant	Ballantine, Montana	55	**104	1	35	1933
				2	20	1934
Roberts Electric Company	Roberts, Montana	40	-	1	40	1934
Ingomar Light & Power Company	Ingomar, Montana	18	-	-	-	-
Montana-Dakota Utilities Company	Baker, Montana	1,000	**2,505	1-2	250	1929
				3	500	1930
Mountain States Power Company	Greybull, Wyoming	128	0	1-2	24	1920
				3	80	1920
Shickley Electric Company	Clearmont, Wyoming	50	-	-	-	-
Lodge Grass, Town of	Lodge Grass, Montana	63	**82	1	20	1930
				2	43	1932
Hysham, Town of	Hysham, Montana	80	**69	1	35	1928
				2	45	1933
Basin, Town of	Basin, Wyoming	395	932	1	100	1922
				2	120	1922
				3	175	1935
U. S. National Park Service	Yellowstone, Wyoming	130	-	1	130	1935
Standard Oil Company(2)	Greybull, Wyoming	312	*0	2	192	1919
				3	120	1919
Russell-Miller Milling Company(2)	Billings, Montana	55	*104	2	55	1923
Total, Public Utilities		1,959	3,692			
Total, Industrial		367	104			
Total, Internal Combustion		2,326	3,796			
Hydroelectric Plants						
Montana Power Company	Alpine, Montana	10,000	50,878	1-2	5,000	1925
Gardiner Electric Light & Water Co.	Gardiner, Montana	150	**299	1	100	1937
				2	50	1930
Roberts Electric Company	Roberts, Montana	45	**24	1	45	1920
U. S. Bureau of Reclamation	Cody, Wyoming	5,600	11,566	1-2	800	1922
				3	4,000	1931
	Morton, Wyoming	1,600	4,179	1	800	1924
				2	800	1929
U. S. National Park Service	Yellowstone, Wyoming	600	**1,163	1-2	300	1935
Mountain States Power Company	Lander, Wyoming	552	1,429	1-2	120	1919
				3	312	1925
	Buffalo, Wyoming	400	**1,112	1-2	200	1931
Dubois Public Service Company	Dubois, Wyoming	188	**100	1	38	1929
				2	150	1935
Meeteetse Light Company	Meeteetse, Wyoming	38	**80	1	38	1929
Tensleep Electric Light & Power Co.	Tensleep, Wyoming	15	**31	1	15	1935
Cody, Town of	Cody, Wyoming	160	**1,438	1	160	1904
Total, Hydroelectric		19,348	72,299			
Total, Public Utilities		36,151	100,801			
Total, Industrial		31,125	46,224			
Total, All Plants		67,276	147,025			

Source: Federal Power Commission records.

* Net generation for 1937. More recent data not available.

** Net generation for 1938. More recent data not available.

(1) As of December 31, 1940

(2) Industrial plant. Capacity is not, in general, available to utility load.

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Table 24

POTENTIAL IRRIGATION PUMPING PROJECTS IN THE REGION

Name of Project (1)	River Basin (2)	Power Requirements for Pumping: Gross Irrigable Acreage (3)	Estimated Annual Power Requirements for Pumping: Energy 1000 Kwh (4)	Estimated Annual Power Requirements for Pumping: Peak Demand Kw (5)	Principal Source of Basic Data From Which Power Requirements Were Determined (6)
Lower Tongue River	Tongue	10,000	631	420	Montana State Water Conservation Board
Big Horn-Tullock	Big Horn	1,127	39	20	U. S. Bureau of Reclamation
North Sanders*	Yellowstone	1,522	64	35	U. S. Bureau of Reclamation
Orinoco "B"*	Yellowstone	1,643	115	65	U. S. Bureau of Reclamation
Sadie Flat "A"	Yellowstone	4,691	838	460	U. S. Bureau of Reclamation
Tongue-Yellowstone*	Tongue	6,000	1,031	570	U. S. Bureau of Reclamation
Shirley*	Yellowstone	5,300	929	520	U. S. Bureau of Reclamation
Saugus-Calypso*	Yellowstone	2,600	456	250	U. S. Bureau of Reclamation
Glendive*	Yellowstone	18,000	6,440	3,570	U. S. Bureau of Reclamation
Marsh	Yellowstone	1,500	195	110	U. S. Bureau of Reclamation
Savage	Yellowstone	2,120	432	240	Montana State Water Conservation Board
Yellowstone Pumping Proj.	Yellowstone	2,000	175	100	No. Dak. State Water Conservation Comm.
Cartwright	Yellowstone	1,000	161	90	No. Dak. State Water Conservation Comm.
Tremont Canal	Big Horn	16,250	1,995	1,110	War Department "308" Report
Upper Hanover Pumping Proj.	Big Horn	7,030	1,749	970	Wyoming State Engineer
Upper Bluff Canal	Big Horn	480	92	50	Wyoming State Engineer
Red Flats	Big Horn	1,400	368	200	Wyoming State Engineer
Total		82,663	15,710	8,780	

Source: "Power Market Survey - Yellowstone River Basin." Federal Power Commission, Oct. 1939.

* Included by the Corps of Engrs., War Dept. (Appendix F of the Progress Report of the National Resources Planning Board) in the Mid-Yellowstone Project, which it proposes as a gravity system.

Name of Plant	Name of Stream	Owner or Operator	Location Nearest Town	State	Installed Wheel Capacity, Hp	Purpose
		Yellowstone (Main stem)*				
1. Huntley	Supply Canal	Huntley Irr. Dist.	Ballantine	Mont.	620	Pumping
2. Gardiner	Yellowstone	Gardiner El. & W. Co.	Gardiner	Mont.	100	Generation of electricity for public use.
3. Mystic Lake	W. Rosebud Creek	Montana Power Co.	Fishtail	Mont.	14,000	Generation of electricity for public use.
4. Russell	Lodgepole	H. Russell	Limestone	Mont.	-	Domestic
5. Jardine Mine	Bear Creek	Jardine Mining Co.	Jardine	Mont.	800	Mill
6. Gardiner	Glen Creek	National Park Serv.	Yellowstone	Wyoming	1,740	Generation of electricity for public use.
		Total Installed Capacity			17,260	
		Clarks Fork				
1. Richel	Black Fork of Rock R.	M. Richel	Red Lodge	Mont.	8	Domestic
2. Simmons	Corral Creek	H. A. Simmons	Red Lodge	Mont.	6	Domestic
3. Niemi	Red Lodge Cr.	I. Niemi	Red Lodge	Mont.	10	Domestic
4. Roberts El. Co.	Rock Creek	Roberts El. Co.	Roberts	Mont.	60	Generation of electricity for public use.
		Total Installed Capacity			84	
		Big Horn				
1. Pilot Butte	Wind River	U. S. Bureau of Reclam.	Riverton	Wyo.	2,400	Generation of electricity for public use.
2. Warm Springs	Warm Springs Creek	Dubois P. S. Co.	Dubois	Wyo.	275	Generation of electricity for public use.
3. Blaha	5-Mile Creek	E. E. Blaha	Dubois	Wyo.	2	Domestic
4. Cody	Shoshone	Town of Cody	Cody	Wyo.	408	Generation of electricity for public use.
5. Shoshone	Shoshone	Bureau of Reclam.	Powell	Wyo.	8,200	Generation of electricity for public use.
6. Pahaska Lodge	Middle Fork Creek	A. Wilkinson	Wapiti	Wyo.	7	Resort Lighting
7. Howell	Kitty Creek	J. W. Howell	Wapiti	Wyo.	10	Resort Lighting
8. Home Colony	Kitty Creek	Home Colony	Wapiti	Wyo.	15	Resort Lighting
9. Dahlen	Grinnel Creek	H. Dahlen	Wapiti	Wyo.	17	Generation of electricity for public use.
10. Meeteetse	Greybull	Meeteetse Light Co.	Meeteetse	Wyo.	50	Generation of electricity for public use.
11. Galena Ridge Min.	Canyon Creek	Galena Ridge Min. Co.	Kirwin	Wyo.	-	Milling
		Big Horn (continued)				
12. Schnitzel	Wood River	H. Schnitzel	Kirwin	Wyo.	-	Milling
13. Jordan Mill	No Wood Creek	H. Jordan	Manderson	Wyo.	65	Milling
14. Tensleep	Tensleep Creek	Tensleep El. & Pwr. Co.	Tensleep	Wyo.	25	Generation of electricity for public use.
15. Wigwam	Tensleep Creek	Wm. Goodwin	Tensleep	Wyo.	4	Resort Lighting
16. Sinks Canyon	Middle Fork Popo Agie	Mountain States Pwr. Co.	Lander	Wyo	860	Generation of electricity for public use.
17. Enterprise Irr. & Pwr. Co.	Saw Mill Creek	Enterprise Irr. & Pwr. Co.	Lander	Wyo.	-	Generation of electricity for public use.
18. Beck Mine	Little Popo Agie River	Beck Mining Co.	Atlantic City	Wyo.	-	Milling
		Total Installed Wheel Capacity			12,338	
		Tongue River				
1. Sheridan Mill	Goose Creek	Sheridan Mill Co.	Sheridan	Wyo.	37	Milling
2. Morgan	Soldier Creek	M.B. Morgan	Sheridan	Wyo.	5	Domestic
3. Dome Lake	W. Fk. Big Goose Creek	Dome Lake Club	Sheridan	Wyo.	16	Resort Lighting
4. Dude Ranch	Wolf Creek	Eaton Bros., Inc.	Wolf	Wyo.	25	Resort Lighting
		Total Installed Wheel Capacity			83	
		Powder River				
1. Buffalo	Clear Creek	Mountain States Pwr. Co.	Buffalo	Wyo.	600	Generation of electricity for public use.
2. Kearney	Piney Creek	Kearney Coop.	Sheridan	Wyo.	47	Milling
		Total Installed Wheel Capacity			647	

* Including minor streams tributary thereto.

Summary of Water Power Plants In The Yellowstone River Basin

Sub-basin	Wyoming No. of Plants	Wyoming Installed Cap. (hp)	Montana No. of Plants	Montana Installed Cap. (hp)	Total No. of Plants	Total Installed Cap. (hp)
Yellowstone, Main Stem	1	1,740	5	15,520	6	17,260
Clark Fork	-	-	4	84	4	84
Big Horn	18	12,338	-	-	18	12,338
Tongue	4	83	-	-	4	83
Powder	2	647	-	-	2	647
Totals	25	14,808	9	15,604	34	30,412

E. WATER LAWS AND THEIR ADMINISTRATION

1. General

When the West was being settled it soon became apparent that the common law doctrine of riparian rights was not suited to the needs of this semi-arid region whose most valuable, though very limited, natural resource was its water supply. Broadly speaking, the riparian principle prohibits the use of the water of a stream in such a manner as to diminish it in quantity or alter it in quality. Inasmuch as the development of the mining and agricultural resources of the region was dependent upon uses of water which could not be reconciled with this principle, the doctrine of appropriation was adopted.

The doctrine of appropriation permits the diversion of water from a stream for the purpose of putting it to beneficial use. The right to use the water of a stream may be acquired by the beneficial application of the water under the applicable local laws and regulations. A water right so acquired may be legally perfected and recorded through the process of adjudication. In Montana the jurisdiction to make such adjudications is conferred by law upon the courts, whereas in Wyoming this authority has been delegated to the State Board of Control, an agency created for the purpose of administering the water laws of the State.

In general, the seniority of water rights is governed by the principle, "priority of appropriation gives the priority of right." It should be emphasized that an adjudication of a water right does not convey ownership of the water; it only grants the privilege of putting

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the water to beneficial use. "The essence of the doctrine of appropriation is beneficial use, not a stale or barren claim."

2. Wyoming

In 1890 Wyoming initiated a procedure for the acquisition of new water rights which has since been adopted, with minor changes, by most of the other western states. In Wyoming, new water rights can be acquired only by application to the State Engineer. When an application is approved the State Engineer issues a permit which defines the amount of water to be appropriated and specifies the date on which the physical structures must be completed. After all the requirements of law have been met, and upon proof of beneficial use, the State Board of Control, of which the State Engineer is a member, issues a certificate of appropriation. The certificate of appropriation is evidence of title to the water right.

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The following water laws were extracted from the preliminary report(1) submitted by the Wyoming State Engineer's office:

> "1. Water is State Property: The water of natural streams, lakes or other collections of still water, within the boundaries of the state is the property of the state.
>
> "2. Board of Control: The Board of Control, composed of the State Engineer and water superintendents of the water divisions have supervision of the appropriation, distribution and diversion of the waters of the state, and their decisions are subject to review by the courts of the state.
>
> "3. Priority of Appropriation: Priority of appropriation for beneficial use gives the better right. No appropriation shall be denied except when the denial is demanded by the public interest.

(1) A report originally submitted by Wyoming, but since superseded by "Water Resources in the Yellowstone River Basin in Wyoming" by H. T. Person.

"4. Municipal Corporations have the same right as individuals to acquire rights by prior appropriation. Cities can acquire by exercising the right of Eminent Domain such water as may be necessary for the well being thereof and for domestic uses from prior appropriations upon payment of just compensation.

"'A water right is a right to use the water of the state.... acquired by the beneficial application of water under the laws' and regulations. Rights to such use are 'limited and restricted to so much thereof as may be necessarily used for irrigation or other beneficial purposes'. 'Beneficial use shall be the basis, the measure and limit of the right'. (122-401-421)

"Rights to the use of water 'attach to the land for irrigation, or to such other purposes or object for which acquired'. 'Water rights for the direct use of the natural unstored flow of any stream cannot be detached from the lands, place or purpose for which they are acquired, without loss of priority'. (122-401). Rights to reservoir water, on the other hand, do not become attached to any particular lands except by deed or a like instrument, and meantime may be acquired by sale or lease. (122-1508).1602). However, the sale of 'any portion of the capacity of any reservoir' carries with it 'an interest in the reservoir and works'. Reservoir water cannot be used outside the state without a special permit from the State Engineer. (122-1601). All deeds of reservoir water rights and all leases of same for more than three years must be executed and acknowledged like deeds of real estate, and recorded in the county records; and leases for less than three years must be in writing and filed in the State Engineer's office. (122-1604).

"'Preferred uses' include rights for 'domestic and transportation purposes'; and unpreferred rights may be condemned for their benefit under the power of 'Eminent Domain'. These 'domestic and transportation purposes' include: Water for (1) drinking, 'for man and beast'; (2) for municipal purposes; (3) for steam engines and general railway use; and (4) for culinary, laundry and bathing use, refrigerating (including ice manufacture), and steam and hot water heating plants. Irrigation is 'preferred' to any use for power purposes' where turbine or impulse water wheels' are used. (122-402).

"The legal standard for measuring the flow of water is one cubic foot per second of time; and the maximum appropriation allowable is for one cubic foot per second for each seventy (70) acres. (122-431-117).

"5. Procedure to Obtain Water Right.

(a) Submit application to State Engineer's office together with maps and plans showing location, size, etc., of ditch and irrigation works and lands to be irrigated.

(b) Approval by State Engineer after any necessary alterations and corrections have been made.

(c) Commencement of Construction. Construction must begin not later than one year after approval by the State Engineer unless the State Engineer grants an extension of time.

(d) Completion of Construction. Construction must be completed at the 'completion time' allowed on permit unless the State Engineer grants an extension of the date of completion.

(e) Application of water to the beneficial use described in the permit together with notice to that effect to the State Engineer's office. This requirement must be complied with, within the period allowed.

(f) Submission of proof of beneficial use to the Division Water Superintendent.

(g) Certificate of Appropriation issued by State Board of Control. Priority dates from time of filing application in State Engineer's office."

3. Montana

"Montana is the only remaining state where irrigation is important in which there is no state supervision by a state administrative officer of the acquirement of new rights. Anyone desiring to appropriate water on an unadjudicated stream posts a notice, records it with the county, and proceeds with construction. Anyone desiring information in regard to the filings on an unadjudicated stream must search the records in the counties through which the stream passes. No limit is placed upon the amount of water that may be claimed in the notice; title, however, can only be acquired to the amount for which beneficial use can be proven. For streams on which existing rights have been defined by court decisions, new rights are required to file petitions for appropriations with the county court; the information and maps in the petition must be prepared by an engineer. The appropriator is under the jurisdiction of the court which issues summons to all known claimants, holds a hearing, and issues an interlocutory decree defining the time for completion

of the appropriation. On completion, the court on further hearing issues a supplemental decree defining the right. This procedure serves to keep the adjudications up to date as new rights are acquired. Because of the generally small size of individual diversions in Montana, this method has operated sufficiently satisfactory so that the state has not yet adopted a system of state control of acquirement of rights.(1)"

The following information regarding water laws of Montana was extracted from a report submitted by the Montana Water Conservation Board, dated September 25, 1938:

"The water laws of Montana are fixed by the Constitution of the State of Montana, and the laws enacted upon the subject and their interpretation by the Supreme Court of this State. The Constitution of Montana provides:

'The use of all water now appropriated, or that may hereafter be appropriated for sale, rental, distribution, or other beneficial use, and the right of way over the lands of others, for all ditches, drains, flumes, canals, and aqueducts, necessarily used in connection therewith, as well as the sites for reservoirs necessary for collecting and storing the same, shall be held to be a public use'. (Article III, Sec. 15)

"This Constitutional provision has received a broad construction by the Supreme Court of the State to the end that flood waters which would otherwise go to waste may be conserved for the purpose of making the arid lands of the state productive.

Donich, et al, v. Johnson, et al, 77 Mont. 229-239
250 Pac. 963

"It has been held that an appropriator derives his right to water from the State and not from the Federal Government.

Mettler v. Ames Realty Co., 61 Mont. 152
201 Pac. 702
Popham v. Hollaran, 84 Mont. 442
275 Pac. 1099

"In the early history of the State, it was suggested that the doctrine of riparian rights controlled in this State. However, the Supreme Court definitely ruled to the contrary. In Mettler v. Ames Realty Company, 61 Mont, 152, 201 Pac, 702, the Supreme Court stated definitely:

(1) Harding, S. T., "Water Rights for Irrigation."

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'Our conclusion is that the common law doctrine of riparian rights has never prevailed in Montana since the enactment of Bannock statutes in 1865; that it is not suited to conditions here', followed in

Wallace v. Goldberg, 77 Mont. 234, 244
231 Pac. 56

"That in accordance with the Constitutional provision above quoted the right of eminent domain may be exercised for the construction of canals, aqueducts, flumes, ditches, or pipes conducting water, and sites for reservoirs necessary for collecting and storing water. (R.C. 9933)

"Many cases decided by the Supreme Court enunciate the principle that an appropriator does not own water but has only a qualified right to use the same.

"The statutes generally upon the subject of water rights in Montana are contained in Chapter 81 of the Civil Code, being Sections 7093 to 7135, relating to water rights and appropriations; Chapter 82, 7136 to 7159 relating to water commissioners--determination of joint rights; Chapter 83, 7161 R. C. to 7165, powers of water users organized under federal law; Chapters 84 to 93 R. C., 7166 to 7264.18, relating to irrigation districts; Chapter 35 of Political Code, R. C. 349.1 to 349.38, relating to the State Water Conservation Board.

"The doctrine of appropriation of water prevails in Montana rather than the common law doctrine of riparian rights. Under this doctrine priority of appropriation of water confers a superiority of right to such water. The one first making appropriation becomes entitled as against all subsequent appropriations to the exclusive use of water to the extent of his appropriation.

Prentice v. McKay, 38 Mont. 114
98 Pac. 1041
Tochey v. Campbell, 24 Mont. 13
60 Pac. 396

"The rights of appropriators to such waters as they have appropriated and need are fixed in the order of their appropriation. Secondary appropriations may be made of surplus water in excess of the amount to which prior appropriators are entitled by virtue of their appropriation.

Custer v. Missoula Public Service Co.
91 Mont. 136
6 Pac. (2) 131
Quigley v. Birdseys, 11 Mont. 439
28 Pac. 741

"A secondary appropriator may impound and divert surplus waters from the source of supply as long as the prior appropriator receives the flow to which he is entitled at the point of his diversion.

Kelly v. Hynes, 41 Mont. 1
128 Pac. 783

"Water rights were acquired as provided by the statute and retained by their beneficial use. There is no officer or regulatory commission which grants, refuses, or limits water rights in the State of Montana. The priority and extent of water rights may be determined by actions commenced by private individuals. These such actions are authorized under the provisions of Sec. 7105, R. C. et sec. It is not obligatory that actions to determine the extent of water rights be brought. The situation exists that in many streams water rights have been adjudicated on the entire stream or part thereof, whereas upon other streams no adjudications have been made.

"Under the provisions of R. C. 7119-7127, it is provided that where a person makes an appropriation from an adjudicated stream, he must comply with certain formal requirements, and proceed by the service of summons against prior appropriators, and proceed as in a civil action before his right becomes authorized.

"At the Extraordinary Session of the Montana Legislature 1933-34, there was created a State Water Conservation Board (R. C. 349.1 to 349.38, Chapter 35 of the Civil Code,)which Board has extensive powers in relation to the appropriation of all unappropriated water within the State."

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4. North Dakota(1)

At present the North Dakota State Water Conservation Commission has general control and supervision over the water supply of the state. The State Engineer may grant water rights subject to the approval of the State Water Conservation Commission, but the Commission may initiate water rights by its own declaration. Prior to 1937 the water laws were administered by the State Engineer in a manner similar to the procedure followed in Wyoming.

(1) At the request of the Federal Power Commission, this information was furnished by the North Dakota State Water Conservation Commission in a letter dated June 7, 1940.

F. EXISTING WATER RIGHTS

1. General

A compilation of all water rights in the basin, listed in order of their seniority, would be very helpful in the drafting of an interstate compact, but it is doubtful that this information is essential. Such a compilation does not exist, and the preparation of a complete and accurate list probably would require a considerable amount of time and research. In Montana and North Dakota many of the water rights have never been adjudicated, but are protected only by notices appearing in the county records. The Montana State College, in cooperation with the Montana State Water Conservation Board, is at present compiling a list of claims to water rights as shown by the county records. In Wyoming water rights are granted by, and recorded in the State Engineer's office, which should make the necessary compilation comparatively simple. However, a list compiled from these sources would no doubt contain a number of water rights which appear on the record as good, but which have been abandoned. Nevertheless, it is believed that, in the near future, there will be available information on existing water rights that is sufficiently accurate, and possibly sufficiently complete, for the needs of the compact commission.

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2. Wyoming

According to the Wyoming report, there are 700,130 acres in Wyoming with adjudicated rights, and an additional 535,410 acres under permits in good standing. In the latter classification it is estimated

that 81,990 acres are being irrigated at present. The location of these areas is indicated by the following tabulation:

Acreage in Wyoming Having Water Rights

Sub-Basin	(Acres) Territorial and Other Adjudicated Rights (1)	Acreage Under Permit in Good Standing (2)	Total
Main Stem	0	0	0
Clark Fork	20,190	4,200	24,390
Big Horn River	413,760	507,110	920,870
Main Stem	46,500	19,400	65,900
Wind River	37,720	153,300	191,020
Popo Agie River	53,100	59,400	112,500
Owl Creek	31,390	610	32,000
No Wood Creek	31,800	1,000	32,800
Greybull River	85,450	39,500	124,950
Shell Creek	15,900	1,000	16,900
Shoshone River	70,350	171,900	242,250
Minor Tributaries	41,550	61,000	102,550
Little Horn River	7,800	500	8,300
Tongue River	95,650	3,600	99,250
Powder River(3)	162,730	20,000	182,730
Total	700,130	535,410	1,235,540

Source: "Water Resources of the Yellowstone River Basin in Wyoming." H. T. Person

(1) Presumably the acreage shown in this column is being irrigated at present.

(2) Presumably only the following acreage shown in this column is being irrigated at present:
Big Horn River: main stem - 130; Shoshone - 41,680;
Wind - 20,180; Popo Agie - 20,000; total - 81,990.
(See Section I-D-1)

(3) Includes the Little Powder River.

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3. Montana

Only a small portion of the existing water rights in Montana have been adjudicated. The Montana Water Conservation Board, in a report dated September 25, 1938, presented abstracts of 79 adjudications of streams in the Yellowstone Basin. A summary of these adjudications is given below. It should be emphasized that all of the streams have

not been adjudicated and that water-right claims filed subsequent to the last adjudication are not included.

Partial Summary of Adjudicated Water Rights in Montana

Stream	Cu. Ft. Per Second
Tributaries of Yellowstone above Clark Fork	*4,123.1
Clark Fork and Tributaries	1,769.0
Tributaries of Yellowstone from Clark Fork to Big Horn	14.9
Tributaries of the Big Horn	76.3
Tongue River	474.6

*Plus all of Dog Creek and Last Chance Creek; amount not given.

4. North Dakota

In a letter dated June 7, 1940, the North Dakota Water Conservation Commission reported the estimated irrigated area under present systems to be 21,138 acres. Of this total, 20,000 acres are in the Lower Yellowstone project of the Bureau of Reclamation, and no doubt obtained water rights when the project was set up.

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G. INTERSTATE COMPACTS

Interstate compacts are provided for under the Constitution of the United States in Section 3 of Article I, Subsection 3 of which reads: "No State shall, without the consent of Congress, lay any duty of tonnage, keep troops or ships of war in time of peace, enter into agreement or compact with another State, or with a foreign power, or engage in war, unless actually invaded, or in such imminent danger as will not admit of delay."

Congress has authorized 57(1) interstate compacts to date, of which 34 have become effective through State ratification.

The compact method has been used with varying degree of success to deal with eight situations: (1) boundaries and cessations of territory, (2) criminal jurisdiction over boundary waters, (3) uniformity of legislation, (4) interstate accounting, (5) taxation, (6) utility regulation, (7) control and improvement of navigable streams, and (8) the conservation of natural resources.(1) The method is particularly well suited whenever the issue, because of its scope, intricacy, and technicalities, presents a problem that is too complex for satisfactory settlement in court. In five(2) instances it has been effectively employed for the settlement of interstate stream controversies. The

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(1) "Regional Factors in National Planning:" National Resources Committee. 1935

(2) a. Colorado River Compact. California, Nevada, Utah, Wyoming, Colorado, New Mexico. (Arizona not signing.)
b. La Plata River Compact. Colorado and New Mexico.
c. Rio Grande River Compact. Colorado, New Mexico, Texas.
d. South Platte River Compact. Colorado and Nebraska.
e. Red River of the North Compact. Minnesota, North Dakota, South Dakota.

development of the water resources of a river basin is a problem of negotiation, not of litigation. The interstate compact lends itself well to future planning, yet, in the settlement of interstate stream controversy it could probably be justified even though it were nothing more than a substitute for litigation. A comprehensive compact, arrived at in a spirit of fairness and cooperation, is far better than a partial settlement by the courts.

The following discussion of the legal aspects of the interstate compact as an instrument in the settlement of interstate stream controversy was prepared by the legal staff of the Federal Power Commission:(3)

Water Rights and State Compacts

Interstate compacts have been resorted to by the States for the settlement of various points of controversy since almost the very beginning of the Union. The use of the compact in the settlement of water controversies between states is a comparatively recent development. Of the five compacts ratified or approved by Congress, which deal with water usage, the earliest, dealing with the resources of the La Plata River, was ratified by Congress January 29, 1925. The resort to the compact form of settling interstate controversy over water rights follows many instances of litigation represented in cases before the United States Supreme Court, involving the States of Arizona, California, Colorado, Connecticut, Delaware, Illinois, Kansas, Massachusetts, Minnesota, Missouri, New Jersey, New York, North Dakota, Oregon,

(3) Memorandum from Mr. E. G. Simpson to the Acting Chairman, 1938.

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Washington, Wisconsin, and Wyoming, among others. The use of compacts appears to be the consequence of the unsatisfactory character of the results obtained by Litigation, where the final determination by the Courts follows only after years of protracted argument, references, fact finding, and review, and is even then, not infrequently, found susceptible of some need of interpretation in Court. Perhaps one important obstacle to the simple solution of water controversies by procedure at law has been in the fact that the United States Supreme Court has no right under the Constitution to issue declaratory decrees. (Arizona v. California (1930) 283 U. S. 423, 464), and the United States Supreme Court has itself sought to avoid having to make technical determinations of water rights where it has believed such determinations could better be made by interstate agreement. It has recommended that the states resort to compact to settle their waters disputes.

Existing Compacts Concerning the Use of Water

Congress has consented to the negotiation of 15 compacts for the apportionment of water in interstate streams, but of these only five have been ratified or approved by two or more of the contracting states and by Congress. (See, Hinderlinder v. La Plata River & Cherry Creek Ditch Co., (U. S. 1938) 58 S. Ct. 803, 809, n. 11).

The five compacts ratified or approved by Congress are the following:

1. La Plata River:

The signatory states are those of Colorado and New Mexico.

The compact was ratified by Congress on January 29, 1925.

The compact provides that each signatory state shall have the unrestricted right to use all water flowing in the La Plata River within the boundaries of the respective states between

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December 1 and February 15; that between February 15 and December 1 each such state shall have such unrestricted right only when the mean daily flow at a given interstate station is 100 cfs or more, and that on all other days Colorado shall deliver at the given interstate station half the mean flow at a given other station the preceding day, not exceeding however 100 cfs; and, finally, that when the water is low its use may be rotated between the states signatory in any manner the state engineers may jointly determine upon.

2. South Platte River:

The signatory states are those of Colorado and Nebraska.

The compact was ratified by Congress on March 8, 1926.

The compact provides that for water use the Longpole Creek shall be considered as divided between the two states; defines two basins: the "upper" and the "lower" basins; apportions, subject to certain conditions, the full flow to Colorado between October 15 and April 1; prohibits Colorado from allowing diversions from the lower basin between April 1 and October 15 to supply adjudicated Colorado priorities dating after June 14, 1897, if such diversions will, with a specific exception, diminish the flow at a given interstate station below 120 cfs mean flow; reserves to Colorado, in addition to perfected appropriations in the lower basin, prior right to store 35,000 acre feet for diversion from the lower basin between October 15 and April 1; awards to Colorado, subject to certain exceptions, the full use of the flow within its boundaries between April 1 and October 15, and the right to extend certain canals within Nebraska; permits Nebraska to operate a canal for the diversion of water within Colorado to be used in Nebraska, as of certain times, under certain conditions, and in fixed amounts.

3. Colorado River:

The signatory states are those of Arizona (the legislature of which refused to ratify), California, Colorado, Nevada, New Mexico, Utah, and Wyoming.

The compact was ratified by Congress on December 21, 1928.

The compact apportions 15 million acre-feet, annually, equally between "upper" and "lower" basins, with the right to the lower basin states to later increase their "beneficial consumptive use" by 1 million acre-feet; embodies a contingent provision covering the supplying of water to fulfill the obligations attending such rights in Mexico

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which may thereafter be recognized by the United States; specifies amendatory procedure for the future apportionment of water (after October 1, 1963); declares the use of the water for navigation to be subservient to its use for domestic, agricultural, and power purposes; declares the use of water for power purposes to be subservient to its use for domestic and agricultural purposes.

4. Rio Grande (above Fort Quitman, Texas):

The signatory states are those of Colorado, New Mexico, and Texas.

The compact was ratified by Congress on June 17, 1930.

The compact recognizes the primary importance of the conservation of the waters of the river basin, of the draining of the San Louis Valley basin in Colorado, and of the turning of such draining waters into the Rio Grande; provides that until the construction of the drain and a reservoir (but not later than June 1, 1925 or such other date as the states signatory may fix) Colorado will not impair the water supply at a given interstate station by diversions or storage unless offset by drainage returns; provides for the use of the waters of the Elephant Butte Dam spill by Colorado and New Mexico; provides for the constitution, by not later than June 1, 1935, of an interstate commission to conclude a compact for the equitable apportionment of the waters of the Rio Grande among the three states; provides for the use of waters of the river for power, subservient to their use for domestic, municipal, and agricultural purposes; protects certain rights vested in private parties; provides that the supply of water in the Elephant Butte reservoir shall not be impaired by diversion or storage in New Mexico, except as offset by drainage returns.(1)

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(1) Of interest with respect to the proposed compact between Wyoming and Montana may be the pending compact between Colorado, New Mexico, and Texas, arising out of the compact of June 17, 1930, summarized in the text of this memorandum. The pending compact relates to the further apportionment of waters of the Rio Grande by the commission designated in the earlier compact. A copy of the compact as signed by the commissioners of the several states on March 18, 1938, is appended for such use as it may prove to have. The pending compact deals with the shortage of water. It is understood that something of the same problem is now faced by Montana and Wyoming, although in this latter case the shortage can be largely reduced by the construction of reservoirs in either or both states. How far the reservoir solution may be reflected in the compact will be determined by the pending negotiations between the states.

5. Red River of the North:

The signatory states are those of Minnesota, North Dakota, and South Dakota.

The compact was approved by Congress on March 24, 1938.

The compact establishes the Tri-State Waters Commission as a body corporate, with the duty of studying the various water problems relating to the supply available within the tri-state waters area (the drainage basin of the Red River of the North lying within the boundaries of the three states signatory), of maintaining and controlling lake levels and stream flow in certain designated areas subject to the approval of the appropriate local agencies in whose territory the waters are located, and of recommending water conservation projects; confers upon such Commission the power of eminent domain to enable it to acquire such real and personal property as may be necessary in the discharge of its duties, and the power of approval with respect to works to be constructed in the drainage area by other agencies (implying the power to disapprove).

The Nature and Effect of Private Water Rights

At the basis of interstate controversy resulting in litigation or compact lies the necessity of local water usage and the rights upon which such usage rests. One region may employ the principles of the common law, another an adaptation or modification of the principles of the common law. Accordingly, one state may proceed in its determination of private water rights on the basis of doctrine of "riparian rights", another on the basis of the doctrine of "appropriation". The so-called "humid" eastern states recognize, generally, the former, the so-called "arid" states of the west, with variations, the latter.

As will be seen in the latter paragraphs of this section the United States Supreme Court gives some weight, according to the controversy involved, to the local law, for in the end controversy between the states arise as an ultimate controversy between the citizens of the states involved in such controversy.

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In the west the great scarcity of water and its vital quality has led to the development of a local custom or usage, sanctioned by the courts and legislation, which allows outright and complete appropriation of such water as may be necessary for actual and reasonable beneficial use. This right became known as the right of "appropriation". The doctrine of appropriation received early legislative recognition in the territories and was enforced in the territorial courts. Often, on admission to statehood, the doctrine received further sanction in state constitutions and statutes. (Wyoming v. Colorado (1921) 259 U. S. 419, 459; Arizona v. California (1935) 298 U. S. 558, 566). The right of prior appropriation has prevailed in both the states of Montana and Wyoming, probably from the first moment that law became established in those states, and continued through the territorial status of each state, into their statehood. (Bean v. Morris (1910) 221 U. S. 485, 487).

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The right of appropriation, arising from the early custom of regarding the waters of streams open to proprietary use in connection with irrigation, mining, domestic, and other beneficial purposes, involves a diversion from the stream and the application of the diverted water to such uses. By this process the appropriator acquires a continuing right to divert and use water to the extent of his existing appropriation, but not beyond what is reasonably required and actually used. The right is deemed a full and complete property right. As between appropriators from the same stream the one first in time is deemed superior in right. (Hinderlinder v. La Plata River & Cherry Creek Ditch Co. (U. S. 1938) 58 S. Ct. 803, 805.) A completed

appropriation is regarded as effective from the time the purpose to make it is definitely formed and actual work thereon is begun, provided the work be carried to completion with reasonable diligence.(1) Under the right of appropriation the appropriator has the privilege of diverting the water appropriated to other watersheds. Diversions from one watershed to another are commonly made in Wyoming, among other states, and the practice is sanctioned by the decisions of its courts. (Wyoming v. Colorado, infra.)

But, as will be shown in the section entitled "Legal Principles Specifically Applicable to Compacts", which follows later, a limitation imposed upon, or accepted by, a state, through a decree of a court or by compact, as the case may be, establishing the amount of

(1) Such rights of appropriation are enjoyed by Federal agencies and such agencies have in several instances, at least, been considered to be bound by the vesting of such prior rights in others. By the Act of June 17, 1902, c. 1093, sec. 8, (32 Stat. 390), the Secretary of the Interior and his agents, acting by authority of the Reclamation Act, and supplementary legislation, must obtain permits and priorities for the use of water from the states, in the same manner as private appropriators, or as irrigation districts formed under the state law. This legislation provided:

> "Nothing in this chapter shall be construed as affecting or intended to affect or to in any way interfere with the laws of any State or Territory relating to the control, appropriation, use or distribution of water used in irrigation, or any vested right acquired thereunder, and the Secretary of the Interior, in carrying out the provisions of this chapter, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any State or of the Federal Government or of any landowner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof."

This statute and its effect within the states applying the doctrine of appropriation has been recognized in cases before the United States Supreme Court. (Nebraska v. Wyoming (1934) 295 U. S. 40, 43.)

water which can be legally diverted within its boundaries, ipso facto "divests" the citizens of such a state of their so-called vested rights of appropriation or diversion.

Rights acquired by appropriation in one state are deemed to be valid against subsequent appropriators on the same stream in another state, and are enforceable as priorities in the courts of the latter state; for, just as the origin of appropriation is based upon the very life giving necessity of water in arid regions so is the origin of this "comity" of private rights in foreign states. To base the conduct of states on any other basis would be to invite suicide. (Bean v. Morris, supra, 487.)

In the latter case the United States Supreme Court said:

> "But with regard to such rights as came into question in the older States, we believe that it always was assumed, in the absence of legislation to the contrary, that the States were willing to ignore boundaries, and allowed the same rights to be acquired from outside the State that could be acquired from within."(1)

In a more recent case (Wyoming v. Colorado (1921) 259 U. S. 419, 468) the Supreme Court inquired:

> ". . . why should not appropriations from this stream be respected, as between the two States, according to their several priorities, as would be done if the stream lay wholly within either State? By what principle of right or equity may either State proceed in disregard of prior appropriations in the other?"(2)

(1) In this case Morris brought suit to prevent the petitioners from diverting waters in the state of Montana in such a manner as to interfere with an alleged prior right in himself based upon an appropriation made in Wyoming. The entire proceedings were had in the Federal courts, which recognized Morris' rights.

(2) A case deciding a controversy between the states of Wyoming and Colorado over diversions by the state of Colorado and two Colorado corporations acting under the authority of that state. The diversions were being made from the waters of the Laramie River.

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It is to be noted that litigation, though involving private rights, has been instituted by the states themselves. States are anxious to protect not only existing but also future use of the waters of streams within their boundaries. In such actions the state is permitted at law to bring suit by virtue of its standing in the relation of parens patriae to its citizens and also because the interests of the state are linked with those of its appropriators. It has been held that though a state has no pecuniary interest in such a controversy, and though it itself owns no land using water from the stream in controversy, it might invoke the original jurisdiction of the United States Supreme Court as parens patriae, trustee, guardian or representative of all or a considerable portion of its citizens. (Kansas v. Colorado (1901) 185 U. S. 125, 142.) The right of a state as parens patriae to bring suit to protect the general comfort, health, or property rights of its inhabitants threatened by the proposed or continued action of another state, is to be differentiated from its power, lost under the Eleventh Amendment to the Constitution, as a sovereign to present and enforce individual claims of its citizens, as their trustee, against a sister state. (North Dakota v. Minnesota (1923) 263 U. S. 365, 375.) But where the welfare, prosperity, and happiness of the people of a river valley in a given state, are in jeopardy and where also a large portion of the taxable resources of local political subdivisions are located, and where all of these matters are dependent on existing water appropriations, then, the interests of the state are indissolubly linked with the rights of the appropriators, and, it has every right to institute its action at law. (Wyoming v. Colorado (1921) 259 U. S. 419, 468.)

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Despite such clear law the United States Supreme Court is not inclined to render judgment upon such alleged rights, and against a sovereign state, unless the threatened invasion is of serious magnitude and established by clear and convincing evidence. (North Dakota v. Minnesota, supra.) Such a fact, of hesitant assumption of jurisdiction may be of some weight in forcing settlement of all the details of a negotiation. This principle, affecting the exercise by the Supreme Court of its jurisdiction, has often been referred to by that Court. (Washington v. Oregon (U. S. 1936) 56 S. Ct. 540, 542.)

Principles Applied By the Supreme Court in Water Proceedings Brought by States

The principles which have been formulated by the United States Supreme Court in rendering its decisions as to the rights of states and their citizens in the water of interstate streams is of some interest in connection with the negotiation of an interstate compact. Not only may the latent controversies underlying such negotiations become active and require quasi-judicial determinations but the tone of the negotiations, even though no specific controversy arise, will undoubtedly be placed upon a judicial plane.

The first matter of major influence upon the Supreme Court is the fact that water is a commodity of great scarcity in the arid areas. Even in the humid areas such as the East it may be a thing of as great relative scarcity due to the concentration and immobility of urban population centers, where the necessity is no less great that such areas have sufficient water supplies. In the case of New Jersey v. New York (1930) 283 U. S. 336, 343, Mr. Justice Holmes, speaking for the Court said:

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> "We are met at the outset by the question what rule is to be applied. It is established that a more liberal answer must be given than in a controversy between neighbors members of a single State. Connecticut v. Massachusetts, 282 U. S. 660. Different considerations come in when we are dealing with independent sovereigns having to regard the welfare of the whole population and when the alternative to settlement is war. A river is more than an amenity, it is a treasure. It offers a necessity of life that must be rationed among those who have power over it. New York has the physical power to cut off all the water within the jurisdiction. But clearly the exercise of such a power to the destruction of the interest of lower States could not be tolerated. . . . .Both States have real and substantial interests in the River that must be reconciled as best as may be."

The above quotation contains a second doctrine equal in importance to that recognizing the sheer necessity of obtaining water. The correlative doctrine is that "a more liberal answer must be given than in a controversy between neighbors members of a single State". Out of this second doctrine flows certain principles hostile to the doctrine of vested interests claimed by members of any given state, which state has limited by compact diversions of water from the portion of the stream within its boundaries in an effort to obtain a fair settlement of the entire controversy.(1)

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A third doctrine of major importance is also contained in the passage from Mr. Justice Holmes' opinion, above set forth, which has an interesting source in international law. The third doctrine is that, as to interstate streams, a state's actual exercise of the theoretical power to monopolize all water within its boundaries will not be tolerated. The contrary argument arises from the metaphysical doctrine of "dominion", and is one generally recognized in international

(1) Such principles are discussed below under the heading "Legal Principles Specifically Applicable to Compacts", which marks the second main division of this discussion, the preceding sections being deemed to apply more to the negotiation of the compact.

law in the absence of some treaty or other obligation assumed by the sovereign binding it to respect the claims or interests of another such sovereign. In the case Kansas v. Colorado, supra, Colorado contended that as a sovereign and independent state she was justified, if in her judgment her geographical situation and material welfare demanded it, in consuming for beneficial purposes all the waters within her boundaries, even to the point of depriving the adjacent state and its citizens of any use or share in the waters of that river whatever. The Supreme Court refused to accept such a rationalization and ordered that the case proceed to issue and proof. The State of Colorado made the same contention twenty years later in the case Wyoming v. Colorado, supra, and again refusing such a theory of domain, the Supreme Court said:

> "The contention of Colorado that she as a State rightfully may divert and use, as she may choose, the waters flowing within her boundaries in this inter-state stream, regardless of any prejudice that this may work to others having rights in the stream below her boundary, cannot be maintained. The river throughout its course in both States is but a single stream wherein each State has an interest which should be respected by the other. A like contention was set up by Colorado in her answer in Kansas v. Colorado and was adjudged untenable." (466)

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The same views have been recently re-expressed in Hinderlider v. La Plata River & Cherry Creek Ditch Co., supra. The Supreme Court has thus refused to consider the given interstate stream as if it were in theory two streams, as divided and apportioned between the states through which it flows, one part thereof commencing in the sources of the stream and continuing to and terminating at the boundary of the state of source, the other part beginning at the boundary and with the springs and sources of the lower state, starting as a new stream, and

flowing onward to its mouth. In Kansas v. Colorado, supra, The Supreme Court said that contrariwise, since from time immemorial the existence of a single continuous river had been recognized by geographers, explorers, and travelers, even the fact that a great variance in the amount of water flowing down the channel at different seasons and in different years, when at times the entire channel was in places dry and the source of the river was broken, would make no difference in its conclusion that the stream should be viewed as a unity.

The cardinal rule to be derived from a review of the decisions of the Supreme Court is that the rule underlying all the relations of states in such matters of water rights is one of "equality of right". Each state stands on the same level with all the rest. From this single principle, with practically no other fundamental rule to guide it the Supreme Court has developed what it candidly calls "interstate common law". Kansas v. Colorado, supra. Mr. Justice Holmes, referred in connection with the passage above quoted from the opinion of the Court in the case New Jersey v. New York, stated, as a corollary to the principle that a liberal rule was to be applied to the judicial settlement of controversies between states, that:

> "The different traditions and practices in different parts of the country may lead to varying results, but the effort always is to secure an equitable apportionment without quibbling over formulas." Supra, 343.(1)

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(1) After consideration of the demands of the two states (New Jersey and New York) in this case, the Supreme Court issued an injunction, against New York, restraining that State from diverting water from the Delaware River, or its tributaries, to the City of New York water supply, in excess of 440 million gallons daily. The Supreme Court required that prior to any diversion an efficient sewerage

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The Supreme Court gives weight, in its decisions relating to the apportionment of water, to the rules recognized by local courts in determining rights between "neighbors members of a single state", but only when such rules assist in determining the equities of apportionment. In the case Wyoming v. Colorado, supra, where both states recognized the doctrine of prior appropriation in determining the rights of their respective citizens inter se, The Supreme Court said:

> "We conclude that Colorado's objection to the doctrine of appropriation as a basis of decision are not well taken, and that it furnishes the only basis which is consonant with the principles of right and equity applicable to such controversy as this is. The cardinal rule of the doctrine is that priority of appropriation gives the priority of right. Each of these States applies and enforces this rule in her own territory, and it is the one to which intending appropriators naturally would turn for guidance. The principle on which it proceeds is not less applicable to interstate streams and controversies than to others. Both States pronounce the rule just and reasonable as applied to the natural conditions in that region; and to prevent any departure from it the people of both incorporated it into their constitutions. . . . . These considerations persuade us that its application to such a controversy as is here presented cannot be other than eminently just and equitable to all concerned." (470)

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(1. Continued)
treatment plant to be constructed at Port Jervis (New York) so that sewerage entering the Delaware and Neversink Rivers, whose waters were used by the State of New Jersey and its citizens, should not do so in injurious quantities. The Supreme Court then, in great detail, provided for suspension of use by New York if at any time the stage of the Delaware at Port Jervis or at Trenton should fall below 0.50 csm, at which time it would be incumbent upon the State of New York to release water from the impounding reservoirs of the City of New York, up to 30 per cent of the diversion area yield of 2.2 csm. This case illustrates the difficulty, visible in other decrees and in compacts in force, of attempting to apportion waters by relating together all the facts pertaining to the amount and character of the existing use of water, the quantity and quality required for the continuance of such uses and new uses, and the amount and quality of water available for apportionment at various intervals.

On the other hand the "local rule" may be discarded where the facts justify it. In the case Connecticut v. Massachusetts (1931) 282 U. S. 660, the former State suggested that under the common law and the doctrine of "riprarian rights", in force in both States, each riprarian owner has a vested right in the use of flowing waters and is entitled to have the flow "as they were wont", unimpaired as to quantity and uncontaminated as to quality. That same State insisted that the Suprome Court follow the law enforced by each of these two States within their respective boundaries and grant an injunction against a proposed diversion on the part of Massachusetts. But, the Supreme Court, adhering to its own new principles of "interstate common law" and the doctrine of "equitable equality" refused, saying:

> "But the laws in respect of riprarian rights that happen to be effective for the time being in both States do not necessarily constitute a dependable guide or just basis for the decision of controversies such as that here presented . . . .
>
> "For the decision of suits between States, federal, state, and international law are considered and applied by this Court as the exigencies of the particular case may require. The determination of the relative rights of contending States in respect of the use of streams flowing through them does not depend upon the same considerations and is not governed by the same rules of law that are applied in such States for the solution of similar questions of private right. Kansas v. Colorado, 185 U. S. 125, 146. And, while the municipal law relating to like questions between individuals is to be taken in account, it is not to be deemed to have controlling weight." (670)

Then the Supreme Court continued, in the same case:

> "As was shown in Kansas V. Colorado, 206 U. S. 46, 100, such disputes are to be settled on the basis of equality of right. But this is not to say that there must be an equal division of the waters of an interstate stream among the States through which it flows.

> It means that the principle of right and equity shall be applied having regard to the "equal level or plane on which all the States stand, in the point of power and right, under our constitutional system" and that, upon a consideration of the pertinent laws of the contending States and all other relevant facts, this Court will determine what is an equitable apportionment of the use of such waters." (670)

From this same decision it appears that in apportioning waters the Supreme Court gives first consideration to "drinking and other domestic purposes" as being "the highest uses of water". In Wyoming v. Colorado, supra, the Supreme Court pointed out that the utilization of water meant the presence of population on the land which must have a living from year to year and the means to make such a living year by year and not simply once in "three or four years". The Supreme Court stated:

> "It is a question of population as well as investment. The population has to exist and stay on the ground." (470)

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Of course the importance of use can be whatever the contracting states may agree upon and establish by the compact.

The Supreme Court considers appropriations as a valid part of a State's water account, but is quick to disregard appropriations which have been abandoned or have suffered the legal effects of a forfeiture through inequitable conduct or laches or otherwise. "The label of the acts is unimportant, whether laches or estoppel or abandonment". Wyoming v Colorado, supra. In the same case the Supreme Court said:

> "A priority once acquired or put in course of acquisition by the posting of a notice may be lost to the claimant by abandonment or laches. There must be no waste in arid lands of the 'treasure' of a river. . . The essence of the doctrine of prior appropriation is beneficial use, not a stale or barren claim. Only diligence and good faith will keep the privilege alive." (544)

Under its doctrines the Supreme Court has indicated that it will weigh the relative merit of the uses of water under valid appropriation. It will not limit the use of water to a state if it would materially injure users without a compensating benefit to proposed users of another state, the complainant. It will not restrain a diversion where to do so will bring distress and even ruin to a long-established settlement of tillers of the soil, especially if all that is involved on the other side is a vindication of a present barren right. It will, however, in its decisions, consider whether the waters diverted are misapplied or wasted with ensuing loss to the complainant State. Washington v. Oregon, supra.

In determining a fair division of the water, vital to the prosperity of an agricultural community, even to its very life, the Supreme Court is inclined to view the welfare of cities within the area as in part determined by the welfare of the area around them. In making an apportionment it will be influenced by the needs of an area, part agricultural, part urban, as dependent upon a unity of growth in the development of the whole community. Ibid.

The Supreme Court has refused to make any final determination on the basis of an average yearly flow, even though it be for all years in a considerable period -- especially where there is a great variation in the flow. Of greater importance is the "unalterable need" for a supply which is fairly constant and dependable, or is susceptible of being

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made so by storage and conservation within practicable limits. In Wyoming v. Colorado, supra, 471, 484, and 480, the Supreme Court recognized the fact, also, that the consensus of opinion among practical irrigators and experienced irrigation engineers is that the "lowest natural flow" of the years is not the test, for:

> "In practice they proceed on the view that within limits, financially and physically feasible, a fairly constant and dependable flow materially in excess of the lowest may generally be obtained by means of reservoirs adapted to conserving and equalizing the natural flow; and we regard this view as reasonable."

Again, to obtain the fair volume of a stream for apportionment it may be necessary to include, in the amounts to be apportioned, in part or in whole that flow from other forks and tributaries that augments the flow of the subject stream on lower reaches. Nebraska v. Wyoming (1934) 295 U. S. 40, 44. This is an application of the rule previously stated that the Supreme Court will not consider the stream as artificially divided into several streams by the crossing of state boundaries but only as a unity. Conversely, it may be necessary, in arriving at an equitable apportionment, to consider the amount diverted not only directly but even indirectly through the pumping from remote wells, when proved to influence the volume of the stream. See Washington v. Oregon, supra, 544. Then, again, equal in importance to the loss of quantity through diversions on upper portions of the stream may be the loss of quality by upper pollution. See Missouri v. Illinois (U.S. 1906) 26 S. Ct. 268, 268.

Legal Principles Specifically Applicable to Compacts:

The commerce clause need not be involved nor form a particular legal basis for the authorization of interstate compacts. Compacts of this character rest directly upon specific constitutional provision for

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their legal sanction. Article I, Sec. 8, Cl, 3, of the Constitution provides:

> "No State shall, without the Consent of Congress, ... enter into any Agreement or Compact with another State, ... ".

Where the compact is used as a method of regulating the navigation of a stream then, of course, the commerce power may induce an additional but unnecessary legal foundation for the compact qua compact. The compact, however, beyond question has its own independent legal basis. Hinderlider v. La Plata River & Cherry Creek Ditch Co., supra.

A compact, sanctioned by Congress, becomes a law of the Union, (Mr. Justice McLean, for the Court, in Pennsylvania v. The Wheeling & Belmont Bridge Co. et al (1851) 53-4 U. S. 521, 631.) although it is doubtful that it is any wise a statute of Congress. (See, dissent of Chief Justice Taney in the Pennsylvania case, immediately cited, to the effect: "It (the act of Congress) leaves the compact as it was; that is, a compact between the two States, and nothing more, and to be enforced by a proceeding upon it.") In the Hinderlider case, supra, it is stated that the compact, though approved by Congress, is not a statute of the United States within the meaning of Sec. 237 (a) of the Judicial Code. However, it seems certain that a state law may not be passed at conflict with the compact with respect to which the given state is a party signatory. Under the Constitution no state may pass any law impairing the obligation of a contract and a compact is a contract within the meaning of that constitutional provision. Green et al v. Biddle (1823) 19-21 U. S. 346, 365. The same view has received approval in a more recent case. Olin v. Kitzmiller et al (1922) 259 U. S. 260, 261, 263.

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Further, a state may not avoid the burden of its duty under a compact by simply placing responsibility for any violation thereof on persons within its borders engaged in private and not official business. Thus, in the case Wyoming v. Colorado, supra, The Supreme Court had under consideration the contention made by Colorado that the acts of diversion complained of (no compact) in violation of a previous decree entered by the Supreme Court were not acts done by Colorado, or under her authority, but acts done by private corporations and individuals, not parties to the then pending suit. The Supreme Court declared any such contention untenable in view of the fact that such acts were done with the "knowledge, permission and cooperation" of that State. It is true that citizens of the contracting states are not deemed to be in any wise parties to the compact. In Georgetown v. The Alexandria Canal Co., et al (1838) 37 U. S. 91, 96, the Supreme Court said:

> "The compact made in the year 1785, between Virginia and Maryland, was made by the two states, in their character as states. The citizens, individually, of both commonwealths, were subject to all obligations imposed, and entitled to all the benefits conferred by that compact. But the citizens as such, individually, were in no just sense parties to it; those parties were the two states, of which they were citizens."

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It is to be emphasized that the compact is binding upon the citizens of the signatory states, especially in view of the theory of the vested rights of property. In Poole et al v. Fleeger et al (1837) 35-37 U. S. 395, 397, a controversy arose between private parties as to the title of realty. The Supreme Court held that the rights of the parties would be determined by a compact entered into in 1820 by the two states, Kentucky and Tennessee, settling the true boundary between them.

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But, in the recent case of Hinderlider v. La Plata River & Cherry Creek Ditch Co., supra, the Supreme Court was more explicit in its decision as to the effect of the La Plata River Compact between the states of Colorado and New Mexico (ratified by Congress on January 29, 1925) upon the citizens of those states. The Supreme Court said:

> "Whether the apportionment of the water of an interstate stream be made by compact between the upper and lower States with the consent of Congress or by a decree of this Court, the apportionment is binding upon the citizens of each State and all water claimants, even where the State has granted the water rights before it entered into the compact." (809)

And, further:

> "As Colorado possessed the right only to an equitable share of the water of the stream, the decree of January 12, 1898, in the Colorado River proceedings did not award to the Ditch Company any right greater than the equitable share. Hence the apportionment made by the Compact can not have taken from the Ditch Company any vested right, unless there was in the proceedings leading up to the Compact or in its application, some vitiating infirmity." (810)

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This case is also authority for the nature of the proceedings involved in framing the compact. It appears to be the only case of such a character. The Supreme Court states that a compact need not embody a decision of a judicial or of a quazi-judicial nature with respect to controverted rights. It can be simply a trading compromise of conflict-claims. It adds that the history and the order of development of the judicial process and of the framing of compacts are entirely diverse (808). Further, as the states have power to bind by compact their respective appropriators, by an agreement dividing the flow of a stream, they have power to reach that and either by providing a con-

tinuous and equal division of the water from time to time or by providing for alternate periods of flow, to first one state and then the other, of all the water in the stream.

It should be noted that indirectly the Supreme Court indicates that the apportionment must be reached by the Commissioners after inquiry, by an honest exercise of judgment, and according to some basis of equity. If those having claims which are to be affected by the compact wish to have their claims presented directly to the Commissioners for consideration, it seems from the Hinderlider case, the Commissioners must arrange for such parties having an opportunity of being heard.

Preliminary Report

on

YELLOWSTONE RIVER BASIN

Section II

DETAILS BY SUB-BASINS

A. Main Stem and Minor Tributaries of the Yellowstone River
B. Clark Fork River
C. Big Horn River
D. Little Horn River
E. Tongue River
F. Powder River
G. Little Powder River

Federal Power Commission
Bureau of Engineering
Denver Regional Office

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A. MAIN STEM AND MINOR TRIBUTARIES OF THE YELLOWSTONE RIVER

1. Stream Flow

The main stem of the Yellowstone River rises in northwestern Wyoming, flows north through Yellowstone Lake to Livingston, Montana, where it makes a big bend and then flows northeastward to its confluence with the Missouri. Since about 1890 the streamflow has been gaged for short periods at several points. Table 26 summarizes the gagings at some of the key stations. Long records are available for the Yellowstone at Corwin Springs, Montana (table 27) and at Intake, Montana (table 15). During the last 35 years the annual discharge at Intake has ranged from about 4 million acre-feet to 15 million acre-feet, and has averaged 10 million. The main stem above Corwin Springs is probably the most dependable stream in the basin. It holds up well almost every year until late in the summer. There is very little, if any, irrigation above Corwin Springs, and no water is diverted below Intake.

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2. Existing Irrigation Projects

Table 28 presents data on the irrigated and irrigable areas in each project (or group of small projects) on the Yellowstone (main stem) and minor tributaries. These data were obtained by the Corps of Engineers through a field survey made in the spring of 1939. The projects are arranged in the table according to location and source of water supply. Map 8 shows the location of the major projects, which can be identified by the numbers thereon and by reference to column 2 of table 28.

Projects on Main Stem in Montana

There are 231,530 acres under canals which divert directly from the Yellowstone. Of this area, 176,810 are being irrigated at

present. Table 28 indicates that the lands irrigated from the main stem suffered a shortage of about 5,000 acre-feet per year during the period 1930-1938. This shortage, all of which occurred on the Cartersville Irrigation District Project, resulted from decreased head on the intake works and not from lack of water in the river. Quite the contrary, it appears that there has always been enough water in the main stem at Corwin Springs to irrigate all the land commanded by the ditches which divert from the main stem of the Yellowstone.

3. Potential Irrigation Projects

Appendix I contains a complete list of potential irrigation projects in this sub-basin. The Brackett Creek Project, the Porcupine Creek Project, and the Lake Basin Project are included in the water use studies of Appendix F of the Progress Report of the National Resources Planning Board (see table 20). It will be noted that much of the area listed under potential projects in Appendix I is included in table 28 as "additional irrigable area by extension of (existing) projects."

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Lake Basin Project

The Lake Basin Project is the only potential project that would divert water directly from the main stem of the Yellowstone. It is proposed to irrigate 239,200 acres in Lake Basin (sometimes called Wheat Basin) through a gravity canal supplied from the potential Lower Canyon Reservoir. The Corps of Engineers estimates that the water duty would be 1.8 acre-feet per acre with no return flow. Lake Basin is at present a closed basin lying between the Yellowstone Basin and the Musselshell Basin, north of Columbus, Montana, and, therefore, its inclusion in the Yellowstone Basin might be questioned. The direction of the water courses in the area indicates that the basin was once drained by the

Yellowstone River through Canyon Creek. The structural geology of the Region indicates that the underground drainage, if any, is to the Yellowstone River via White Beaver Creek (see U.S.G.S. Bulletin 691 D). If the rights of the lands of Lake Basin to waters of the Yellowstone River were clearly defined in the compact, the possibility of future controversy might be eliminated.

Mid-Yellowstone Project

The greatest area classified as "irrigable by extension of existing projects" is the group of projects collectively known as the Mid-Yellowstone Project. Two units of the Buffalo Rapids District, embracing 22,300 acres, are being considered by the U. S. Bureau of Reclamation for immediate construction(1). Present plans are to irrigate the entire 22,300 acres by pumping directly from the Yellowstone River, although the Mid-Yellowstone Project has previously been considered as a gravity project.

Ultimate Irrigable Area

The ultimate irrigable area of this sub-basin, as estimated by the Corps of Engineers, is 738,515 acres (see tables 18 and 19). This area may be classified as to source of water supply and state of development as follows:

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(1) From a pamphlet, "Northern Great Plains", published by the National Resources Planning Board, May 1940.

Ultimate Irrigable Area on the Main Stem and Minor Tributaries - Acres

	Main Stem Direct	Minor Tributaries	Total
Irrigated at present	176,810	129,665	306,475
Under ditch, but not irrigated at present	54,720	9,090	63,810
Irrigable by extension of projects	106,130	10,700	116,830
Area in potential projects	239,200	12,200	251,400
Total	576,860	161,655	738,515

According to the above estimate, all of the irrigable area of the basin lies in Montana except the Lower Yellowstone Project, which lies partly within North Dakota. Estimates of the irrigable area in North Dakota are discussed fully in Section I-D-1. The Montana reports do not give an estimate of the ultimate irrigable area in Montana, but indicate that the Army figure should be increased by at least 90,000 acres (see Appendix I, table 2).

Appendix I lists four potential projects reported by the Montana State Water Conservation Board and two potential projects reported by the North Dakota Water Conservation Commission, which, apparently, are not included in the tabulation given above. These six projects contain 72,650 irrigable acres, 70,000 of which are in Montana and 2,650 in North Dakota.

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4. Reservoirs for Irrigation Storage

Existing Reservoirs

There are no existing reservoirs on the main stem of the Yellowstone, and only two on its minor tributaries. These two, Lake Adams and Lake Walvoord, are on the Sweetgrass Creek and have a combined capacity of 18,000 acre-feet (see table 17).

Potential Reservoirs

The only irrigation storage reservoir known to have been proposed for the main stem of the Yellowstone River is the Lower Canyon reservoir above Livingston. About 30 reservoirs, having a total capacity of more than 250,000 acre-feet, have been proposed for the minor tributaries, principally in the Shields River Basin. These potential reservoirs are all in Montana, and are listed in Appendix II, tables 2 and 3. Table 29 gives a probable schedule of operations of the seven reservoirs which were included in the water use studies of the Progress Report of the National Resources Planning Board (Appendix F).

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Table 26

MAXIMUM, MINIMUM, AND MEAN RUN-OFF OF THE YELLOWSTONE RIVER (MAIN STEM), AND MINOR TRIBUTARIES

(1,000 Acre-feet)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Yellowstone River at Intake and Glendive, Montana													
Drainage Area: 67,901 Sq. Mi.									Period:	Oct. 1905 - Sept. 1938			
Maximum	1790	720	536	806	855	1480	2330	2340	4600	3940	1480	797	15,400
Minimum	229	232	180	128	155	307	260	594	690	204	154	142	4,231
Mean	490	385	329	318	319	633	637	1268	2788	1768	697	455	10,055
Mean 1930 - 37	386	329	244	220	270	504	446	977	2030	909	384	292	6,994
Yellowstone River at Huntley, Montana													
Drainage Area: 12,826 Sq. Mi.									Period:	Oct. 1907 - Nov. 1916			
Maximum	432	306	258	209	265	512	455	1170	2240	2000	719	438	7,410
Minimum	238	187	130	123	108	116	182	516	1060	568	226	211	4,580
Mean	308	235	184	173	167	308	288	784	1730	1140	489	317	6,120
Yellowstone River near Livingston, Montana													
Drainage Area: 3,514 Sq. Mi.								Period:	Oct. 1900 - Dec. 1905:		Sept. 1928 - Sept. 1938		
Maximum	152	107	90	84	72	90	190	580	1030	681	285	172	3,360
Minimum	70	60	46	40	36	40	50	75	270	150	100	75	1,590
Mean	103	82	70	61	56	69	101	322	783	385	192	122	2,180
Mean 1930 - 37	92	74	64	54	52	62	106	311	591	307	164	105	1,900
Mean Run-off for the period 1930-1937 of the Yellowstone River (Main Stem) at various points in Montana													
Corwin Spgs.	73	55	48	42	37	44	85	330	526	279	141	84	1,750
Livingston (b)	92	74	64	54	52	62	106	311	591	307	164	105	1,900
Columbus (a)	122	105	88	85	83	100	152	410	688	344	189	129	2,500
Laurel (a)	158	128	99	98	97	132	172	471	910	420	214	150	3,050
Billings (b)	196	159	124	122	118	160	213	604	1140	500	235	175	3,750
Miles City (b)	352	301	228	211	240	396	370	940	1970	844	388	284	6,520
Intake	386	329	244	220	270	504	446	977	2030	909	384	292	6,990

(a) Estimated by U. S. Geological Survey, Helena, Mont.
(b) Partially estimated by U. S. Geological Survey, Helena, Mont.

Run-off for the year 1934* of the Yellowstone River at various points in Montana

Corwin Springs	69a	53a	55a	49b	45	52	155	369	253	129	86	60	1,380
Livingston	70a	65a	60a	56a	60a	70a	190a	420a	270a	150a	100a	75a	1,590
Columbus	90a	80a	70a	66a	80a	100a	220a	440a	300a	170a	115a	90a	1,820
Laurel	166a	118a	76a	78a	108a	122a	240a	460a	430a	180a	100a	95a	2,173
Billings	200a	150a	100a	100	130	153	280	633	586	210	105	112	2,760
Miles City	318	316	236	302	336	343	395	859	775	245	164	176	4,450
Intake	340	345	207	275	260	343	425	780	728	226	154	142	4,230

*1934 is the minimum year of record
a - Estimated b - Partially estimated

Shields River near Clyde Park, Montana													
Drainage Area: 600 Sq. Mi.										Period:	Oct. 1929 - Sept. 1938		
Maximum	4.6	4.7	3.7	2.8	5.2	10.6	24.2	40.0	27.9	12.6	2.6	2.2	116
Minimum	1.3	1.5	1.2	1.5	1.4	3.4	7.7	3.9	4.2	1.0	0.4	0.4	38
Mean	2.8	2.9	2.6	2.1	2.4	4.8	13.3	20.2	14.9	3.3	1.1	1.2	71
Stillwater River near Absarokee, Montana													
Drainage Area: 943 Sq. Mi.										Period*:	Oct. 1929 - Sept. 1938		
Maximum	30	24	18	16	14	19	50	150	230	146	70	30	590
Minimum	16	13	11	7	6	10	13	56	114	38	24	17	370
Mean	19	16	14	12	12	14	22	90	180	90	35	22	530

* Run-off estimated October 1929 to March 1935 by U. S. Geological Survey, Helena, Mont.

Boulder River near McLeod, Montana

1911 - 12	13.5a	8.0a	5.8a	5.2a	4.9a	6.2a	11.1b	47.8	183	124b	37.8a	15.8a	463
1912 - 13	17.8a	12.2a	8.0a	6.5a	5.0a	8.0a	22.6a	84.8	206	100	54.6	26.3	552
1913 - 14	25.9	19.6	8.9a	7.4a	6.1a	6.8a	11.1	87.3	168	74b	18.1a	16.5a	449
1928 - 29	10.1a	9.2a	5.8a	4.0a	4.2a	5.5a	8.6	29.0	108	59	12.9	6.0a	263

a - estimated b - Partially estimated

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Table 27

RUN-OFF OF THE YELLOWSTONE RIVER AT CORWIN SPRINGS, MONTANA

Drainage Area: 2,599 Square Miles (1,000 Acre-feet)

Year Ending Sept. 30:	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual Total
1911	78.1	66.1	61.2	55.3	50.0	64.6	83.3	269	1010	571	233.0	129.0	2670
1912	101.0	79.1	73.8	74.4	64.4	67.0	69.6	206	725b	479	254.0	143.0	2340
1913	114.0	82.7	63.2b	55.8a	48.8a	64.5b	106.0	442	976	568	333.0	166.0	3020
1914	111.0	82.7	70.6b	62.0a	54.3a	68.7b	88.1	410	631	366	172.0	123.0	2240
1915	140.0	96.4	73.6b	64.5a	56.6a	67.5b	155.0	263	375	304	175.0	112.0	1880
1916	99.6	70.2	68.9	56.1	56.2	75.6	104.0	254	744	713	279.0	145.0	2670
1917	114.0	81.5	73.6a	65.1a	53.6	67.0	82.1	269	762	769	292.0	170.0	2800
1918	122.0	86.9	81.2	71.3	56.6	73.8	96.4	295	1110	525	220.0	133.0	2870
1919	144.0	88.7	71.9	62.1	53.8	64.0	105.0	380	271	125	81.2	64.3	1510
1920	60.5	56.2	51.2	46.3	46.3	55.1	56.8	242	696	517	231.0	133.0	2190
1921	103.0	78.6	63.3	58.1	54.1	66.4	72.6	386	803	319	159.0	108.0	2270
1922	78.7	64.3	64.0	55.2b	45.4b	52.0	69.6	259	643	303	170.0	108.0	1910
1923	78.1	62.5	54.5	51.3	44.4	48.8	57.9	275	562	370	184.0	112.0	1900
1924	91.0	69.0	61.4	61.5	57.3	60.1	64.3	320	402	270	143.0	98.2	1700
1925	97.2	76.2	69.4b	58.6b	62.2	71.3	127.0	553	752	506	252.0	155.0	2890
1926	124.0	95.2	79.9	68.2	61.1	67.6	152.0	465	405	226	129.0	91.0	1960
1927	83.6	67.8	64.6	60.7	56.1	66.4	92.8	298	928	573	259.0	161.0	2710
1928	129.0	123.0	86.1	75.5a	68.2a	70.7	88.1	836	684	529	240.0	126.0	3060
1929	97.2	71.4	60.3	53.7	44.4	58.0	64.2	237	619	363	157.0	97.0	1920
1930	78.7	60.1	59.3	48.0	42.0	51.5	117.0	332	498	288	191.0	109.0	1880
1931	121.0	72.0	62.7	55.3	48.4	52.5	69.6	274	413	160	94.7	64.9	1490
1932	57.4	50.6	41.4	39.7	36.9	45.9	39.4	344	666	446	182.0	98.2	2070
1933	71.9	58.7	44.8	41.5	35.8	50.1	71.4	189	708	302	137.0b	81.0a	1790
1934	69.0a	53.0a	55.0a	49.4b	45.2	51.9	154.7	369	253	129	85.7	60.5	1380
1935	58.4	51.7	47.0	39.1	28.9	30.5	57.0	257	665	382	167.0	97.4	1880
1936	68.9	51.5	43.8	39.5	37.2	44.5	114.5	534	546	252	140.7	82.6	1960
1937	58.7	42.2	33.9	27.6	22.8	25.3	34.3	341	455	273	130.9	80.0	1520
Maximum	144.0	123.0	86.1	75.5	68.0	75.6	155.0	836	1110	769	333.0	170.0	3060
Minimum	57.4	42.2	33.9	27.6	22.8	25.3	34.3	189	253	125	81.2	60.5	1380
Mean-27 yrs	94.4	71.8	62.2	55.4	49.3	58.6	89.4	344	641	397	188.6	112.9	2166
Mean 1930-37	73.0	55.0	48.5	42.5	37.2	44.0	84.7	330	526	279	141.1	84.2	1746

a - Estimated

b - Partially estimated

Table 28

EXISTING IRRIGATION PROJECTS

Main Stem and Minor Tributaries of the Yellowstone River

(Acres)

Project Name and Location**	Project No.*	Average Acres Irrigated 1930-1938	Average Annual Shortage 1930 - 1938 (Acre-Feet)	Irrigable Area Under Present System	Additional Irrigable Area by Extension of Project	Ultimate Irrigable Area in Project
Above Livingston		26,835	10,260	32,435	6,500	38,935
Main Stem		7,100	0	12,500	3,000	15,500
Livingston Ditch	29	1,800		3,000	2,000	5,000
Park Branch Canal	30	5,300		9,500	1,000	10,500
Minor Tributaries		19,735	10,260	19,935	3,500	23,435
Misc. (Reese Creek - 3 Projects)		2,000	910	2,000		2,000
Misc. (Miner Creek & Trib.-20 Projects)		2,000	260	2,000	1,000	3,000
Misc. (Six Mile Creek)		500	270	500	500	1,000
Misc. (Strickland - 7 Projects)		600	160	600		600
Misc. (Big Creek - 5 Projects)		1,100	750	1,100		1,100
Misc. (Elbow Creek)		1,035	490	1,035	500	1,535
Misc. (Strawberry Creek - 7 Projects)		1,000	230	1,000		1,000
Misc. (Trail Creek - 20 Projects)		850	450	1,000		1,000
Misc. (Deep Creek - 12 Projects)		2,500	1,100	2,500	500	3,000
Misc. (Pine Creek - 10 Projects)		2,500	740	2,500	1,000	3,500
Misc. Creeks and Springs - (13 Streams)		2,200	3,140	2,200		2,200
Misc. (Barrett, Little Trail & Cedar Creeks - 8 Projects)		450	280	500		500
Misc. (Billman Creek - 15 Projects)		3,000	1,480	3,000		3,000
Livingston to Stillwater River		99,140	42,450	107,260	17,500	124,760
Main Stem		9,800	130	12,500	12,500	25,000
Hunters Hot Springs Canal	27	3,500		3,500	10,000	13,500
Larsen Ditch	28	1,000		1,000	1,000	2,000
Misc. (County Ditch)		500		600	1,500	2,100
Misc. (Westfall)		4,000		4,000		4,000
Columbus Irrigation District	23	500		3,100		3,100
Misc. (Campbell Ditch)		300	130	300		300
Minor Tributaries		89,340	42,320	94,760	5,000	99,760
Misc. (Duck Creek)		600	320	600		600
Misc. (Little Timber Creek)		1,500	720	1,500		1,500
Dry Creek Canal	25	3,000		3,000	2,000	5,000
Post Kellog Ditch	26	1,100		1,200		1,200
Pioneer Canal	26a	1,700		2,000		2,000
Misc. (Boulder River)		13,500		13,500	2,000	15,500
Big Timber Project	24	8,550		11,380		11,380
Misc. (Big Timber Creek)		6,000	2,600	6,500		6,500
Misc. (Sweetgrass Creek)		20,000	9,800	20,000		20,000
Misc. (Deer Creek)		850	1,090	1,000		1,000
Misc. (Bridge Creek)		500	920	500		500
Shields River						
Misc. (Above Wilsal)		6,500	5,090	7,000		7,000
Misc. (Below Wilsal)		5,300		6,000		6,000
Misc. (Elk Creek)		1,100	720	1,100		1,100
Misc. (Daisy Dean Creek)		715	1,170	715		715
Misc. (Horse Creek)		2,850	4,260	2,850		2,850
Misc. (Tobin Creek)		2,620	3,520	2,620		2,620
Misc. (Flat Head Creek)		1,660	1,430	1,660	500	2,160
Misc. (Cottonwood Creek)		5,035	5,680	5,035	500	5,535
Misc. (Rock Creek)		3,000	1,430	3,000		3,000
Misc. (Brackett Creek)		1,850	1,700	2,000		2,000
Misc. (Canyon Creek)		300	460	400		400
Misc. (Bang Tail Creek)		210	330	250		250
Misc. (Willow Creek)		900	1,080	950		950
Stillwater River to Clark Fork		74,280	0	84,130	7,250	91,380
Main Stem		57,060	0	66,560	5,250	71,810
Billings Bench Water Ass'n.	15	15,000		23,000	200	23,200
Cove Irrigation District	18	6,060		6,060	50	6,110
Big Ditch Co.	19	32,000		32,000		32,000
Mill Ditch	19a	2,000		3,000	2,000	5,000
Italian Ditch	19b	2,000		2,500	3,000	5,500
Minor Tributaries		17,220	0	17,570	2,000	19,570
Stillwater River						
Misc. (Rosebud Creek)		1,450		1,600	2,000	3,600
Misc. (West Fork Rosebud Creek)		2,270		2,270		2,270
Misc. (East Fork Rosebud Creek)		1,490		1,490		1,490
Misc. (Rosebud River)		330		330		330
Misc. (Fish Tail Creek)		1,920		2,000		2,000
Misc. (Above Absorokee, Mont.)		5,380		5,380		5,380
Misc. (Below Absorokee, Mont. including Flaherty Flat Ditch)		4,380		4,500		4,500
Clark Fork to Big Horn River		42,360	950	48,830	9,370	58,200
Main Stem		40,590	0	43,940	9,170	53,110
Huntley Project, U.S.B.R.	14	23,590		23,590	8,920	32,510
Coulsen Ditch	16	1,300		3,000		3,000
Grey Eagle Ditch	16a	1,000		1,000		1,000
Miller & McGirl Ditch	16b	2,000		2,000		2,000
Suburban Ditch	16c	1,200		1,200		1,200
Lockwood Irrigation District	17	2,500		2,500		2,500
Canyon Creek Ditch Co.	20	6,000		6,500		6,500
Waco-Custer Ditch Co.	13	3,000		4,150	250	4,400
Minor Tributaries		1,770	950	4,890	200	5,090
Crow Indian Project	Pt. 83	970	440	3,890		3,890
Misc. (Pryor Creek)		800	510	1,000	200	1,200
Big Horn River to Tongue River		27,530	7,590	36,630	20,390	59,020
Main Stem		25,930	5,290	37,030	20,390	57,420
Mid-Yellowstone Project, U.S.B.R. (Upper Division)		2,150		2,150	18,890	21,040
Fort Keogh Project	4)	Included in Mid-Yellowstone Project, U.S.B.R.				
Sheffield Project	5)					
Hathaway Project	7)					
North Sunders Irrigation District	10)					
	)					
Hammond Irrigation District	8	3,230		4,080		4,080
Yellowstone Irrigation District	9	7,000		11,040	1,500	12,540
Box Elder Irrigation District	11	1,250		1,380		1,380
Rancher Ditch	12	4,300		6,000		6,000
Cartersville Irrigation District	6	8,000	5,230	12,380		12,380
Minor Tributaries		1,600	2,300	1,600	0	1,600
Misc. (Rosebud Creek)		1,600	2,300	1,600	0	1,600
Tongue River to Powder River		180	0	180	55,820	56,000
Main Stem		180	0	180	55,820	56,000
Mid-Yellowstone Project-U.S.B.R. (Lower Division)		80		80	55,820	55,900
Upper Glendive-Fullon Irrigation District	2)	Included in Mid-Yellowstone Project, U.S.B.R.				
	)					
Buffalo Rapids Irrigation District	3)					
	)					
Misc. (Miles City, Montana)		100		100		100
Minor Tributaries		0	0	0	0	0
Powder River to Mouth		36,150	0	58,820	0	58,820
Main Stem		36,150	0	58,320	0	58,820
Lower Yellowstone Irrig. Project**	1	36,000		58,320		58,320
Misc. (Yellowstone River)		150		500		500
Minor Tributaries		0	0	0	0	0
Total, Yellowstone River		306,475	61,250	370,285	116,830	487,115
Main Stem		176,810	5,420	231,530	106,130	337,660
Minor Tributaries		129,665	55,830	138,755	10,700	149,455

Source: Appendix F - Progress Report of the National Resources Planning Board.

* Numbers are those assigned by Corps of Engineers in 308 Report. See Map 8.

** All projects except the Lower Yellowstone Irrigation Project lie entirely within Montana. It is estimated that 5,000 acres of the Lower Yellowstone Project are in North Dakota and the remaining 31,000 acres are in Montana.

Table 29

SELECTED POTENTIAL RESERVOIRS

(And Probable Schedule of Storage and Release Operations)

Main Stem and Minor Tributaries of the Yellowstone River

(Acre-Feet)

Name of Reservoir	Total Capacity	Nov. 1 to Mar. 31	April	May	June	July	Aug.	Sept.	Oct.	Evaporation Losses
Above Clark Fork										
Mill Creek Res.	7,500	- 4,120	- 230	- 900	- 1,800	3,000	3,380	600	- 450	520
Brackett Cr. Res.	31,670	- 17,420	- 950	- 3,800	- 7,600	12,670	14,250	3,170	- 1,900	1,580
Potter Cr. Res.	20,000	- 11,000	- 600	- 2,400	- 4,800	8,000	9,000	2,000	- 1,200	1,000
Lower Canyon Res.	156,000	- 86,000	-5,000	-19,000	-37,000	63,000	70,000	17,000	- 9,000	6,000
Sweetgrass Res.	18,000	- 9,900	- 540	- 2,160	- 4,320	7,200	8,100	1,800	- 1,080	900
Total	233,170	-128,440	-7,320	-28,260	-55,520	93,870	104,730	24,570	-13,630	10,000
Below Clark Fork										
McGinnis Cr. Res.	5,000	- 2,750	- 150	- 600	- 1,200	2,000	2,250	400	- 300	350
Rosebud Cr. Res.	3,200	- 1,760	- 100	- 380	- 770	1,280	1,440	160	- 190	320
Total	8,200	- 4,510	- 250	- 980	- 1,970	3,280	3,690	560	- 490	670
Total, Main Stem	241,370	-132,950	-7,570	-29,240	-57,490	97,150	108,420	25,130	-14,120	10,670

Source: Field Survey Sheets (1939) of the Corps of Engineers, War Department.

0690

B. CLARK FORK RIVER

1. Stream Flow

The Clark Fork of the Yellowstone River rises near the northeastern corner of Yellowstone Park, near the Montana-Wyoming State line, and flows southeastward to its confluence with Sunlight Creek. It then turns northward and flows in a northeasterly direction into Montana, where it joins the main stem of the Yellowstone a few miles above Laurel, Montana. The principal tributary in Montana is Red Lodge Creek, which drains the northwestern portion of the basin.

In 1905 a stream-gaging station was established at Fromberg, Montana, a few miles above the mouth, where a continuous record was kept (except for winter months) until 1914. In 1921 a station was established at Edgar, Montana, about ten miles downstream. The record at Edgar has been continuous to date. A station at Chance, Montana, near the state line, also has a continuous record from 1921 to date. The flow at Chance (at state line) has been extended by comparison with the Clark Fork at Clark and at Fromberg, and the results presented in table 31. Extreme and mean flows for other streams in the basin are shown in table 30.

0651

2. Existing Irrigation Projects

Table 32 presents data on the irrigated and irrigable areas in each project (or group of small projects) in the basin. These data were obtained by the Corps of Engineers through a field survey made in the spring of 1939. The projects are arranged in the table according to location and

source of water supply. Map 8 shows the location of the major projects, which can be identified by the numbers thereon and by reference to column 2 of table 32.

A total of 85,500 acres in the basin are under canals. Of this area, 73,300 acres are being irrigated at present.

Projects on Main Stem in Montana

The projects in Montana which take their water supply directly from the main steam of the Clark Fork are grouped in table 32, and the data concerning them totaled. It will be noted that of the 33,810 acres irrigated from the main stem in Montana only one group of projects shows a shortage. This shortage, which is given as an average for the period, occurred, according to the field survey sheets, as an 8,500 acre-foot shortage during the months of August and September of a single year, 1930. This reported shortage is difficult to understand, particularly in view of the fact that in 1930 the water supply during the latter part of the irrigation season was better than for any other year of the period (see table 31).

0652

3. Potential Irrigation Projects

Tables 1 and 2 of Appendix I list six potential projects in the Clark Fork basin, which include a total of 105,900 acres.

Clark Fork Project

The Clark Fork Project (scheme 1) is the only potential project included in the water-use studies of Appendix F of the Progress Report of the National Resources Planning Board (see table 20). It is proposed to irrigate 60,800 acres in Wyoming and Montana along the banks of the western tributaries of the Clark Fork. The canal would divert water from the main stem in northern Wyoming (T. 56 N., R. 104 W.) and follow down the west side of the river at a considerable distance from the

stream. The natural flow of the river would be supplemented by 60,000 acre-feet of storage in Sunlight Reservoir on Sunlight Creek. Of the total of 60,800 irrigable acres, probably 80 percent is in Montana and 20 percent in Wyoming. The cost is estimated in the 308 Report at $122 per acre.

Ultimate Irrigable Area

The ultimate irrigable area of the basin, as estimated by the Corps of Engineers, is 148,500 acres (see tables 18 and 19). This area may be classified as to location and state of development as follows:

Ultimate Irrigable Area in the Clark Fork Basin - Acres

	Wyoming	Montana		Total
		Main Stem	Tributaries	
Irrigated at present	10,450	33,810	29,040	73,300
Under ditch, but not irrigated at present	5,370	250	6,580	12,200
Irrigable by extension of projects	1,400	800	0	2,200
Area in potential projects	12,160	48,640	0	60,800
Total	29,380	83,500	35,620	148,500

The Wyoming Report estimated the ultimate irrigable area in Wyoming at 61,430 acres. (See table 18 and Appendix I, table 2.) The Montana Reports do not give an estimate of the ultimate irrigable area in Montana.

4. Reservoirs for Irrigation Storage

Existing Reservoirs

There are in the basin five reservoirs having a total capacity of 37,990 acre-feet. As indicated in table 17, two reservoirs with a capacity of 32,840 acre-feet are in Montana, and the other three (capacity, 5,150 acre-feet) are in Wyoming.

0653

Potential Reservoirs

The three tables of Appendix II list five potential reservoirs in the Clark Fork basin. Three of these have capacities less than 1,000 acre-feet, and a fourth, Sunlight Reservoir, has a capacity of 60,000 acre-feet. The latter has been mentioned above in connection with the Clark Fork potential irrigation project. The probable schedule of storage and release operations of Sunlight Reservoir is given below in acre-feet.

Nov. thru March	- 33,000 storage	July	- 24,000 release
April	- 1,800 "	Aug.	- 27,000 "
May	- 7,200 "	Sept.	- 6,600 "
June	- 17,400 "	Oct.	- 3,600 "

Evaporation losses, estimated at four percent of the capacity, will amount to 2,400 acre-feet each year.

No information other than that shown in Appendix II, table 2, is available on the Broadwater Curl reservoir.

0654

Table 30

MAXIMUM, MINIMUM AND MEAN RUN-OFF OF MAJOR STREAMS IN THE CLARK FORK BASIN

(1,000 Acre-feet)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Clark Fork at Edge and Fromberg, Mont.													
Drainage Area: 2,100 Sq. Mi.													
Period: June 1905-Dec. 1913; Aug. 1921-July 1933; Feb. 1934-Sept. 1937													
Maximum	56.8	46.2	34.4	30.7	31.1	40.2	63.1	343	502	380	117.0	52.8	1,210
Minimum	18.8	17.3	13.4	13.4	6.8	14.1	15.6	56	156	20	13.1	14.5	505
Mean	30.8	26.3	22.4	20.9	18.7	23.7	32.6	136	269	150	54.2	30.9	832
Mean 1930 - 37	31.1	24.1	19.8	18.9	16.3	21.4	32.0	122	223	78	30.1	21.7	-
Rock Creek at Rockvale, Mont.													
Drainage Area: 555 Sq. Mi.													
Period: Oct. 1920-Sept. 1922; Broken 1932-1937													
Maximum	14.3	12.9	9.2	8.6	9.2	11.6	12.8	41.6	75.0	13.1	5.6	8.4	136
Minimum	2.3	4.3	3.1	3.1	3.9	6.4	6.3	0.8	13.2	1.3	0.6	2.8	71
Mean	7.2	8.3	6.8	6.4	6.6	9.3	8.6	15.3	35.1	6.2	2.0	4.7	110
Clark Fork below Crandall Creek, Wyo.													
Drainage Area: 401 Sq. Mi.													
1929 - 30	6.5	4.0	4.1	3.2	2.7	3.8	23.8	91.0	149	59.5	35.0	11.9	404
1930 - 31	26.2	8.3	4.2	2.5	2.2	3.7	6.0	76.2	127	23.4	12.9	7.6	300
1931 - 32	7.9	5.4	3.4	3.4	3.5	4.0	10.5	108.0	200	109.0	18.4	6.7	480
Sunlight Creek near Painter, Wyo.													
Drainage Area: 139 Sq. Mi.													
1929 - 30	3.7	3.3	2.1	1.5	1.5	2.0	3.2	11.0	24.2	17.0	12.9	5.4	87.8
1930 - 31	6.0	2.5	1.7	1.5	1.4	1.7	2.0	8.5	26.1	6.5	4.9	3.3	66.1
1931 - 32	2.4	1.8	1.6	1.6	1.4	1.7	2.0	14.3	40.2	21.5	5.8	3.0	97.3

Table 31

RUN-OFF OF THE CLARK FORK RIVER AT CHANCE, MONTANA

Drainage Area: 1,310 Square Miles (1,000 Acre-feet)

Year Ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1905 (1)								-	250	161	56.1	18.6	
1906	13.2	15.4	13.5	13.5	12.2	20.0	28.2	122	185	154	70.0	22.6	670
1907	10.6	12.8	13.5	13.5	14.0	12.4	24.6	128	299	384	114.5	46.2	1,073
1908	21.8	13.9	11.1	9.3	3.7	8.9	37.6	105	266	263	89.3	31.9	862
1909	26.7	17.5	11.5	11.0	9.9	11.0	10.6	113	467	305	78.5	45.5	1,107
1910	15.8	11.2	10.1	10.1	10.7	20.1	46.6	170	264	92	36.0	15.3	702
1911	10.3	12.1	11.2	8.5	8.4	9.9	16.4	143	387	177	57.8	19.8	861
1912	15.7	15.7	10.1	10.1	8.4	10.2	16.8	111	391	204	109.6	45.2	948
1913	20.7	15.3	11.8	11.0	9.9	10.2	16.7	108	365	175	117.5	36.7	898
1914	13.2	13.1	13.1	-									
1919 (2)								-	183	97	34	21.1	16.7
1920	14.7	-	-	-	-	-	12.9	89	291	233	71.3	24.9	
1921	17.6	12.3	-	-	-	-	17.5	151	364	116	38.6	19.9	
1922	11.7	9.8b	9.8a	8.4a	5.0a	5.8b	10.6	82	279	103	40.2	18.0	584
1923	9.5	12.4	8.3a	8.3a	6.8a	12.0b	15.6	100	225	158	36.6	26.2	618
1924	34.8	19.6	16.9a	8.6a	7.5a	8.4b	24.2	151	193	125	31.2	22.7	643
1925	36.4	23.9	20.0b	12.3a	10.6a	11.7b	52.6	219	284	232	70.1	29.3	1,000
1926	23.1a	19.9	15.4a	10.1a	9.2a	10.1b	49.6	192	186	111	34.6	21.5	682
1927	25.8	19.9	12.3b	10.8a	8.3a	9.1b	28.7	130	395	212	86.1	43.0	981
1928	24.0	38.6	26.5a	23.7a	21.3a	25.2b	22.5	350	218	240	70.1	27.9	1,090
1929	19.2	14.9	10.8b	10.5a	9.4a	12.0b	14.3	100	237	148	37.6	19.9	634
1930	15.7	14.8	11.7a	9.4a	8.3a	8.1b	32.8	111	193	107	63.3	21.1	596
1931	44.6	21.9	13.8	14.8a	10.6a	9.5b	12.0	96	187	29	19.0	10.3	468
1932	15.5	11.4b	10.8a	-	-	9.8b	15.7	133	267	132	25.8	13.0	
1933	11.9	13.9	9.2	10.9a	8.3a	13.3a	16.2	56	294	52b	-	-	
1934	-	-	-	-	9.7b	11.3	51.0	188	146	56	19.7	10.8	
1935	14.5	16.6	14.3	15.5	11.8	11.6	19.6	60	262	154	31.5	17.3	629
1936	13.8	16.9	14.1	13.9	10.4	13.4	48.0	232	234	62	33.6	18.4	710
1937	16.1	16.0	11.0	10.4	11.0	13.2	14.9	136	200	93	16.9	10.8	549
Maximum	44.6	38.6	26.5	23.7	21.3	25.2	52.6	350	467	384	117.5	46.2	1,107
Minimum	9.5	8.3	8.1	8.1	3.7	5.8	10.6	56	97	29	16.9	10.3	468
Mean-28 Yrs.	19.4	16.5	13.0	11.6	9.8	12.0	25.2	139	265	154	54.8	24.2	776
Mean-1930-37	18.9	15.9	12.1	12.5	10.0	11.3	26.3	126	223	86	30.0	14.5	-

(a) Estimated (b) Partially Estimated

(1) Record from June 1905 to December 1914 estimated by comparison with Clark Fork at Fromberg, Mont.

(2) Record from May 1919 to July 1921 is that of Clark Fork at Clark, Wyo.

0655

Table 32

EXISTING IRRIGATION PROJECTS

Clark Fork Basin

(Acres)

Project Name and Location	Project No.*	Average Acres Irrigated 1930-1938	Average Annual Shortage 1930-1938 (Acre-feet)	Irrigable Area Under Present System	Additional Irrigable Area by Extension of Project	Ultimate Irrigable Area in Project
Wyoming		10,450	6,280	15,820	1,400	17,220
Paint Creek Ditch & Reservoir Co.	32	800		800	1,200	2,000
Sirrine Ditch	33	2,100		2,200		2,200
Clark Fork Irrigation District	34	2,000		2,670		2,670
Misc. (Pat O'Hara Creek)		1,200	1,420	1,200		1,200
Misc. (Paint Creek)		600		600		600
Misc. (Bennett Creek & Little Rock Creek)		2,400	4,350	6,000		6,000
Misc. (Green - Bush)		650		650		650
Misc. (Line Creek)		700	510	1,700	200	1,900
Montana		62,850	25,160	69,680	800	70,480
Main Stem		33,810	950	34,060	800	34,860
Whitehorse Ditch	22	1,400		1,400	200	1,600
Wrangler Ditch	22a	5,250		5,250		5,250
Sand Creek Ditch	22b	4,950		4,950		4,950
Bridger Ditch	22c	2,400		2,400		2,400
Misc. (Above Rock Creek)		16,200	950	16,200		16,200
Danford Irrigation District	21	1,230		1,480	300	1,780
Misc. (Below Rock Creek)		2,380		2,380	300	2,680
Tributaries		29,040	24,210	35,620		35,620
Misc. (Rock Creek)		21,000	22,540	21,000		21,000
Red Lodge - Rosebud Irrigation District	31	2,000		8,520		8,520
Misc. (Red Lodge Creek)		740		800		800
Misc. (Below Red Lodge Creek)		5,300	1,670	5,300		5,300
Total, Clark Fork		73,300	31,440	85,500	2,200	87,700

Source: Appendix F - Progress Report of the National Resources Planning Board.

*Numbers are those assigned by Corps of Engineers in 308 Report. See Map 8.

C. BIG HORN RIVER

1. Stream Flow

The Wind and Popo Agie Rivers come together near Riverton, Wyoming, to form the Big Horn River.(1) The Big Horn then flows north about 150 miles to the Wyoming-Montana State line where it turns northeastward for a hundred miles to its confluence with the Yellowstone near Big Horn, Montana. Its two largest tributaries, the Shoshone and the Greybull, enter from the west in Wyoming. The Little Horn River and Shell and Nowood Creeks, which rise in the Big Horn Mountains, enter from the east.

The longest record of stream flow is that of the Big Horn at Thermopolis, Wyoming. Long records also exist for the Wind River at Riverton and for the Shoshone River below Shoshone Reservoir. Table 33 gives the maximum, minimum, and mean flows as recorded at the principal gaging stations in the basin. The flow of the Big Horn River at the state line has been estimated from records at Kane and Byron, Wyoming, and Hardin, Montana, and is shown in table 34.

0657

2. Existing Irrigation Projects

Table 35 presents data on the irrigated and irrigable areas in each project (or group of small projects) in the Big Horn Basin. These data were obtained by the Corps of Engineers through a field survey made in the spring of 1939. The projects are arranged in the table according

(1) The stream is often called the Wind River until it leaves the Wind River Canyon, near Thermopolis, Wyoming.

to location and source of water supply. Map 8 shows the location of the major projects, which can be identified by the numbers thereon and by reference to column 2 of table 35. A total of 547,780 acres in the basin are under canals, of which 383,660 acres are being irrigated at present.

Projects on Main Stem in Montana

The projects in Montana which take their water supply directly from the main stem of the Big Horn are grouped in table 35, and the data concerning them totaled. It will be noted that an average annual shortage of 2,650 acre-feet was reported for the 40,525 acres in Montana which divert from the main stem. The water requirement of this acreage probably never exceeds a continuous flow of 800 second-feet. According to stream flow records, which are summarized in table 36, the flow at the state line seldom falls below 800 c.f.s. The reported shortage can probably be explained by the fact that the diversion dams, being generally constructed of brush mats, leak so much water that they cannot maintain the proper head on the canal intakes during extreme low flow. The combined capacity of the diversion canals for this group of projects is about 1,280 c.f.s. The present canals, apparently, were designed to irrigate at least 60,000 acres, and are capable of irrigating 90,000 acres if the maximum diversion is limited, as in Wyoming(1), to one second-foot to every 70 acres. It is evident from table 36 that, if there is any further depletion upstream, the Montana irrigators will have difficulty keeping the existing canals full in extremely dry years.

0658

In Wyoming serious shortages exist in dry years on the Greybull River, on minor tributaries of the Big Horn, and on many of the small streams throughout the basin. The recently completed Upper Sunshine Reservoir will relieve the shortages on the Greybull River, and the Bull Lake

(1) See estimates of water duty in Section I-D-1.

Reservoir (also recently completed) will permit additional irrigation along the Wind River.

3. Potential Irrigation Projects

Table 1 of Appendix I lists 15 potential projects in the Big Horn Basin having a total area of 544,464 acres, excluding duplicated areas. This entire area is included in the ultimate irrigable area of table 18, either as "irrigable area by extension of project" (see table 35), or as "irrigable area in potential projects" (see table 19). Brief descriptions of these projects are given in Appendix I (table 1) and complete descriptions are given in Appendix IV of the 308 Report. Table 2 of Appendix I lists, by sub-basins, 139,000 acres in miscellaneous small projects, which were included in the Wyoming Report, and 23,000 acres in the Polecat Bench Irrigation District, which was taken from the Army report. No further information is available on the projects of table 2.

0659

Big Horn Irrigation Project

Several schemes have been proposed for irrigating the high benches along the Big Horn River below the Big Horn Canyon in Montana. The irrigable area included in the various surveys has ranged from 21,000 acres (U. S. Office of Indian Affairs Survey) to 60,000 acres (Koch Survey). All of the plans require a rather high diversion dam in Big Horn Canyon, and some of the investigations have considered irrigation as part of a multi-purpose project which would include power, flood control, and navigation benefits.

The 308 Report (Appendix IV) included 50,100 irrigable acres in the project, and estimated the total cost at $12,570,000 or $250 per acre. The project was also considered in combination with power, and it was concluded that, if all the expense of the dam and reservoir were borne by

power, the cost of developing the irrigation project would amount to $100 per acre.

Appendix F of the Progress Report (1939) of the National Resources Planning Board, which, in some respects, is a revision of the irrigation section of the 308 Report, places the irrigable area in the Big Horn Project at 47,500 acres. This is the figure used in this report. No cost estimates are given for the revised figure, but, presumably, they are about the same as those given above. The Big Horn River carries a heavy silt load, and, unless the silt were removed by upstream control, the capacity of a reservoir at this site would be greatly reduced in a relatively short time (see 308 Report, page 157).

Potential Projects in Wyoming

All of the potential projects in Wyoming, except the two on the main stem, contemplate supplementing natural stream flow with reservoir storage. The total potential (additional) irrigable area in Wyoming is estimated at 596,825 acres (see text table below), and the total capacity of the selected potential reservoirs is 749,910 acre-feet (table 37). This is probably insufficient storage to carry the additional acreage through the latter part of the irrigation season in dry years, and, apparently, there is not enough water in the river to make up the difference. There are many more reservoir sites in Wyoming (table 1, Appendix II), but, at present, it is not known to what extent they will be found infeasible because of duplication, insufficient water supply, and other reasons.

Ultimate Irrigable Area

The ultimate irrigable area of the basin, as estimated by the Corps of Engineers, is 1,078,860 acres (see table 18). This area may be classified as to location and state of development as follows:

0990

Ultimate Irrigable Area in the Big Horn Basin - Acres

	Wyoming(1)	Montana		Total
		Main Stem	Tributaries(1)	
Irrigated at present	342,285	40,525	850	383,660
Under ditch, but not irrigated at present	144,145	18,875	1,100	164,120
Irrigable by extension of projects.	176,525	28,700	2,200	207,425
Area in potential projects	276,155	47,500	0	323,655
Total	939,110	135,600	4,150	1,078,860

(1) Little Horn River not included.

The Wyoming Report estimated the ultimate irrigable area in Wyoming at 1,233,465 acres (see table 18 and Appendix I, table 2). The Montana Report did not give an estimate of the area in Montana, but, in commenting on the estimates of the 308 Report, it did not offer any revisions.

0661

4. Reservoirs for Irrigation Storage

Existing Reservoirs

The existing reservoirs in the basin have a total capacity of 660,660 acre-feet of useful storage. The major reservoirs are listed in table 17. Over half of the total capacity is in the Shoshone Reservoir, which is operated by the Bureau of Reclamation, and more than 80 percent of the total is included in the four largest reservoirs. Bull Lake Reservoir, capacity 150,000 acre-feet, and Upper Sunshine Reservoir, capacity 43,500 acre-feet, have just been completed, and, therefore, their operations are not reflected in stream flow records to date. The entire area for which the Shoshone Reservoir was designed has not yet been developed, so that, normally, the reservoir should have a surplus storage capacity. Part of the capacity of Bull Lake Reservoir is intended for

new lands, and, until these lands are brought under irrigation, there should be a surplus available from this reservoir. The Upper Sunshine Reservoir was built to alleviate a serious shortage along the Greybull River, and it is expected that its entire capacity will be utilized immediately.

Potential Reservoirs

Table 1 of Appendix II lists nearly 100 potential reservoirs, having a total capacity of 1,366,180 acre-feet in the Big Horn Basin (excluding Little Horn) in Wyoming. The total capacity, less duplications, is given as 1,357,740 acre-feet. No information, other than that shown in the table, is available to this office, but it is very likely that many of these potential reservoirs will be found infeasible on further study. The only potential reservoirs in Montana are the Big Horn Canyon Reservoir, which has been discussed under the Big Horn Irrigation Project, and the Porcupine Creek Reservoir (Appendix II, table 3). Twenty-four potential reservoirs were selected by the Corps of Engineers for inclusion in the water use studies of Appendix F. The capacity and probable schedule of operations of each of these reservoirs are given in table 37.

0662

Table 33

MAXIMUM, MINIMUM, AND MEAN RUN-OFF OF MAJOR STREAMS IN THE BIG HORN RIVER BASIN

(1,000 Acre-feet)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Big Horn River at Kane, Wyoming													
Drainage Area: 15,900 Sq. Mi.										Period: Sept. 1928 - Oct. 1937			
Maximum	125	100	68	58	63	317	165	425	823	427	393	117	2,007
Minimum	32	51	42	36	30	57	68	127	61	41	29	23	776
Mean 1930 - 37	75	70	52	46	50	78	96	252	489	195	108	49	1,562
Big Horn River at Thermopolis, Wyoming													
Drainage Area: 8,080 Sq. Mi.										Period: Broken 1900-1906; Oct. 1910-Sept.1937			
Maximum	160	99	44	53	64	158	350	621	774	593	305	185	2,334
Minimum	25	32	15	20	20	30	29	98	60	57	10	28	581
Mean	65	46	33	31	31	58	72	210	450	265	125	74	1,430
Mean 1930 - 37	49	38	28	24	26	41	57	178	357	163	98	43	1,100
Wind River at Riverton, Wyoming													
Drainage Area: 2,320 Sq. Mi.										Period: Broken 1906 - 1911; Oct. 1911-Sept. 1937			
Maximum	73	40	24	23	20	40	60	201	428	357	188	107	1,172
Minimum	17	17	12	11	11	16	19	58	36	44	34	16	370
Mean	38	24	18	17	16	22	33	110	260	180	91	49	850
Mean 1930 - 37	30	21	15	15	14	18	29	103	213	110	66	26	630
Popo Agie River below Arapahoe, Wyoming													
Drainage Area: 1,535 Sq. Mi.										Period: Broken 1906 - 1918			
Maximum	38	-	-	-	-	-	38	124	303	197	55	47	685
Minimum	14	-	-	-	-	-	15	48	127	36	5	5	351
Mean	21	10*	8*	8*	7*	10*	23	69	193	100	30	22	490

*Estimated

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Nowood Creek at Bonanza, Wyoming													
Drainage Area: 1,774 Sq. Mi.										Period: Broken, 1910 - 1928			
Maximum	46.2	23.5	-	-	-	-	67.8	144.0	146.0	70.7	24.8	34.5	555
Minimum	8.7	8.6	-	-	-	-	8.6	35.4	19.9	1.5	2.1	5.0	175
Mean	17.1	14.0	10*	9*	9*	17*	30.3	81.7	94.8	38.8	12.4	12.8	340

* Estimated

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Greybull River at Meeteetse, Wyoming													
Drainage Area: 695 Sq. Mi.										Period: Broken 1910 - 1928; April 1930 - Sept. 1937			
Maximum	36.5	11.9	8.7	7.2	7.5	14.8	28.8	87.3	132.0	98.4	65.2	31.8	407
Minimum	6.1	5.6	4.1	2.9	2.2	4.0	6.2	24.0	16.9	17.9*	11.3*	6.2*	173*
Mean	13.0	8.2	6.6	5.3	4.7	6.3	11.3	45.6	88.4	45.2	24.0	13.4	280
Mean 1930 - 37	9.8	7.2	5.8	4.6	3.5	5.2	10.6	42.0	88.6	34.5	22.8	9.7	255

* No record during dry years of 1919 and 1934.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Shell Creek at Shell, Wyoming													
Drainage Area: 246 Sq. Mi.										Period: Broken 1911-1912; Oct. 1913 - Sept. 1923			
Maximum	7.0	5.8	4.1	3.8	3.1	4.0	16.3	43.4	63.1	15.9	7.9	7.3	132
Minimum	3.3	3.3	3.1	3.1	2.5	2.5	2.2	9.7	8.8	4.0	3.5	2.9	74
Mean	5.0	4.4	3.7	3.3	2.9	3.3	4.6	20.0	35.5	11.3	6.1	5.3	105
Shoshone River below Shoshone Reservoir, Wyoming													
Drainage Area: 1,470 Sq. Mi.										Period: Jan. 1921 - Sept. 1937			
Maximum	57.8	63.1	44.1	50.3	33.2	79.3	103.0	342	462	334	177	134	1,350
Minimum	6.9	6.7	11.0	10.8	9.8	5.3	16.9	60	105	86	51	26	537
Mean	33.8	24.5	22.0	20.0	15.5	19.5	32.0	118	300	190	87	57	920
Mean 1930 - 37	32.0	21.7	19.1	14.2	12.2	12.4	29.0	94	278	162	96	65	836

0663

Table 34

ESTIMATED* RUN-OFF OF THE BIG HORN RIVER AT MONTANA-WYOMING STATE LINE

(1,000 Acre-feet)

Year Ending Sept. 30:	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Annual
1906	108	82	89	94	107	203	210	498	777	649	329	168	3,314
1907	81	81	87	57	49	92	152	495	954	1315	406	158	3,907
1908	106	81	94	65	70	80	152	322	1286	862	326	150	3,594
1909	140	92	79	85	106	267	117	252	1267	1008	284	258	3,955
1910	110	113	55	88	93	194	235	512	501	332	180	108	2,521
1911	82	84	81	56	62	78	100	206	794	502	260	161	2,463
1912	94	58	50	50	51	101	194	309	1037	708	338	290	3,280
1913	262	82	98	85	85	245	391	442	846	626	272	152	3,586
1914	117	72	91	97	83	99	187	589	979	436	172	97	3,019
1915	129	106	89	63	54	95	125	201	857	518	210	305	2,752
1916	236	130	106	105	107	131	158	295	914	732	224	118	3,246
1917	116	102	71	60	99	314	279	409	1094	1075	238	184	4,041
1918	106	101	126	142	101	262	175	316	1267	632	188	153	3,569
1919	138	104	78	94	82	92	106	175	145	36	59	61	1,170
1920	99	88	74	82	109	161	181	402	970	673	167	76	3,082
1921	102	118	126	105	119	119	96	341	1152	297	97	76	2,748
1922	74	93	87	92	72	116	173	305	970	481	170	156	2,789
1923	90	94	73	70	62	162	177	374	857	797	260	291	3,307
1924	467	233	167	78	103	123	764	904	1421	732	156	146	5,294
1925	197	174	113	100	132	136	275	529	-	-	-	-	
1929	123	109	100	74	60	374	192	404	702	351	105	140	2,734
1930	131	108	104	66	88	112	155	281	626	350	475	175	2,671
1931	183	141	96	74	76	85	83	308	581	83	122	59	1,891
1932	83	70	70	75	83	129	119	496	853	459	113	180	2,730
1933	94	95	63	62	46	88	112	272	995	228	215	101	2,371
1934	94	94	75	77	64	72	103	199	128	79	67	58	1,110
1935	90	75	66	58	71	81	87	154	1048	398	61	50	2,239
1936	74	74	71	76	67	104	146	338	697	220	151	52	2,070
1937	102	100	64	46	46	97	131	348	763	534	64	84	2,379
Maximum	467	233	167	142	132	374	764	904	1421	1315	475	305	5,294
Minimum	74	58	50	46	46	72	83	154	128	36	59	52	1,110
Mean-28 yrs	132	102	88	78	81	146	185	368	874	540	204	143	2920
Mean-1930-37	106	95	76	67	68	96	117	300	711	294	158	95	2,180

* Run-off at state line from Feb. 1929 to Sept. 1937 taken as the run-off of the Big Horn River at Kane plus the Shoshone River at Byron. Run-off at state line from Oct. 1906 to Jan. 1929 estimated by comparison with the Big Horn River at Hardin.

Table 22

EXISTING IRRIGATION PROJECTS

Big Horn River Basin(1)

(Acres)

Project Name and Location	Project No.*	Average Acres Irrigated 1930 - 1938	Average Annual Shortage 1930 - 1938 (Acre-Feet)	Irrigable Area Under Present System	Additional Irrigable Area by Extension of Project	Ultimate Irrigable Area in Project
Wyoming		342,285	167,000	486,430	176,525	662,955
Main Stem		48,900	15,710	61,380	4,000	65,380
Kirby Ditch	128	2,000		2,370		2,370
Hanover Irrigation Dist.(Upper)	123	11,000		13,880	3,300	17,180
Bluff Irrigation Co.	124	2,800	420	3,500	700	4,200
Misc. (Along Big Horn)		400		400		400
Big Horn Canal Ass'n.	115	18,000	9,130	25,000		25,000
Fritz Ditch	121	1,000		1,160		1,160
Lower Hanover Canal	122	12,000	6,160	13,000		13,000
White & Pease Ditch	113	300		370		370
Tillard Canal	114	1,400		1,700		1,700
Tributaries		293,383	151,290	425,050	172,525	597,575
Wind River		52,175	5,410	89,825	78,350	168,175
Misc. (Wind River & Long Creek)		250	10	250		250
Misc. (Du Noir River)		2,050	190	2,050	300	2,350
Diamond A Ditch	168	400		400		400
Misc. (Wind River)		4,150		4,150		4,150
Duncan Ditch	159	500	10	500	500	1,000
Misc. (North Fork)		1,275		1,275		1,275
Wind River Project (Indian)	Pt. 142	3,500		15,300	1,700	17,000
Misc. (Crow Creek)		1,000	1,610	2,000		2,000
Misc. (Big Wind River)		200		200		200
Riverton Project, U.S.B.R.	141	12,500		32,000	68,000	100,000
Misc. (Dry Creek)		1,000	2,280	2,000	4,000	6,000
Misc. (Big Wind River)		1,000		1,000	1,000	2,000
Riverton Valley Irrigation Dist.	139	7,500		8,500		8,500
LeClair-Riverton Irrig. Project	140	12,500		12,500		12,500
Wind River Project (Indian)	Pt. 142	1,500		3,600	800	4,400
Wind River Project (Johnstown Ditch)	Pt. 142	900		1,200	50	1,250
Misc. (Wind River)		1,000		1,500		1,500
Misc. (Muddy Creek)		950	1,410	1,400	2,000	3,400
Popo Agie River		40,470	15,460	62,960	12,600	75,560
Wind River Project (Indian)	Pt. 142	15,000		31,000	6,900	37,900
Misc. (Private Projects)		500		2,000	1,500	3,500
Red Butte Ditch	152	800		1,800		1,800
North Fork Ditch	155	625		625		625
Big Cottonwood Ditch	157	2,000		2,070		2,070
Misc. (North Fork Popo Agie River)		3,250	130	3,770		3,770
(St. John Ditch	149)					
(Peterson Ditch	150)					
(Lunn Williams-Sharp Ditch	151)	600		600		600
(Harting-Sharp Ditch	154)					
(Harris-Meyers Ditch	156)					
Misc. (Baldwin Creek)		620	680	920		920
Dutch Flat Ditch	145	1,700	2,020	3,050	200	3,250
Nicol & Table Mt. Ditch	146	2,500	3,630	3,300		3,300
Enterprise Ditch	147	2,850	1,780	2,850		2,850
Gaylor & Warnick Ditch	148	850	1,240	1,100		1,100
Cemetery Ditch	153	950	470	950		950
Misc. (Middle Fork)		3,400	2,470	3,400		3,400
Rogers & Gregg Ditch	144	800	500	800		800
Lyons Ditch	144a	825	730	1,025		1,025
Misc. (Little Popo Agie River)		2,100	630	2,100	2,000	4,100
Samuel P. Large Ditch	143	700	850	1,000		1,000
Misc. (Beaver Creek)		400	430	600	2,000	2,600
Owl Creek		10,980	18,890	21,690	1,000	22,690
Dempsey Canal Co.	129	2,000	2,470	3,200		3,200
South Side Ditch	130	600	1,080	1,790		1,790
DeWitt Ditch	131	500	940	1,340		1,340
Baylor and Purvis Ditch	132	1,000	1,780	3,700		3,700
Mountain View Ditch	133	2,000	2,670	3,000	1,000	4,000
Southside Irrigation Canal	134	1,000	2,090	1,230		1,230
Morrison & McCanaughy Ditch	135	650	1,150	1,350		1,350
Woodward & Johnson Ditch	136	730	1,280	1,080		1,080
Misc. (Along Owl Creek)		2,500	5,430	5,000		5,000
No Wood Creek		11,900	8,780	17,250	2,700	19,950
Highland Ditch	116	1,100	760	1,160	200	1,360
Anita Ditch	117	1,000		2,700		2,700
VanAlstine-Walker Ditch	118	1,000		1,390		1,390
Harmony Ditch	119	800		1,000		1,000
Booker Ditch	137	1,000	1,260	1,500	1,000	2,500
Misc. (Paintrock & Med. Lodge Crs.)		2,000	1,180	2,500	1,500	4,000
Misc. (Norwood Creek)		5,000	5,580	7,000		7,000
Greybull River		58,800	75,810	71,370	7,000	78,370
Butte Ditch	110	2,000	2,740	2,300		2,300
Greybull Ditch	111	1,500	1,660	1,770		1,770
Misc. (Above Wood River)		1,100	1,180	1,100		1,100
Sunshine Basin Ditch	112	1,500	2,040	1,820		1,820
Misc. (Along Wood River)		5,000	7,960	5,300		5,300
Misc. (Greybull & Meeteetse Creek)		3,500	6,400	4,000		4,000
Dyer Ditch, Cheesman Ditch	109	1,000	1,480	1,275		1,275
Misc. (Incl. Arnold #1 Ditch)		900		900		900
Gould Ditch	96	1,000		1,225		1,225
Wood & Burnett Ditch	97	1,500		2,080		2,080
J.F.W. Ditch	98	1,400	1,240	2,000		2,000
Perkins Ditch	99	1,900		1,950		1,950
Beck & Allen Ditch	100	2,000	1,800	2,250		2,250
Farmer's Canal	101	13,000	20,890	15,000		15,000
Bench Canal	102	12,000	16,260	15,000	7,000	22,000
Avent Ditch	103	1,200		1,430		1,430
Sandstone Ditch	104	1,700	3,530	3,270		3,270
Grout Ditch	105	1,000	1,370	1,780		1,780
Croxall & Brown Ditch	106	1,520	800	1,860		1,860
Tutman Canal	107	1,700	2,570	2,000		2,000
German Ditch	108	1,230	2,030	1,860		1,860
Misc. (Along Greybull River)		1,150	1,860	1,200		1,200
Shell Creek		8,760	3,690	13,500	0	13,500
Shell Canal	94	4,000	750	8,000		8,000
Whaley Ditch	95	1,250		1,500		1,500
Misc. (Porter Canal)		1,000		1,000		1,000
Misc. (Shell and Beaver Creeks)		2,500	2,940	3,000		3,000
Shoshone River		98,500	5,630	129,955	70,375	200,330
Misc. (North Fork Shoshone)		1,700	2,000	2,600		2,600
Hunnitt Canal	93a	7,000	2,970	8,000		8,000
Misc. (South Fork Shoshone)		1,500	660	3,000		3,000
Cody Canal Irrigation District	93	11,000		13,500		13.500
Big Forks Ditch	86	2,500		3,000		3,000
Independent Ditch	87	1,000		1,330	400	1,730
Hunt & Godfrey Canal	88	2,800		2,800		2,800
Lovell Canal	89	10,000		15,000	700	15,700
Globe Canal	90	3,000		3,000		3,000
Siden Irrigation District	91	6,000		20,000		20,000
Shoshone Project	92	52,000		57,725	69,275	127,000
Minor Tributaries		11,810	17,620	18,500	500	19,000
Lost Cabin Waterworks Ditch	138	1,200	1,930	1,200		1,200
Misc. (Badwater Creek)		2,250	3,230	2,250	500	2,750
Misc. (Big Horn Trib.)		1,000	1,570	2,000		2,000
Misc. (Grass & Cottonwood Creeks)		3,660	5,110	6,400		6,400
Blake-Denton Project	125	500	660	1,000		1,000
Sunnyside Ditch	126	1,500	2,130	2,650		2,650
Holly-Niccolls Ditch	127	500	700	1,000		1,000
Misc. (Gooseberry Creek)		1,200	2,290	2,000		2,000
Montana		41,375	3,260	61,350	30,900	92,250
Main Stem		40,525	2,650	59,400	28,700	89,100
Two Legging Water Users Ass'n.	82	20,000	1,880	26,000		26,000
Crow Indian Project	Pt. 83	15,600		23,600	28,700	52,300
Big Horn Tullock Irrigation Dist.	79	0		1,000		1,000
Victory Irrigation District	80			2,000		2,000
Big Horn Low Line Ditch Co.	81	4,725	770	6,000		6,000
Misc. (Big Horn River)		200		800		800
Minor Tributaries		850	610	1,950	2,200	4,150
Misc. (Soap Creek)		850	610	1,950	2,200	4,150
Total, Big Horn River		383,660	170,260	547,780	207,425	755,206

Source: Appendix F - Progress Report of the National Resources Planning Board.

(1) Does not include the Little Horn River Basin.

(2) Numbers are those assigned by Corps of Engineers in 308 Report. See Map 8.

(3) Includes Heart Mountain Division.

Table 36

BIG HORN RIVER AT MONTANA-WYOMING STATE LINE*

Low Flows During Irrigation Season

Month	Number of days with flow less than:- 1200 c.f.s.	1000 c.f.s.	800 c.f.s.	600 c.f.s.	Monthly Mean Flow c.f.s.
July					
1930	0	0	0	0	5700
1931(1)	19	17	12	8	1350
1932	0	0	0	0	7470
1933	0	0	0	0	3700
1934	23	18	14	3	1290
1935	0	0	0	0	7520
1936	0	0	0	0	3670
1937	0	0	0	0	9180
1938	0	0	0	0	7630
August					
1930	0	0	0	0	7730
1931(1)	8	3	1	0	1990
1932(1)	0	0	0	0	1840
1933(1)	0	0	0	0	3490
1934	22	18	4	0	1080
1935	2	0	0	0	1560
1936	0	0	0	0	3020
1937	10	3	0	0	1380
1938	0	0	0	0	1930
September					
1930	0	0	0	0	2940
1931	19	19	19	0	990
1932	0	0	0	0	3030
1933	0	0	0	0	1700
1934	23	21	3	0	980
1935	6	0	0	0	1380
1936	5	0	0	0	1330
1937	0	0	0	0	1800
1938	0	0	0	0	2640

Source: Water Supply Papers, U. S. Geological Survey

* 1930-1934, flow of Big Horn at Kane plus flow of Shoshone at Byron. 1935-1938, flow of Big Horn at St. Xavier.

(1) Stream flow records include the following special or unusual releases from Shoshone Reservoir (Source: Letter from U. S. Bureau of Reclamatio dated September 27, 1940):

1931.	From 7/24 to 7/25	125 c.f.s.
	From 7/26 to 8/1	50 c.f.s.
1932.	From 8/5 to 8/28	1000 c.f.s.
1933.	From 8/5 to 8/28	2500 c.f.s.

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Table 37

SELECTED POTENTIAL RESERVOIRS
(And Probable Schedule of Storage and Release Operations)

Big Horn River

(Acre-Feet)

Name of Reservoir	Total Capacity	Nov. 1 to Mar. 31	April	May	June	July	Aug.	Sept.	Oct.	Evaporation Losses
Wind River	219,000	-120,450	- 6,570	- 26,280	- 52,560	87,860	98,550	23,680	-13,140	9,170
Torrey Lake Res.	6,000	- 3,300	- 180	- 720	- 1,440	2,400	2,700	480	- 360	420
Wind River No. 1	40,000	- 22,000	- 1,200	- 4,800	- 9,600	16,000	18,000	4,400	- 2,400	1,600
Dinwoody Res.	23,000	- 12,650	- 690	- 2,760	- 5,520	9,200	10,350	2,300	- 1,380	1,150
Bull Lake Res.*	150,000	- 82,500	- 4,500	- 18,000	- 36,000	60,000	67,500	16,500	- 9,000	6,000
Popo Agie River	117,820	- 64,800	- 3,540	- 14,130	- 28,280	47,130	53,020	11,830	- 7,070	5,840
Raft Lake Res.	30,000	- 16,500	- 900	- 3,600	- 7,200	12,000	13,500	3,000	- 1,800	1,500
Tuygee Res.	10,000	- 5,500	- 300	- 1,200	- 2,400	4,000	4,500	800	- 600	700
Long Beach Res.	12,620	- 6,940	- 380	- 1,510	- 3,030	5,050	5,680	1,010	- 760	880
Christiana Lake(Enl.)	5,200	- 2,860	- 160	- 620	- 1,250	2,080	2,340	420	- 310	360
Louis Lake Res.	60,000	- 33,000	- 1,800	- 7,200	- 14,400	24,000	27,000	6,600	- 3,600	2,400
Greybull River	124,690	- 68,575	- 3,745	- 14,960	- 29,930	49,870	56,115	13,575	- 7,480	5,130
Upper Sunshine*	45,000	- 24,750	- 1,350	- 5,400	- 10,800	18,000	20,250	4,950	- 2,700	1,800
Lower Sunshine	43,500	- 23,925	- 1,305	- 5,220	- 10,440	17,400	19,575	4,785	- 2,610	1,740
Meadows Res.	34,000	- 18,700	- 1,020	- 4,080	- 8,160	13,600	15,300	3,740	- 2,040	1,360
Phelps Res.	860	- 470	- 30	- 100	- 210	340	390	40	- 50	90
Sandstone Res.	670	- 370	- 20	- 80	- 160	270	300	30	- 40	70
Gould Res.	660	- 360	- 20	- 80	- 160	260	300	30	- 40	70
Shoshone River										
Oregon Basin Res.	150,000	- 82,500	- 4,500	- 18,000	- 36,000	60,000	67,500	16,500	- 9,000	6,000
Misc. Above Shoshone R.	138,400	- 76,125	- 4,415	- 16,610	- 33,210	55,360	62,290	15,970	- 8,310	6,780
South Owl Cr. Res.	9,800	- 5,390	- 290	- 1,180	- 2,350	3,920	4,410	780	- 590	690
Basin Reservoir	6,000	- 3,300	- 180	- 720	- 1,440	2,400	2,700	480	- 360	420
Grass Creek Res.	2,600	- 1,430	- 80	- 310	- 620	1,040	1,170	130	- 160	260
Buffalo Cr. Res.	100,000	- 55,000	- 3,000	- 12,000	- 24,000	40,000	45,000	11,000	- 6,000	4,000
Tensleep Meadows	13,500	- 7,425	- 405	- 1,620	- 3,240	5,400	6,080	1,080	- 810	940
Solitude Res.	6,000	- 3,300	- 180	- 720	- 1,440	2,400	2,700	480	- 360	420
Shell Lake Res.	500	- 280	- 10	- 60	- 120	200	230	20	- 30	50
Total, Wyoming	749,910	-412,450	-22,500	- 89,980	-179,980	299,960	337,475	79,555	-45,000	32,920
Big Horn Canyon Res.	200,000	-110,000	- 6,000	- 24,000	- 48,000	80,000	90,000	22,000	-12,000	8,000
Total, Big Horn Basin	949,910	-522,450	-28,500	-113,980	-227,980	379,960	427,475	101,555	-57,000	40,920

Source: Field Survey Sheets (1939) of the Corps of Engineers, War Department.

* Project recently constructed. Included here because reservoir operations are not reflected in stream flow records to date.

D. LITTLE HORN RIVER

1. Stream Flow

The Little Horn River is a tributary of the Big Horn River, but it is treated separately in this report because it crosses the Montana-Wyoming state line. It is a small stream, rising in the Big Horn mountains in northern Wyoming, and flowing northward across Montana to its confluence with the Big Horn near Hardin. Several of its tributaries also rise in Wyoming and parallel the main stem until they reach Montana where they converge and join the main stem. The main stem is about 125 miles long, and by far the greater portion is in Montana. Its major tributary, Lodgegrass Creek, lies almost entirely within Montana.

In 1905 a gaging station was established near Crow Agency, Montana, not far from the mouth. The station was discontinued after two years, but it was re-established in 1912 and has been operated, with minor interruptions, to date. The average annual discharge of the river at this point is about 225,000 acre-feet. A gage was established at Wyola, Montana, in 1912, and a continuous record kept until 1924 when the station was abandoned. This gage probably represents fairly accurately the total discharge at the state line of all the tributary streams of the Little Horn that rise in Wyoming. For this reason, the entire record (by months) of this station has been given in table 39. Table 38 gives the maximum, minimum, and mean monthly discharges of the Little Horn River, near Crow Agency, and of Lodgegrass Creek, near Lodge Grass, Montana.

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2. Existing Irrigation Projects

By far the greater portion of the land irrigated by the Little Horn is in Montana, although estimates of the area under irrigation in Wyoming vary widely. Table 40 presents data on the irrigated and irrigable areas in each project (or group of small projects) in the basin. These data were obtained by the Corps of Engineers through a field survey made in the spring of 1939. The projects are arranged in the table according to location and source of water supply. Map 8 shows the location of the major projects, which can be identified by the numbers thereon and by reference to column 2 of table 40. According to Corps of Engineers' survey, there are 20,990 acres under canals, of which 13,780 acres are being irrigated at present. This survey reports about 1,600 acres in Wyoming under canal, all of which are being irrigated. The Wyoming Report estimates this figure at 7,800 acres (see table 18). Most of the land in Montana is irrigated from systems under the control of the U. S. Indian Irrigation Service (see Section I-B-1).

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Projects on Main Stem in Montana

The projects in Montana that take their water supply directly from the main stem of the Little Horn are grouped in table 40, and the data concerning them totaled. An average annual shortage of 6,120 acre-feet was reported for the 8,410 acres irrigated. Shortages occurred all along the stream during the late season of each year from 1930 to 1938, Evidence of this shortage is apparent in the stream-gaging records of the station near Crow Agency, which show that frequently there is less than 50 second-feet in the river during August and September, and that occasionally the stream is practically dry.

3. Potential Irrigation Projects

The only potential projects in the Little Horn Basin are the Parkman Irrigation District project and the group of miscellaneous small projects having a total area of 7,000 acres which were included in the Wyoming Report. Data on these projects are presented in tables 1 and 2 of Appendix I. The Parkman Irrigation District project is described in Appendix IV of the Corps of Engineers 308 Report, but no further information on the miscellaneous small projects is available. Under the Parkman Irrigation District project, it is proposed to divert water from the upper Tongue River to West Fool Creek, a tributary of the Little Horn, to supplement the water supply for lands now under irrigation and to irrigate 5,470 acres of new land. The water would be applied to the land from the existing distribution system. It is estimated that new project features would cost $200,000.

Ultimate Irrigable Area

The ultimate irrigable area in the basin, as estimated by the Corps of Engineers, is 42,460 acres (see table 18). This area may be classified as to location and state of development as follows:

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Ultimate Irrigable Area in the Little Horn Basin - Acres

	Wyoming	Montana		
		Main Stem	Tributaries	Total
Irrigated at present	1,600	8,410	3,770	13,780
Under ditch, but not irrigated at present	0	6,330	880	7,210
Irrigable by extension of projects	2,030	9,320	4,650	16,000
Area in potential projects	5,470	0	0	5,470
Total	9,100	24,060	9,300	42,460

The Wyoming Report estimated the ultimate irrigable area in Wyoming at 14,800 acres (see table 18 and Appendix I, table 2). The Montana Report did not give an estimate of the area in Montana, but, in commenting on the estimates of the 308 Report, did not offer any revision. The Indian Irrigation Service estimates that the ultimate area that can be irrigated by the extension of systems under its control is about 27,000 acres. This area is listed by systems in Section I-B-1.

4. Reservoir for Irrigation Storage

The only reservoir in the Little Horn Basin is the Willow Creek reservoir on Willow Creek (Montana), which was completed recently. Its operations (capacity 22,800 acre-feet) are not reflected in the stream flow records to date. The only known potential reservoir is the Twin Creek Reservoir listed in table 1 of Appendix II. This potential reservoir, which would have a capacity of 1,000 acre-feet, is not included in the water use studies of Appendix F of the Progress Report (1939) of the National Resources Planning Board.

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Table 38

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MAXIMUM, MINIMUM, AND MEAN RUN-OFF OF MAJOR STREAMS IN THE LITTLE HORN RIVER BASIN

(1,000 Acre-feet)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual Total
Little Horn River near Crow Agency, Mont.													
Drainage Area: 1,157 Sq. Mi.					Period: Oct. 1904-Sept. 1906; Apr. 1912 - Sept. 1924; Aug. 1928-Nov. 1933								
Maximum	52.9	33.7	-	-	-	-	115.0	66.4	78.6	49.6	16.9	22.7	486
Minimum	3.6	3.1	-	-	-	-	7.0	14.4	7.4	3.1b	1.7	2.3	110
Mean	12.0	10.4	9a	8a	8a	25a	31.1	39.6	49.7	18.9	8.6	7.9	224
Little Horn River near Wyola, Mont.													
Drainage Area: 246 Sq. Mi.											Period: Broken 1912 - 1924		
Maximum	20.4	13.5	-	-	-	-	11.5	34.2	56.8	24.8	10.8	9.5	209
Minimum	3.9	4.2	-	-	-	-	4.9	10.1	8.6	4.0	3.3	3.2	86
Mean	7.7	6.6	6a	5a	5a	7a	7.4	20.3	33.1	13.4	7.4	6.5	125
Lodgegrass Creek near Lodge Grass, Mont.(1)													
Drainage Area: 146 Sq. Mi.											Period: Broken 1912 - 1924		
Maximum	6.0	3.3	-	-	-	-	10.9	11.1	29.8	8.6	3.5	3.1	59.9
Minimum	0.5	0.6	-	-	-	-	1.4	2.7	0.7	0.0	0.0	0.0	12.5
Mean	1.8	1.6	1a	1a	1a	5a	5.4	7.1	12.5	4.0	1.6	1.5	42.3

a Estimated.

b Measured in 1931. An extended record for July 1906 indicates a run-off of 1,840 acre-feet for that month.

a Estimated

a Estimated

(1) From 1916 to 1920 the gaging station was 6 miles downstream at Lodge Grass. Drainage Area: 181 square miles.

Table 39

RUN-OFF OF THE LITTLE HORN RIVER NEAR WYOLA, MONTANA

Drainage Area: 246 Square Miles (1,000 Acre-feet)

Year Ending Sept. 30:	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1912								19.1	50.9	24.6b			
1913							11.3b	33.0	34.6	15.4	8.4	6.8	
1914	7.1	6.2	5.8a	5.2a	4.7a	5.5b	8.0	31.1	27.1	10.5	7.6	7.1b	126
1915								19.5	29.5	15.0	8.8	7.6	
1916	7.3	6.6	6.5b	5.5a	5.2a	15.4b	6.8	16.0	33.6	14.7	8.2	7.1	133
1917	7.4	6.6	6.6b	5.5a	5.0a	6.8b	6.8	16.4	46.5	20.8	9.1	6.7	144
1918	7.1	6.7	6.8a	5.5a	5.0a	8.6b	8.3	22.0	50.3	15.2	8.4	7.5	151
1919	7.8							14.0	8.6	4.0	3.3	3.4	
1920	5.2	5.2b	5.2a	4.9a	4.6a	6.0b	5.7	10.1	18.7	7.3	6.5	6.3	86
1921	6.4	5.9	5.3	4.9a	4.4a	6.5b	6.1	15.1	23.3	5.2	5.0	3.2	91
1922	3.9	4.6	4.6a	4.3a	3.9a	5.4b	5.1	14.0	24.7	7.2	5.1	3.9	87
1923	4.3	4.2b	4.2a	4.0a	3.3a	4.5b	4.9	19.2	26.3	9.6	7.4	9.2	101
1924	20.4	13.5	10.0	6.8a	5.2a	5.7b	11.5	34.2	56.8	24.8	10.8	9.5	209
Maximum	20.4	13.5	10.0	6.8	5.2	15.4	11.5	34.2	56.8	24.8	10.8	9.5	209
Minimum	3.9	4.2	4.2	4.0	3.3	4.5	4.9	10.1	8.6	4.0	3.3	3.2	86
Mean	7.7	6.6	6.1	5.2	4.6	7.1	7.4	20.3	33.1	13.4	7.4	6.5	125

a - Estimated
b - Partially Estimated

Source: Appendix II, H.D. 256

Table 40

EXISTING IRRIGATION PROJECTS

Little Horn River Basin

(Acres)

Project Name and Location	Project No.*	Average Acres Irrigated 1930 - 1938	Average Annual Shortage 1930 - 1938 (Acre-Feet)	Irrigable Area Under Present System	Additional Irrigable Area by Extension of Project	Ultimate Irrigable Area in Project
Wyoming		1,600	1,480	1,600	2,030	3,630
Jones Ditch	85	800	740	800	900	1,700
Misc. (Little Horn River)**		800	740	800	1,130	1,930
Montana		12,180	10,300	19,390	13,970	33,360
Main Stem		8,410	6,120	14,740	9,320	24,060
Misc. (Little Horn River)**		900	830	900	1,270	2,170
Crow Indian Project	Pt. 83	2,760	2,530	5,680	6,300	11,980
Crow Indian Project	Pt. 83	4,650	2,760	8,000	1,750	9,750
Misc. (Little Horn River)		100		160		160
Tributaries		3,770	4,180	4,650	4,650	9,300
Lodge Grass 1 & 2	Pt. 83	3,050	3,980	3,050	3,650	6,700
Stevens Ditch	84	500	140	1,000		1,000
Misc. (Lodge Grass Creek)		220	60	600	1,000	1,600
Total, Little Horn River Basin		13,780	11,780	20,990	16,000	36,990

Source: Appendix F - Progress Report of the National Resources Planning Board.

* Numbers are those assigned by Corps of Engineers in 308 Report. See Map 8.

** An arbitrary distribution between states of a single grouping by the Corps of Engineers.

E. TONGUE RIVER

1. Stream Flow

The Tongue River rises in the northeastern portion of the Big Horn Mountains in Wyoming in a number of small streams that flow through gently rolling country before they unite, just south of the Montana-Wyoming boundary line, to form a single stream. From the state line the stream flows northeastward through Montana for 125 miles to Miles City, where it empties into the main stem of the Yellowstone. Throughout the lower area in Wyoming irrigation water is diverted from the tributary streams, many of which are almost completely depleted.

Stream gagings above the diversions have been inadequate, which renders it impossible to estimate with confidence the natural or undepleted stream flow. In 1928 a gaging station was established at Decker, Montana, two miles north of the Wyoming line, and was operated until September 1938. The entire record, by months, for this station is reproduced in table 42. Short or broken records exist for several other gaging points in the basin. Table 41 presents the maximum, minimum, and mean monthly run-off at three of these stations.

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2. Existing Irrigation Projects

Table 43 presents data on the irrigated and irrigable areas in each project (or group of small projects) in the basin. These data were obtained by the Corps of Engineers through a field survey made in the spring of 1939. The projects are arranged in the table according to location and source of water supply. Map 8 shows the location of the major

projects, which can be identified by the numbers thereon and by reference to column 2 of table 43. Appendix III of the Corps of Engineers 308 Report contains a brief description of each existing project. According to the 1939 survey, a total of 57,605 acres are under canals, of which 53,305 acres are being irrigated at present. Of the area under canals, about 75 percent is in Wyoming and 25 percent in Montana.

Projects on Main Stem in Montana

It will be noted from table 43 that all of the existing projects in Montana take their water supply directly from the main stem of the Tongue River. This table also indicates that the 13,840 acres being irrigated in Montana suffered an average annual shortage of 10,450 acre-feet during the period 1930-1938. According to the field survey sheets from which the table was prepared, shortages occurred during July, August, and September of every year, and were particularly severe in 1934. From table 44, it is evident that there is frequently less than fifty second-feet in the river at the state line. From July 18 to September 3, 1934, there was never more than ten second-feet in the river at this point. The combined capacity of the diversion canals in Montana is about 300 cubic feet per second, and the gage at Miles City shows that the canals divert the entire stream during most of the irrigation season.

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3. Potential Irrigation Projects

Appendix F of the Progress Report (1939) of the National Resources Planning Board includes only two potential projects in the basin: (1) the Tongue River Water Users' Association project of 19,000 acres, and (2) a group of small projects on Pumpkin Creek aggregating 3,200 acres. Both of these projects are in Montana. The area in the Tongue River Water Users' project is limited by the capacity of the Tongue River Reservoir.

The Wyoming Report estimates the potential irrigable area in Wyoming to be 24,500 acres under the classification "misscellaneous (potential) projects and extensions of present projects." These projects are all listed in tables 1 and 2 of Appendix I. The Parkman Irrigation District project, which diverts water from the Tongue River, has been discussed in Section II-D (Little Horn River).

During the months of September and October 1934, the Montana Water Conservation Board made a plane table survey of the Tongue River Valley, beginning at the site of the Tongue River Dam and extending continuously down the river to the Northern Pacific Railway bridge at Miles City. The irrigated and irrigable lands were classified as follows:

A. Good soil and easy to irrigate.
B. Good soil but needing special preparation for irrigation.
C. Poor soil, or too rough to irrigate easily.

The results of the survey were reported by Mr. Fred E. Buck in a memorandum to the Montana Water Conservation Board dated March 19, 1935. The totals shown in the memorandum are tabulated below:

Land Class	Acres Irrigated	Acres Irrigable	Total Acres
A	4,966	4,544	9,510
B	3,132	11,729	14,861
C	519	6,148	6,667
Brush	-	5,893	5,893
Total	8,617	28,314	36,931

Of this total area, it was estimated that the portion indicated below could best be irrigated by pumping:

Class	No. of Acres
A	3,546
B	6,059
C	2,563
Brush	1,706
Total	13,874

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The 19,000 acres listed under the Tongue River Water Users' Association project may have been selected by the Army Engineers from the details of this survey.

It is evident from the stream flow records that additional irrigation in this basin must depend upon new storage capacity. The Tongue River Reservoir has recently been built near Decker to permit more extensive irrigation in Montana. Contracts are being made for storage space in the reservoir, including one for 7,500 acre-feet with the Federal government for the use of the Indians on the Tongue River Reservation.

Ultimate Irrigable Area

The ultimate irrigable area of the basin, as estimated by the Corps of Engineers, is 86,155 acres (see table 18). This area may be classified as to location and state of development as follows:

Ultimate Irrigable Area in the Tongue Basin - Acres

	Wyoming	Montana		Total
		Main Stem	Tributaries	
Irrigated at present	39,465	13,840	0	53,305
Under ditch, but not irrigated at present	3,200	1,100	0	4,300
Irrigable by extension of projects	5,100	1,250	0	6,350
Area in potential projects	0	19,000	3,200	22,200
Total	47,765	35,190	3,200	86,155

The Wyoming Report estimated the ultimate irrigable area in Wyoming at 125,650 acres (see table 18 and Appendix I, table 2). The Montana Reports do not give an estimate of the ultimate irrigable area in Montana, but indicate that the Army estimate should be increased by 1,000 acres (see Appendix I, table 2). The Indian Service has authorized construction of several pumping projects to irrigate from 1,000 to 1,500 acres, and is

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reserving 7,500 acre-feet of storage capacity in the Tongue River Reservoir (see Section I-B-1).

4. Reservoirs for Irrigation Storage

Existing Reservoirs

As shown in table 17, there are four existing reservoirs in the basin having a combined capacity of 73,020. Big Horn, Dome Lake, and Park reservoirs are all in Wyoming and have a total capacity of 13,020 acre-feet. The Tongue River Reservoir, which is in Montana, has a capacity of 60,000 acre-feet.

Potential Reservoirs

Table 1 of Appendix II lists eight potential reservoirs in Wyoming having an aggregate capacity of 103,446 acre-feet. Pumpkin Creek Reservoir, with a capacity of 6,800 acre-feet, is listed in table 3 of Appendix II. Two additional reservoirs on Pumpkin Creek are listed in table 2 of Appendix II. Four potential reservoirs were selected by the Corps of Engineers for inclusion in the water use studies of Appendix F. The capacity and probable schedule of operations of each of these reservoirs is given in table 45. The Tongue River Reservoir was included in the table because its operations are not yet reflected in stream flow measurements.

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Table 41

MAXIMUM, MINIMUM, AND MEAN RUN OFF OF MAJOR STREAMS IN THE TONGUE RIVER BASIN

(1,000 Acre-feet)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Tongue River near Dayton, Wyo.													
Drainage Area: 204 Sq. Mi.										Period: Oct. 1918 - Sept. 1929			
Maximum	17.5	9.2	6.6	5.5	4.7	4.4	21.1	64.6	83.9	37.9	15.0	9.3	229
Minimum	3.5	2.8	2.5	2.9	2.7	3.0	3.0	19.8	12.7	5.0	3.3	2.6	78
Mean	6.7	4.9	4.3	4.0	3.5	3.7	7.8	38.2	45.2	18.2	8.9	6.2	145
Tongue River at Carneyville, Wyo.													
Drainage Area: 509 Sq. Mi.										Period: Broken, 1911 - 1917			
Maximum	-	-	-	-	-	-	-	78.5	96.4	25.5	9.3	10.8	-
Minimum	-	-	-	-	-	-	-	21.0	21.9	6.2	5.3	5.1	-
Mean	9.7	6.5[a]	4.0[a]	3.7[a]	3.4[a]	10.2[a]	15.0	43.8	63.2	18.0	7.7	7.9	215
Goose Creek near Sheridan, Wyo.													
Drainage Area: 110 Sq. Mi.						Period: Broken 1896-97; broken 1911-16; Oct. 1930 - Sept. 1937							
Maximum	7.5	8.9	5.5	2.5	2.2	2.5	5.4	32.9	64.9	12.4	3.2	3.2	114.0
Minimum	0.7	0.4	0.4	0.3	0.2	0.2	1.2	2.6	3.0	0.9	0.4	0.7	25.6
Mean	2.5	2.4	1.5	1.0	0.9	1.1	3.2	14.5	26.4	4.5	1.6	1.5	64.7
Mean 1930 - 37	1.4	1.1	0.7	0.6	0.5	0.6	2.4	15.9	23.9	3.9	1.5	1.0	55.6

[a] Estimated

Table 42

RUN-OFF OF THE TONGUE RIVER NEAR DECKER, MONTANA

Drainage Area: 1,610 square miles (1,000 Acre-feet)

Year Ending Sept. 30:	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1928							13.5	147.0	122.0	105.0	22.3	17.8	
1929							55.8	133.0	195.0	45.1	9.7	13.2	
1930	17.1	15.4				11.9	33.4	56.8	38.0	7.3	6.4	5.0	
1931	14.7	11.7				10.6	15.9	73.2	44.1	3.4	3.3	4.3	
1932	13.1	11.7	9.2	8.6	8.3	12.4	20.3	130.0	84.5	14.2	3.5	6.1	322
1933	13.8	13.0	10.1	9.8	7.2	17.7	38.3	127.0	162.0	11.4	4.6	7.7	423
1934	12.3	13.4	10.2	9.2	8.6	9.7	19.5	19.0	8.2	1.1	.3	.8	112
1935					6.5	7.7	12.0	32.6	105.0	17.3	2.1	5.2	
1936	8.8	9.6	9.3	8.7	7.1	23.6	18.6	30.4	40.5	5.7	2.7	2.6	168
1937	9.9	11.0	7.6	4.0	4.5	12.6	25.7	49.7	114.0	32.5	4.5	4.6	281
Maximum	17.1	15.4	10.2	9.8	8.6	23.6	55.8	147.0	195.0	105.0	22.3	17.8	423
Minimum	8.8	9.6	7.6	4.0	4.5	7.7	12.0	19.0	8.2	1.1	0.3	0.8	112
Mean	12.8	12.3	9.3	8.1	7.0	13.5	26.6	79.8	91.3	24.3	5.9	6.8	261

Table 43

EXISTING IRRIGATION PROJECTS

Tongue River Basin

(Acres)

Project Name and Location	Project No.*	Average Acres Irrigated 1930 - 1938	Average Annual Shortage 1930 - 1938 (Acre-Feet)	Irrigable Area Under Present System	Additional Irrigable Area by Extension of Project	Ultimate Irrigable Area in Project
Wyoming		39,465	22,250	42,665	5,100	47,765
Main Stem & Minor Tributaries		11,345	4,170	11,345	2,650	13,995
Tongue River No. 1 Ditch	37	2,550		2,550	200	2,750
Oz & K & Hanover Ditch	38	2,000		2,000		2,000
Tongue River Ditch Co.	39	1,200	450	1,200		1,200
Wyoming & Five Mile Ditch	40	1,900	2,640	1,900	400	2,300
Stewart Ditch	42	500	960	500	1,000	1,500
South Side Tongue & Dayton Ditch	43	1,450		1,450	750	2,200
Highline Ditch	44	1,185		1,185	300	1,485
Misc. (Including Reliable Ditch)		560	120	560		560
Goose Creek & Tributaries		27,410	17,300	30,610	2,450	33,060
Peralta Ditch Co.	48	4,000	4,450	5,700		5,700
Last Chance Ditch Co.	52	2,700	1,240	2,700	1,500	4,200
Colorado Colony Ditch	59	6,700	3,920	6,700		6,700
Alliance Ditch Co.	45	4,150	1,700	4,150		4,150
Big Goose and Beaver Ditch Co.	47	6,000	2,940	7,500		7,500
Suburban Homes Co.	41	1,660	1,330	1,660	300	1,960
Patrick Land & Livestock Co.	46	2,200	1,720	2,200	650	2,850
Prairie Dog Creek		710	780	710	0	710
Misc. (Prairie Dog Creek)		710	780	710		710
Montana		13,840	10,450	14,940	1,250	16,190
Main Stem		13,840	10,450	14,940	1,250	16,190
Misc. (Prairie Dog to Otter Creek)		600	750	600		600
Tongue River Irrigation Project (Indian)		100		1,200	1,250	2,450
Misc. (Otter to Pumpkin Creek)		3,340	3,520	3,340		3,340
Tongue & Yellowstone Irrigation District	35	9,800	6,180	9,800		9,800
Tributaries		0	0	0	0	0
Total, Tongue River Basin		53,305	32,700	57,605	6,350	63,955

Source: Appendix F - Progress Report of the National Resources Planning Board.

* Numbers are those assigned by Corps of Engineers in 308 Report. See Map 8.

Table 44

TONGUE RIVER AT MONTANA-WYOMING STATE LINE[1]

Low Flows During Irrigation Season

Month	Number of days with flow less than: 200 c.f.s.	150 c.f.s.	100 c.f.s.	50 c.f.s.	Monthly Mean Flow c.f.s.
July					
1930	31	26	10	0	119
1931	31	31	27	13	55
1932	19	16	12	0	231
1933	19	15	10	2	186
1934	31	31	31	29	17
1935	14	9	6	0	281
1936	28	27	25	10	92
1937	1	0	0	0	528
1938	0	0	0	0	575
August					
1930	31	31	15	0	104
1931	31	31	29	20	53
1932	31	31	31	14	56
1933	29	27	25	12	75
1934	31	31	31	31	5
1935	31	31	31	27	34
1936	31	31	31	24	44
1937	31	30	25	3	74
1938	31	29	11	0	109
September					
1930	30	30	27	0	84
1931	29	22	21	20	73
1932	30	25	18	0	102
1933	30	20	2	0	130
1934	30	30	30	30	13
1935	30	30	18	1	87
1936	30	30	29	22	43
1937	30	28	24	0	77
1938	30	30	8	0	110

Source: Water Supply Papers, U. S. Geological Survey

(1) Tongue River near Decker, Montana.

0681

Table 45

SELECTED POTENTIAL RESERVOIRS
(And Probable Schedule of Storage and Release Operations)

Tongue River Basin

(Acre-Feet)

Name of Reservoir	Total Capacity	Nov. 1 to Mar. 31	April	May	June	July	Aug.	Sept.	Oct.	Evaporation Losses
Wyoming										
Rockwood Res.	21,750	-11,960	- 650	- 2,610	- 5,220	8,700	9,790	2,170	-1,310	1,090
North Fork Res.	28,000	-15,400	- 840	- 3,360	- 6,720	11,200	12,600	2,800	-1,680	1,400
South Fork Res.	25,000	-13,750	- 750	- 3,000	- 6,000	10,000	11,250	2,500	-1,500	1,250
Total, Wyoming	74,750	-41,110	-2,240	- 8,970	-17,940	29,900	33,640	7,470	-4,490	3,740
Montana										
Tongue River Res.*	60,000	-33,000	-1,800	- 7,200	-14,400	24,000	27,000	6,600	-3,600	2,400
Pumpkin Cr. Res.	6,800	- 3,740	- 204	- 816	- 1,632	2,720	3,060	540	- 408	480
Total, Montana	66,800	-36,740	-2,004	- 8,016	-16,032	26,720	30,060	7,140	-4,008	2,880
Total, Tongue Basin	141,550	-77,850	-4,244	-16,986	-33,972	56,620	63,700	14,610	-8,498	6,620

Source: Field Survey Sheets (1939) of the Corps of Engineers, War Department.

*Project recently constructed. Included here because reservoir operations are not reflected in stream flow records to date.

F. POWDER RIVER

1. Stream Flow

The Powder River rises on the eastern slope of the Big Horn Mountains in Wyoming and flows northeastward across the state line into Montana. A few miles below Powderville, Montana, the river turns north-northwestward and continues in that general direction to its confluence with the Yellowstone River, near Terry. The air-line distance from the headwaters to the mouth is about 250 miles. The Wyoming portion of the basin is divided naturally into three sub-basins, the Clear Creek Basin, the Crazy Woman Creek Basin, and the Upper Powder River Basin. Irrigation is rather extensive in all of these three sub-basins. In its lower reaches the Powder River follows a winding course through a valley varying in width from one-half to three miles, and flanked by rolling benches 100 to 500 feet high. Irrigation along the lower reaches is at present almost negligible, as is indicated by the fact that less than 400 acres in Montana are irrigated from the Powder River.

0683

In 1915 a stream gage was established on the main stem below Arvada, Wyoming. In 1919 it was moved 20 miles upstream to Arvada, and has been operated, with minor interruptions, to date. The total record of these two gages is the longest period of record in the Powder River Basin. The annual discharge of the stream at Arvada has ranged from 165,000 to 840,000 acre-feet, averaging 440,000 acre-feet. The gage at Moorhead, Montana, which was established in 1915, is probably a better representation of the flow at the state line. The entire record of this gage is given in table 47. It will be noted from this record that the flow at the state line

is extremely low during the late irrigation season. A number of gages have been operated from time to time in the tributary basins, but the gagings are inadequate to permit accurate stream flow reconstruction. Extreme and mean discharges at several points are shown in table 46.

2. Existing Irrigation Projects

Practically all the irrigated land in the Powder River Basin is in Wyoming. Table 48 presents data on the irrigated and irrigable areas in each project or group of small projects. These data were obtained by the Corps of Engineers through a field survey made in the spring of 1939. The projects are arranged in the table according to location and source of water supply. Map 8 shows the location of the major projects, which can be identified by the numbers thereon and by references to column 2 of table 48. Appendix III of the 308 Report contains a brief description of each existing project. According to the 1939 survey, a total of 75,480 acres are under canals, of which 63,785 acres are being irrigated at present. As indicated in table 48, shortages are general throughout the basin, amounting to an average of 47,000 acre-feet annually during the period 1930 to 1938. Shortages occurred during every month of every year of this period, but were most severe in 1934.

0684

Projects on Main Stem in Montana

Only 380 acres in the Powder River Basin in Montana are irrigated at present. This area is in small tracts along the river, in Custer and Prairie Counties, and is irrigated from the main stem by pumping. The capacity of the pumps is given as seven cubic feet per second. Although the average annual shortage during the period 1930 to 1938 is reported at 60 acre-feet, from the record at Moorhead, it appears that the flow at that point seldom falls below the combined pump capacity

of seven cubic feet per second.

3. Potential Irrigation Projects

Table 1 of Appendix I lists five potential projects in the Powder River Basin. The Sussex project is considered a duplication of the Red Fork project, and there is insufficient water for both the Johnson County project and the Northern Wyoming Land Company project, which leaves three potential projects in the basin, with a combined area of 41,325 acres. These three projects are included in the water-use studies of Appendix F of the Progress Report of the National Resources Planning Board, and are listed in table 20. Table 2 of Appendix I lists 18,000 acres in potential miscellaneous small projects in Wyoming. Table 2 also shows six potential projects having an area of 14,600 acres that were reported by the Montana Water Conservation Board. No further information is available on the projects in table 2. Inspection of stream flow records in the basin and of existing shortages as reported in table 48 indicates that additional irrigation in the Powder River Basin must depend upon new storage capacity.

0685

Ultimate Irrigable Area

The ultimate irrigable area of the basin as estimated by the Corps of Engineers is 122,705 acres (see table 18). This area may be classified as to location and state of development as follows:

Ultimate Irrigable Area in the Powder Basin - Acres

	Wyoming(1)	Montana		Total
		Main Stem	Tributaries(1)	
Irrigated at present	63,405	380	0	63,785
Under ditch, but not irrigated at present	11,695	0	0	11,695
Irrigable by extension or projects	5,900	0	0	5,900
Area in potential projects	28,675	12,650	0	41,325
Total	109,675	13,030	0	122,705

(1) Little Powder River not included.

The Wyoming Report estimated the ultimate irrigable area in Wyoming at 216,500 acres (see table 18 and Appendix I, table 2). The Montana Reports do not give an estimate of the ultimate irrigable area in Montana, but indicate that the Army figure should be increased by 14,600 acres (see Appendix I, table 2).

4. Reservoirs for Irrigation Storage

Existing Reservoirs

The existing reservoirs in the basin have a total capacity of 35,013 acre-feet. The major reservoirs, all of which are in Wyoming, are listed in table 17. About three-fourths of the total existing storage capacity is the Lake DeSmet Reservoir in Clear Creek Basin.

Potential Reservoirs

More than 30 sites for potential reservoirs have been investigated in the Powder River Basin. The combined capacity of the 34 potential reservoirs listed for Wyoming in table 1 of Appendix II is 255,270 acre-feet. The capacity of the potential Moorhead Reservoir in Montana is 46,000, which makes a total of 301,270 acre-feet for the entire basin. The Montana Water Conservation Board reports (Appendix II, table 2) three small potential reservoirs in Montana, but detailed data on the projects are lacking. Only seven reservoirs, having a combined capacity of 115,430 acre-feet, were included in the water-use studies of Appendix F of the Progress Report of the National Resources Planning Board. The estimated storage and release schedule of each of these seven reservoirs is given in table 49.

0686

Table 46

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MAXIMUM, MINIMUM, AND MEAN RUN-OFF OF MAJOR STREAMS IN THE POWDER RIVER BASIN

(1,000 Acre-feet)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Powder River at Arvada, Wyo.												Period: May 1919 - Sept. 1937	
Maximum	182.0	18.0	-	-	-	133.0	231.0	146.0	119.0	115.0	67.0	350.0	840
Minimum	0.4	0.7	-	-	-	15.3	7.9	3.2	11.7	2.8	0.4	0.0	165
Mean	20.4	10.9	10.8a	11.7a	27.7a	46.1	44.3	66.6	55.7	31.2	18.6	28.3	441
Mean 1930-37	6.1	6.7	-	-	-	28.0	22.9	45.0	43.6	22.3	11.9	6.2	-
a Estimated													
Clear Creek near Buffalo, Wyo.							Period:	Broken June 1894 - Dec. 1899; June 1917-Oct.1927					
Maximum	15.9	5.6	3.2	2.5	1.7	1.7	4.9	22.6	34.8	19.1	9.1	6.4	107.9
Minimum	0.9	0.5	0.3	0.2	0.0	0.3	0.7	6.1	5.2	1.8	1.0	1.1	26.6
Mean	3.0	1.6	1.0	0.7	0.5	0.7	2.5	14.2	21.0	10.8	4.3	2.7	58.9
Piney Creek at Kearney, Wyo.								Period:	Broken 1901 - 1906;			Broken 1911 - 1923	
Maximum	5.3	-					7.3	34.8	39.9	21.4	6.0	11.0	97.4
Minimum	1.1	-					1.8	10.8	2.6	1.5	1.0	0.7	40.3
Mean	2.2	2.3a	1.3a	0.6a	0.5a	1.8a	4.2	19.7	22.4	6.9	2.4	2.4	70.3
a Estimated													
Crazy Woman Creek near Buffalo, Wyo.													
1928-29									28.4	2.0	0.6	1.3	
1929-30	1.6	1.9					4.1	2.5	0.6	0.2	1.0	0.7	
1930-31	2.0	1.7	1.4	1.1	1.4	2.3	1.0	1.0	1.4	0.5	0.2	0.5	14.5
1931-32	0.2	0.7	0.7	0.7	8.6	3.5	2.4	11.3	10.3				

Table 47

RUN-OFF OF THE POWDER RIVER AT MOORHEAD, MONTANA

(1,000 Acre-feet)

Year Ending Sept. 30:	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual Total
1916*	33.2	23.2b	18.5a	16.0a	16.7a	87.0a	52.4b	78.8b	93.2	36.3	26.0b	1.1b	483
1917	10.0b	12.4b	12.3a	11.7a	9.4a	43.7a	100.6a	206.6b	230.4b	37.0	4.5	6.1	684
1918	10.1	14.7	17.2a	15.1a	14.1a	29.8a	41.2	132.0	180.9	111.2	23.4	12.1	602
1928								89.8	82.2	86.4	21.4	10.2	
1929	16.5	17.7	8.5a	12.0a	10.4a	157.0	111.0						
1930	19.6	29.2	18.0a	16.0a	48.0a	37.6	39.9	45.4	14.7	18.2	35.0	11.2	333
1931	24.1	14.3	13.0a	10.0a	12.0a	14.0a	16.3	62.7	31.7	7.9	19.1	4.1	229
1932	7.5	8.1	5.5a	8.0a	11.3	33.1	23.9	89.2	78.6	12.5	0.4	1.4	280
1933	6.3	9.8	3.5	5.4	1.2	25.9	45.5	173.0	123.0	3.2	25.0	16.0a	438
1934	11.0	14.0	11.0a	9.0a	15.0a	20.0	24.2	5.1	16.8	12.9	3.0	4.6	147
1935	9.2	6.2	4.3	5.1	11.9	12.9	12.9	26.4	112.2	15.9	6.2	2.9	226
1936	4.4	4.8	6.2	6.2	17.3	93.8	22.4	7.7	34.3	59.0	2.3	1.0	259
1937	6.2	9.9	5.5	2.8	1.9	40.0	32.5	44.6	110.8	153.7	5.1	5.8	419
1938	12.0	12.2	8.6	12.4	12.5	73.5	22.4	73.9	78.2	62.2	4.4	9.4	382
Maximum	33.2	29.2	18.5	16.0	48.0	157.0	111.0	206.6	230.4	153.7	35.0	16.0	684
Minimum	4.4	4.8	3.5	2.8	1.2	12.9	12.9	5.1	14.7	3.2	0.4	1.0	147
Mean	13.1	13.6	10.2	10.0	14.0	51.4	41.9	79.6	91.3	47.4	13.5	6.6	374
Mean 1930-37	11.0	12.0	8.4	7.8	14.8	34.7	27.1	56.8	65.3	35.4	12.0	5.9	291

a - Estimated
b - Partially estimated
* - Figures prior to April 1929 are for the Powder River near Arvada plus Clear Creek near Arvada.

Table 4b

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EXISTING IRRIGATION PROJECTS

Powder River Basin**

(Acres)

Project Name and Location	Project No.*	Average Acres Irrigated 1930 - 1938	Average Annual Shortage 1930 - 1938 (Acre-Feet)	Irrigable Area Under Present System	Additional Irrigable Area by Extension of Project	Ultimate Irrigable Area in Project
Wyoming		63,405	47,410	75,100	5,900	81,000
Upper Powder		11,815	3,580	16,240	1,200	17,440
Sahara Ditch Co.	73	3,700	1,960	4,100	450	4,550
Boughton Ditch	76	630		1,000	250	1,250
Buffalo Creek Livestock Co.	78	650	1,280	4,000		4,000
Misc. (Middle Fork)		600		600		600
Big Four Ditch	77	1,200		1,200		1,200
Vruwink Ditch	75	835		1,140	500	1,640
Misc. (Beaver Creek, Red & Middle Fork)		1,700	340	1,700		1,700
Willow Creek Ditch Co.	74	2,500		2,500		2,500
Crazy Woman Creek		11,360	20,930	12,200	200	12,400
Blue Gap Ditch	65	900	1,420	900		900
Cook Ditch	66	800	1,400	800	200	1,000
John R. Smith Ditch	67	1,000	1,590	1,000		1,000
Mitchell & Long Ditch	68	700	1,570	700		700
Devoe No. 1 Ditch	69	1,000	2,030	1,500		1,500
Devoe No. 2 Ditch	70	1,500	3,060	1,500		1,500
Teddy Miller Ditch	71	800	1,630	800		800
Moreton Ditch	72	1,000	2,030	1,000		1,000
Misc. (Crazy Woman Creek)		3,660	6,200	4,000		4,000
Clear Creek		40,230	22,900	46,660	4,500	51,160
Lake De Smet Ditch Co.	58	6,000	5,900	6,000	2,000	8,000
Clear Creek Land & Ditch Co.	60	1,000		2,080		2,080
Crown Ditch	61	1,400	750	1,500		1,500
Six Mile Ditch	62	1,500	850	2,500	500	3,000
Johnson & Holt Ditch	63	1,000	710	1,210		1,210
Four Lakes & French Creek Ditch & Flume Co.	64	3,650	280	3,650		3,650
Misc. (Clear Creek)		400	60	400		400
Big Bonanza Ditch	55	1,500		1,500		1,500
Redman Ditch	57	1,200	80	1,200		1,200
Piney & Cruse Creek Ditch Co.	49	4,880	8,660	5,000		5,000
Mead Ditch	50	2,000	1,980	3,000		3,000
Montana		380	60	380	0	380
Main Stem		380	60	380	0	380
Misc. (Powder River)		380	60	380		380
Tributaries		0	0	0	0	0
Total, Powder River Basin		63,785	47,470	75,480	5,900	81,380

Source: Appendix F - Progress Report of the National Resources Planning Board.

* Numbers are those assigned by Corps of Engineers in 308 Report. See Map 8.

** Does not include the Little Powder River Basin.

Table 49

SELECTED POTENTIAL RESERVOIRS
(And Probable Schedule of Storage and Release Operations)

Powder River Basin

(Acre-Feet)

Name of Reservoir	Total Capacity	Nov. 1 to Mar. 31	April	May	June	July	Aug.	Sept.	Oct.	Evaporation Losses
Wyoming										
Red Fork Res.	30,000	-16,500	- 900	- 3,600	- 7,200	12,000	13,500	3,000	-1,800	1,500
Elk Lake Res.	1,500	- 820	- 50	- 180	- 360	600	680	70	- 90	150
Clear Cr. Nos. 1&2	16,600	- 9,130	- 500	- 2,000	- 4,000	6,640	7,470	1,660	- 970	830
Henry Res.	12,000	- 6,600	- 360	- 1,440	- 2,880	4,800	5,400	960	- 720	840
Piney Res.	5,250	- 2,890	- 160	- 630	- 1,260	2,100	2,360	420	- 310	370
Cloud Peak Res. (Enl)	4,080	- 2,250	- 120	- 490	- 980	1,630	1,840	330	- 240	280
Total, Wyoming	69,430	-38,190	-2,090	- 8,340	-16,680	27,770	31,250	6,440	-4,130	3,970
Montana										
Moorhead Res.	46,000	-25,300	-1,380	- 5,520	-11,040	18,400	20,700	5,060	-2,760	1,840
Total, Powder Basin	115,430	-63,490	-3,470	-13,860	-27,720	46,170	51,950	11,500	-6,890	5,810

Source: Field Survey Sheets (1939) of the Corps of Engineers, War Department.

G. LITTLE POWDER RIVER

The Little Powder River is in no sense a major stream of the Yellowstone Basin, but, because its drainage area is divided about equally between Wyoming and Montana, it is treated separately in this report. The stream rises in the northern part of Campbell County, Wyoming, and flows north across a portion of Powder River County, Montana, to its confluence with the Powder River. The air-line distance from its head, near Gillette, Wyoming, to its mouth near Broadus, Montana, is about 75 miles.

The stream's entire drainage area lies within the plains in an area of low water yield. No gaging station is known to have been established on the Little Powder River or any of its tributaries. Appreciable flow of the stream is, no doubt, confined to periods immediately following heavy rains.

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There is little developed storage capacity in the basin, and irrigation, if practiced at all, must necessarily be haphazard. According to Appendix F of the Progress Report of the National Resources Planning Board, there is no irrigation in the basin, but the Wyoming Report gives the irrigated area in Wyoming as 6,230 acres (see table 18). The only potential irrigation project reported in Appendix F is the Cottonwood project, having an irrigable area of 2,300 acres. The Wyoming Report shows the irrigable area of the Cottonwood project as 3,200 acres, and estimates that an additional 4,300 acres in Wyoming may be irrigated from miscellaneous small ditches.

The only reservoir in the basin at present is the Rawhide reservoir with a capacity of 514 acre-feet. Two potential reservoirs, the

Cottonwood and the Lonetree, are listed in table 1 of Appendix II. The former has been included in the water use studies of Appendix F in connection with the potential Cottonwood irrigation project.

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Preliminary Report

on

YELLOWSTONE RIVER BASIN

APPENDICES

I - Potential Irrigation Projects in the Yellowstone River Basin
II - Potential Reservoirs in the Yellowstone River Basin
III - Potential Power Sites in the Yellowstone River Basin.
IV - Congressional Authorization
V - Progress Report of the Compact Commission

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Federal Power Commission
Bureau of Engineering
Denver Regional Office

APPENDIX I
POTENTIAL IRRIGATION PROJECTS IN THE YELLOWSTONE RIVER BASIN

The principal source of information on potential irrigation projects is the 308 Report of the Corps of Engineers, War Department. Table 1, which was taken directly from the 308 Report, lists every project described by the Corps of Engineers regardless of its physical or economic desirability. Only projects footnoted either (a) or (b) are included in the "Ultimate irrigable area" as given in the main sections of this report. A brief description of each project is contained in Table 1. Further information on these projects is given in considerable detail in Appendix IV of the 308 Report.

Table 2 lists the potential irrigation projects not given in the 308 Report but which were mentioned in the following sources:

1. Appendix F of the Progress Report (1939) of the National Resources Planning Board.
2. A report by the Montana Water Conservation Board, dated September 25, 1938.
3. "Water Resources of the Yellowstone River Basin in Wyoming", by H. T. Person - October 1938.
4. A letter from the North Dakota Water Conservation Commission, dated June 7, 1940.
5. A "Progress report" prepared by the Montana Water Conservation Board and submitted by Mr. E. B. Donohue at the meeting of the Compact Commission held in Billings, Montana, on October 10, 1940.

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An effort was made to avoid duplicating, in table 2, areas listed in table 1, but because of the absence of detailed information in the above five sources the effort may not have been entirely successful.

Appendix F was prepared in 1939 by the Corps of Engineers, War Department. It is, to a certain extent, a revision of part of the material of the 308 Report. A few additional potential projects are considered, and some of the projects of the 308 Report are excluded from further study, apparently because of lack of merit. (Appendix F, however, makes no comment on the feasibility of the various projects.) The potential projects carried in the basin totals of the main section of this report (projects footnoted (a) and (b) in tables 1 and 2) are those selected for consideration by Appendix F. The other projects were omitted in order to avoid the possibility of duplication, and not because they are considered to be lacking in merit.

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Appendix I
Table 1

Potential Irrigation Projects in the Yellowstone River Basin
(As Listed in the Corps of Engineers 308 Report)

Name of Project	Source of Water Supply	Irrigable Acreage	Description
			Main Stem of Yellowstone River, and Minor Tributaries
Lower Yellowstone project improvement	Yellowstone River	10,871[a]	On west side of Yellowstone River, below Intake, Mont., being built by Bureau of Reclamation; construction began 1906. Direct diversion from Yellowstone River at Intake; no storage. Potential development limited to 871 acres now in suspended status on account of incomplete drainage system. Completion dependent on policies of Bureau of Reclamation.
Huntley project improvement	Yellowstone River	(c)[a]	On south side of Yellowstone River, between Huntley and Bull Mountain, Mont., built by Bureau of Reclamation; construction began in 1905. Direct diversion from Yellowstone River, about 2 miles above Huntley; no storage. Potential development limited to land now in suspended status on account of incomplete drainage.
Brackett Creek:			
Scheme No. 1)	Brackett	(9,791[b]	On both sides of Brackett Creek, west of Clyde Park, Mont. Involves storage in Brackett Creek Reservoir; 2 schemes of development proposed: Scheme No. 1 - Area, 9,791 acres; reservoir capacity, 31,668 acre-feet; North Canal, 10.5 miles long, initial capacity, 42.5 second-feet; South Canal, 24 miles long, initial capacity, 87.4 second-feet; estimated cost $1,189,100, or $121.45 per acre.
Scheme No. 2)	Creek	(5,550	Scheme No. 2 - Area, 5,550 acres; reservoir capacity, 14,229 acre-feet; North Canal. 13 miles long, initial capacity, 62 second-feet; South

Name of Project	Source of Water Supply	Irrigable Acreage	Description
			Canal, 6 miles long, initial capacity, 20 second-feet; estimated cost, $568.100, or $102.36 per acre.
Glendive-Fallon[1] Upper unit) Lower unit)	Yellowstone River	(3,370[a] (5,600[a]	On north side Yellowstone River, between Glendive and Fallon, Mont. Glendive Land & Irrigation Co. started construction in 1908, but did not complete; rights and works later purchased by Upper Glendive-Fallon Irrigation District. Construction not completed. No storage involved. Water supply by pumping from Yellowstone River, Two units in project: Upper unit - Two pumping plants, 43- and 75-foot lifts; 1 canal 11.7 miles long and 35 second-feet capacity; another 4.8 miles long and 15 second feet capacity; cost $132,700, or $39.38 per acre. Lower unit - Pumping plant, 100-foot lift; canal 12 miles long and 80 second-feet capacity; cost $272,600, or $48.68 per acre.
Total		8,970	
Hysham[1]	Yellowstone River	6,400[a]	On south side of Yellowstone River, near Hysham, Mont. Surveyed by Hysham Irrigation district in 1913. No storage involved; water pumped from river. Lifts of 98 and 66 feet; 18 miles of canals; initial capacities, 20 and 68 second-feet. Total cost $340,000, or $53.13 per acre.
Sheffield[1]	Yellowstone River	5,800[a]	On north side of river, near Miles City, Mont. No storage involved. Primary pump from river, 20-foot lift; secondary pump from canal, 35-foot lift. 21.8 miles of canal; initial capacity, 83 second-feet. Total cost $209,200, or $36.07 per acre.
Highland Park Irrigation District	Yellowstone River	4,933	On south side of river, east of Forsyth, Mont. Pumping project with no storage; 220-foot lift. Canal, 10 miles long.

Name of Project	Source of Water Supply	Irrigable Acreage	Description
Shirley-Blatchford(1)	Yellowstone River	4,160[a]	On south side of river, between Shirley and Blatchford, Mont. Investigated by Northern Pacific Railway in 1894. No storage involved. Pumping plant lift 42 feet. Canal 13.9 miles long; initial capacity, 60 second feet. Total cost $171,000, or $41.11 per acre.
Upper Yellowstone Irrigation District	Yellowstone River	3,680	On west side Yellowstone River, 12 miles above Livingston, Mont. Direct diversion without storage. Canal, 10 miles long. District requested certification of a $75,000 bond issue.
Cedar Creek(1)	Yellowstone River	3,440[a]	On north side of river below Terry, Mont. No storage involved. Water pumped from river; 2 plants with lifts of 60 and 45 feet. 15.1 miles of canals; initial capacities, 31 and 21 second-feet. Total cost $171,400, or $49.83 per acre.
Kinsey(1)	Yellowstone River	2,840[a]	On north side of river near Kinsey, Mont. No storage involved. Pumping plant from river; lift of 40 feet. 10.2 miles canal; initial capacity, 41 second-feet. Total cost $100,000, or $35.21 per acre.
Graycliff Irrigation District	Boulder River	2,000	On south side Yellowstone River, near Graycliff, Mont. Direct flow project; no storage. Canal extension of old Bailey Ditch. Estimated cost, $70,000, or $35 per acre.
Calypso(1)	Yellowstone River	1,700[a]	On north side of river, w est of Terry, Mont. No storage involved. Water pumped from river; 52-foot lift. Canal, 5.3 miles long; initial capacity, 24 second-feet. Total cost, $64,200, or $37.76 per acre.

Name of Project	Source of Water Supply	Irrigable Acreage	Description
Orinoco(1)	Yellowstone River	1,250[a]	On north side of river, below Forsyth, Mont. No storage involved; 25-foot lift pumping plant; 20 second-feet canal, 5.3 miles long. Total cost, $34,500, or $27.60 per acre.
Hathaway(1)	Yellowstone River	1,000[a]	On south side of river, near Hathaway, Mont. No storage involved; 40-foot lift pump at river. Canal, 4.6 miles long; initial capacity, 14 second-feet. Total cost, $38,000, or $38 per acre.
Terry(1)	Yellowstone River	940[a]	On south side of river, near Terry, Mont. No storage; 2 separate pumping plants, lifts of 85 to 90 feet each.
Saugus(1)	Yellowstone River	720[a]	On north side of river, just above Saugus, Mont. No storage required. Single pumping unit, lift 35 feet. Canal, 3 miles long; initial capacity, 11 second-feet. Total cost $22,600, or $31.39 per acre.
Total for main stem of Yellowstone River and miscellaneous tributaries		68,495	

Clark Fork River and Tributaries

Clark Fork:			On west side of Clark Fork, north of Clark, Wyo.
Scheme No. 1)	Clark Fork,	(60,800[b]	Involves 2 schemes of utilizing direct flow of Clark Fork and storage
Scheme No. 2)	Sunlight Creek,	(14,700	on Sunlight Creek, and a scheme utilizing storage and direct diversion
Scheme No. 3)	and East Rosebud Creek	(24,900	from East Rosebud Creek:

Name of Project	Source of Water Supply	Irrigable Acreage	Description
			Scheme No. 1 - 60,000 acre-feet storage in Sunlight Reservoir. Canal, 57.8 miles long; initial capacity, 950 second-feet. Estimated cost $7,434,300, or $122.20 per acre. Scheme No. 2 - 20,000 acre-feet storage in Sunlight Reservoir. Canal, 34 miles long; initial capacity, 296 second-feet. Estimated cost, $1,749,800, or $119 per acre. Scheme No. 3 - 37,500 acre-feet storage in East Rosebud Reservoir. No data on canal system. Estimated cost of reservoir $422,900, or $11.30 per acre-foot.
Joliet and White Horse Bench Irrigation District	Rock Creek and East Rosebud Creek	8,000[d]	On north side of Rock Creek, north of Joliet, Mont. Involves direct flow of Rock Creek and storage on East Rosebud Creek. East Rosebud Reservoir capacity, 10,000 acre-feet. Diversion canal, 7 miles long; capacity, 150 second-feet. Main canal, 18 miles long; initial capacity, 182 second-feet. Estimated cost $474,300, or $59.29 per acre.
Chapman Bench	Clark Fork	8,000	On easterly side of Clark Cork, near Clark, Wyo. Involves direct diversion only. Requires 7 miles canal through practically inaccessible canyon. Due to apparent infeasibility of main canal, no designs or estimates made.
East Side Irrigation District	Clark Fork	7,100	On east side of Clark Fork, in Carbon County, Mont. Direct-diversion project; no storage. Involved extension of old Wills Ditch. Proposed bond issue $460,000, or $64.79 per acre. No construction cost data.
Total for Clark Fork and tributaries		75,900	

Name of Project	Source of Water Supply	Irrigable Acreage	Description
Big Horn River and Tributaries			
Shoshone project extension (incompleted divisions):			
Heart Mountain)		41,000[a]	Under construction by Bureau of Reclamation. Shoshone Reservoir storage completed. Lands located on both sides of Shoshone and Greybull Rivers. Project started in 1905; system now complete for Garland, Frannie, and Willwood divisions. Incompleted work involves Canyon Canal, initial capacity, 1,200 second-feet; length, 2.9 miles. Heart Mountain Canal, initial capacity, 910 second- feet; length, 27.97 miles. Oregon Basin Canal, initial capacity, 600 second-feet; length, 22.95 miles. Oregon Basin Reservoir, capacity, 150,000 acre-feet and laterals.
Oregon Basin)	Shoshone	48,000[a]	
Greybull Valley)	River	46,000[e]	
Irrigation Dis-)			
trict)			
Riverton project extension	Wind River	80,000[a]	On north side of Wind River, vicinity of Riverton, Wyo. Being built by Bureau of Reclamation. Construction began in 1920. Undeveloped portion of project (80,000 acres) involves additional storage either at Bull Lake Creek or Dinwoody Creek sites, or both; extension of present canals and laterals; new laterals; and a drainage system.

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Name of Project	Source of Water Supply	Irrigable Acreage	Description
Wind River Indian project extension	Wind and Little Wind Rivers, and Dinwoody Creek	21,218[a]	On Shoshone Indian Reservation. Lands on south side of Wind River and both sides of Little Wind River. Being built by Bureau of Indian Affairs. Potential development involves extension of existing canals, construction of Dinwoody Canal from Dinwoody Creek and construction of necessary storage (about 12,000 acre-feet) on either North Fork or South Fork of Little Wind River.
Crow Indian project extension	Big Horn and Little Horn Rivers, and Pryor Creek.	11,991[a]	On Crow Indian Reservation. Being developed by Bureau of Indian Affairs. Potential development involves extension of existing canals and possibly a small amount of storage on Little Horn River, Lodge Grass and Pryor Creek.
Louis Lake	Little Popo Agie River	78,920[b]	On east side of Little Popo Agie River, east of Lander, Wyo. Filings made by Louis Lake Conservation Co. in 1911. Involves both direct diversion and storage. Louis Lake Reservoir, capacity, 72,700 acre-feet; on the headwaters of east branch of Little Popo Agie River. No cost data available.
Fremont Canal	Wind River and Torry Creek	64,000[b]	On north side of Wind River, near Lenore, Wyo. Wyoming Central Irrigation Co. made filing in 1906; involves both direct diversion and storage, 2 potential reservoir sites: Wind River Reservoir - No. 1 - Capacity, 40,000 acre-feet; 10 miles above Dubois, Wyo. Torry Lake Site - Capacity, 6,000 acre-feet; on Torry Creek. Length of canal, 35 miles. Original estimated cost without storage, $458,000; estimated cost of storage, $1,315,000; total cost, $1,773,000, or $27.70 per acre.

0701

Name of Project	Source of Water Supply	Irrigable Acreage	Description
Buffalo Basin	Greybull and Wood	47,500[b]	On both sides Dry Cottonwood and Gooseberry Creeks, in vicinity of Worland, Wyo. Involves diversion from Greybull and Wood Rivers with storage in Buffalo Creek Reservoir (capacity 145,000 acre-feet). Supply canals include Greybull-Francis Fork Canal, 20 miles long, Wood River Canal, 10.44 miles long, and Buffalo Creek Canal, 7.74 miles long. Distribution canals include Gooseberry No. 1, 12 miles long, and Gooseberry No. 2, 10.75 miles long. Estimated cost $1,890,000, or $39.80 per acre.
Big Horn	Big Horn River	50,100[b]	On both sides of Big Horn River, south of Hardin, Mont. High diversion dam on Big Horn River, near mouth of Big Horn Canyon, provides 16,000 acre-feet of storage. Involves 2 canals; West Side Canal, 63.3 miles long, initial capacity 890 second feet; East Side Canal, 12.8 miles long, initial capacity 65 second-feet. Estimated cost $12,569,500, or $250.89 per acre,
Wind River Canal	Wind River	22,680[b]	On Southerly side of Wind River, near Riverton, Wyo. Land entirely within Shoshone Indian Reservation. Involves direct diversion without storage. Canal 32 miles long. Original cost estimated at $250,000, or $11.02 per acre.
Tremont Canal	Big Horn River	16,250[b]	On easterly side of Big Horn River, near Neble and Bonneville, Wyo. Direct-diversion project without storage. Partly a Carey Act enterprise; 8,709 acres included in Wyoming. Segregation list No. 81. Construction included pumping lift of 35 feet, and 32 miles canal. Filings made by Mr. Asmus Boysen in 1910.

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Name of Project	Source of Water Supply	Irrigable Acreage	Description
Upper and Lower Sunshine Reservoirs. (Note: Lower Sunshine Reservoir has been constructed to a capacity of 43,500).	Greybull and Wood Rivers	(16,000 (55,000[e]	Supplemental storage for existing irrigation along Greybull River, below Meeteetse, Wyo., and undeveloped land in Greybull Valley. Surveyed by Greybull Irrigation District in 1919. Involves 2 off-stream reservoir sites: Upper Sunshine site - Capacity, 50,100 acre-feet; supplied from Greybull River, Lower Sunshine site - Capacity, 43,500 acre-feet; supplied from Wood River; total cost $6,440,000. Cost of supplemental water $57.04 per acre; cost to undeveloped land $206.40 per acre.
Paintrock	Paintrock Creek	15,600[b]	On north side of Nowood Creek below Paintrock Creek. Proposed as Carey Act project in 1907. Involves both natural flow and storage. Solitude Reservoir on Middle Fork of Paintrock Creek developed to 6,000 acre-feet capacity. Canal, 35 miles long; initial capacity, 219 second-feet. Original estimated cost $484,500, or $31.06 per acre.
Tensleep and Bonanza	Tensleep Creek	15,000[b]	In Nowood Creek Valley, below Tensleep Creek. Proposed as Carey Act project in 1909. Involves both natural flow and storage, Tensleep Meadows Reservoir on East Tensleep Creek; capacity, 13,500 acre-feet; 2 canals; one 25 miles long, and the other 8 miles long; initial capacities, 211 and 21 second-feet, respectively. Engineer's estimated cost $684,575, or $45.65 per acre.
Lander Valley	Popo Agie River	9,275[b]	On east side Pope Agie River, near Arapahoe, Wyo. Filings made by Lander Valley Reservoir and Irrigation Co. Involves both direct-diversion and storage. Long Beach Reservoir, capacity 15,000 acre-feet, located on headwaters of North Fork Popo Agie River. Length of canal, 21.75 miles. Original cost estimate $110,000, or $11.86 per acre.

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Name of Project	Source of Water Supply	Irrigable Acreage	Description
Riverside Canal	Big Horn River	6,930[b]	On easterly side of Big Horn River, near Neble, Wyo. Direct-diversion project without storage. Construction involves pumping plant with lift of 35 feet and canal 10 miles long. Filing made by Mr. Asmus Boysen in 1911. No cost data available.
Gooseberry Creek	Wood River	6,800[a]	On both sides of Gooseberry Creek, near Worland, Wyo. Water supply from Wood River, with 38,000 acre-feet of storage in Buffalo Creek Reservoir. Involves 9.7 miles supply canal; initial capacity of 1,000 second-feet; and 2 distribution canals; aggregate length 15.1 miles; initial capacities, 106 and 20 second-feet, respectively. Estimated cost $2,374,100, or $349.13 per acre.
Total for Big Horn River and tributaries		54,464	
			Tongue River and Tributaries
Parkman Irrigation District	North Fork Tongue and Fool Creek	(5,471[b] (7,020[e]	For new lands and supplemental water supply for lands along Pass Creek (Little Horn drainage), north of Parkman, Wyo. Filings and some construction accomplished in 1909. Rialto Canal, initial capacity, 94 second-feet, to divert surplus waters from North Tongue River and Fool Creek to West Pass Creek. Original estimated cost, $200,000.
Total for Tongue River and tributaries		5,471	

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Name of Project	Source of Water Supply	Irrigable Acreage	Description
			Powder River and Tributaries
Northern Wyoming Land Co.	Clear Creek	13,803[b]	Located between Dry and Crazy Woman Creeks, near Buffalo, Wyo. Involves both natural flow and storage; 2 reservoirs on Dry Creek: No. 1 reservoir - Capacity, 21,451 acre-feet. No. 2 reservoir - Capacity, 13,150 acre-feet, about 8,000 acre-feet being dead storage; 2 canals aggregating 17.81 miles in length. Estimated cost $2,267,000, or $164.24 per acre, not including cost of supply canal for which data are not available.
Johnson County	Clear Creek	13,167[f]	In Valley of Crazy Woman Creek, near Buffalo, Wyo. Involves both natural flow and storage; 2 reservoirs on Buffalo Wallow Creek: Peck Reservoir - Capacity, 14,200 acre-feet. Hall Reservoir - Capacity, 3,580 acre-feet. Supply canal, 32 miles long; initial capacity, 365 second-feet. Estimated cost, not including distribution system, $2,246,000, or $170.58 per acre.
Red Fork	North and Middle Forks Powder River	14,877[b]	On west side of Powder River, near Sussex, Wyo. Filings made by Northern Wyoming Land Co., in 1911. Water supply depends on storage in Red Fork Reservoir. Reservoir capacity 51,490 acre-feet. Length of canal, 58 miles; initial capacity, 330 second-feet. Total cost $600,000, or $40.33 per acre.
Powder River	Powder River	12,650[b]	Lands in 2 units, 1 on each side of river, near Broadus and Powderville, Mont., 2 schemes of development proposed: Scheme No. 1 - Involves direct diversion through 2 main canals; Broadus Canal 28 miles long and 54 second-feet initial capacity; Powderville Canal, 49.2 miles long and 127 second-feet initial

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Name of Project	Source of Water Supply	Irrigable Acreage	Description
			capacity; total cost $1,125,000, or $88.93 per acre. Scheme No. 2 - Involves both direct diversion and storage; Moorhead Reservoir developed to 56,000 acre-feet capacity; canal system same as for scheme No. 1; total cost $4,040,000, or $319.37 per acre.
Sussex	North and Middle Forks of Powder River	4,500[g]	On west side of river, north of Sussex, Wyo. Involves both natural flow and storage in Red Fork Reservoir on Red Fork Creek, developed to 16,000 acre-feet capacity. Canal system includes enlargement of 18.3 miles of Sahara Canal to capacity of 130 second-feet and construction of Sussex Canal, additional 17.2 miles with capacity of 65 second-feet. Total cost $658,000, or $146.22 per acre.
Cottonwood	Cottonwood Creek	2,302[b]	On both sides of Cottonwood Creek and Little Powder River, near Adon, Wyo. Involves 4,963 acre-feet storage in Cottonwood Reservoir and Cottonwood Ditch, 6.23 miles long, initial capacity 100 second-feet. Estimated cost $350,000, or $152.04 per acre.
Total for Powder River and tributaries		56,799	

Source 308 Report, H.D. 256, pages 53 through 59.

(1) Included in the Mid-Yellowstone Project - U.S.B.R.

a This area, either as it appears here or as amended, is included in the "ultimate irrigable area" given in this report under the classification "irrigable area by extension of (existing) projects."

b This area, either as it appears here or as amended, is included in the "ultimate irrigable area" given in this report under the classification "irrigable area in potential projects."

c Annual reports of the Bureau of Reclamation do not show any definite acreage of suspended acreage. Although the drainage system is incomplete, the affected acreage is comparatively small.

d Acreages indicated are for areas that are duplicated in other listed projects. Duplicated areas are not included in totals.

e Acreage indicated is the area of land for which a supplemental water supply is included in the plan of reclamation. These acreages are not shown in the totals for the basin or subbasins.

f Depends upon same water supply in Clear Creek as Northern Wyoming Land Co. Project, which is insufficient for both. Compromise necessary.

g Most of the area of the Sussex Project is included in the Red Fork Project; hence, the Sussex Project is considered a duplication.

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Appendix I
Table 2

Potential Irrigation Projects in the Yellowstone River Basin
(Projects not listed in the 308 Report)

Name of Project	Source of Water Supply	Irrigable Acreage	Source of Information
Main Stem and Minor Tributaries			
Rosedale-Elbow Irrigation Project	Yellowstone River	3,000	Appendix F(1)
Park-Sweet Grass Irrigation Project	Yellowstone River	12,500	Appendix F(1)
Lake Basin Irrigation Project	Yellowstone River	239,200[b]	Appendix F(1)
Miscellaneous (Porcupine Creek)	Porcupine Creek	2,400[b]	Appendix F(1)
Sadies Flat Irrigation Project*	Yellowstone River	6,200[a]	Appendix F(1)
North Sanders Irrigation Project*	Yellowstone River	5,400[a]	Appendix F(1)
Sidney Pumping Project**	Yellowstone River	5,300[a]	Appendix F(1)
Savage Pumping Project**	Yellowstone River	2,100[a]	Appendix F(1)
McGinnis Creek	Not given	5,000	Montana Report(2)
Sioux Charley Lake	Not given	10,000	Montana Report(2)
Mission Ditch	Not given	25,000	Montana Report(2)
East Rosebud	Not given	30,000	Montana Report(2)
Cartwright Irrigation District	Yellowstone River	840	North Dakota(4)
Yellowstone Pumping Irrigation District	Yellowstone River	1,810	North Dakota(4)
Upper Clear Creek (Dawson County)	Clear Creek	6,600	Montana Progress Report(5)
Fairchild Reservoir (Dawson County)	Three Mile Creek	260	Montana Progress Report(5)
Hardy Reservoir (Dawson County)	Seven Mile Creek	530	Montana Progress Report(5)
Rake (Dawson County)	Beaver Creek	-	Montana Progress Report(5)
Mission Ditch Extension	Yellowstone River	2,675	Montana Progress Report(5)
O'Fallon Creek (Prairie County)	O'Fallon Creek	10,000	Montana Progress Report(5)
Sunday Creek (Rosebud County)	Sunday Creek	-	Montana Progress Report(5)
Bensley Creek Reservoir (Custer County)	Bensley Creek	426	Montana Progress Report(5)
Kircher Creek (Custer County)	Kircher Creek	-	Montana Progress Report(5)

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Name of Project	Source of Water Supply	Irrigable Acreage	Source of Information
Clark Fork River			
Stanley Ditch	Rock Creek	-	Montana Progress Report (5)
Sand Coulee Area (S. and E. of Clark Fork, Chapman Bench excluded)	Clark Fork	20,000	Wyoming Report(3)
Miscellaneous Ditches	Clark Fork & Tribs.	10,000	Wyoming Report(3)
Big Horn River			
Hanover Pumping Project***	Big Horn River	15,000	Wyoming Report(3)
Miscellaneous (Pumping Projects)***	Big Horn River	8,300	Wyoming Report(3)
Miscellaneous Small Ditches	Shoshone River	10,000	Wyoming Report(3)
Miscellaneous Small Projects	Greybull & Tribs.	15,000	Wyoming Report(3)
Miscellaneous Small Projects	Wind River & Tribs.	17,900	Wyoming Report(3)
Miscellaneous Small Projects	Popo Agie River & Tribs.	5,600	Wyoming Report(3)
Miscellaneous Small Projects	No: Wood Creek & Tribs.	6,400	Wyoming Report(3)
Miscellaneous Small Projects	Shell Creek & Tribs.	500	Wyoming Report(3)
Miscellaneous Small Ditches	Little Horn & Tribs.	7,000	Wyoming Report(3)
Miscellaneous Small Projects	Miscellaneous Tribs.	60,300	Wyoming Report(3)
Polecat Bench Irrigation District	Shoshone River	23,000	Appendix F(1)
Tongue River			
Little Young's Creek	Young's Creek	200	Montana Progress Report(5)
Lower Pumpkin Reservoir	Pumpkin Creek	800	Montana Progress Report(5)
Tongue River Water Users Ass'n.	Tongue River	19,200[b]	Appendix F(1)
Miscellaneous	Pumpkin Creek	3,200[b]	Appendix F(1)
Miscellaneous Projects & Extensions of Present Projects	Tongue River & Tribs.	24,500	Wyoming Report(3)

Name of Project	Source of Water Supply	Irrigable Acreage	Source of Information
Powder River			
Hicklex (Carter County)	Stump Creek	900	Montana Progress Report(5)
Bradshaw Reservoir (Custer County)	Locate Creek	300	Montana Progress Report(5)
Traub (Powder River County)	Bay Horse Creek	400	Montana Progress Report(5)
Lower Powder River	Powder River	10,500	Montana Progress Report(5)
Lamey Creek (Custer County)	Lamey Creek	-	Montana Progress Report(5)
Campbell Brown	Powder River	2,500	Montana Progress Report(5)
Miscellaneous Small Projects	Minor Tribs. & Main Stem	13,000	Wyoming Report(3)
Miscellaneous Small Projects	Crazy Woman Creek & Tributaries	5,000	Wyoming Report(3)
Little Powder River			
Herman	Ranch Creek	300	Montana Progress Report(5)
Miscellaneous Small Projects	Little Powder & Tribs.	4,300	Wyoming Report(3)

(1) Appendix F of the Progress Report of the National Resources Planning Board (1939).
(2) A report prepared by the Montana State Water Conservation Board, dated September 25, 1938.
(3) "Water Resources of the Yellowstone River Basin in Wyoming", by H. T. Person - October 1938.
(4) North Dakota Water Conservation Commission, letter dated June 7, 1940.
(5) A "Progress Report" submitted by Mr. E. B. Donohue at the meeting of the Compact Commission on October 10, 1940.

a This area, either as appears here or as amended, is included in the "ultimate irrigable area" given in this report under the classification "irrigable area by extension of (existing) projects".

b This area is included in the "ultimate irrigable area" given in this report under the classification "irrigable area in potential projects".

* Included in the Mid-Yellowstone Project - U.S.B.R.

** Included in the Lower Yellowstone Project extension.

*** Presumably these projects include the three projects shown in table 24 as reported by the Wyoming State Engineer.

APPENDIX II

POTENTIAL RESERVOIRS IN THE YELLOWSTONE RIVER BASIN

This appendix contains pertinent information concerning each potential reservoir of which this office has knowledge, regardless of its physical or economic feasibility. Information on potential reservoirs was obtained from the five sources listed below.

1. The 308 Report (H.D. 256, 73d Congress, 2d Session), of the Corps of Engineers, War Department.
2. Appendix F of the Progress Report (1939) of the National Resources Planning Board.
3. "Water Resources of the Yellowstone River Basin in Wyoming", by H. T. Person - October 1938.
4. A report by the Montana Water Conservation Board, dated September 25, 1938.
5. A report by the Montana Water Conservation Board, submitted at the meeting of the Compact Commission in Billings, Montana, on October 10, 1940.

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Table 1 is a reproduction of tables contained in the Wyoming Report. Table 2 was compiled from potential projects listed in the two Montana Reports. Table 3 contains all of the potential reservoirs that were listed in Appendix F. These tables present the data as they were given in the original sources. No attempt has been made to eliminate duplications or to reconcile inconsistent data. The potential reservoirs included in the water use studies of Appendix F are shown by sub-basins, in Section II of this report, in tables headed "Selected Potential Reservoirs".

More detailed information on some of the reservoirs listed in tables 1, 2 and 3 is contained in Appendix IV of the 308 Report. Other potential

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reservoirs that are listed in the 308 Report and are not included in one of the three tables are listed below.

Reservoir	Source of Supply	Capacity (A.F.)
Livingston	Yellowstone River	1,500,000
Big Timber	Yellowstone River	800,000
Columbus No. 2	Yellowstone River	400,000
Pompey's Pillar No. 1	Yellowstone River	150,000
Boulder	Boulder River	50,000
Stillwater	Stillwater River	100,000
Goose Creek	Tongue River	50,000
Biddle	Little Powder River	50,000
Sutherland No. 1	Powder River	50,000
Sutherland No. 2	Powder River	200,000
So. Fork Powder River	Powder River	50,000

The 308 Report concluded that the above potential reservoirs were economically undesirable at the present time but merited further study. Recently the Corps of Engineers has investigated the feasibility of a 3,000,000 acre-foot reservoir at the site of the abandoned Boysen dam in Wind River Canyon. The report of this investigation has not yet been made public. The location of the principal potential reservoirs in the basin is shown on map 7.

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Table 1

IN THE YELLOWSTONE RIVER BASIN IN WYOMING

rces of Yellowstone River Basin in Wyoming")

	Source of Supply	Type of Dam	Capacity (Acre-Feet)	Estimated Cost
SW	Beaver Creek	60' Earth	3,300	38,300
SW	Beaver Creek	30' Earth	400	3,000
IW	Little Popo Agie	40' Masonary	7,700	7,100
IW	Roaring Fork			
	Big Popo Agie	65' Masonary	1,300	6,000
2W	S. Fk. of N. Fk.			
	Popo Agie	30' Concrete	16,100	30,000
IW	Little Popo Agie	35' Earth	8,000	31,000
SW	Devils Dive Cr.	90' Earth	9,100	
5W	No. Fk. Little Wind R.	60' to 200' Concrete	30,000	325,000
			100,000	1,250,000
2W	Middle Fk. of Little Popo Agie	82' Masonary	2,900	150,000
2W	Stough Creek	79' Masonary	3,800	175,000
2W	Middle Fork of Popo Agie	80' Masonary	1,700	85,000
			164,300	
3W	So. Fork of Medicine Lodge Cr.	22' Earth	2,200	15,000
3W	Trout Creek	32' Earth	1,300	15,000
3W	Medicine Lodge Creek	13' Earth	8,700	1,500
3W	None Creek	30' Earth	9,800	13,000
3W	Paint Rock Creek	50' Earth	6,700	2,000
3W	Middle Fork Paint Rock Cr.	65' Masonary	8,600	75,000
3W	Paint Rock Cr.	35' Earth	5,800	$ 2,000
3W	Tensleep Creek	23' Earth	3,500	
			46,600	
4W	Shell Creek	48' Earth	3,200	34,500
4W	Willett Creek	40' Earth	900	11,000
			4,100	
W	East Pass & Twin Crks.	55' Earth	1,000	6,800
W	So. Fork of Elk Creek	37' Earth	900	8,500
W	Buffalo Creek	72' Masonary	2,700	27,000
W	Cottonwood Cr.	49' Earth	1,300	38,000
W	So. Fork of Elk Creek	42' Earth	700	6,500
W	Nowater Creek	35' Earth	900	4,600
W	Elk Creek	29' Earth	1,100	11,000
W	Elk Creek	41' Earth	1,400	13,000
W	Gooseberry Cr.	21' Earth	600	8,300
W	East Fork of Nowater Creek	38' Earth	7,200	25,000
W	East Fork of Nowater Creek	47' Earth	5,300	30,000
W	East Fork of Nowater Creek	28' Earth	800	1,200
W	East Fork of Nowater Creek	35' Earth	1,000	9,000
W	Muskrat Creek	25' Earth	700	7,400
W	Buffalo Creek	102' Earth	8,100	221,000
W	Gooseberry Creek	48' Earth	1,800	25,000
W	Gooseberry Creek	80' Earth	8,500	30,000
W	Grass Creek	65' Earth	2,600	$ 77,300
W	E. Fk. of Nowater Cr.	20' Earth	700	3,100
W	Muskrat Creek	46' Earth	3,900	24,400
W	Dry Cheyenne Draw	45' Earth	4,700	2 00

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SEE FULL TABLE ATTACHED

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Name	Location	Source of Supply	Type of Dam	Capacity (Acre-Feet)	Estimated Cost
Tongue River					
Lake Geneva	S19, T52N, R 86W	E. Fk. Big Goose Cr.	14' Earth	783	3,500
North Fork Res.	S 4, T55N, R 89W	No. Fk. Tongue River	130' Earth	42,500	1,063,000
Parkman Irr. Dist. 1	S11, T54N, R 86W	So. Fk. Tongue River	16' Earth	1,323	12,000
Rockwood Reservoir	S24, T56N, R 86W	Tongue River	332' RockFill	31,000	4,257,000
South Fork Reservoir	S33, T56N, R 88W	So. Fk. Tongue River	152' RockFill	25,000	1,675,000
Tongue River Reservoir	S11, T57N, R 84W	Tongue River	39' Earth	1,337	17,000
Union Number 1	S21, T53N, R 86W	E. Fk. Big Goose	25' Earth	600	2,000
Willow Creek Reservoir	S26, T54N, R 87W	Big Goose Cr. Willow Creek	30' Earth	903	27,000
Total Tongue River				103,446	
Powder River					
Main Stream & Tribs.					
Briggs Reservoir	S27, T50N, R 74W	Wild Horse Creek	40' Earth	1,130	8,000
Coal Draw	S12, T40N, R 79W	Coal Draw	60' Earth	780	46,000
Cottonwood Res. No. 2	S16, T38N, R 85W	Cottonwood Gulch	43' Earth	820	8,225
Indian Springs	S16, T38N, R 84W	Dry Gulch	50' Earth	5,400	5,600
Lewis	S 1, T40N, R 79W	Salt Creek & Powder R.	42' Earth	930	101,000
Mable	S16, T46N, R 75W	No. Pumpkin Creek	38' Earth	590	5,840
Midwest	S30, T40N, R 78W	Salt Creek	57' Earth	5,490	$ 60,000
Middle Fork Reservoir	S33, T43N, R 83W	Middle Fork Powder River	100'	2,400	
Murphy Flat	S 2, T41N, R 82W	Willow Creek	10' Earth	1,040	1,400
Red Fork Res.	S 8, T43N, R 83W	Red Fork	162' Concrete	51,490	400,000
Sunset	S26, T38N, R 85W	Cottonwood Creek	12' Earth	3,200	4,000
Total Main Stream & Tribs:				73,270	
Clear Creek & Tribs.					
Cloud Peak Res. (Enl.)	S16, T51N, R 85W	So. Fk. Piney Cr.	34' Earth	4,300	
Camp Comfort	S 7, T50N, R 83W	Clear Creek		16,600	
Dry Creek No. 1	S22, T50N, R 81W	Clear Creek	107' Earth	21,450	1,175,000
Dry Creek No. 2	S16, T50N, R 81W	Clear Creek	76' Earth	13,150	1,017,000
Elk Lake No. 1	S15, T51N, R 85W	So. Prong So. Fk. Piney	13' Earth	2,550	10,000
Elk Lake No. 2	S14, T51N, R 85W	Elk Creek	22' Earth	2,590	8,000
Henry	S26, T50N, R 82W	Sand Creek	126' Earth	20,480	200,000
Kearney Lake (Enl.)	S30, T52N, R 85W	So. Fk. Piney Cr.	45' Earth	1,300	
Piney	S24, T52N, R 85W	So. Fk. Piney Cr.	55' Earth	11,040	60,000
Red Man Draw	S 7, T 51N, R 81W	Rock Creek	58' Earth	2,500	14,000
Seven Brothers	S 2, T50N, R 85W	Seven Brothers Lake	70' Earth	7,770	100,000
Triangle	S31, T51N, R 84W	So. Fk. Rock Creek	80' Rubble Mason	2,820	133,784
Willow Park	S24, T52N, R 85W	Piney Creek	55' Earth	6,620	150,000
Wyo. Land Co. No. 1	S15, T50N, R 81W	Clear Creek	55' Earth	9,770	110,000
Wyo. Land Co. No. 2	S17, T50N, R 81W	Clear Creek	66' Earth	21,390	130,000
Wyo. Land Co. No. 3	S11, T50N, R 81W	Clear Creek	85' Earth	10,870	80,000
Total Clear Creek & Tribs:				155,000	
Crazy Woman Creek & Tribs.					
Hall	S23, T49N, R 82W	Buffalo Wallows Cr.	96' Earth	3,580	59,000
Hawk	S20, T49N, R 80W	Crazy Woman Middle Wallow Cr.	Earth	520	5,500
Hazelton	S33, T48N, R 84W	Doyle & Middle Fk. Crazy Woman Creek	64' Earth	3,870	20,000
Keays	S26, T49N, R 84W	No. Prong No. Fk. Crazy Woman Creek	80' Earth	3,920	60,500
Kelly	S31, T50N, R 80W	Dry Creek	18' Earth	570	$ 1,000
Peak	S20, T49N, R 81W	Wallows Creek	145' Earth	14,200	300,000
"41"	S26, T49N, R 84W	North Fork Crazy Woman Creek	33' Rock Fill	610	10,700
Total Crazy Woman & Tribs:				27,270	
Total Powder River Basin (Excl. Little Powder				255,540	

Table 2

POTENTIAL RESERVOIRS FOR IRRIGATION STORAGE IN THE YELLOWSTONE BASIN IN MONTANA

(As Listed in the Montana Reports*)

Name of Reservoir	Source of Water Supply	Capacity (Acre-feet)
Main Stem and Minor Tributaries		
Mill Creek	Mill Creek	7,500
Lower Canyon	Yellowstone River	156,000
Sweetgrass	Sweetgrass Creek	18,000
McGinnis Creek	McGinnis Creek	5,018
Sarpy Creek	Sarpy Creek	600
East Rosebud	East Rosebud Creek	-
Kircher Creek (Custer County)	Kircher Creek	2,000
Upper Clear Creek (Dawson County)	Clear Creek	-
Hardy (Dawson County)	Seven Mile Creek	530
Sandstone Creek (Fallon County)	Sandstone Creek	1,000
Pennell Creek (Fallon County)	Pennell Creek	1,000
Rock Creek (Park County)	Rock Creek	3,000
Eight Mile (Park County)	Eight Mile Creek	2,140
Cottonwood Creek (Park County)	Cottonwood Creek	1,700
Rock Creek Lake (Park County)	Rock Creek	600
Vinden (Prairie County)	-	1,500
O'Fallon Creek (Prairie County)	O'Fallon Creek	-
Rosebud River	Rosebud River	3,242
Sunday Creek (Rosebud County)	Sunday Creek	2,000
Sioux Charley Lake	Stillwater River	2,300
Brackett Creek	Brackett Creek	32,000
Shields River	Shields River	30,000
Clark Fork		
Broadwater Curl Lakes	Clark Fork	5,000
Big Horn River		
Big Horn Canyon	Big Horn River	1,000,000
Tongue River		
Pumpkin Creek	Pumpkin Creek	6,800
Minafee Ranch	Pumpkin Creek	15,000
Pumpkin Creek	Pumpkin Creek	600
Powder River		
Moorhead	Powder River	46,000
Lamey Creek	Lamey Creek	1,146
Campbell Brown	-	2,655
Traub Project	-	600
Little Powder River		
Herman Project	Ranch Creek	400

* Source: 1. A report by the Montana Water Conservation Board, dated September 25, 1938.
2. A report submitted at the meeting of the Compact Commission in Billings, Montana, on October 10, 1940.

Table 3

POTENTIAL RESERVOIRS FOR IRRIGATION STORAGE IN THE YELLOWSTONE BASIN

(As Listed in Appendix F of the Progress Report (1939) of the National Resources Planning Board)

Name of Reservoir	State	Section	Township	Range	Source of Water Supply	Capacity (Acre-Feet)
Main Stem and Minor Tributaries						
Above Clark Fork						
Mill Creek	Montana	11	6S	9E	Mill Creek	7,500*
Lower Canyon	Montana	2	3S	9E	Yellowstone River	156,000*
Sweetgrass Creek	Montana	19	5N	13E	Sweetgrass Creek	18,000*
Shields River						
Brockett Creek	Montana	2	1N	8E	Brockett Creek	31,670*
Potter Creek	Montana		4N	8E	Potter Creek	20,000*
Porcupine Creek	Montana				Porcupine Creek	1,000
Lat Dam	Montana				Shields River	80,000
Antelope	Montana				Not given	9,100
Wilsall	Montana				Shields River	30,000
Small Wilsall	Montana				Not given	2,000
4 small reservoirs	Montana				Various	1,350
Below Clark Fork						
McGinnis Creek	Montana	7	11N	36E	McGinnis Creek	5,000*
Rosebud Creek	Montana		3S	39E	Rosebud Creek	3,200*
Clark Fork River						
Sunlight	Wyoming					60,000*
Mountain View	Wyoming					897
Big Horn River						
Wind River						
Torrey Lake	Wyoming		40N	106W	Torrey Creek	6,000*
Wind River No. 1	Wyoming	25	42N	108W	Wind River	40,000*
Dinwoody	Wyoming		5N	5W	Dinwoody Creek	23,000*
Black Mountain	Wyoming	11	6N	3W	Dry Creek	1,713
Dry Creek	Wyoming	22	6N	3W	Dry Creek	987
Dry Lake	Wyoming	1	2N	2E	Not given	2,305
Jessamine	Wyoming	24	3N	5W	Five Mile Creek	1,332
Popo Agie River						
Raft Lake	Wyoming		1S	5W	N.F. Little Wind River	30,000*
Tuygee	Wyoming	3	33N	104W	S.F. Little Wind River	10,000*
Long Beach	Wyoming		33N	102W	N.F. Popo Agie River	12,620*
Christiana Lake enl.	Wyoming	8	30N	101W	Little Popo Agie River	5,200*
Louise Lake	Wyoming		30N	101W	M.F. Popo Agie River	60,000*
Enterprise	Wyoming	26	32N	101W	M.F. Popo Agie River	1,208
Beaver Creek Nos. 1&2	Wyoming		30N	98W	Beaver Creek	3,678
Greybull River						
Lower Sunshine	Wyoming	28	48N	101W	Greybull River	43,500*
Meadows	Wyoming	27	46N	103W	Wood River	34,000*
Phelps	Wyoming	13	49N	103W	Rawhide Creek	860*
Sandstone	Wyoming	29	51N	95W	Greybull River	670*
Gould	Wyoming	19	51N	94W	Greybull River	660*
Rawhide Creek	Wyoming	2	48N	102W	Greybull River	54,755
Dry Cottonwood & Buffalo Basin	Wyoming	23	49N	100W	Greybull River	4,753
Sage Creek enl.	Wyoming				Dry Creek	1,465
Junietta	Wyoming	29	51N	95W	Dorsey Creek	1,275
4 small reservoirs	Wyoming				Various	2,570
Shoshone River						
Oregon Basin	Wyoming	27	52N	100W	Shoshone River	150,000*
Belknap No. 1	Wyoming	13	50N	104W	S.F. Shoshone River	4,816
Thompson	Wyoming				Not given	1,011
Lagoon Lake	Wyoming				Not given	1,320
2 small reservoirs	Wyoming				Not given	1,577
Minor Tributaries						
Above Shoshone River						
South Owl Creek	Wyoming				S.F. Owl Creek	9,800*
Basin	Wyoming	13	43N	100W	N.F. Owl Creek	6,000*
Grass Creek	Wyoming	6	45N	99W	Grass Creek	2,600*
Buffalo Creek	Wyoming	19	47N	98W	Greybull River	400,000*
Tensleep Meadows	Wyoming	32	49N	86W	E.F. Tensleep Creek	13,500*
Solitude	Wyoming	31	51N	86W	M.F. Paintrock Creek	6,000*
Shell Lake	Wyoming		52N	91W	Shell Creek	500*
Hrolf	Wyoming				Muskrat Creek	3,873
King Gorm	Wyoming				Muskrat Creek	4,765
Muskrat No. 2	Wyoming				Muskrat Creek	2,038
Queen Thyra	Wyoming				Muskrat Creek	1,053
Buffalo	Wyoming				Buffalo Creek	2,695
Anchor	Wyoming		8N	1W	Owl Creek	12,464
Community	Wyoming				Not given	2,024
South Side No. 1	Wyoming				Not given	3,575
Cottonwood Irrig. Co.	Wyoming				Grass Creek	1,267
Dempsey	Wyoming		43N	94W	Owl Creek	1,074
Kirby Irrig. Co.	Wyoming				Kirby Creek	3,088
Gooseberry	Wyoming	36	47N	101W	Wood River	42,550
Gooseberry No. 2	Wyoming				Gooseberry Creek	8,500
Farmers	Wyoming	31	47N	97W	Wood River	14,500
Little Buffalo Basin	Wyoming	4	47N	99W	Wood River	75,810
Buffalo Basin No. 1	Wyoming	24	49N	98W	Wood River	42,875
Stone Springs	Wyoming	27	49N	98W	Wood River	46,081
Fruitland No. 1	Wyoming				No. Water Creek	7,245
Fruitland No. 2	Wyoming				No. Water Creek	5,318
Dougherty	Wyoming				Canyon Creek	42,500
Medicine Lodge	Wyoming	11	51N	88W	Medicine Lodge Creek	2,247
Paint Rock	Wyoming	14	51N	88W	Medicine Lodge Creek	1,296
Peay No. 2	Wyoming				Medicine Lodge Creek	9,840
Summit	Wyoming				Not given	5,820
Elk Creek Valley No. 1	Wyoming				Elk Creek	1,100
Elk Creek Valley No. 2	Wyoming				Elk Creek	1,140
Shell	Wyoming				Shell Creek	1,367
Adelarde Lake enl.	Wyoming				Adelarde Creek	1,790
Willis	Wyoming				Not given	2,132
11 small reservoirs	Wyoming				Various	8,277
Below Shoshone River						
Big Horn Canyon	Montana	18	6S	31E	Big Horn River	200,000*
Porcupine Creek	Montana				Porcupine Creek	14,661
Little Horn River						
Twin Creek	Wyoming				Twin Creek	1,000
Tongue River						
Rockwood	Wyoming	24	56N	88W	Tongue River	21,750*
North Fork	Wyoming	4	55N	89W	N.F. Tongue River	28,000*
South Fork	Wyoming		56N	88W	S.F. Tongue River	25,000*
Pumpkin Creek	Montana		2S	49E	Pumpkin Creek	6,800*
Tongue River	Wyoming	11	57N	84W	Tongue River	1,337
2 small reservoirs	Wyoming				Goose Creek	1,383
Powder River						
Upper Powder River						
Red Fork	Wyoming	8	43N	83W	Red Fork of Powder	30,000*
Murphy Flats	Wyoming				S.F. Powder River	1,038
Indian Springs	Wyoming				S.F. Powder River	5,400
Sunset	Wyoming				S.F. Powder River	3,200
Midwest	Wyoming				Salt Creek	5,486
Briggs	Wyoming				Wild Horse Creek	1,131
4 small reservoirs	Wyoming				Various	3,133
Crazy Woman Creek						
Hazelton	Wyoming				Crazy Woman Creek	3,870
Keay	Wyoming				Crazy Woman Creek	3,922
3 small reservoirs	Wyoming				-	1,692
Clear Creek						
Elk Lake	Wyoming	14	51N	85W	Elk Creek	1,500*
Clear Creek Nos. 1&2	Wyoming		50N	81W	Clear Creek	16,600*
Henry	Wyoming		50N	82W	Sand Creek	12,000*
Piney	Wyoming		52N	85W	S.F. Piney Creek	5,250*
Cloud Peak enl.	Wyoming		51N	85W	S.F. Piney Creek	4,080*
Triangle Park	Wyoming				Clear Creek	2,823
Little Sourdough	Wyoming				Clear Creek	1,642
Wyo. Land Co. No. 2	Wyoming				Clear Creek	21,320
Seven Brothers	Wyoming				Clear Creek	7,774
Camp Comfort	Wyoming				Clear Creek	11,640
Hall	Wyoming				Clear Creek	14,200
Peck	Wyoming	20	49N	81W	Clear Creek	3,580
Red Man Draw	Wyoming				Clear Creek	2,502
Kearney Lake enl.	Wyoming				Piney Creek	1,400
Lower Powder River						
Moorhead	Montana	18	9S	48E	Powder River	46,000*
Little Powder River						
Cottonwood	Wyoming		53N	70W	Cottonwood Creek	3,000*
Lonetree Nos. 1 & 2	Wyoming		53N	70W	Lone Tree Creek	3,000

* This capacity is included in the water-use studies of Appendix F.

APPENDIX III

POTENTIAL POWER SITES IN THE YELLOWSTONE RIVER BASIN

The only complete survey of power sites in the basin was made by the Corps of Engineers, and was published in their 308 Report (H.D. 256, 73d Congress, 2d Session). The first three tables presented in this appendix were taken from that document. These tables classify the projects as follows:

Table 1. Potential power projects. (Potential projects involving primary output costs below 8 mills per kilowatt-hour).

Table 2. Power sites surveyed but found infeasible.

Table 3. Power sites found infeasible by reconnaissance.

In addition to the projects listed in the tables, one project was found that had a primary output cost ranging between eight and sixteen mills per kilowatt-hour. This was the Wind River project on the north fork of the Wind River. The project would have an installed capacity of 2,200 kilowatts and a prime power rating of 1,010 kilowatts. The primary output cost was estimated at 10.93 mills per kilowatt-hour. Further information relative to the projects listed in table 1 is contained in Appendix V of the 308 Report.

The Wyoming Report, "Water Resources of the Yellowstone Basin in Wyoming", by H. T. Person, also lists the potential hydroelectric developments in the basin. The Wyoming compilation appears to have been based on the Corps of Engineers' survey, with which it agrees very closely except for a few additions. Table 4 lists those potential hydroelectric developments contained in the Wyoming Report that could not be definitely identified in tables 1, 2 and 3 of this appendix.

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Appendix III
Table 1

Potential Power Projects in the Yellowstone River Basin
Involving Primary Output Cost Below 8 Mills

Name of Project	Location	Prime Power Rating (kilowatts)(1)	Description
		Main Stem Yellowstone River	
Yankee Jim Canyon	North of Yellowstone Park, in T. 8 S., R. 7 E. Park County, Mont.	15,000	Reservoir plant; power house integral with dam. Reservoir capacity, 270,000 acre-feet; useful storage, 176,300 acre-feet. Gross head, 194 feet; normal head, 175 feet. Installed capacity, 44,000 kilowatts. Unit cost of prime, 6.37 mills.
Lower Canyon	43 miles below Yankee Jim site, in sec. 2, T. 3 S., R. 9 E. Park County, Mont.	45,000	Reservoir plant; power house 600 feet below dam. Reservoir capacity, 1,384,000 acre feet; useful storage, 888,320 acre-feet. Gross head, 254 feet; normal head, 229 feet. Installed capacity, 135,000 kilowatts. Unit cost of prime, 7.50 mills.
Yankee Jim-Lower Canyon, combined	Same as Yankee Jim and Lower Canyon above described.	63,000	Yankee Jim plant as described above. Lower Canyon plant; reservoir capacity, 1,384,000 acre-feet; useful storage, 947,000 acre-feet. Gross head, 254 feet; normal head, 229 feet. Installed capacity, 160,000 kilowatts. Unit cost of system prime, 7.05 mills.
		Clark Fork River	
Clark Fork System	Shoshone National Forest Park County, Wyo.	-	5-plant system, described below. Unit cost of prime 1.18 mills

Name of Project	Location	Prime Power Rating (kilowatts)(1)	Description
Upper Clark Fork Plant	Reservoir on Clark Fork above Crandall Creek. Power house near mouth of Beartooth Creek.		Reservoir plant; 33,000 feet of tunnel to power house. Reservoir capacity, 180,000 acre-feet; useful storage, 91,900 acre-feet. Gross head, 657 feet; normal head, 600 feet. Installed capacity, 15,500 kilowatts.
Beartooth Lake Plant	On Clark Fork at mouth of Beartooth Creek.		Plant utilizes controlled outflow of Beartooth Lake through 29,500 feet of penstock. Gross head, 2,680 feet; normal head, 2,390 feet. Installed capacity, 6,000 kilowatts.
Thief Creek Plant	Reservoir on Clark Fork, near mouth of Thief Creek. Power house at mouth of Sunlight Creek	94,400	Reservoir plant; 32,400 feet of tunnel to power house. Reservoir capacity, 144,000 acre-feet; useful storage, 86,800 acre-feet. Gross head, 1,305 feet; normal head, 1,177 feet. Installed capacity, 50,000 kilowatts.
Sunlight Creek Plant	Reservoir on Sunlight Creek. Power house at mouth of Sunlight Creek.		Reservoir plant; 30,300 feet of tunnel to power house. Reservoir capacity, 74,200 acre-feet; useful storage, 37,500 acre-feet. Gross head, 1,900 feet; normal head 1,861 feet. Installed capacity, 18,000 kilowatts.
Dead Indian Plant	Diversion dam on Clark Fork, below mouth of Sunlight Creek. Power house at lower end of Clark Fork Canyon.		Run-of-river plant; 31,700 feet of tunnel to power house. Gross head, 450 feet; normal head, 417 feet. Installed capacity, 24,000 kilowatts.
	Little Popo Agie River		
Louis Lake	Reservoir on Louis Creek. Power house on Little Popo Agie, in sec. 28, T. 31 N., R. 100 W.	1,450	Reservoir plant with diversion from Little Popo Agie; 21,500 feet of high line and penstock to power house. Reservoir capacity, 8,000 acre-feet; all useful. Gross head, 769 feet; normal head, 711 feet. Installed capacity, 2,200 kilowatts. Unit cost of prime, 4.07 mills.

Name of Project	Location	Prime Power Rating (kilowatts) (1)	Description
			Tensleep Creek
Tensleep Creek	Big Horn National Forest, Big Horn County, Wyo.	-	4-plant system, described below. Unit cost of prime 4.63 mills
West Tensleep Lake Plant.	Diversion near West Tensleep Lake	3,440	(Run-of-river plant; 21,000 feet of high line and penstock to power house. Gross head, 592 feet; normal head, 529 feet. Installed capacity, 200 kilowatts.
Junction Plant	(Between West Tensleep Lake plant and Tensleep Canyon Plant		(Run-of-river plant; 28,000 feet of high line and penstock to power house. Gross head, 1,545 feet; normal head, 1,395 feet. Installed capacity, 1,600 kilowatts.
Lee Canyon Plant			(Run-of-river plant; 17,000 feet of high line and penstock to power house. Gross head, 1,205 feet; normal head, 1,075 feet. Installed capacity, 1,200 kilowatts.
Tensleep Canyon Plant	Power house about 2 miles above Burra, Wyo.		(Run-of-river plant; 21,000 feet of high line and penstock to power house. Gross head, 650 feet; normal head, 585 feet. Installed capacity 1,400 kilowatts.
			Paintrock Creek
Paintrock Creek	Big Horn National Forest Big Horn County, Wyo.	-	2-plant system, described below. Unit cost of prime 6.48 mills.
Buckskin Ed Plant Tunnel Plant	T.50 N. R. 88 W. On North Fork of Paintrock Creek	1,335	(Run-of-river plant; 37,500 feet of tunnel, high line and penstock to power house. Gross head, 2,570 feet; normal head, 2,320 feet. Installed capacity 1,900 kilowatts. (Run-of-river plant; 3/4 mile of tunnel to power house. Gross head, 180 feet; normal head, 170 feet. Installed capacity, 200 kilowatts.

Name of Project	Location	Prime Power Rating (kilowatts) (1)	Description
			Shell Creek
Shell Creek	Big Horn National Forest, Big Horn County, Wyo.	-	2-plant system, described below. Unit cost of prime 3.81 mills
Upper Shell Creek Plant	Diversion in sec. 29, T. 53 N., R. 88 W.		(Run-of-river plant, 56,400 feet of high line and penstock to power house. Gross head, 2,700 feet; normal head, 2,430 feet. Installed capacity, 1,800 kilowatts.
Lower Shell Creek Plant	Powerhouse about 4 miles above Shell, Wyo.	2,590	(Run-of-river plant; 14,000 feet of high line and penstock to power house. Gross head, 860 feet; normal head, 758 feet. Installed capacity, 1,300 kilowatts.
			Big Horn River
Cave Canyon	Sec. 17, T. 55 N., R. 94 W., near Kane, Wyo.	10,800	Reservoir plant, power house integral with dam. Reservoir capacity, 393,000 acre-feet; useful storage, 276,500 acre-feet. Gross head, 113 feet; normal head, 98 feet. Installed capacity, 38,100 kilowatts. Unit cost of prime 7.05 mills.
Upper Big Horn	2 miles south of Montana-Wyoming State line	11,300	Reservoir plant, power house about 150 feet below dam. Reservoir capacity, 479,000 acre-feet; useful storage, 350,700 acre-feet. Gross head, 108 feet; normal head, 98 feet. Installed capacity, 34,000 kilowatts. Unit cost of prime 4.39 mills.
Big Horn Canyon	Sec. 18, T. 6 S., R. 31 E., Big Horn County, Mont.	61,000	Reservoir plant, power house just below dam. Reservoir capacity, 830,000 acre-feet; useful storage, 700,000 acre-feet. Gross head, 435.5 feet; normal head 368.5 feet. Installed capacity, 190,000 kilowatts. Unit cost of prime, 6.29 mills.
Big Horn 3-Plant System	-	-	3-plant system, described below. Unit cost of prime 5.41 mills.

Name of Project	Location	Prime Power Rating (kilowatts)(1)	Description
Cave Canyon Plant	Sec. 17, T. 55 N., R. 94 W., (near Kane, Wyo.)		(Reservoir plant; power house integral with dam. Reservoir capacity, 393,000 acre-feet; useful storage, 262,700 acre-feet. Gross head, 108 feet; normal head, 96 feet. Installed capacity, 82,000 kilowatts.
Upper Big Horn Plant	2 miles south of Montana-Wyoming State line	85,000	(Reservoir plant; power house about 150 feet below dam. Reservoir capacity, 342,000 acre-feet; useful storage, 252,770 acre feet. Gross head, 87 feet; normal head, 82 feet. Installed capacity, 46,000 kilowatts.
Big Horn Canyon Plant	Sec. 18, T. 6 S., R. 31 E., Big Horn County, Mont.		(Reservoir plant; power house just below dam. Reservoir capacity, 582,000 acre-feet; useful storage, 330,400 acre-feet. Gross head, 390.5 feet; normal head, 354 feet. Installed capacity, 197,000 kilowatts.
Custer	Sec. 8, T. 3 N., R. 34 E., Big Horn County, Mont.	18,900	Reservoir plant; about 1,500 feet of conduit and penstocks to power house. Reservoir capacity, 501,000 acre-feet; useful storage, 253,600 acre-feet. Gross head, 99 feet; normal head, 99 feet. Installed capacity, 40,000 kilowatts. Unit cost of prime, 7.61 mills.
		Little Horn River	
Little Horn	2 miles south of Montana-Wyoming State line.	1,020	Run-of-river plant; 11,200 feet of high line and penstock to power house. Gross head, 485 feet; normal head, 442.5 feet. Installed capacity, 1,400 kilowatts. Unit cost of prime 2.26 mills.
		Boulder River	
Natural Bridge	Secs. 13 and 14, T. 3 S., R. 12 E. Sweetgrass County, Mont.	1,700	Reservoir plant; 1,300 feet of penstock to power house. Reservoir capacity 33,000 acre-feet; useful storage, 27,260 acre-feet. Gross head, 210 feet; normal head, 183 feet. Installed capacity, 3,800 kilowatts. Unit cost of prime, 7.94 mills.

Name of Project	Location	Prime Power Rating (kilowatts)(1)	Description
			Tongue River
Tongue River	Above Dayton, Sheridan County, Wyo.	-	4-plant system, described below. Unit cost of prime 5.46 mills.
Plant No. 1	Below South Fork Reservoir. Intake in sec. 33, T. 56 N., R. 88 W.	21,800	(Reservoir plant; 14,100 feet of tunnel and penstock to power house. Reservoir capacity, 25,000 acre-feet; useful storage, 24,000 acre-feet. Gross head, 590 feet; normal head, 549 feet. Installed capacity, 3,500 kilowatts
Plant No. 2	Below Rockwood Reservoir. Intake in sec. 24, T. 56 N., R. 88 W.		(Reservoir plant; 2,400 feet of pipe line and penstock to power house. Reservoir capacity, 31,000 acre feet; useful storage, 29,000 acre-feet. Gross head, 500 feet; normal head, 428 feet. Installed capacity, 4,350 kilowatts.
Plant No. 3	Diversion in sec. 18, T. 56 N., R. 87 W.		(Run-of-river plant; 25,200 feet of high line tunnel and penstock to power house. Gross head, 2,090 feet; normal head, 1,890 feet. Installed capacity, 16,000 kilowatts.
Plant No. 4	Diversion in sec. 10, T. 56 N., R. 87 W.		(Run-of-river plant; 10,500 feet of high line and penstock. Gross head, 310 feet; normal head, 277 feet. Installed capacity, 2,450 kilowatts

Source: 308 Report, H.D. 256, 73rd Congress, 2nd session, pages 87-90
(1) Apparently minimum continuous rate of output.

Appendix III
Table 2

Potential Hydroelectric Power Sites Surveyed But Found Infeasible
(As Listed in the Corps of Engineers 308 Report)

Yellowstone River Basin

Project	Location	Pertinent Data	Reason for Rejection
Wind River			
Wind River No. 1	On Wind River 2½ miles below confluence of Du Noir Creek	Useful storage 35,000 acre-feet; average head, 98 feet, prime rate, 800 kilowatts.	(a)
Wind River No. 2	On Wind River 2 miles above confluence of Du Noir Creek	Useful storage, 4,000 acre-feet; average head, 90 feet; prime rate 105 kilowatts.	(a)
Horse Creek	On Horse Creek, in T. 44 N., R. 107 W.	Useful storage, 3,500 acre-feet; head (using penstock),165 ft.; prime rate, 200 kilowatts	(a)
Torrey Lake	At Torrey Lake on Torrey Creek	(	
Dinwoody Lake	At Dinwoody Lake on Dinwoody Creek	(Storage contemplated in lake	(c)
Bull Lake	At Bull Lake on Bull Lake Creek	(	
Popo Agie River			
North Fork Popo Agie	16 miles above Lander, Wyo.	Useful storage, 15,650 acre-feet; head, 180 feet; prime rate, 550 kilowatts.	(a)
Middle Fork Popo Agie	T. 32 N., R. 100 W.	Pipe line development considered 818 foot head	(b)
Tuygee Lake	Sec. 3, T. 33 N., R. 104 W.	Reservoir capacity, 12,500 acre-feet; dam height, 46 feet.	(b)

Project	Location	Pertinent Data	Reason for Rejection
North Fork Little Wind	12 miles above confluence of South Fork	No useful storage; head, 170 feet; prime rate, 115 kilowatts.	(a)
South Fork Little Wind	16 miles above confluence of Little Wind	No useful storage; head, 150 feet; prime rate, 100 kilowatts.	(a)
Trout Creek	Reservoir on Trout Creek, near Fort Washakie, Wyo.		(b)
Big Horn River			
Anchor	Reservoir on South Fork of Owl Creek, secs. 23 and 24, T. 8 N., R. 1 W., and secs. 26 and 27, T. 43 N., R. 100 W.	Water supply augmented by diversion from North Fork, reservoir capacity, 12,464 acre-feet; dam height, 128 ft.	(b)
Basin	Dam site, sec. 13, T. 43 N., R. 100 W.	Water from North Fork Owl Creek, reservoir capacity 6,000 acre-feet; dam height 81 feet.	(b)
Mountain View	Off-stream reservoir, secs. 26 and 35, T-44 N., R. 98 W.	Water supply from North and South Forks Owl Creek, reservoir capacity, 5,830 acre-feet; dam height, 83 feet.	(b)
Morrison-McConaughy	Off-stream reservoir, dam site in sec. 36, T. 9 N., R. 2 E.	Water supply from Owl Creek, reservoir capacity, 2,024 acre-feet; dam height, 89 feet.	(b)
Dempsey	Off-stream reservoir near Lucerne, Wyo., dam site in sec. 31, T. 44 N., R. 94 W.	Diversion from Owl Creek, reservoir capacity, 1,070 acre-feet; dam height 46 feet.	(b)
Meadows	Dam site on Wood River, sec. 27, T. 46 N, R. 103 W.	Reservoir capacity, 34,000 acre-feet, dam height, 323 feet.	(b)

Project	Location	Pertinent Data	Reason for Rejection
Buffalo Creek	Dam site on Buffalo Creek, in T. 47 N., R. 99 W.	Reservoir capacity, 38,000 acre-feet; dam height, 125 feet.	(b)
Farmers	Dam site on Grass Creek, sec. 31, T. 47 N., R. 97 N.	Water supply from Wood River and Gooseberry Creek. Reservoir capacity, 14,500 acre-feet; dam height, 112 feet.	(b)
Upper Sunshine	Reservoir on Sunshine Creek, T. 47 N., R. 102 W.	Canal diversion from Greybull River.	(a)
Lower Sunshine	Reservoir on Sunshine Creek, T. 48 N., R. 101 W.	Canal diversion from Wood River.	(a)
Tensleep Meadows	Dam site on East Tensleep Creek, secs. 32 and 33, T. 49 N., R 86 W., and sec. 5, T. 48 N., R. 86 W.	Reservoir capacity, 13,500 acre-feet; dam height, 50 feet.	(d)
Tongue River			
Park	Reservoir on East Fork Goose Creek, secs. 15, 16, and 21, T. 53 N.,R.86 W.	Reservoir capacity 7,347 acre-feet; dam height, 80 feet	(b)
Big Goose Creek	Dam in sec. 9, T. 54 N., R. 86 W.	Run-of-river plant. Prime rate 300 kilowatts.	(a)
Lower Tongue River Canyon	Reservoir on Tongue River, sec. 33, T. 7½ S., R. 41 E.	Reservoir capacity, 224,000 acre-feet; dam height, 158 feet	(a)
Powder River			
Red Fork	On Red Fork, near Kaycee, Wyo., T. 43 N., R. 83 W.	Reservoir capacity, 51,590 acre-feet; gross head, 160 feet	(a)
Fort McKinney	Dam on Clear Creek in Fort McKinney Wood Reservation	Run-of-river plant. Prime rate, 1,200 kilowatts.	(a)

Project	Location	Pertinent Data	Reason for Rejection
Clear Creek Canyon Reservoir	5 miles above Buffalo, on Clear Creek	Reservoir capacity, 3,530 acre-feet; head, 80 feet; prime power, 80 kilowatts.	(a)
Peck	Off-stream reservoir, dam site in sec. 20, T. 49 N., R. 81 W.	Water supply from Clear Creek; reservoir capacity, 14,200 acre-feet; dam height, 117 feet.	(b)
Hall	Off-stream reservoir, dam site in sec. 24, T. 49 N., R. 82 W.	Water supply from Clear Creek; reservoir capacity, 3,580 acre-feet; dam height, 91 feet.	(b)
Henry	Dam site on Sand Creek, sec. 26, T. 50 W., R. 82 W.	Dam height, 126 feet.	(b)
North Wyoming Land Co., No. 1	On Dry Creek, T. 50 N., R. 81 W.	Reservoir capacity, 21,451 acre-feet; dam height, 107 feet.	(b)
North Wyoming Land Co., No. 2	On Dry Creek, T. 50 N., R. 81 W.	Reservoir capacity, 13,150 acre-feet; dam height, 76 feet.	(b)
Piney	Reservoir on South Fork Piney Creek, T. 52 N., R. 85 W.	Reservoir capacity, 5,251 acre-feet; dam height, 46 feet.	(b)
Piney Creek	On Piney Creek, sec. 28, T. 53 N., R. 84 W.	Run-of-river plant. Prime rate, 460 kilowatts.	(a)
Moorehead	On Powder River, near Moorhead, Mont.	Reservoir capacity, 234,000 acre-feet; normal head, 90 feet.	(a)
Cottonwood	Reservoir on Cottonwood Creek, secs. 22, 23, and 26, T. 53 N., R. 70 W.	Reservoir capacity, 4,963 acre-feet; dam height, 55 feet.	(b)

Source: 308 Report, H.D. 256, Pages 84, 85, and 86.

(a) Excessive construction cost.
(b) Insufficient stream flow.
(c) Inconsequential prime power output.
(d) Insufficient power head.

Appendix III
Table 3

Potential Hydroelectric Power Sites Found Infeasible By Reconnaissance

Yellowstone River Basin

Project	Location	Pertinent Data	Reason for Rejection
Yellowstone River			
Twenty-two mile site	Reservoir on Yellowstone River between Yankee Jim and Lower Canyon sites	100-foot head	(a)
Yellowstone River Reservoirs:	Reservoirs along the main stem of the Yellowstone, between Livingston and Glendive.		(a)
Springdale			
Big Timber			
Columbus No. 1			
Stillwater			
Columbus No. 2			
Pompeys Pillar No. 1			
Pompeys Pillar No. 2			
Custer No. 1			
Terry			
Glendive No. 1			
Glendive No. 2			
Glendive No. 3			
Glendive No. 4			
Glendive No. 5			
Shields River			
Brackett Creek	Reservoir on Brackett Creek T. 1N., R.8 E	Reservoir capacity, 14,229 second feet; dam height, 97 ft.	(a)

Project	Location	Pertinent Data	Reason for Rejection
Boulder River			
Lower Boulder	Reservoir on Boulder River, below McLeod	Would involve a diversion to the Yellowstone River	(a)
Stillwater River			
East Rosebud Creek	Reservoir in T. 6S., R. 18E	Reservoir capacity, 37,500 acre-feet; dam height, 80 feet.	(b)
Clark Fork River			
Timber Creek	Reservoir on Timber Creek, a tributary of Crandall Creek		(b)
Big Horn River			
Long Beach	Reservoir on North Fork Popo Agie, T. 33 N., R. 102 W	Reservoir Capacity, 15,000 acre-feet; dam height, 30 feet	(b)
Boysen	On Big Horn, near Shoshone, Wyo.	Plant built and abandoned	(d)
Little Buffalo Basin	Dam site in sec. 4, T. 47 N., R. 99 W	Water from Wood and Greybull; reservoir capacity, 51,200 acre-feet; dam height, 162 feet.	
Buffalo No. 2	Dam site in sec. 6, T. 48 N., R. 95 W	Water from Dry Cottonwood Creek and Greybull; reservoir capacity, 10,000 acre-feet; dam height, 40 feet	
Stone Springs	Dam site in sec. 27, T. 49 N., R. 98 W	Reservoir capacity, 46,100 acre-feet; dam height, 125 feet	(b)
Greybull	Dam site in sec. 21, T. 48 N., R 101 W	Reservoir capacity, 84,200 acre-feet; dam height, 190 feet	
Rawhide Creek	Dam site in sec. 2, T. 48 N., R. 102 W	Reservoir capacity, 34,700 acre-feet; dam height, 150 feet	
Spring Creek	Dam site in sec. 2, T. 48 N., R. 101 W	Reservoir capacity, 64,600 acre-feet dam height, 165 feet	

Project	Location	Pertinent Data	Reason for Rejection
West Tensleep Lake East Tensleep Lake	Reservoirs on Tensleep Creek		(c)
Shell Creek	3 reservoirs on Shell Creek		
Paintrock	Reservoir on Trout Creek, T. 51 N., R. 88 W.	Reservoir capacity, 1,297 acre-feet) dam height, 32 feet)	
Solitude	Reservoir on Middle Fork Paintrock Creek sec. 31, T. 51 N., R. 86 W., and sec. 36, T. 51 N., R. 87 W.	Reservoir capacity, 6,000 acre-feet)))	(b)
Medicine Lodge	Reservoir in sec. 11, T. 51 N., R. 88 W	Reservoir capacity, 2,248 acre-feet) dam height, 22 feet.)	
Shoshone	3 reservoirs on Shoshone River, and one off-stream (Oregon Basin)		(a)
Tongue River			
North Fork	Dam site in sec. 4, T. 55 N., R 89 W	Reservoir capacity, 42,500 acre-feet; dam height, 130 feet.	(b)
Powder River			
Middle Fork	Reservoir on Powder River, 22 miles west of Kaycee, Wyo.		(b)
Cloud Peak	Reservoir on South Fork Piney Creek, sec. 16, T. 51 N., R. 85 W.	Reservoir capacity, 2,500 acre-feet; dam height, 19 feet (existing reservoir.)	(b)
Lake DeSmet	Off-stream reservoir, near South Fork Piney Creek		(b)
Kearney Lake	Reservoir on South Fork Piney Creek, sec. 30, T. 52 N., R. 85 W.	Reservoir capacity, 2,500 acre-feet; dam height, 25 feet (existing reservoir)	(b)

Source: 308 Report, H.D. 256 Pages 82-83
(a) Excessive construction cost.
(b) Insufficient stream flow.
(c) Run-of-river projects preferable.
(d) Operation has proved site to be impracticable.

Appendix III
Table 4

Miscellaneous Potential Hydroelectric Projects in Wyoming

As Reported in "Water Resources of the Yellowstone Basin in Wyoming"

(Plants That Could be Definitely Identified in Tables 1, 2, or 3 of Appendix III are not Included)

Plant Name	Location Section	Township	Range	Source of Water Supply	Proposed Installed Capacity (hp)
Main Stem and Minor Tributaries					
None					
Clark Fork River					
Benninghoff	27	56N	105W	Clark Fork	2,784
Clark Fork	3	56N	106W	Crandall Creek	3,094
Clark Fork Power	35	56N	104W	Clark Fork	5,397
Dead Indian Power	8	55N	104W	Dead Indian Creek	2,272
Sunlight Power	33	56N	104W	Sunlight Creek	13,523
Big Horn River					
Deer Creek Ranch	33	49N	106W	Reed Spring (Shoshone)	19
Miller Ditch Enlargement	32	42N	107W	Warm Spring Creek (Wind)	154
North Fork Flume	7	33N	101W	N.F. Popo Agie	1,200
Raft Lake	-	1N	3W	N.F. Little Wind	5,400
Little Horn River					
None					
Tongue River					
None					
Powder River					
None					
Little Powder River					
None					

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APPENDIX IV
CONGRESSIONAL AUTHORIZATION

Original Act

(Public - No. 237 - 75th Congress)
(Chapter 552 - 1st Session)
(S. 534)

AN ACT

Granting the consent of Congress to the States of Montana and Wyoming to negotiate and enter into a compact or agreement for division of the waters of the Yellowstone River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That consent of Congress is hereby given to the States of Montana and Wyoming to negotiate and enter into a compact, or agreement, not later than June 1, 1939, providing for an equitable division and apportionment between the States of the water supply of the Yellowstone River and of the streams tributary thereto, upon condition that one suitable person, who shall be appointed by the President of the United States, shall participate in said negotiations as the representative of the United States and shall make report to Congress of proceedings and of any compact or agreement entered into: Provided, That such compact or agreement shall not be binding or obligatory upon either of the parties thereto unless and until the same shall have been approved by the legislatures of each of said States and by the Congress of the United States: Provided further, That nothing in this Act shall apply to any waters within or tributary to the Yellowstone National Park or shall establish any right or interest in or to any lands within the boundaries thereof.

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Approved, August 2, 1937.

Amended Act

(Public - No. 632 - 76th Congress)
(Chapter 372 - 3d Session)
(S. 1759)

AN ACT

Granting the consent of Congress to the States of Montana, North Dakota, and Wyoming to negotiate and enter into a compact or agreement for division of the waters of the Yellowstone River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act of Congress approved August 2, 1937 (50 Stat. 551), granting the consent of Congress

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to the States of Montana and Wyoming to negotiate and enter into a compact or agreement for division of the waters of the Yellowstone River be, and it is hereby, amended to provide that the consent of Congress is given to the State of North Dakota to negotiate and to enter into the compact or agreement therein authorized providing for an equitable division and an apportionment between the States of the water supply of the Yellowstone River and of the streams tributary thereto, upon condition that the representative appointed by the President of the United States under the Act of August 2, 1937, to participate in said negotiations as the representative of the United States and to report to Congress of proceedings and of any compact or agreement entered into, shall continue to represent the United States and to report under this Act: Provided, That such Act of August 2, 1937, is amended by striking out "June 1, 1939" and inserting in lieu thereof "June 1, 1943": Provided, That such compact or agreement shall not be binding or obligatory upon any of the parties thereto unless and until the same shall have been approved by the legislatures of each of the said States and by the Congress of the United States: Provided further, That nothing in this Act shall apply to any waters within or tributary to the Yellowstone National Park or shall establish any right or interest in or to any lands within the boundaries thereof.

Approved, June 15, 1940.

APPENDIX V
PROGRESS REPORT OF THE COMPACT COMMISSION

(Copy of the letter, dated March 8, 1939, from Hon. Clyde L. Seavey to the Vice President and the Speaker of the House:)

Federal Power Commission,
Washington, March 8, 1939.

Hon. John N. Garner,
President of the United States Senate.

My Dear Mr. President: Pursuant to an act of Congress approved August 2, 1937 (50 Stat. 551), granting the consent of the Congress to the States of Montana and Wyoming to negotiate and enter into a compact or agreement for an equitable division and apportionment of the waters of the Yellowstone River, four representatives of each of the States of Montana and Wyoming and the undersigned representative of the United States were duly appointed to negotiate the compact contemplated by the act. Transmitted herewith is a progress report on this subject, addressed to the Governors of the States of Montana and Wyoming and to the Congress of the United States.

It will be noted that the act of Congress cited above requires that the compact be negotiated and entered into not later than June 1, 1939. Due to the volume of work to be performed and to lack of certain essential information, the aforesaid State and Federal representatives have been unable as yet to negotiate a compact, and hence a final report cannot be submitted to the Congress at this time. It appears certain moreover, that all of the information essential to an equitable division of the waters in question will not be available until sometime after June 1, 1939.

The Yellowstone River discharges into the Missouri River in the State of North Dakota near the Montana-North Dakota State line and about 740 square miles of its watershed lies within the State of North Dakota. It appears desirable, therefore, that the act of August 2, 1937, be amended so as to give to the State of North Dakota the consent of the Congress to participate in the negotiations along with the States of Montana and Wyoming.

It is respectfully recommended that the act of August 2, 1937, be so amended that the consent of the Congress shall be given to the States of Montana, Wyoming, and North Dakota to negotiate and enter into a compact or agreement providing for an equitable division and apportionment among the three States of the waters of the Yellowstone River and of the streams tributary

thereto, subject to all of the conditions and provisos contained in said act of August 2, 1937, except that requiring that the compact be entered into not later than June 1, 1939.

Respectfully submitted.

Clyde L. Seavey,
Representative of the United States.

(Enclosure)

* * *

PROGRESS REPORT TO THE GOVERNORS OF THE STATES OF MONTANA AND WYOMING AND TO THE CONGRESS OF THE UNITED STATES REGARDING YELLOWSTONE BASIN COMPAC

Pursuant to the authority granted by Congress in Public - No, 237 - 75th Congress, Chapter 552 - 1st Session (S.534) authorizing the States of Montana and Wyoming to negotiate and enter into a compact providing for an equitable division of the water supply of the Yellowstone River basin, the President appointed Mr. Clyde L. Seavey, (Acting Chairman, Federal Power Commission) to be the representative of the United States, and the Governor of the States of Montana and Wyoming respectively appointed representatives as follows:

Montana:
Mr. E. B. Donohue, Chairman, Helena, Montana
Mr. Rockwood Brown, Billings, Montana
Mr. J. D. Scanlan, Miles City, Montana
Mr. B. B. Armstrong, Livingston, Montana.

Wyoming:
Mr. John D. Quinn, Chairman, Cheyenne, Wyoming
Mr. L. F. Thornton, Thermopolis, Wyoming
Mr. J. R. Ellis, Basin, Wyoming
Mr. Will C. Metz, Cheyenne, Wyoming

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The above representatives of Federal and State interests comprise the Yellowstone River Compact Commission.

Following the appointment of these representatives, meetings were held on May 5, 1938, in Billings, Montana and on November 21 and 22, 1938 in Thermopolis, Wyoming. In addition to members of the Commission, there were also present at these meetings representatives of federal bureaus and agencies as follows: Bureau of Reclamation; Indian Service; Forest Service Corps of Engineers, U. S. Army; National Park Service; and Federal Power Commission. The purpose of these meetings was to ascertain the character of information required for the drafting of the Yellowstone River Basin Compact, and the extent to which data on climate, topography, land ownership, population, and water development are available; to investigate the uses of water for irrigation, power, navigation, domestic and industrial purposes, and to study the laws of the States of Montana and Wyoming with respect thereto. Such information as is available at the present time from Federal and State sources has been collected and compiled by the

Denver Regional Office staff of the Federal Power Commission, under the direction of the Compact Commission.

From an analysis of the available information, it is the consensus of the Compact Commission:

1. That adequate factual data necessary to the drafting of a compact between the States of Montana and Wyoming are not available at the present time; however, studies now being carried on by the Bureau of Reclamation, U. S. Army Engineers, Forest Service, Indian Service, and other Federal agencies will produce a considerable amount of additional data, which will be useful for this purpose. Information which is presently inadequate or entirely lacking is as follows:

   (a) Existing diversions for irrigation;
   (b) Priorities of irrigation appropriations and rights;
   (c) Acreages presently being irrigated and which are irrigable from existing works;
   (d) Net water duty on irrigated lands;
   (e) Crops grown on irrigated lands;
   (f) Potentially irrigable lands and their water requirements.
   (g) Stream flow data on minor tributaries;
   (h) Location and cost of additional storage;
   (i) Soil surveys;
   (j) Studies of soil erosion, and silting of reservoirs;

2. That apparently the annual run-off of the Yellowstone River basin is sufficient to meet all existing and potential consumptive uses if and when a comprehensive plan of storage has been developed and put into effect;

3. That the Indian rights, under various treaties, to the waters of the Wind, Big Horn, and Tongue Rivers for irrigation purposes have not been definitely determined. These rights likely will be more definitely defined by a decision of the Supreme Court of the United States in connection with litigation now pending before that tribunal;

4. That approximately 740 square miles of the drainage basin of the Yellowstone River lies within the State of North Dakota; therefore it appears desirable that the Congress of the United States amend its authorization for a compact with reference to the waters of the Yellowstone River to include the State of North Dakota as a signatory thereto.

5. That, because existing water supplies as presently developed are inadequate to fully meet demands for irrigation and other uses in critically dry years, there is imminent danger that irrigators in certain areas will resort to costly and protracted litigation in order to protect their rights; therefore,

it is essential that additional storage be constructed at strategic points at the earliest possible date in order to relieve this situation; and that the respective State Compact Commissions be given adequate authority and funds with which to proceed with the collection of data necessary to the drafting of a Compact;

6. That, pending the negotiation of a formal compact and without prejudice to existing water rights, the representatives of the States of Montana and Wyoming agree to cooperate to the fullest extent in securing such administration of rights in their respective states as will tend to alleviate water shortages during dry years.

7. That, in view of the size of the task now facing the Compact Commission, it is the Commission's opinion and recommendation that the Congress of the United States should extend indefinitely the time limit within which this compact may be consummated.

Respectfully submitted.

E. B. Donohue,
Rockwood Brown,
J. D. Scanlan,
B. B. Armstrong,
Representing the State of Montana.
John D. Quinn,
L. F. Thornton,
J. R. Ellis,
Will G. Metz,
Representing the State of Wyoming.
Clyde L. Seavey,
Representing the United States.

Dated February 25, 1939.

0736

Proposed Yellowstone River Compact Explanation of Article V by Montana State Engineer's Office, Jan. 30, 1943

0737

1943

PROPOSED YELLOWSTONE RIVER COMPACT

EXPLANATION OF ARTICLE V

Montana State Engineer's Office, Jan. 30,1943

It is the intention herein to briefly explain the contents of Article V in as simple language as possible.

Allotments of water were made for the following interstate streams; Clarks Fork, Big Horn, Tongue and Powder Rivers; and Yellowstone River at Sidney. An attempt has been made by the Compact Commission to set up the division of water of each interstate stream (except Yellowstone at Sidney) on (A) the basis of acres irrigated and the corresponding water requirement, and (B) the potentially irrigable lands and potential water requirements for such lands. In most cases the acres now irrigated and the potential acres were obtained from the Bureau of Reclamation as a result of its survey in 1940. In some instances data were used from the Indian Service and the Bureau of Census.

In setting up the divisions of water on some of the interstate streams, it became necessary to depart from the true mathematical calculations. Such deviations were the result of compromises agreed upon in order to settle disputed questions.

Before the end of the first ten years and at the end of each ten years thereafter, the Commission shall re-examine the allotments of water and make such modifications as may be equitable. If they fail to agree at the end of the first ten years, then the allotment shall be suspended until an agreement can be reached, and in the meantime the rights of appropriators shall revert back to their original status. If they fail to agree on the modification of any allotment during any succeeding ten-year period, then the allotment previously agreed upon shall continue in force. (Article V, Sec. B).

It gives the Commission an opportunity to study basic data, such as water supplies, water use, land areas, etc., which are essential in making readjustments of allotments. (Art. III, Sec. C, D, and Art. IV). These provisions give the water users on any interstate stream an opportunity to drop out of the Compact within the first ten years if they are not satisfied.

It is recognized that seasons change, climatic conditions are irregular, snowfall and resulting stream flows are not constant, cloudbursts and drouths are intermittent; and many other irregularities which make it impossible to divide the stream flows on a fixed formula. The Compact is elastic enough so that "minor compensating irregularities and fluctuations in the flow shall be permitted". (Art. V, Sec. C).

The Compact itself and amendments of it that are substantial and are not modifications of water allotments, shall be approved by the three state legislatures and Congress. (Art. V, Sec. B, and Art. XI).

Before studying the following pages it is absolutely necessary to get a clear conception of "divertible flow".(Art. II, Sec. 1). In simple language, it is the algebraic sum of the following three items:-

(a) The quantity of water that flows into a reservoir, minus the quantity of water released from the reservoir. 1/

(b) The summation of all water diverted into all ditches. 1/

(c) The water left in the stream at the point of measurement.

By adding together (a), (b), and (c) we get the "divertible flow".

1/ Every reservoir and every ditch above the point of measurement must be included.

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Explanation of Article V.

Mean Divertible Daily Flow:

If it was physically possible to measure items (a), (b), and (c) within any one 24-hour period, there would be no reason for injecting this term into the Compact. It may take a week or ten days to make all these measurements,(due to long distances, poor roads,etc). When all the measurements are made and added up, the sum is then divided by the number of days it took to make the measurements, and the result is the "mean divertible daily flow". (Art. II, Sec. J).

Abbreviations: For the sake of brevity in the following pages, these abbreviations are used:-

USBR - United States Bureau of Reclamation
USIS - United States Indian Service
Ac.Ft.- Acre Feet
Sec.Ft.- Cubic Feet Per Second.

Definitions:

Acre Foot is enough water to cover an acre one foot deep.
Second foot is one cubic foot of water flowing at the rate of one foot per second.
Miners Inch - In Montana a miners inch is one-fortieth of a second foot.
In North Dakota - - - - - one-fiftieth of a second foot.
In Wyoming - miners inch is not recognized.
One second foot flowing 24 hours equals two acre feet.
One miners inch (in Montana) flowing 20 days equals one acre foot.

* * * * * * * * * * * *

CLARKS FORK

Compact Provides:

Mean divertible daily flow is to be determined at the mouth of Rock Creek.
(A) First 1,600 acre feet is divided; 27% to Wyoming- 73% to Montana
(B) (Block of water for potential development is not necessary)
(C) Any excess flow is subject to future appropriation.

(A) Present Irrigation:

Acres irrigated in Wyoming (USBR)	-	12,000
Acres irrigated in Montana (USBR)	-	33,000
		45,000

Water Requirement:

Maximum monthly use is estimated at 1.1 acre feet per acre.
Wyo., 12,000 acres x 1.1 ÷ 31 days - 426 acre feet per day - 26.7%
Mont., 33,000 acres x 1.1 ÷ 31 days -1171 acre feet per day - 73.3%
1597 100 %

The Commission adopted - - - - 1600 acre feet per day, divided; Wyoming; 27% and Montana; 73%

(B) Potential Development:

The USBR shows no potential development in Clarks Fork Basin.

Whatever areas there might be in either State are so small that it was not deemed necessary to set up a second block of water to provide for it. Any excess flow is subject to future appropriation.

0739

BIG HORN

Compact Provides:

Mean divertible daily flow is to be determined at the lowest diversion point in Montana.

Indians in Montana and Wyoming have the first reasonable use of water.
(A) Remainder of the first 15,000 acre feet is divided; Wyo.,90%-Mont.,10%.
(B) Next 15,000 acre feet is divided; 93% to Wyoming and 7% to Montana.
(C) Any excess flow is subject to future appropriation.

(A) - Present Irrigation:

The development of Montana's present irrigated area was virtually completed in 1910, but Wyoming's development has progressed steadily, therefore, the division of water was based upon areas irrigated in 1910. Exact acres are not available, but the following deductions were estimated:-

	Wyoming	Montana
Approximate total acres irrigated in 1920 (US Census) - -	299,000	44,400
Deduct estimated increase from 1910 to 1920. Shoshone and Riverton Project in Wyoming and private development in Montana -	47,000	4,400*
Total irrigated in 1910 - - - - - - - - - - - - - - - - -	252,000	40,000
Deduct Indian lands - - - - - - - - - - - - - - - - - - -	30,000	18,000
Total acres of White-owned land irrigated in 1910 - - -	222,000	22,000
Per cent of total. - - - - - - - - - - - - - - - - - - -	91	9

* If these 4,400 acres in Montana were not deducted, the percentages will be; Wyoming-89.4% - - Montana-10.6%.

Division agreed upon by the Compact Commission - - - - - 90% 10%

Water Requirements:

Maximum monthly use is estimated at 1.1 acre feet per acre.
Total area now irrigated in both states as given by USBR - - - 425,600Ac.
425,600 x 1.1 ÷ 31 days = 15,100 acre feet per day.
Commission adopted - 15,000 acre feet per day.

(B) -Potential Irrigation:

Acres	Wyoming	Montana
Total ultimate development	741,900 (USBR)	117,754 (USIS)
Less ultimate Indian acres	130,246 (USIS)	90,696 (USIS)
Total ultimate, Whites	611,654	27,058
Present White lands irrigated	345,000 2/	27,058 (USIS)
Ultimate increase, White land	266,654	
Arbitrary estimate of increase of White lands		20,000
Total ultimate White lands	266,654	20,000
Per cent	93.02	6.98
Percentage agreed upon	93	7

2/ Total irrigated in Wyoming in 1940 (USBR) 374,500 acres
Indian lands irrigated on Wind River Reservation 29,500 acres
Total per cent White lands 345,000 acres

0740

TONGUE RIVER

Compact Provides:

Mean divertible daily flow is to be determined at the last diversion point in Montana.

(A) First 2,200 acre feet is divided; 72% to Wyoming - 28% to Montana.
(B) Next 1,200 acre feet is divided; 43% to Wyoming - 57% to Montana.
(C) Any excess flow is subject to future appropriation.

(A) Present Irrigation:

		(1950)
Acres irrigated in Wyoming (USBR) -	47,000	64998
Acres irrigated in Montana (USBR) -	18,400	30318
	65,400	95316

Water Requirement:

Maximum monthly use is estimated at 1.1 acre feet per acre;

Wyo., 47,000 acres x 1.1 ÷ 31 days =	1,668 ac.ft. per day -	71.9%
Mont., 18,400 acres x 1.1÷ 31 days =	653 ac.ft. per day -	28.1%
	2,321 ac.ft. per day -	100 %

A lengthy debate arose over the point of determining the divertible flow and the amount of water to be set up in the first block. Montana wanted the point of measurement to be at the state line, while Wyoming insisted it should be at the last diversion in Montana. When the mean divertible daily flow decreased to 1,000 acre feet per day or less, Wyoming wanted all the stream flow. As a final compromise, the point of measurement is to be at the last point of diversion in Montana, and the block of water is to be 2,200 acre feet per day divided; Wyoming- 72% and Montana - 28%.

This gives Wyoming a slight advantage in the method of measurement when stream flows are relatively high, but in case the tributaries in Montana are dry, this advantage would disappear, and in case of extremely low flows, it would work out to the advantage of Montana.

(B) Potential Irrigation:

Potential acres in Wyoming (USBR) -	15,000
Potential acres in Montana (USBR) -	27,800
	42,800

The original figures submitted by the Bureau differed from the above. Furthermore, it was intended to make the state line the place of measurement. As a result, the original computations were; 1,200 acre feet to be divided; Wyoming - 45% and Montana - 55%.

According to the potential acres given above, the block should be 1,519 acre feet. (42,800 x 1.1 ÷ 31 days = 1,519). To compromise the arguments that ensued concerning the place of measurement, it was finally arbitrarily agreed to leave the block at 1,200 acre feet divided; Wyoming - 43% and Montana - 57%.

Since this allotment is for potential development, and the right is provided to appropriate additional water in excess of 3,400 acre feet,(Art. V, Sec.3) neither state is injured by fixing the block at 1,200 in place of 1,519 acre feet.

If the states go ahead with the Compact, the Commission can accumulate additional data and make further adjustments if deemed necessary.

POWDER RIVER

Compact Provides:

Mean divertible daily flow is to be determined at the state line.
(A) First 2,000 acre feet divided; 96½% to Wyoming - 3½% to Montana.
(B) Next 2,600 acre feet divided; 60% to Wyoming - 40% to Montana.
(C) Any excess flow is subject to future appropriation.

(A) Present Irrigation:

Acres irrigated in Wyoming (USBR)	56,500
Acres irrigated in Montana (US Census,1939)	2,195*
Total acres	58,695

* (USBR reported no land irrigated in Montana. Army Engineers show 380 acres. Therefore, the Census figures of 2,195 acres were used).

Water Requirements:

Maximum monthly use is estimated at 1.1 acre feet per acre. Since the mean divertible flow is to be determined at the state line, return flow in Wyoming will be accounted for in the measurement of divertible flow, but return flow in Montana will not. The estimated factor agreed upon to balance this difference was 0.8(That is 20% return flow in Montana).

Wyo.,	56,500 acres x 1.1	= 62,150 acre feet per mo. -	97%
Mont.,	2,195 acres x 1.1 x 0.8	1,932 acre feet per mo. -	3%
		64,082	100%

64,082 ÷ 31 days = 2,070 acre feet per day.

It was finally agreed to give Montana 3½% and cut the block to 2,000 acre feet per day, which is slightly to Montana's advantage.

(B) Potential Irrigation:

Acres in Montana (USBR)	45,300
Less acres irrigated (1939 Census)	2,195
Potential acres in Montana	43,105
Potential acres in Wyoming(USBR)	45,600
	88,705

Water required for potential lands will be:-

Wyo.,-	45,600 acres x 1.1	= 50,160 acre feet per mo. -	57%
Mont,-	43,105 acres x 1.1 x 0.8	37,932 acre feet per mo. -	43%
		88,092	100%

88,092 ÷ 31 days = 2,841 acre feet per day

Accurate data are not available on potential irrigation in either State. Potential acreages shown by other state and Federal agencies indicate that Wyoming's ultimate development will exceed the above estimate of the USBR. Further, as more new lands are put under irrigation the return flow in Montana will undoubtedly exceed the 20% estimated above.

If return flow in Montana had been estimated at 30% in place of 20%,which would be more nearly correct for a potential area as large as this,(43,105 acres), the results would have been:-

Wyo.,	- 45,600 acres x 1.1	= 50,160 ac.ft. per mo. -	60.2%
Mont,	- 43,105 acres x 1.1 x 0.7	- 33,191 ac.ft. per mo. -	39.8%
		83,351 ac.ft. per mo. -	100%

83,351 ac.ft. per month ÷ 31 days = 2,689 ac.ft. per day.

After weighing the different sources of information, and considering the expected increase of return flow in Montana, it was the best judgment of the Commission that this potential block should be fixed at 2,600 acre feet per day divided; Wyoming, 60% and Montana, 40%

0742

YELLOWSTONE MAIN STEM

Compact Provides:

Lands below Intake shall be entitled to the beneficial use of the available residual flow on a pro rata basis of acreage irrigated. Residual flow after Montana and Wyoming have made full beneficial use, is allotted to North Dakota, subject to existing water rights in lower states.

Acreages:

Acres irrigated now on Main-St. not including

	North Dakota	Montana
Interst.te basins (USBR)	15,300	219,000
Potential acres (USBR)	7,800	165,800
Ultimate development	23,100	384,800

RESERVOIRS BUILT IN YELLOWSTONE BASIN

	Wyoming Ac.Ft.	Montana Ac. Ft.	Total Ac. Ft.
Clarks Fork	5,150	32,840	37,990
Big Horn	660,660	0	660,660
Tongue	13,020	60,000	73,020
Powder	35,013	0	35,013
	713,843	92,840	806,683

GRAND TOTAL ACREAGES IN ENTIRE YELLOWSTONE BASIN:

	Wyoming	Montana	North Dak.	Total
Acres irrigated now (USBR)	498,700	625,500	15,300	1,139,600
Percents	44	55	1	100
Potential acres (USBR)	428,000	319,800	7,800	755,600
Percent	57	42	1	100
GRAND TOTAL	926,700	945,300	23,100	1,895,100
Percent	49	50	1	100

DRAINAGE AREAS IN YELLOWSTONE BASIN IN SQUARE MILES

	Wyoming	Montana	North Dak.	Total
Clarks Fork	1184	1664	0	2848
Percent	41.6%	58.4		100%
Big Horn	18,259	4,683	0	22,942
Percent	79.6%	20.4%	0	100%
Tongue	1,645	3,796	0	5,441
Percent	30.2%	69.8%		100%
Powder	9,710	3,705	0	13,415
Percent	72.4%	27.6%		100%
Entire Basin	32,960	36,700	740	70,400
Percent	46.8%	52.1	1.1%	100%

0743

Message to Congress from President Roosevelt re: Establishment of Missouri River Basin Authority, Sept. 21, 1944, 78th Congress, 2nd Session 1944

0744

MISSOURI RIVER BASIN AUTHORITY

On September 21, 1944, the President sent a message to Congress advocating the enactment of legislation creating an Authority to deal with all problems in connection with the development of the Missouri River Basin. The President also requested that renewed consideration be given to a study of the Arkansas and Columbia River Basins. See 90 Congressional Record 8220.

To the Congress of the United States:

I enclose a copy of a resolution adopted by all but one of the Missouri River States represented in a recent meeting of their Governors and the members of the Missouri River States Committee. In general, the resolution asks for executive and legislative action toward procuring a single, coordinated plan for the development of the Missouri River Basin "for the greatest benefit of its citizens, both present and future, and for the greatest benefit to the United States."

As the Congress knows, I have for many years advocated the establishment of separate authorities to deal with the development of certain river basins where several States were involved. The general functions and purposes of the Tennessee Valley Authority might well serve as a pattern for similar developments of other river basins. The Tennessee Valley Authority was charged by the Congress with the development of practically all of the factors which are important in establishing better living standards and a better life for the people throughout that great watershed.

The benefits which have resulted in the Tennessee River Valley include flood prevention, irrigation, increased electric power for farms and shops and homes and industries, better transportation on land and water, reforestation and conservation of natural resources, the encouragement of small businesses and the growth and expansion of new businesses, development and widespread use of fertilizers and improved agricultural methods, better education and recreational facilities—and many kindred improvements which go to make for increased security and greater human happiness.

The Congress has at all times retained the final authority over the Tennessee Valley Authority, for the Authority comes before the Congress each year to obtain appropriations to continue its work and carry out its plans.

I have heretofore suggested the creation of a similar authority for the development of the Arkansas River watershed from the Mississippi all the way west to its source in Colorado.

I have also suggested the creation of an authority to render a similar service in the Columbia River watershed, including the States of Washington, Oregon, Idaho, and Montana.

I now make a similar recommendation for the Missouri River Basin.

The resolution very properly asks that the legislation dealing with matters relating to the waters of the Missouri River Basin recognize that it is dealing with one river and one problem; and points out the necessity of a comprehensive development of the Missouri River, indicating that there can be no piecemeal legislative program. The resolution asks that "the Congress should recognize now the problem in its entirety as it affects the people of the Missouri Basin and their economic destiny and that of the United States."

I am in hearty accord with these principles. I hope that the Congress will give careful and early consideration to the creation of this Federal authority to consider the problem in its entirety, remembering always that any appropriations to carry out any plan are and will be within the complete control of the Congress, and that the interest of each of the States in the basin will, of course, be given full consideration. I am sure that

0745

none of the States in the Tennessee River Basin have lost any of their rights because of the creation of the Authority in that valley.

May I also ask that renewed consideration be given to a study of the Arkansas and Columbia River Basins? The fact has been established that such legislation can do much to promote the welfare of the great mass of citizens who live there—as well as their fellow citizens throughout the United States.

I need hardly point out to the Congress, in addition, how helpful this legislation will be in the creation of employment and in the stimulation of industry, business, and agriculture throughout the areas involved, in the days which will follow the end of the war.

FRANKLIN D ROOSEVELT

THE WHITE HOUSE,
September 21, 1944.

PETROLEUM AGREEMENT BETWEEN THE UNITED STATES AND GREAT BRITAIN

On August 24th President Roosevelt sent to the Senate for ratification the petroleum agreement between the United States and Great Britain which was signed in Washington, D. C. on August 8th. See 90 Congressional Record 7388.

August 24, 1944.

To the Senate of the United States:

To the end that the Senate may give its advice and consent to ratification, if it approve thereof, I transmit herewith an agreement on petroleum between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland, signed in Washington August 8, 1944.

With the agreement I transmit for the information of the Senate the report made to me by the Secretary of State relating thereto.

FRANKLIN D. ROOSEVELT.

[Enclosures: (1) Report of the Secretary of State; (2) agreement on petroleum between the United States and the United Kingdom, signed August 8, 1944.]

DEPARTMENT OF STATE,
Washington, August 24, 1944.

The PRESIDENT,
The White House:

The undersigned, the Secretary of State, has the honor to lay before the President, with a view to its transmission to the Senate to receive the advice and consent of that body to ratification, if his judgment approve thereof, an agreement on petroleum between the Government of the United States of America and the Government of the United Kingdom of Great Britain and Northern Ireland, signed in Washington August 8, 1944.

The agreement expresses the mutual understanding of the two Governments with respect to certain principles governing international trade in petroleum. These principles have relation to (1) the making available of adequate petroleum supplies to the nationals of all peaceable countries at fair prices and on a nondiscriminatory basis, subject to such collective security arrangements as may be established; (2) the development of petroleum resources with a view to encouraging the sound economic advancement of producing countries; (3) equal opportunity in the acquisition of exploration and development rights in areas not now under concession; (4) respect for valid concession contracts and lawfully acquired rights; and (5) safeguarding the production and distribution of petroleum from restrictions inconsistent with the principles and purposes of the agreement.

0746

Discussion of the Yellowstone River Compact and Its Effect Upon the Water Users of the Upper Tongue River Basin in Wyoming , E.C. Gwillim, Jan. 22, 1949

0747

Discussion

of the

Yellowstone River Compact

and

Its Effect Upon the Water Users

of the

Upper Tongue River Basin

in Wyoming

By E. C. GWILLIM
Irrigation Engineer

0748

January 22, 1949

SHERIDAN, WYOMING

MT v. WY/M.T.D. App.
82 (WY)

THE YELLOWSTONE RIVER COMPACT AND ITS PROPOSED ADMINISTRATION OF THE WATERS OF TONGUE RIVER BASIN IN THE STATE OF WYOMING

This report on the Yellowstone River Compact was prepared at the request of the Tongue River Basin Water Users Association by Edward C. Gwillim, Irrigation Engineer, Sheridan, Wyoming.

Information used in compiling this report was obtained from the following agencies, reports and individuals: U. S. Geological Survey—Water Resources Branch, Sheridan; United States Weather Bureau, Sheridan; Tabulation of Adjudicated Water Rights compiled by the Wyoming State Board of Control; Senate Document No. 191, 78 Congress 2nd Session, Missouri River Basin; Water Resources Survey, Montana by Montana State Engineer's Office; Water Resources of Yellowstone River Basin in Wyoming by Wyoming State Water Conservation Board; Minutes of hearing on the Compact, Miles City, August 11, 1944; Minutes of a meeting on the Compact Sheridan, Wyoming, October 28, 1944; Bureau of Reclamation at Billings, Montana, December 27, 1948; Sixteenth Census of the United States 1940, Irrigation of Agricultural Lands; The Parkman Irrigation District by Fields, Fellows and Hinderlider, Engineers; Application by Montana State Water Conservation Board on P. W. A. Project, Montana 1054-D, Tongue River Project; and the following persons, Alonzo R. Shreve, President of the Tongue River Basin Water Users Association and a land owner in Tongue River Basin, Wyoming; Archie Ewoldsen, Secretary of the Tongue River Basin Water Users Association; State Senator N. V. Kurtz, attorney; E. J. Johnson, Water Superintendent of Water Division No. 2; R. E. McNally, attorney and Henry Burgess, attorney and member of the Wyoming State Legislature, all of Sheridan, Wyoming.

MT v. WY/M.T.D. App.
83 (WY)

0749

THE YELLOWSTONE RIVER COMPACT AND ITS PROPOSED ADMINISTRATION OF THE WATERS OF TONGUE RIVER BASIN IN THE STATE OF WYOMING

CONCLUSIONS AND RECOMMENDATIONS:

1. The citizens of Tongue River Basin, Wyoming are opposed to he Yellowstone Compact because they do not believe adequate information of the physical conditions in regard to Tongue River Basin, Vyoming were obtained before the compact was drawn.

2. There are now shortages of irrigation water in Wyoming each ear during the irrigation season and regulation of ditches is required. his shortage may be increased if the compact is accepted.

3. It is questionable if any appreciable amount of the determined levertible flow, if it is less than 308 cubic feet per second would reach he lowest point of diversion under existing conditions.

4. Further studies to determine accurately the irrigated and irrigable creage, stream discharge, return flow, stream losses, water use, water equirements and land classifications should be completed, before Wyoning considers a division of the water of Tongue River Basin with Montana.

5. Field reconnaissance of the claims of Montana to irrigable and rrigated acreage is advisable to determine which lands are irrigated rom Tongue River.

6. Potential storage sites should be studied.

7. Estimates indicate there is, except in dry years, sufficient annual lischarge to meet the demands of each state. Stream regulation through onstruction of storage is required to overcome seasonal deficiencies.

8. Measuring stations should be installed on most of the minor streams of Tongue River Basin, Wyoming, so that more accurate estimates of stream flow can be made.

9. The practicability of attempting to use the formula in the compact for determining the daily divertible flow should be shown. We do not believe this formula is workable in Tongue River Basin, Wyoming.

10. The wording of the compact should be simplified so that it is understandable to laymen.

11. The place and method of measurement for the division of the stream flow between Montana and Wyoming should be clearly defined.

12. The Compact in so far as it pertains to Tongue River Basin, Wyoming should not be considered at this time because it is not based on complete information, and further the Bureau of Reclamation will not complete their studies until 1950.

0750

MT v. WY/M.T.D. App.
84 (WY)

THE YELLOWSTONE RIVER COMPACT AND ITS PROPOSED ADMINISTRATION OF THE WATERS OF TONGUE RIVER BASIN IN THE STATE OF WYOMING

HISTORY:

A Yellowstone River Compact has been under discussion and consic eration since the first Congressional authorization in 1932. The firs discussions were between Montana and Wyoming. The first tentativ draft was prepared in Denver, Colorado in October 1942. A revise draft was presented at Billings, Montana, on December 22, 1942 to th joint compact commission, which consisted of representatives of Mon ana, North Dakota, and Wyoming. The compact with additional rev sions was approved and agreed to by all except one of the represent tives of the three states. The final draft of the compact was prepare by representatives of federal agencies, namely; the United State Bureau of Reclamation and the United States Federal Power Commis sion. "A Bill for An Act to provide for the ratification and approval c the Yellowstone River Compact" was presented to the 1943 Wyomin Legislature. The compact was amended to exclude Tongue and Powde Rivers and was so passed by the Wyoming Legislature. The states c Montana and North Dakota would not accept the compact as amended The original compact was presented to the 1945 Wyoming Legislatur and was approved by that body, but was vetoed by the Governor. Man interested persons and some compact commissioners favor having bill introduced in the 1949 legislature for ratification. The legislature of Montana and North Dakota have ratified the compact as approve at Billings, Montana on December 22, 1942.

PURPOSE:

This report is prepared to point out to the interested water users i Tongue River Basin, Wyoming, the legislators and others concerned the need of further studies of the physical factors, such as the presentl irrigated areas, irrigible areas, stream flows and water requirement before a Yellowstone River compact is agreed to by the Wyoming Com pact Commissiones and presented to the legislature.

SCOPE:

The compact embraces the waters of the following streams whic are tributaries of the Yellowstone River, namely; Clarks Fork River Big Horn River, (exclusive of the Little Horn River), Tongue River Powder River, (exclusive of Little Powder River) and the Yellowston —Main Stem (near the Montana-North Dakota State Line).

This report will be largely limited to that portion of Tongue Rive in Wyoming.

COMPACT:

The Compact, page 6, Article V, paragraph 3 explains the divisio of the flow of Tongue River as follows:

'Each day during the period May 1st to September 30th, inclusive of each year, the first 2,200 acre-feet of the mean divertible daily flow of the Tongue River, determined at the lowest point of diversion on thi

stream, shall be divided seventy-two (72) per cent to Wyoming and twenty-eight (28) per cent to Montana; and the next 1,200 acre-feet of mean divertible daily flow shall be divided forty-three (43) per cent to Wyoming and fifty-seven (57) per cent to Montana; Provided, That either State may temporarily divert, consume, or store for its beneficial use any unused part of the above flows allotted to the other, but no continuing right to such unused flows shall be established thereby. Unappropriated divertible daily flows in excess of 3,400 acre-feet occuring during the period May 1st to September 30th, inclusive, and all presently unappropriated flows occuring during the period October 1st to April 30th, inclusive, of each year, shall be subject to future appropriation for beneficial use within the Yellowstone River Basin in Wyoming, Montana, and North Dakota in accordance with the laws of said respective States.

The provisions herein, and each of them, and in particular the allotments, and each of them, shall be subject to the following conditions:

(a) For the purpose of determining the engineering feasibility, particularly as to water supply, of any project or program of the United States for the further conservation and utilization of the waters of the Tongue River, particularly the storage of waters in the State of Wyoming for beneficial use in that State, the allotments herinabove made, and each of them, may be assumed as the measure of an equitable apportionment of the waters of the Tongue River between the States of Wyoming and Montana to satisfy, as of the date of this Compact, those established rights for beneficial consumptive uses which are exercised beneficially and which are valid under the laws of the States of Wyoming or Montana, as the case may be.

(b) Such provisions and allotments shall become operative either ten (10) years from and after the date that this Compact is ratified by the Congress; or on June 15 of the year in which water is available for release through any adequate distributary system, other than the stream bed, from the Tongue River Reservoir of the Montana Water Conservation Board for beneficial uses in Montana, the amount of water so released, however, shall be equal to at least one-half of the working capacity of such reservoir; or on June 15 of the year in which water is available for release through any adequate distributary system, other than the stream bed, if such be necessary, from any storage reservoir constructed in Wyoming to conserve for beneficial uses in Wyoming the waters of the Tongue River, the amount of water released, however, shall be equal to at least one-half of the working capacity of such reservoir; or whichever of said dates is the earlier."

The Divertible Flow is to be determined as set forth in the Compact under Article II, paragraph I, page 3 as follows:

"I. The term "Divertible Flow" means the quantity of water that could be diverted from the stream flow above a designated point of measurement during a specified period of time. It is comprised of three elements: (a) the total net inflow to storage; (b) the total diversions; and (c) the remaining flow in the stream at the designated point of measurement for which the divertible flow is being determined. It is computed as follows:

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The algebraic sum of:

(a) The quantity of water (in acre-feet) that flowed into reservoirs situated above the point of measurement during the specified period of time; less the outflow and diversions made directly from reservoirs (in acre-feet) during the same period; plus

(b) The quantity of water (in acre-feet) that was diverted from the stream above the point of measurement (including diversions made directly from reservoirs) during the specified period of time; plus

(c) The quantity of water in the stream (in acre-feet) that flowed past the point of measurement for which divertible flows are being determined during the specified period of time."

A state, before agreeing to a compact for the division of its great natural resource—Water—with another state or states, should certain that all basic information has been obtained. It is questional if accurate and adequate information was obtained before the Yello stone River Compact was written.

The compact should be written in clear, concise language so th the terms can be clearly understandable to the people most vita concerned, the Water Users.

WATER SUPPLY:

All the stream-flow of Tongue River originates in Wyoming exce for intermittent runoff from small creeks and streams in Montana.

Stream gauging have been recorded intermittently on some strea for many years. These gaugings were not sufficient to make accura estimates of the total water supply of the Tongue River Basin in Wy ming. During recent years stream flow measuring stations have be installed on the larger tributaries at selected points. From the recor of these stations the yearly annual discharge can be accurately c culated. These stations are located as follows: Tongue River ne the highway bridge on the Sheridan-Birney road about 3 miles bel Acme, Tongue River at the mouth of the canyon above Dayton, W Creek at Eaton's Ranch, Big Goose about 13 miles southwest of She dan at T-T Ranch and Little Goose Creek in canyon above Big Ho near the Watts Smyth Ranch, North Fork Tongue River and Sou Fork of Tongue River on top of the Big Horns. Estimates of strea flows on Columbus, Amsden, Little Tongue, Beaver, Rapid and oth smaller streams must be made as their confluence with the larg streams is below the above mentioned gauging stations, except the o near Acme. Since the topography, precipitation, temperatures a other physical conditions along the smaller streams are not compa able to those of the larger streams, estimates of the discharge of t smaller streams are subject to error.

The following tables show the average annual discharge for t period of record on the streams for which complete yearly records a available.

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TABLE I

Total measured discharges of Tongue River at Decker in 1000 Acre Feet by water years* and average by months for the irrigation season.

Water Year	Irrigation Season May	June	July	Aug.	Sept.	—Total—1000 A. F.— Irrig. Season	Non-Irrig. Season	Annual
31-32	130.0	84.5	14.2	3.5	6.1	238.3	83.6	321.9
32-33	127.0	162.0	11.4	4.6	7.7	312.7	109.9	422.6
33-34	19.0	8.2	1.1	0.3	0.8	29.4	82.9	112.3
35-36	30.4	40.5	5.7	2.7	2.6	81.9	85.7	167.6
36-37	49.7	114.0	32.5	4.5	4.6	205.3	75.3	280.6
37-38	82.1	106.9	35.4	6.7	6.6	237.7	77.5	315.2
Total	438.2	516.1	100.3	22.3	28.4	1105.3	514.9	1620.2
Average	73.0	86.0	16.7	3.7	4.7	184.2	85.8	270.0

Under the terms of the compact Wyoming and Montana divide the first 2200 acre feet (1100 cubic feet per second)** of the daily divertible flow, 28 per cent to Montann and 72 per cent to Wyoming. Table I shows the flow near the Wyoming-Montana Line and is the depleted flow after diversions for irrigation in Wyoming, plus increment to the stream from return flow. The total amount of water originating in Wyoming cannot be computed without obtaining reasonably accurate figures on the acres irrigated, net consumptive water use per acre, losses through conveyance, evaporation, and increment to the streams for reuse above the Acme gauging station.

Assuming that there is 2200 acre-feet of divertible flow originating in Wyoming daily during the period of record shown in Table I, Wyoming would be required to close a sufficient number of headgates to deliver the allotted discharge to Montana. The use of water for irrigation in Wyoming would have to be restricted in variable amounts during each of the six years to deliver the amount allotted to Montana. "Throughout the lower area in Wyoming water for irrigation is diverted from the tributary streams. Because of the large acreage under irrigation many of the streams are completely depleted."***

TABLE II

Total measured discharge of Tongue River at Acme in 1000 Acre Feet by water years and average by months for the irrigation season.

Water Year	Irrigation Season May	June	July	Aug.	Sept.	—Total—1000 A. F.— Irrig. Season	Non-Irrig. Season	Annual
38-39	59.4	63.9	7.1	3.9	3.4	137.7	70.8	208.5
39-40	36.0	38.4	5.8	0.7	1.6	82.5	56.2	138.7
40-41	71.0	43.7	7.5	4.1	20.0	146.3	58.4	204.7
41-42	97.4	88.9	11.8	3.6	6.7	208.4	114.0	322.4
42-43	82.4	126.3	27.6	5.4	10.3	252.0	106.8	358.8
43-44	155.2	211.0	51.7	8.5	8.0	434.4	76.8	511.2
44-45	55.4	151.2	53.9	11.7	16.5	288.7	75.5	364.2
45-46	67.8	130.4	35.8	7.1	14.7	255.8	112.4	368.2
46-47	99.6	116.2	49.9	8.9	11.9	286.5	109.3	395.8
Total	724.2	970.0	251.1	53.9	93.1	2092.3	780.2	2872.5
Average	80.5	107.8	27.9	6.0	10.3	232.5	86.7	319.2

*Period October 1 to September 30, inclusive.

**One cubic foot per second is equal to approximately 2 acre feet per day. 2200 acre feet equals 1100 cubic feet per second—28% of 2200 is 616 acre feet and 72% is 1584 acre feet.

***Water Resources Survey—Big Horn County, Montana. Part I, page 30—Tongue River.

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This table shows the total annual discharge after depletion by diversions for irrigation. Shortages did occur in Wyoming for this period, during the irrigation season, and if Montana is to receive its full allotment, further regulation of the Wyoming diversions will be required. These shortages were recognized in the Missouri River Plan, which points out the need for supplemental water for 38000 acres in Wyoming.

When the discharge of the depleted flow at the Decker or Acme stations (Tables I and II) is under 28% of the divertible flow, 308 Cu. Ft. Sec. (616 A. F.) adjustments must be made in the amounts being diverted on Tongue River and tributaries in Wyoming.

TABLE III

The following table gives the year, date depleted flow fell below 308 Cu. Ft. per second, and the number of days by months the flow, during the irrigation season, was below 308 Cu. Ft. per second and the annual precipitation at Sheridan.

Date Depleted Flow Went Under 308 Cu. Ft. Sec.	Number of Days by Months the Depleted Flow is Under —308 C. Ft. Per Second—						Min. Flow	—Amount—		Annual Precipitation at Sheridan in
Yr. Month Day Cu. Ft.	May	June	July	Aug.	Sept.	Total Days	Date	Cubic Feet	A. F.	Inches
DECKER										
1932 July 9.....303	....	....	23	31	30	84	Aug. 20-21	34.0	68.0	19.53
1933 July 6.....300	....	....	26	31	30	87	Aug. 17-18	38.0	76.0	12.18
1934 May 17.....306	15	30	31	31	30	137	Aug. 20.....	2.9	5.8	11.56
1935 May 1.....164	17	....	21	31	30	99	Aug. 16.....	19.0	38.0	12.09
1936 May 23.....306	4	11	31	31	30	107	Sept. 13.....	26.0	52.0	11.14
1937 May 2.....304	1	....	6	31	30	68	Aug. 19.....	47.0	94.0	15.23
1938 July 27.....284	....	....	5	31	30	66	Aug. 14.....	86.0	172.0	16.98
ACME										
1939 July 1.....296	....	....	31	31	30	92	Aug. 4.....	6.0	12.0	16.40
1940 June 27.....270	....	4	31	31	30	96	Aug. 24.....	3.4	6.8	13.69
1941 June 27.....300	....	4	31	31	9	75	Aug. 7.....	31.0	62.0	15.18
1942 July 7.....292	....	....	25	31	29	85	Aug. 31.....	32.0	64.0	16.51
1942 July 18.....301	....	....	14	31	30	75	Aug. 23.....	61.0	122.0	17.85
1944 July 29.....297	....	....	2	31	30	63	Aug. 19, 20, 28, 29th	98.0	196.0	24.58
1945 May 1.....221	3	....	5	31	16	55	Aug. 12.....	138.0	276.0	18.69
1946 July 20.....273	....	....	12	31	28	71	Aug. 24.....	88.0	176.0	23.57
1947 July 26.....304	....	....	6	31	30	67	Several	109.0	218.0	18.87
Total	40	49	300	496	442	1327		819.3	1638.6	
Average	3.0	3.0	19.	31.	2.8	83.9		51.2	102.4	

Table III shows that during the 7 years of record at the Decker Station, and 9 years at the Acme Station there is not one year when the depleted flow passing either station, during the irrigation season, was not under 308 cubic feet per second for 63 days or more. The number of days annually the flow was below 308 cubic feet varied from 63 to 137 days, the average for the 16 years of record being 83. There is no stream flow diverted below the Acme station in Wyoming. The daily shortage to give Montana its allotment under the compact of 308 cubic feet per second, will vary from 308 to 2 cubic feet per second. When the daily depleted flow is below 308 cubic feet per second Wyoming will have to supply Montana with 28 per cent of the determined divertible flow. Shortages now occur in Wyoming during three months of the irrigation season. If Wyoming agrees to the compact these shortages will be increased by 28 per cent.

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The distance by stream channel from the Acme station to the lowest point of diversion is about 175 miles. The velocity of the stream flow will approximate about one and one-third miles per hour or it will require five and one-half days to deliver water to the lowest diversion. As the amount of flow decreases the velocity decreases, while the proportional loss from seepage, evaporation and transpiration increases. It's problematical how much of the total flow of 808 cubic feet per second would reach the lowest point of diversion, and for lesser flows its doubtful if any water would arrive at its proposed point of use.

The following tables give the annual discharge of various streams in Tongue River Basin, Wyoming by water years, average by months, and totals for the irrigation and non-irrigation season.

TABLE IV

Tongue River near Dayton*

Water Year	Irrigation Season					Total—1000 A. F.		
	May	June	July	Aug.	Sept.	Irrig. Season	Non-Irrig. Season	Annual
40-41	33.9	21.8	9.2	5.9	7.7	78.5	15.3	**93.8
41-42	43.4	36.6	9.6	6.0	4.4	100.0	47.0	147.0
42-43	29.6	48.5	17.2	6.6	5.6	107.5	36.1	143.6
43-44	56.2	70.6	20.6	8.2	5.2	160.8	25.9	186.7
44-45	23.8	52.1	22.0	8.5	6.9	113.3	24.3	137.6
45-46	30.7	44.5	13.6	6.9	6.9	102.6	39.9	142.5
46-47	43.0	49.1	25.0	8.3	5.7	131.1	28.8	159.9
Total	260.6	323.2	117.2	50.4	42.4	793.8	217.3	1011.1
Average	37.2	46.2	16.7	7.2	6.1	113.4	31.0	144.4

TABLE V

Goose Creek above Cave Creek.

Water Year	Irrigation Season					Total—1000 A. F.		
	May	June	July	Aug.	Sept.	Irrig. Season	Non-Irrig. Season	Annual†
36-37	15.6	36.3	8.2	1.9	1.7	63.7	4.5	68.2
37-38	18.6	27.9	8.4	2.2	2.0	59.1	8.7	67.8
38-39	15.7	15.8	2.7	1.6	1.5	37.3	7.1	44.4
39-40	12.4	14.5	2.5	1.6	1.1	32.1	3.8	35.9
40-41	18.8	11.8	2.3	1.9	6.9	41.7	4.9	46.6
41-42	20.3	23.7	3.9	2.0	1.6	51.5	15.9	67.4
42-43	18.7	37.2	7.4	2.1	1.6	67.0	13.4	80.4
43-44	35.4	43.2	10.8	1.9	2.1	93.4	5.9	99.3
44-45	13.8	37.2	16.3	2.6	3.9	73.8	6.3	80.1
45-46	13.9	34.7	8.9	1.8	2.9	62.2	14.3	76.5
46-47	19.6	30.9	14.1	2.3	3.0	69.9	13.2	83.1
Total	202.8	313.2	85.5	21.9	28.3	651.7	98.0	749.7
Average	18.4	28.5	7.8	2.0	2.6	59.3	8.9	68.2

*Highline ditch diverts above this station.

**Total for 11 months.

†Includes releases from Park, Dome Lake and City Storage. City intake and PK ditch divert above measurement.

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TABLE VI

Wolf Creek at Wolf.

Water Year	Irrigation Season May	June	July	Aug.	Sept.	Total—1000 A. F. Irrig. Season	Non-Irrig. Season	Annual*
44-45	4.8	11.2	3.9	1.1	0.6	21.6	3.3	24.9
45-46	6.1	8.2	2.6	0.7	0.6	19.2	3.9	23.1
46-47	7.8	9.4	3.8	1.0	0.5	22.5	3.1	25.6
Total	18.7	29.8	10.3	2.8	1.7	63.3	10.3	73.6
Average	6.2	9.9	3.4	0.9	0.6	21.1	3.4	24.5

TABLE VII

Little Goose Creek Canyon, near Watts Smyth's Ranch.

Water Year	Irrigation Season May	June	July	Aug.	Sept.	Total—1000 A. F. Irrig. Season	Non-Irrig. Season	Annual**
40-41	16.9	11.0	4.9	3.9	3.7	40.4	1.2	***41.6
41-42	12.4	11.5	5.6	3.5	2.0	35.0	10.3	45.3
42-43	10.7	15.4	6.7	4.6	2.5	39.9	10.4	50.3
43-44	20.9	21.6	5.3	4.3	2.1	54.2	4.5	58.7
44-45	8.4	18.5	7.0	5.0	2.2	41.1	3.8	44.9
45-46	10.1	20.4	6.7	3.9	3.5	44.6	8.7	53.3
46-47	13.8	15.3	7.9	4.5	3.6	45.1	6.1	51.2
Total	93.2	113.7	44.1	29.7	19.6	300.0	45.0	345.3
Average	13.3	16.2	6.3	4.2	2.8	42.9	6.4	49.3

The total average annual discharge of Tongue River, Wolf, Big Goose, and Little Goose Creeks comprises most of the wate supply of Tongue River Basin The yearly total discharge of these streams plus the yearly discharge of minor streams such as Columbus, Smith, Amsden, Soldier, Rapid, and Beaver Creeks and Little Tongue River should approximate the total amount of water originating in Tongue River Basin, Wyoming. There are no stream measuring stations on the minor streams, therefore it is not possible to calculate accurately the total discharge from Tongue River Basin in Wyoming. Assuming that the total annual dischargeof all the minor streams is 40,000 acre feet per year, the total amount of undepleted flow originating in the basin will be approximately as shown in Table VIII.

TABLE VIII

Stream	Years of Record	Average Annual Discharge A. F. Irrig. Season	Non-Irrig. Season	Annual
Tongue	7	113.4	31.0	144.4
Wolf	3	21.1	3.4	24.5
Big Goose	11	59.3	8.9	68.2
Little Goose	7	42.9	6.4	49.3
Minor Tributaries	None	30.0	10.0	****40.0
Total average discharge Tongue River Basin above the measuring station near Acme, Wyoming		266.7	59.7	326.4

*easured discharge April 1 to September 30th was 21,880 A. F. Estimated flow October 1 o March 31—3,000 A. F. making a total for the year 24,880 A. F.

**Includes diversion from Cross Creek and releases from Big Horn and Park Reservoirs.

***For 6 months.

****Estimated.

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The years of record for all of the streams in the preceding tables were years of above average precipitation at Sheridan, as shown in the following table.

TABLE IX

Table showing the number of years of record of stream measurement, mean precipitation at Sheridan, average yearly precipitation for the period of measurement and the difference between the mean and the average of the period of measurement.

	Years of Stream Flow Records	Mean Precipitation	Average Precipitation for This Period	Difference Plus	Difference Minus	Percent Difference Plus	Percent Difference Minus
Tongue	1941-47	15.06	19.32	4.26	.....	128	.....
Wolf	1945-47	15.06	20.38	5.32	.....	135	.....
Big Goose	1937-47	15.06	17.95	2.89	.....	119	.....
Little Goose	1941-47	15.06	19.32	4.26	.....	128	.....
Minor Streams	None	15.06	.....	.....	.....	.....	.....

Assuming that the runoff varies directly in proportion to the precipitation, which is doubtful, then from Table IX the average annual discharges, shown in Tables VIII, when adjusted to the mean precipitation at Sheridan would become in 1000 Acre Feet:

	Annual
Tongue River	112.0
Wolf Creek	18.1
Goose Creek	57.3
Little Goose	38.5
Minor Streams	31.5
Total adjusted annual undepleted flow of Tongue River Above the Acme Station	257.4

This figure is approximately 69000 acre feet less than the average for the years of above normal precipitation.

The following analysis of the discharges of Tongue River is taken from "Water Resources of Yellowstone River Basin in Wyoming," pages 34 and 35.*

"The mean annual undepleted, present depleted, and future depleted runoffs from the Tongue River Basin in Wyoming are summarized below:

Mean annual undepleted flow Tongue River at Decker Montana (1927-28 to 1935-36)	444,300 A. F.	78%
Long time mean annual undepleted flow Tongue River at Decker (Compared with Powder River at Arvada)	570,000 A. F.	100%
Present annual use 95,650 acres irrigated at 1.5 ac. ft.	143,500 A. F.	25.2%
Mean annual present depleted runoff from Wyoming	426,500 A. F.	74.8%
Future annual use (125,650 acres irrigated plus irrigable at 1.6 ac. ft.)	201,000 A. F.	35.3%
Mean annual future depleted runoff from Wyoming	369,000 A. F.	64.7%

*Compiled under the direction of the Wyoming State Engineers Office and Wyoming Water Conservation Board, September 1938.

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The long time mean annual undepleted runoff is about 570,000 acre-feet. At the present time Wyoming Irrigators are using 143,500 acre feet or about 25.2% of Wyoming's water production on the Tongue River Basin. This leaves a mean annual present depleted runoff of about 426,500 acre feet or 74.8% of the water which originates in Wyoming.

The total future annual use in Wyoming will be about 201,000 acre feet or 35.3% of Wyoming's production. This will leave a mean annual future depleted runoff of 369,000 acre feet or about 64.7% of Wyoming's production.

The annual undepleted, present depleted, and future depleted runoffs from the Tongue River Basin in Wyoming for a minimum flow year are summarized below:

Minimum annual undepleted runoff from Tongue River Area in Wyoming (1933-34) _____197,500 A. F.__100%

Present annual use (95,650 acres irrigated at 1.5 acre-feet) ____143,500 A. F.__72.6%

Minimum annual present depleted runoff _____54,000 A.F.__27.4%

Future annual use 125,650 acres (irrigated plus irrigable) at 1.6 acre feet _____201,000 A. F.__

Minimum annual future depleted runoff (3,500) A. F.__Shortage

The minimum annual undepleted runoff from Wyoming was about 197,500 acre feet in 1933-34. The present use of about 143,500 acre feet in Wyoming is about 72.6% of the minimum undepleted runoff from Wyoming. If all the irrigated and irrigable lands had been rrrigated in that year the water requirement in Wyoming would have been about 201,000 acre feet. In other words with full development there would have been a water shortage of about 3,500 acre feet in a year like 1933-34."

This analysis by the State Water Conservation Board was prepared from records which were incomplete and had to be reconstructed in some instances, while the discharges given in Tables I to VII are computed from actual measurements. However, the latter records are of short duration for long time estimating.

Table VIII shows the average annual discharge during the irrigation season at the measuring stations on major tributaries of Tongue River, at the base of the mountains, plus the estimated flow of the minor streams, to be 266,700 acre feet.

Table II shows the average annual discharge for the irrigation season at Acme Station as 232,500 acre feet, a difference of 34,200 acre feet. This difference represents the depleted flow in Tongue River Basin by diversions and natural losses. During the 10 year period 1938 to 1947 the average annual precipitation was 18.23 inches or 3.19 inches above normal. The annual precipitation during 1944 was 9 inches and 1946 was 8 inches above normal. The ten year average for the five irrigation months was 10.76 inches. It is reported that many farmers did not use any water during many of these years. The distribu- reduced the irrigation requirements. Rains which cause flash runoff below the measuring station will be reflected at the Acme Station. It has been shown that during the ten year period 1938-1947 the precipi-

tation was above normal and during this period there were shortages in the available water supply to irrigators in Wyoming. This shortage is much more tragic when the precipitation is below normal as it was for the four year period 1933 to 1936. During this period the average annual precipitation was 11.74 inches or 79 per cent of normal. During the year 1934 the discharge of Big Goose Creek at the T-T Ranch for the five irrigation months was 15,300* acre feet per second or only 25.8 per cent of the annual average for the 11 year period 1936-1947 as shown in Table X.

The following are the monthly measured flows at Big Goose Station for the irrigation season 1934 in acre feet.

May	June	July	Aug.	Sept.	Total
9200	3000	1800	600	700	15,300

Big Goose Creek supplies about 22 per cent of the total inflow to Tongue River Basin, Wyoming during the irrigation season. Therefore, from Table X the total inflow to the basin in 1934 during the irrigation season was approximately 1.17 acre feet per acre or about 44 per cent of the irrigation requirement. This was a very low water year, but it is years such as 1934 that it would be difficult for Wyoming farmers to give away any of their short water supply. The Wyoming Water Conservation Board estimates the annual depletion by consumptive use as 143,000 acre feet.† These variations clearly show the need for further investigations.

WATER SHORTAGES:

The following tables show the water shortages.

TABLE X

Average measured and estimated runoff by streams to Tongue River Basin in Wyoming by months during the irrigation season in acre feet.

	Monthly Divertible Flow					Irrig. Season	
Stream	May	June	July	Aug.	Sept.	Total	Annual
Tongue River	37,200	46,200	16,700	7,200	6,100	113,400	144,400
Goose Creek	18,400	28,500	7,800	2,000	2,600	59,300	68,200
Wolf Creek	6,200	9,900	3,400	900	600	21,100	24,500
Little Goose	13,300	16,200	6,300	4,200	2,800	42,800	49,300
Minor Streams	9,000	11,000	4,500	3,000	2,500	30,000	*40,000
Total	84,500	111,800	38,700	17,300	14,600	266,600	326,400
**First Block by the Compact	68,200	66,000	68,200	68,200	66,000		
Surplus	16,300	45,800					
Shortage			29,500	50,900	51,400		

The above totals by months approximates the monthly divertible flow of Tongue River. There is surpus during May and June, and shortages during July, August and September. Converting these shortages from a monthly to a daily basis, the average shortage for each day of the three months in acre feet is shown in the following table.

†Water resources Yellowstone River Basin, Wyoming.

*Estimated.

**2,200 acre feet multiplied by days in months.

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TABLE XI

Shortages by months and day in acre feet and amount below 2,200 A. F. to be divided:

July	Day	Amt. to Divide A. F.	August	Day	Amt. to Divide A. F.	Sept.	Day	Amt. to Divide A. F.
29,500	952	1,248	50,900	1,642	558	51,400	1,713	487
Montana would receive 28 percent in Acre Feet		349			156			136
Percent of 616 A. F.		57			25			22
Wyoming would receive 72 percent in Acre Feet		899			402			351

Table X shows the measured runoff from Tongue River Basin in Wyoming except for a few diversions above the measuring stations. Table XI represents approximately the divertible daily flow to be divided between Montana and Wyoming as shown in the compact. No allowance is made for stream losses or increment to the stream, as studies have not been made to determine them.

IRRIGATED AREAS:

There are adjudicated water rights in Tongue River Basin in Wyoming for approximately 95,000 acres.* Priorities apparently were not given consideration when the compact was agreed to. The portion of this acreage that is actually irrigated is not definitely known. The Bureau of Reclamation estimates that approximately 60,000 acres are irrigated.** The 1940 Census gives 72,222 acres irrigated in Tongue River Basin Wyoming in 1939.*** The records in the Assessor's office, Sheridan County, shows 55,000 acres irrigated on Tongue River. This acreage is probably low as many people fail to report complete acreage under irrigation.

The Bureau of Reclamation is re-checking it's figures.**** With such variance in the estimated irrigated acreage in Wyoming it is evident that further studies are needed before a compact is agreed upon, as the division of the divertible flow is predicated on the irrigated and irrigable acreage in each state.

The potential irrigable land in Wyoming in Tongue River Basin is not known. Estimates of 30,000 acres had been made.† Senate document No. 191†† states, "Limited water supply on Tongue River in Wyoming precludes additional irrigation there." This is an errooneous statement, as shown by records. There are irrigable lands east of Parkman, Wyoming, additional lands on Wolf Creek, south of Tongue River near Ranchester, and in other locations. It has been estimated by persons familiar with these areas that they embrace about 15,000 acres.

*State of Wyoming Tabulation of Adjudicated Water Rights in Division No. Two.

**Mr. Sloan, U. S. B. R. speaking at a hearing in Sheridan, October 24, 1944.

***Sixteenth Census U. S. 1940—Page 642.

****Stated by Mr. Myers at conference with Bureau officials in Billings, Mont., December 27, 1948.

†Water Resources of Yellowstone River Basin in Wyoming, compiled by State Engineer and State Water Conservation Board (page 34).

†† 78th Congress—2nd session—Senate Document 191.

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The feasibility of construction to convey water to these lands and the soil fertility has not been determined. The Bureau of Reclamation has stated that they will survey these areas. If the surveys result in a favorable report, the land should be considered in the compact.

The irrigated areas in Montana were not determined accurately before the compact was drawn. Mr. Sloan estimated the irrigated areas in Montana to be some 15,000 or 16,000 acres.*** His statement follows: "There are 60,000 acres now irrigated on the Tongue River in Wyoming and 15,000 or 16,000 in Montana. That formula has been drawn up on these figures.*** Montana estimates that there are 22,136 acres of irrigated land in Tongue River Basin.**** Of this amount probably 6000 acres are on tributary streams and do not use water direct from Tongue River. The 1940 Census shows 13,880 acres irrigated in 1939 on Tongue River in Montana.***** Difficulty in maintaining diversion dams in Tongue River has restricted irrigation in both Wyoming and Montana. It is estimated there are 7,479**** acres of potential irrigable land in Tongue River Basin Montana. Much of this land is on tributaries and could not use Tongue River Water. Senate document 191 shows 26,100 acres of irrigable land. Most of this land extends like a shoestring along Tongue River and will be irrigated by pumping. The economy of the Tongue River Basin is largely livestock. Under normal prices, livestock raisers cannot afford to pump water for hay production. It is certainly very evident that Wyoming should have more detailed information before giving away what we now have, and the Montana estimates should be re-verified.

FIELD INVESTIGATION:

Before the compact was drawn few, if any, field investigations in Tongue River Basin were made either by the State Engineers Office, Bureau of Reclamation, or by local people. For four years, 1941-1944 inclusive, the State Engineer, Canal Companies and County Commissioners cooperated with the U. S. G. S. Water Resources Branch in Big Horn Basin measuring water diverted and net water used. The acreage under the large irrigation districts was checked and the Bureau of Reclamation had complete data on its projects. This survey covered 85 per cent of the land on the Big Horn River. On the contrary the State Engineer has made no field investigations in the Tongue River Basin in Wyoming. The Bureau of Reclamation is reported to have estimated the irrigated land on Tongue River from aerial photographs. The State Engineer, after a special invitation, spent a few hours in driving over Tongue River Basin in Wyoming, and this was after the compact had been approved by the Compact Commissioners. The residents of Tongue River Basin in Wyoming are not satisfied with the division of the water of the basin with Montana. They ask, why has the State Engineer failed to make studies of irrigation in this basin? Are not the people in Sheridan County entitled to the same service from the State Engineer as those in Big Horn Basin? The Bureau of Reclamatoin has assured the residents of Tongue River Basin in Wyoming that it is now and will continue to make studies in Wyoming.

***Mr. Sloan, U. S. B. R. speaking at a hearing in Sheridan, Wyoming—Oct. 24, 1944. Meaning formula in compact for division of divertible flow.

****Water Resources—Rosebud County, Montana, Part I, page 21.

*****Sixteenth Census U. S.—Page 329.

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The Montana State Engineer and the State Water Conservation Board of Montana are making detailed surveys of the irrigated and irrigable lands in Yellowstone Basin in Montana. They have completed the Survey of Tongue River Basin, Montana and know where of they speak. Why can't Wyoming protect their interests by carrying on field investigations? It is repeatedly stated that the compact method of dividing water between states is much cheaper than by litigation. That's agreed, but it may not be cheaper if we let this natural resource —water—be given away to be re-captured by another state.

The people of Big Horn Basin want the compact approved by the Wyoming Legislature. It is not a fact that about 50 per cent of their irrigated lands are now in Federal projects and an adequate water supply is assured them from two big storage reservoirs? Additional development in Big Horn Basin is assured by the Bureau of Reclamation and these projects have already been accurately surveyed and the facts regarding them are known. The planning on this side of the Big Horns has not yet reached that stage. Under the compact—Big Horn River—the division is 90% to Wyoming and 10% for Montana. The net use of water in the Big Horn Basin is about 2.75 acre feet annually of which 10% is 3½ inches or about three-fifths of an inch per month during the irrigation season. The use in Tongue River Basin is 2.65 A. F. annualy of which 28% is about 9 inches or 1.8 inches per month. How would the Basin people feel toward the compact if they were losing 28½ of their water or 9 inches per acre of their irrigation supply? With the completion of the Boysen Dam an adequate water supply is assured for practically all irrigated land on the Big Horn River. The people of Tongue River do not have such insurance. They can only hope storage reservoirs might be constructed in the future.

The water users in Tongue River Basin, Wyoming can't understand why they are being asked to give up 28½ of the first 2200 acre feet of divertible flow, when just across the line in Montana there is a reservoir with sufficient capacity (74,000 acre feet) to meet Montana's demands.

The annual water supply of Tongue River Basin if conserved by storage dams, except in extremely dry years such as 1934 would be adequate to satisfy the demands in both states. Shortages occur practically each year in Wyoming, due to low stream flow and heavy irrigation demands. Storage in the Big Horn Mountains is required to stabilize stream flow. The Bureau of Reclamation contemplates a reservoir on the South Fork of Tongue River, but additional storage will be required to meet present and expanded demands.

Article I—Paragraph A of the Yellowstone River Compact refers to political subdivisions. It is assumed this includes municipalities. Article V—Paragraph C states: "The allocations made herein shall be exclusive of the use of water for domestic and stock use, and each signatory state shall be allowed unrestricted use for these purposes, except that no reservoir for such use shall exceed 20 acre-feet in capacity." Water appropriated to municipalities including domestic, commercial, industrial, irrigation of lawns, parks and cemeteries and government hospitals should be excepted from the compact and be unaffected by it.

The City of Sheridan has a storage reservoir in the mountains having a capacity of about 1500 acre-feet. This storage must not be affected by any compact.

North Dakota is one of the parties to this compact. Under the compact it is allotted only the residual flow of Yellowstone River below Sidney, Montana, yet it has an equal vote with Wyoming and Montana. Nothing could stop North Dakota from using this flow, so why should it be an interested party?

INDIAN WATER RIGHTS

In the compact Article V, paragraph 3, Tongue River; no mention is made to Indian-treaty-water-rights for lands in Montana. The Tongue River Indian Reservation have water rights from Tongue River for about 6000 acres.*

"In 1905 the United States began construction of the Tongue River Irrigation Project, which is located in Rosebud County to divert water from Tongue River to irrigate 7000 acres of land."** The plan was abandoned and probably not more than 600 acres were ever irrigated. This is one of the early priorities from Tongue River.

The Indian Service have purchased 7500 acre feet of water in Tongue River Reservoir from the Montana Water Conservation Board. Will the Indians at some future date be granted priority over all other appropriations in Tongue River Basin?

RETURN FLOW:

Return flow to streams in the Tongue River Basin occurs largely in the upper basin. Return flow is the result of several factors of which the most important are available water supply, irrigation efficiency, slope, soil porosity, and type of crops. During the early portion of the irrigation season when the water supply is abundant most water users flood their lands, resulting in much surface runoff. The soils become saturated and due to the slope and soil porosity much water returns to the streams. These conditions are more prevalent where hay is the major crop. There are no seeped areas of any magnitude in Tongue River Basin, Wyoming which is evidence of good drainage. The topography on Tongue River and Goose Creek in the vicinity of the coal mines of the Sheridan Wyoming Coal Company restricts the width of the valleys to little more than the channel width. Practically 100 per cent of the return flow in Wyoming occurs above the narrow valleys of these two streams. The measuring station at Acme is downstream from this point.

Irrigation along Tongue River below the Montana Reservoir is in small, intermittent, shoestring tracts until you reach the Yellowstone-Tongue River Project near Miles City, a distance of about 150 miles. Since the lowest point of measurment as used in the formula is just below the diversion to this project, the return flow between Acme Station and the lowest point of measurement will be little under existing conditions. No information on return flow has been compiled.

*Information from Mr. W. L. Hanna, District Engineer, Billings, Montana.
**Water Resources Survey—Rosebud County, Montana—Page 11.

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When a stream is high a certain amount of the flow seeps into the banks. As the sream flow recedes much of this water seeps back into the stream channel.

GENERAL:

The Yellowstone River compact says that the compact commission may make adjustments in allocations if injustices develop, but such adjustments must be by unanimous consent. Would it not be better to have complete information before signing a compact? At least give the citizens of Wyoming an opportunity to check the estimates of irrigated and irrigable land, stream discharge, water use and water requirements.

It is often stated that the Bureau of Reclamation will not carry on construction in Wyoming until a compact between the three states Montana, North Dakota and Wyoming is consummated. On the contrary, construction is now underway on a storage dams on Wind River, Owl Creek and Powder River. An argument used is that if a compact is not signed immediately, Montana will build reservoirs and have priority to the water. It is not one of the arguments fo rthe Missouri River Basin Pan, that all reservoirs have the same date of priority, particularly if constructed by the Bureau of Reclamation? There is also another angle; Is the Missouri River Plan final once and for all, or is it flexible and subject to change? If it's not flexible, then Wyoming should not sign the Yellowstone Compact because the "Plan" as conceived does not contemplate storage on the North Fork of Tongue River or Soldier Creek, or irrigation of additional land.

The question of priorities of appropriation for the use of water has often been raised, but they were not considered in writing the compact. Montana cannot demand that Wyoming close headgates on its ditches, even though some of our rights may be subsequent to some of those in Montana. If this could be done Montana would have had it done years ago. If we sign the compact then Wyoming will have to close headgates on her ditches to try to deliver water to Montana. Such situations are provided for in the compact.

Many people object to the compact because it doesn't require Montana to use storage water in the dam near Decker which was constructed by the Montana Water Conservation Board. The compact does not mention the already constructed storage in either state. It is rightly presumed that all existing storage will be filled when the streams are at flood stage. Water released from storage reservoirs during the irrigation season is given consideration in the algebaic formula in the compact for the determination of the divertible flow.

The workability of the formula for determining the divertible flow is questionable. With few exceptions most of Wyoming diversions are for individual farms. To determine the divertible flow requires installing measuring devices on all ditches. In Tongue River Basin Wyoming there are over 400 diversions. To determine the daily divertible flow, a measurement must be taken every day during the period of May 1st to September 30th on each diversion. These measurements will be in cubic feet per second—the basis of measurement of irrigation water in Wyoming. Such measurements must be converted to acre feet. After the total divertible flow is determined then headgates must

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be adjusted to comply with the excess or deficit. Perhaps the stream flow has now varied and new measurements must be again taken. The same situation exists in Montana. The miles to be covered in making such measurements daily will require the service of many people, many vehicles, and equipment. Installation of measuring boxes will be at the expense of each individual ditch owner and must be maintained by him. On the Big Horn River, of the 134,800 acres irrigated from Big Horn River 85 per cent of the water is diverted through 28 ditches, and of this amount 75% is diverted through seven ditches. The measurement of the water diverted in Big Horn Basin is relatively easy. The division of water on the daily divertible flow basis as determined by the formula has not been used in any other compact that has been drawn up in other states.*

One argument that is used for the compact method of dividing water between states is that it will avoid court action. It is conceded the more nearly the waters are equitably divided by agreement the less likelyhood of court action, but there can be no guarantee against litigation in any case. If one state finds that it is not receiving just consideration under the compact is it not subject to attack in the Federal Courts?

The compact divided the water on a daily basis. Irrigation requirements for crop production varies during the irrigation season for each month, each type of crop, daylight hours, temperature, soil fertility and other factors. The water requirements for Wyoming have been tentatively set at 2.65 Acre Feet per year, and would be divided approximately in acre-feet as follows:

May	June	July	August	September
0.265	0.795	0,795	0.53	0.265

If the actual amount of irrigated land was known the amount of water required by months could be estimated. The compact allocates to Wyoming 1584 Acre Feet for 24 hours. How do the people of Wyoming know whether that amount is too little or too much?

The compact states, the first 2200 acre feet shall be divided 28% to Montana and 72% to Wyoming. Mr. Sloan stated at a hearing in Sheridan, October 24, 1944 that the division was made on the acreage of irrigated land in each state, namely, 60,000 acres in Wyoming and 15,000 or 16,000 acres in Montana. If that is the case Wyoming should receive 79 and Montana 21 percent.

Where did the figure 2200 Acre Feet come from? The total measured runoff to Tongue River in acre feet for the irrigating season is estimated to be 266,700 annually. Over a five month period May to September there are 153 days. Multiplying 2200 by 153, the result is 336,600 acre feet or 69,900 acre feet more than it is estimated originates during the five months in Tongue River basin, Wyoming.

Who wants the compact? The Bureau of Reclamation officials said recently they were not promoting it.*

As far as is known there is no controversy now and there hasn't been any between the water users of the two states on Tongue River.

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When the Tongue River Dam was under consideration for construction the people of Wyoming didn't object, in fact they were most favorable and gave their unqualiifed support to it. The reservoir was built with federal loan and grant funds to furnish supplemental water primarily to lands in the vicinity of Miles City. All Wyoming asks now is that Montana utilize it. The Montana Water Conservation Board had subscriptions for 270 Water Purchase Contracts totaling 35,000 acre feet of water.

The people of the upper basin are not in favor of this compact and will leave nothing done to defeat it. They may accept a compact that is more favorable to them. When all the basic information for a compact is obtained and presented factually to Wyoming, it is believed they will weigh the benefits against the losses, and decided for the greatest good for the majority of people in both states.

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Department of the Interior News Release, 1949

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Peterson - Int. 4662

Yellowstone Compact File

DEPARTMENT OF THE INTERIOR

INFORMATION SERVICE

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BUREAU OF RECLAMATION

For Immediate Release OCTOBER 26, 1949.

R. J. NEWELL NAMED U. S. COMMISSIONER ON YELLOWSTONE BASIN COMPACT

R. J. Newell, who recently retired as regional director of the Bureau of Reclamation at Boise, Idaho, has been named by President Truman to be United States commissioner for the formulation of an interstate compact providing for an equitable division and apportionment of the waters of the Yellowstone River and its tributaries among the States of Wyoming, Montana, and North Dakota.

The river basin is an important water resource for the Missousi River Basin Project and a compact will have material effect upon the development of the basin, according to Reclamation Commissioner Michael W. Straus.

The river rises in Yellowstone National Park in northwestern Wyoming and flows across most of the length of Montana to join the Missouri River immediately east of the Montana-North Dakota boundary. Most of its larger tributaries, such as the Bighorn and Powder Rivers, originate in Wyoming.

The appointment is made under authorization of Public Law 83, approved June 2, 1949, which is the latest in several laws, authorizing compact negotiations relating to the waters of the Yellowstone River. The present law sets a time limit of June 1, 1952, on efforts to reach an agreement.

Mr. Newell, who had many years of experience in construction and operation of reclamation projects in Oregon, Washington, and Idaho prior to his retirement as regional director on June 30, is also Federal representative on the Idaho-Wyoming Snake River compact commission.

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P.N. 64869

Land Planning and Classification Report, Bureau of Land Management, March 1949

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United States
Department Of The Interior
Bureau Of Land Management
Region III

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Missouri River Basin Investigations

LAND PLANNING AND CLASSIFICATION REPORT

as Relates to the Public Domain Lands

in the

POWDER RIVER BASIN

(Montana and Wyoming)

(For Administrative Use Only)

March, 1949

This report was compiled in connection with the program of the Department of the Interior for the development of the resources of the Missouri River Basin.

UNITED STATES
DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

MISSOURI RIVER BASIN INVESTIGATIONS

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POWDER RIVER BASIN

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ACKNOWLEDGEMENTS

The preparation of this report entailed the gathering of factual data from many sources including published reports and documents, the principal ones of which are cited in the appendix of this report.

Other no less important sources of information include: records of land status obtained from the Bureau of Land Management, the U. S. Forest Service, Production and Marketing Administration and from official county records for all the various counties included in this report; land-use development and conservation program reports, maps and records of the Production and Marketing Administration, and the Soil Conservation Service, especially as they involve Campbell, Johnson, Natrona and Sheridan Counties, Wyoming and Custer and Powder River Counties, Montana; land-use and tenure problems from the records of the County Extension Agents in Campbell, Johnson, Natrona and Sheridan Counties, Wyoming, and from the records of the Soil Conservation Service in Johnson and Sheridan Counties, Wyoming; published and unpublished reports, manuscripts and records and preliminary findings regarding existing and proposed irrigation developments from the U. S. Bureau of Reclamation, Fish and Wildlife Service, Geologic Survey, Forest Service, Soil Conservation Service, Bureau of Agricultural Economics, and the Montana and Wyoming State Extension Services; and other pertinent and related subject matter from the yet-clear memory of many local long-time residents of the area as well as interviews with various Federal, state and county officials.

Special mention should be made of the assistance rendered by the Production and Marketing Administration office and the County Extension Agents of Campbell, Johnson and Natrona Counties, Wyoming, and by the Range Manager, Montana Grazing District No. 3, in furnishing data on land resources, uses and problems as they relate to the public domain.

Field reconnaissance work, the assembly and analysis of pertinent information and the preparation of the report was conducted by Harold T. Tysk, Land Economist. The map was prepared under the supervision of William C. Anderson, Engineering Draftsman. The study in all its aspects was under the direction of R. D. Nielson, Land Economist in Charge of Missouri Basin Studies, Bureau of Land Management, Region III, Billings, Montana.

PURPOSE AND SCOPE

This report presents a preliminary analysis of the physical and economic features of the area in Montana and Wyoming within the drainage system of the Powder River. It is intended to serve as a guide in carrying out detailed studies of problems pertaining to the use and management of the remaining 1,800,000 acres of unappropriated, unreserved public domain lands in this area in furtherance of the total Missouri River Basin Development Program.

In carrying on the preliminary investigation and in presenting the information in this report, our primary concern and interest has been to develop factual data relating to the utilization management and development of the "public domain" lands and the resources thereon. Some study of the over-all land use economy was necessary to ascertain the interrelationships between the public land and other resources. In this connection, a general analysis of all land management programs operating in this area was made.

Particular emphasis was given to the appraisal of problems such as soil erosion and sedimentation and maladjustments in public land use. Problem areas requiring further investigation were delineated, and a more complete and detailed survey and report for such areas will immediately follow this preliminary study.

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SUMMARY

"Powder River! A mile wide and an inch deep!" How often that colorful phrase has brought to mind the unique glamour of the cattle country -- the open range. "Too thick to drink and too thin to plow!" Another picturesque Powder River phrase, somewhat distorted perhaps, but one that nevertheless peculiarly focuses attention to the compelling problems to be faced by the public land administrator, who is charged among other things with the responsibility of maintaining optimum watershed conditions on the public lands in this basin. Nearly one-fourth of the total land area in the Powder River basin is administered by the Bureau of Land Management. Probably the biggest problem inherent in these lands is watershed deterioration and a resultant increase in run-off, siltation and sedimentation. While not peculiar to the public lands only, the consequences of continued impairment of these resources will adversely affect human welfare and economy throughout the basin.

Comprising a drainage area of 13,193 square miles, Powder River is an interstate stream which drains portions of central and northeastern Wyoming and southeastern Montana. Seventy percent of the watershed is located in Wyoming and about sixty percent, or 7,880 square miles, lies tributary to the site of the proposed Moorhead reservoir. The damsite is located in Montana just north of the Wyoming-Montana state line and was authorized by Congress in 1947, primarily as a silt and flood control project. It will also afford storage capacity for the irrigation of about 43,000 acres of land in Montana.

The climate in the Powder River basin is that characteristic of the Northern Great Plains, semi-arid and continental, with extreme variations and fluctuations in temperature and precipitation which in turn contribute greatly to the relative abundance or depletion of native vegetation. The vicissitudes of climate also play an important part in the methods employed in livestock and farming operations. Severe winter and spring storms, for example, present a constant threat to the stability of sheep operations.

Physiographic features are sharply contrasting. Half of the area is comprised of sharply rolling plains, another quarter is gently rolling plains, while the Big Horn Mountains and their flanking foothills make up the remainder of the basin. Elevations range from 2,250 feet above sea level at the confluence of the Powder and Yellowstone Rivers in Montana to 13,165 feet at the summit of Cloud Peak in Wyoming. The rugged Big Horn Mountains are the outstanding physiographic feature. Powder River "breaks", the badlands flanking the main river, is another important feature of the landscape. Powder River and its principal tributaries receive most of their water from the Big Horn Range. Very little perennial run-off is yielded by the low altitude plains area.

Most of the soils in the basin are shallow, heavy soils derived mainly from shale formations, although they differ materially in various parts of the area and present a wide variation in their development.

Native vegetation occupies about 96 percent of the total watershed, while the remaining area comprises crop and hay lands, water surfaces, roads and waste lands. Range lands are primarily of four types, timber, open mountain parks, sagebrush grass and grasslands, the latter type being the most extensive.

About two-thirds of the basin is in private ownership, while the remainder is in Federal or state ownership. A total of 1,830,953 acres, or 22 percent of all lands in the basin, are under the custody of the Bureau of Land Management. The greatest concentrations of such public domain lands occur in the southern portion of the basin in Wyoming, where they dominate all other classes of land ownership. While a similar pattern persists in the breaks of the Powder River, the public domain becomes progressively more widely scattered as the mouth of the river is approached.

The production of range beef cattle and sheep is the predominating enterprise in the basin. Calculated on the basis that five sheep are equivalent to one horse or cow, cattle comprise 65 percent, sheep 30 percent and horses 5 percent of the livestock population in the basin.

Crop and hay production by irrigation is an important feature of the agricultural economy. About 100,000 acres are under irrigation, while approximately 154,000 acres are dry farmed. The development of additional irrigated lands will help to balance and integrate crop and range use in areas where range livestock production is almost wholly pastoral.

Powder River basin presents a picture of diverse Federal and state land management programs including two National Forests, two Taylor Grazing Districts, one Public Domain administrative program, six Soil Conservation Districts, two State land leasing programs, two State Cooperative Grazing Districts, three Land Utilization Project Areas, one Naval Petroleum Reserve, one county park and eleven Production and Marketing Administration Agricultural Conservation programs and eleven county extension programs. Doubtless there are others.

The problems relating to the management, protection, development and utilization of the public domain lands and their resources are broadly described in the following categories:

(1) Watershed impairment and consequent siltation of stream courses and impoundments.
(2) Maladjustments in land use.
(3) Complexity of land ownership and operating patterns.
(4) Abuses on the public stock driveways and resulting soil and forage depletion.
(5) Ineffectual integration of land uses.
(6) Rodent and insect infestations.
(7) Poisonous plants.

The present study has not been of sufficient detail to determine the scope and seriousness of these problems, nor to prescribe detailed corrective measures. Further studies are necessary to obtain the basic data necessary to the solution of these and other problems which will appear as the study progresses.

Four problem areas will be studied in detail and in the following sequence:

(1) Upper Powder River, Wyoming, which will include the drainages of North, Middle and South Forks of Powder River and Salt Creek.
(2) Powder River breaks, Wyoming and Montana, which will include the main stem of Powder River tributary to the proposed Moorhead reservoir.
(3) Moorhead-Powderville area, Montana.
(4) The remainder of the basin, Montana and Wyoming, which will include those areas in the basin which contain relatively little public domain and what remains consists of small isolated tracts of land.

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GENERAL DESCRIPTION

Location and Size

Powder River, a tributary of Yellowstone River, is an interstate stream draining portions of northeastern Wyoming and southeastern Montana. The basin drains an area of 13,193 square miles, equivalent to 19 percent of the entire area of Yellowstone River basin. The length of its basin in a north and south direction is about 275 miles and the maximum width is about 100 miles. The average east-west width of the basin in Wyoming is 53 miles, decreasing progressively northward to an average width of 38 miles in Montana. (See map appendix.)

The basin has its headwaters in almost the exact geographical center of the state of Wyoming from whence it flows in a generally northeasterly direction through northeastern Wyoming and southeastern Montana to its confluence with the Yellowstone River. The Powder River basin is bounded on the east by O'Fallon Creek, Little Missouri, Belle Fourche and Cheyenne River watersheds, on the south by the North Platte River basin and on the west by the Wind River, Big Horn, Tongue and Yellowstone River watersheds.

The Moorhead dam was authorized by Congress in 1947 as a flood control project and is located in Montana about three miles north of the Wyoming-Montana state line. According to plans of the Bureau of Reclamation, the dam will be of earth and rock construction and have an estimated storage capacity of 700,000 acre-feet. Its primary purpose is for flood and silt control. The dam will also afford storage capacity for the irrigation of an estimated 43,000 acres, adjacent to the Powder River in Montana. Table 1 shows by states, counties and by watershed units embraced above and below the proposed Moorhead Reservoir, the gross area contained within Powder River basin.

About sixty percent of the entire watershed lies tributary to the proposed Moorhead Reservoir and almost completely within Wyoming, less than one-half of one percent of the watershed being in Powder River County, Montana. This portion of the watershed, roughly oval in shape, contains 7,880 square miles, with maximum dimensions of about 155 miles north and south and about 60 miles east and west. The area embraces nearly one-twelfth the land area of Wyoming, including 97 percent of Johnson County, 33 percent of Natrona County, 29 percent of Campbell County, 21 percent of Sheridan County, 5 percent of Washakie County and less than 1 percent of Crook and Converse Counties.

Forty percent of Powder River basin lies below the site of the proposed Moorhead dam, three-quarters of which is in Montana, with the balance in the Little Powder River watershed in Campbell and Crook Counties, Wyoming. This portion of the watershed, roughly dagger-like in shape, contains 5,313 square miles, with maximum dimensions of 170 miles north and south and 55 miles east and west. It embraces less than three percent of the land area of Montana and one percent of that of Wyoming, and includes 61 percent of Powder River County, 34 percent of Custer, 16 percent of Carter and 4 percent of Prairie County in Montana. In Wyoming, 29 percent of Campbell County and about one percent of Crook County are embraced by the Little Powder River watershed.

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Table 1 - Area of Powder River Basin
by Counties and Watershed Units (1)
Montana and Wyoming

Name of County	Area Entire Watershed		Area Below Moorhead Res. Site		Area Above Moorhead Res. Site	
WYOMING	Acres	Percent	Acres	Percent	Acres	Percent
Campbell	1,757,060	20.8	872,060	10.3	885,000	10.5
Converse	3,600	0.1			3,600	0.1
Crook	12,860	0.2	12,860	0.2		
Johnson	2,597,760	30.8			2,597,760	30.8
Natrona	1,141,190	13.5			1,141,190	13.5
Sheridan	332,020	3.9			332,020	3.9
Washakie	46,010	0.5			46,010	0.5
Total	5,890,500	69.8	884,920	10.5	5,005,580	59.3
MONTANA						
Carter	347,898	4.1	347,898	4.1		
Custer	805,749	9.5	805,749	9.5		
Powder River	1,333,857	15.8	1,296,005	15.4	37,852	0.4
Prairie	65,261	0.8	65,261	0.8		
Total	2,552,765	30.2	2,514,913	29.8	37,852	0.4
Entire Watershed	8,443,265	100.0	3,399,833	40.3	5,043,432	59.7

(1) Figures computed from county and state maps prepared by various agencies.

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Climate

The climate of the Powder River Basin is typically semi-arid and continental with wide variations in the occurrence, duration, intensity and distribution of rainfall and with wide ranges in extreme temperatures, all characteristic of the Northern Great Plains. Maximum summer temperatures in excess of 110 degrees are experienced in the plains where seasonal variations are much greater than in the mountains. Minimum temperatures of -54 degrees have been recorded. With the exception of the mountainous area at the higher elevations, comprising approximately 25 percent of the basin, the growing season is of sufficient length, about 120 days, to mature the majority of general farm crops. Along the mountain front of the Big Horn Range, the growing season progressively decreases as elevations increase until in the higher elevations of the mountains, the growing season is often less than 60 days with killing frosts reported during every month of the year. (See Table 3.)

Yearly precipitation ranges from less than twelve inches in the vicinity of Kaycee and Sussex, Wyoming, to more than 25 inches in the nearby mountains of the Big Horns. It is this mountainous zone that provides the water for the irrigation of lands in the lower plains. Snow accounts for a considerable part of the total precipitation in this humid mountain belt and in the highest

reaches surrounding Cloud Peak are found limited areas of perennial snow fields. Runoff from the melting snow takes place principally during May, June and early July, at which time the mountain streams flow at maximum sustained rates. More than 70 lakes in the Big Horn National Forest are replenished principally by snow, and these lakes in turn feed a large number of springs, streams and wells. This zone is virtually snowbound from November to May, and inhabitants migrate to lower elevations each year.

During exceptionally severe winters, large areas of winter range in the lower elevations become practically cut off from the outside world and natural forage becomes inaccessible to livestock. When ranges are closed for either brief or extended periods, supplementary feeding becomes necessary. Feed shortages develop quite often and livestock loss and shrinkage may become severe when ranges are closed to grazing for extended periods. In the dry farming areas, such heavy snows are ordinarily very beneficial to winter and spring wheat crops.

Heavy unseasonable snows in June accompanied by cool damp weather are not uncommon. Heavy livestock losses are experienced during such storms, especially by newly shorn sheep and young lambs. Hail storms are not uncommon in some of the dry-farming areas, and they are of sufficient intensity to cause severe damage about one year in five.

Surface evaporation records during the growing season are meager. At Sheridan, the nearest station at which evaporation from a free water surface is recorded and considered as representative of conditions in the upland plains area of Powder River basin, the total evaporation averages 25.64 inches for the period April through September.

Prevailing wind direction is from the southwest. The wind is usually of low velocity which lengthens the period of surface runoff in higher elevations where drifting snow forms temporary snowfields. As a rule, strong winds are uncommon and seldom reach damaging proportions. However, when associated with winter storms, drifting snow causes considerable difficulty in both transportation and livestock movements.

The annual and growing season precipitation, together with monthly averages for the period covered, are shown in Table 2 for weather stations in or near the Powder River drainage area. The months of April, May, June, July, August and September included in the above table are shown as seasonal precipitation. Too much emphasis should not be placed upon the total precipitation because many factors such as seasonal distribution, character of precipitation, temperature and wind velocity have a very great effect upon the net benefit to growing crops. For the selected weather stations shown in Table II, seasonal precipitation averages 75 percent of mean annual precipitation for Montana stations and 69 percent for the indicated Wyoming weather stations. The range in seasonal precipitation throughout the basin varies from less than 8 inches to greater than 14 inches. Most of the areas where dry-farming presists receive from 10 to 12 inches of moisture during the growing season.

Table 2 - Average Annual Precipitation and its Seasonal Distribution (inches) (1)
Powder River Basin

Location	Length of Record Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Seasonal Apr. thru Sept.
MONTANA:															
Ekalaka*	37	0.38	0.32	0.62	1.04	2.29	2.81	1.78	1.32	1.18	0.78	0.34	0.31	13.17	10.42
Knowlton (near)	15	0.63	0.58	0.69	1.42	2.18	2.96	2.39	1.09	1.09	0.98	0.71	1.04	15.76	11.13
Miles City*	40	0.64	0.46	0.83	0.97	1.89	2.42	1.67	1.20	1.07	0.83	0.55	0.63	13.16	9.22
Broadus	11	0.50	0.41	0.72	1.53	2.64	3.72	1.78	1.04	1.15	0.89	0.76	0.48	15.62	11.86
Biddle	20	0.46	0.35	0.59	1.23	2.46	2.98	2.10	1.59	1.50	1.03	0.56	0.35	15.11	11.86
Fallon*	12	0.33	0.21	0.28	0.43	2.54	3.36	1.97	1.56	1.22	0.95	0.30	0.21	13.36	11.08
Ashland (near)	11	0.68	0.53	1.19	1.65	2.09	2.18	1.57	1.65	1.10	1.20	0.73	0.54	14.51	9.64
WYOMING:															
Echeta	21	0.91	0.71	1.02	1.80	2.29	2.14	1.84	1.09	1.46	1.26	0.96	0.90	16.38	10.62
Gillette*	28	0.68	0.44	1.00	1.73	2.33	2.21	1.72	1.21	1.21	0.93	0.61	0.71	14.78	10.41
Rocky Point*	28	0.91	0.75	1.23	1.71	2.63	2.72	2.10	1.24	1.52	1.27	0.81	0.72	17.61	11.92
Ross*	13	0.35	0.46	0.75	1.35	1.97	1.91	1.26	1.01	0.93	0.92	0.55	0.39	11.85	8.43
Barnum	25	0.39	0.31	0.77	1.48	2.24	1.25	1.31	0.75	0.93	1.08	0.49	0.47	11.47	7.96
Buffalo	32	0.48	0.46	0.86	1.60	2.43	1.89	1.28	1.04	1.23	0.78	0.48	0.54	13.07	9.47
Hunter's*Station	30	0.72	0.64	1.50	2.39	3.10	2.42	1.95	1.57	1.54	1.50	0.62	0.58	18.53	12.97
9-Mile Creek	16	0.28	0.30	0.75	1.75	2.13	1.84	1.66	1.05	1.19	0.77	0.53	0.45	12.10	9.02
Casper*	29	0.60	0.71	1.15	2.06	2.20	1.38	1.20	0.93	1.15	1.25	0.79	0.73	14.15	8.92
Ervay	31	0.46	0.65	1.13	2.16	2.91	1.66	1.60	1.21	1.57	1.70	0.77	0.69	16.51	11.11
Salt Creek*	17	0.54	0.50	1.14	1.81	2.26	1.64	1.50	0.94	1.15	1.10	0.63	0.56	13.77	9.30
Sheridan	44	0.52	0.50	1.11	2.31	2.65	2.50	0.97	0.74	1.45	1.33	0.80	0.52	15.40	10.59

(1) From U. S. Weather Bureau Record.

* Stations located outside of but near Powder River watershed.

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Table 3 - Climatological Data (1)
Powder River Basin

Location	Length of Record Years	Temperatures Degrees Fahrenheit Jan. Avg.	July Avg.	Maximum	Minimum	Length of Record Years	Average Dates Killing Frosts Last in Spring	First in Fall	Average Growing Season Days	Elevation Feet
MONTANA:										
Ekalaka*	37	19.0	71.2	108	-43	37	May 19	Sept. 23	127	3,427
Knowlton (near)	14	16.4	71.6	108	-46	15	May 15	Sept. 22	130	
Miles City*	40	14.5	72.9	111	-49	40	April 30	Oct. 5	158	2,351
Biddle	19	19.4	70.4	110	-41	22	May 23	Sept. 21	121	
Broadus	11	20.3	71.8	- -	- -	--	- - -	- - - -	- -	3,026
Fallon*	12	9.6	70.4	108	-54	12	May 19	Sept. 18	122	
Ashland (near)	11	21.1	70.5	108	-43	12	May 9	Sept. 28	142	3,900
WYOMING:										
Echeta	12	20.6	70.0	106	-45	17	May 20	Sept. 15	108	
Gillette*	27	21.4	71.1	110	-40	26	May 14	Sept. 30	139	4,542
Ross*	14	20.0	69.9	102	-40	14	May 15	Sept. 22	130	
Barnum	17	21.9	68.8	108	-45	19	May 25	Sept. 19	117	
Buffalo	32	21.8	68.6	106	-40	30	May 23	Sept. 17	117	5.240
Hunter's Station*	28	18.6	58.0	99	-42	32	July 5	Aug. 25	51	7,400
Nine-Mile Creek	10	21.2	71.0	103	-43	14	May 25	Sept. 20	118	
Casper*	28	26.4	72.1	109	-41	28	May 19	Sept. 29	133	5,134
Ervay	29	20.6	66.0	100	-38	30	June 1	Sept. 14	105	
Salt Creek*	16	22.7	71.4	106	-41	16	May 11	Sept. 26	138	4,850
Sheridan*	38	19.4	68.9	106	-45	36	May 15	Sept. 22	130	3,800

(1) From U. S. Weather Bureau Record.
* Stations located outside of but near Powder River watershed.

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Physiography

The basin forms a part of two well-marked physiographic regions, the Big Horn Mountains and the Great Plains, which have sharply contrasting surface features, although minor details of relief in many cases determine the utilization of the land. Topographically, the area is most varied. About 10 percent of the area is mountainous, 15 percent foothills, 50 percent sharply rolling plains, and 25 percent gently rolling plains. The minimum elevation is approximately 2,250 feet at the confluence of the Powder River and Yellowstone River in Montana, and the maximum is 13,165 feet at the summit of Cloud Peak in the Big Horn Mountains in northwestern Johnson County, Wyoming. About three-quarters of the basin lies at elevations below 5,000 feet. The general slope is north and northeasterly.

The mountainous portion of the area, confined entirely to Wyoming, is confined to the lofty Big Horn Mountains and to the Rattlesnake Range, the latter a short comparatively low mountain range bordering Sweetwater River basin to the south. While the east-facing slope of the Big Horn Mountains is quite steep, abrupt and in places precipitious, the hinterlands for the most part consist of undulating plateaus and rounded ridges, interspersed with a few rocky knolls and peaks with intervening sharply cut valleys and gorges. In the Cloud Peak region of the Big Horns in northwestern Johnson County, the ridges rise from 3,000 to 4,000 feet above the valleys and the general configuration is very rugged, presenting some of the boldest alpine scenery in the country. There are many precipices over 1,000 feet high and many of the steeper slopes consist of talus of huge granite blocks. Most of the topographic features of this high region are those characteristic of glacial erosion. The most marked of these are the many deep cirques that are cut back to the main divide. Glaciation or glacial deposits have produced most of the many small lakes found in this area. Diminutive remnants of glaciers are still to be found in the vicinity of Cloud Peak, lying in cirques cut deeply into some of the higher mountain slopes.

The rugged to roughly rolling foothills and valleys at the base of the mountain slope to the eastward have a great variety of surface features, characteristics of which are gravel-capped terraces, narrow bottomlands, flood plains, alluvial fans of gravel, sand and clay derived from erosion of the mountain slopes and small outlying uplifts. There are many deeply dissected steep, narrow valleys which have left benches and high mesas between the drainage courses.

Part of the Great Plains Province, the sharply rolling plains lie east and north of the belt of foothills and consist of comparatively broad tabular divides between the larger streams which are more or less thoroughly dissected by narrow valleys of the lateral drainageways. The greater part of the area is characterized by a vast rolling to rough expanse of sharply rounded ridges and hills with occasional bold, conspicuous escarpments formed by the tilted edges of pine-covered sandstone which often form prominent land marks. Intervening valleys are often broad flats with numerous deep-cut gullies. The soft shales in places have eroded rapidly and the entire surface has been so

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thoroughly dissected that the original plains character is suggested and represented now only by the crests of the main ridges which are all at about corresponding elevations. The topography along both sides of the Powder River from Sussex, Wyoming to Moorhead, Montana, is mainly of the badland type, especially close to the main stream and lateral tributaries, but there are found areas of more gentle relief as well. Vegetation is comparatively sparse, and the soft shales and sandstones are carved by runoff into an intricately dissected surface of steep raw slopes, extended escarpments and sharp ridges, buttes, domes, precipitious bluffs, pinnacles and vertical-walled gullies. One of the most outstanding and best known examples of badlands in the basin is "Hell's Half Acre" or "Devil's Kitchen", a small area of precipitious crags and needles in Natrona County, Wyoming. In limited parts of the area, burned-out coal beds along outcrops have left "scoria" or "slags", resistant masses of overlying baked clay as caps, ledges and small buttes. These slags, reddish-orange in color, cap or rim the upland areas and effectually retard the down-cutting of the drainageways to form miniature terraces. Drainage courses are intermittent, but during heavy downpours, the dry stream beds are filled with rushing torrents, sometimes 20 or 30 feet in depth. Erosion at such times is extremely rapid, great masses of shale caving from the steep banks into the water, there to be rapidly disintegrated and carried on downstream.

The gently rolling plains include several areas which have escaped thorough dissection and are comparatively smooth. One of the largest of these, comprising about ten townships in central Johnson County near Sussex, is locally known as the "Nine-Mile District". Other such areas in Wyoming are found as narrow belts along the eastern divide in Campbell County. Comparable areas are found in Montana, notably in the vicinity of Broadus. The undulating surface of these upland plains are often interrupted by the rough breaks of Powder River and its lateral tributaries. Pumpkin Buttes, four flat-topped buttes in southwestern Campbell County, resemble giant tepees and rise several hundred feet above the surrounding rolling country to form a conspicuous landmark in the southeastern part of the basin.

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Geology

The rocks appearing at the surface within the Powder River basin afford a record of physical geology ranging from the Pre-Cambrian time to the present.

The Big Horn Mountains, forming an outlying portion of the Rocky Mountain Range, represents a great uplift by which a thick series of sedimentary rocks have been elevated high above the plains to the east. The deeply eroded crest of this uplift presents an exposed central nucleus of Pre-Cambrian granites and constitutes the floor of sedimentary deposits of more recent ages.

In the plains area, the geologic formations generally dip slightly to the east, but are modified locally by moderate to sharply dipping folds. The materials of the formations were derived mainly from the west and were deposited, layer by layer, either by streams on their flood plains or in lakes, or during even earlier times, in the sea.

The geologic formations present alternations of beds of various geologic materials, principally of sedimentary origin, shales, sandstones and limestones. These give rise to abrupt transitions in the character of their disintegration products, soils which differ widely in composition and agricultural capabilities often occurring side by side. The only areas in which the boundaries between different soils do not coincide with the boundaries of the rock formations are in the stream bottoms, in the areas of high-level gravel terraces, in many of the small tributaries, and upon steep slopes where transported soils have washed down and mingled with or covered the residual soils.

Drainage

The main stem of the river is roughly 155 miles in length in Wyoming and 120 miles in length in Montana and flows in a generally northeasterly direction. Its headwaters are near the geographical center of Wyoming. About three-fourths of the drainage area in Wyoming lies west of Powder River. Its largest tributaries are Clear, Crazy Woman, Salt and Buffalo Creeks, and North, Middle and South Forks of the Powder River. South Fork and Salt Creek are the only tributaries mentioned which might be considered as intermittent streams, although their drainage areas comprise almost one-fourth of the watershed above Moorhead Reservoir site. It is significant to note that all tributary drainages east of Powder River in Wyoming likewise flow only intermittently. The largest tributary in this portion of the area is Wild Horse Creek, which joins Powder River at Arvada, Wyoming. The principal tributaries which join Powder River below the site of the proposed Moorhead Reservoir are Little Powder, East Fork of Powder, Timber, Ash, Mizpah and Locate Creeks. These main tributaries and their small ones, form a mature and well established drainage pattern for the entire basin.

Powder River and its principal tributaries receive most of their water from the Big Horn Mountains in Wyoming and very little perennial runoff is yielded by the low altitude plains area. Elevations in the basin range from 2,250 feet at the mouth of the Powder River to a maximum of 13,165 feet at Cloud Peak in the Big Horn Mountains. The general stream gradient ranges from 2 feet per mile at the mouth to 30 feet per mile at the headwaters. Below the mountains, the main stream as well as its large tributaries have cut deeply entrenched channels into the sediments of the narrow valleys. The lower flood plains are usually dissected by the meandering flood channels of intermittent tributaries.

Soils

The soils of Powder River basin, like the soils of most of the semi-arid West, present a wide variation in soil development which differs materially in various parts of the area. Being derived in most cases from shale formations, they are often high in soluble salts and low in nitrogen. In places, capping of sandy materials over the shale formations has produced areas of sandy loams and loams, but generally speaking, heavy clay soils are dominant within the basin.

In general, soils of the flood plains, terraces, sloping benches, alluvial fans and stream bottoms are moderately deep, medium to heavy-textured

and usually adequately drained, although occasionally saline. Subsoils may be moderately heavy to tight. These are the most desirable soils for irrigation and where the relief is favorable for the distribution of water, there are found some of the most highly developed and valuable irrigated districts in the basin. Soils of poorly drained bottomlands are commonly silty or sandy over a gravel sub-stratum, occasionally slightly saline.

Soils on the more gently sloping uplands and benches are usually deep, moderately heavy clay soils with scattered areas of sandy clay loams developed from sediments washed down from areas of fine-grained sandstones. These soils are usually lighter in color than those of the irrigated lands and are situated in areas where dry-farming is practiced.

The greater part of the soils in the basin are shallow heavy soils on hilly to rough and broken uplands. On sloping benches adjacent to drainageways, the soils may be deep and moderately heavy to gravelly. They are unsuitable for cultivation due to one or more of the following factors: shallowness, stoniness, rough relief, frequent flooding by nearby streams, poor drainage, alkali accumulation, short growing season because of high elevations and inadequate moisture. The soils of this group include both the rough land of the dry plains and foothills and the rough and partly-forested mountain lands. Most of the public domain lands come within this category.

Vegetation

Ecologically, the basin has been differentiated into five life zones.(1) The Upper Sonoran Zone occupies the lower elevations and is followed, as the elevation increases, by the Transition, Canadian, Hudsonian and Arctic Alpine zones, in that respective order. Roughly speaking, the upper limits of each of the zones in this latitude may be considered to be 4,500 feet, 7,500 feet, 9,000 feet, 10,500 feet and above 10,500 feet, respectively.

About 96 percent of the basin is occupied by natural vegetation, the remaining four percent of the area comprising hay and croplands, water surfaces, roads and waste lands. Native vegetation, therefore, is the basis for the principal enterprise, the livestock industry, and is also the principal instrument through which the stabilization of the soil and improvement of the economy must be brought out. By judicious management, a maximum forage production can be attained and is indeed imperative. In the face of declining production on a considerable part of the native range lands, a large part of which is public lands, a vigorous program of constructive and united action is urgently needed to promote proper range and watershed management.

(1) For a more complete description of the life zones, see North American Fauna No. 42; Life Zone Investigations in Wyoming; Fish and Wildlife Service, Department of the Interior.

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The forage resources of the area have been delineated into four major types, namely, Timber, Open Mountain Parks, Sagebrush-Grass and Grass. Inaccessible and barren wastelands occupy parts of the basin. The timber type, based primarily upon the elevation, has been subdivided into three classes, the mountain timber type, the open pine type and the pine-savannah type.

The mountain timber type ranges from about 6,500 feet to 13,165 feet in elevation, occupies about three percent of the basin, and is confined to the Big Horn Mountains in Wyoming. The predominating specie are lodgepole pine (Pinus contorta), with spruce (Picea engelmannii) and fir (Abies lasiocarpa) occurring in small patches on the north slopes. Aspen (Populus tremuloides) border the conifers on the lower limits and extend along the live streams. The understory generally consists of a sparse growth of various grasses, shrubs, perennial and annual weeds. A litter of pine needles and organic matter forms a protective cover against soil erosion. Relatively unimportant as a source of summer forage for domestic livestock, the greatest benefits to be derived from this timber type are watershed protection for flood control and the conservation of moisture and for wildlife protection. A program of selective timber harvesting is being carried out in this type of the Big Horn National Forest which furnishes the principal supply of timber for the sawmill located in Buffalo, Wyoming, where approximately four million board feet of lumber is produced annually. Public land ownership within this type, except for the Big Horn National Forest, is relatively small.

The open pine type, ranging from about 3,500 feet to 5,000 feet in elevation comprises about four percent of the basin. It occupies part of northeast Sheridan and northwest Campbell Counties, Wyoming, and southwest Powder River County, Montana, and portions of the Powder River breaks. The open stands of yellow pine timber are commercially unimportant as saw timber because of their scattered location, but the vegetation in this type furnishes an important source of livestock forage, especially for cattle. The principal specie of grass in this type are wheatgrasses (Agropyron spp), blue grass (Poa spp), and blue grama (Boutelona gracilis). An estimated 20 percent of this type occurs on public domain lands.

The pine-savannah type, ranging from about 3,000 feet to 4,500 feet in elevation and comprising about five percent of the basin, occupies the higher elevations of the watershed divide in Montana and in Campbell County, Wyoming. The yellow pine is considerably more scattered than is found in the open pine type and is very often associated with sandstone or scoria outcrops. The principal forage specie are wheatgrasses, blue grama and niggerwool. Public land ownership varies from 5 to 15 percent within this type and consists of relatively small scattered tracts.

The open-mountain park type ranging from about 7,500 feet to 12,000 feet in elevation occupies about five percent of the basin and is found exclusively in the Big Horn Mountains in Wyoming. The principal specie are sedges (Carex spp.), blue grasses, wheatgrasses, fescues (Festuca spp.), phlox (Phlox spp.), old man whiskers (Siversia spp.), cinquefoil (Potentilla spp.), lupine (Lupinus spp.), balsam root (Balsamorrhiza spp.) and mountain dandelion (Agoseris spp.). These plants are vigorous and furnish adequate

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cover for protection against soil erosion except in localized over-grazed areas such as in the vicinity of public stock driveways. This type furnishes summer grazing for sheep and cattle from about June 15 or July 1 to October 1st. Except for stock driveway withdrawals and National Forest lands, public land ownership within this type is comparatively small.

The sagebrush-grass type occupies areas from 3,000 feet to 7,500 feet in elevation and comprises about one-third of the range area in the basin. The greater part of this type occurs in Wyoming and in large part is coextensive with the Powder River breaks and heavy shale areas. The principal specie in this type are blue steam wheatgrass, niggerwool, big sagebrush (Artemisia tridentata), needle and thread grass (Stipa comata), blue grama prickley pear (Opuntia polyacantha), valley sage (Artemisia cana), brown sage (Artemisia pedatifida), silver sage (Artemisia frigida), winter fat (Eurotia lanata), rabbit brush (Chrysothamnus spp.). Some greasewood (Sarcobatus vermiculatus) occurs along the creek bottoms and on saline flats. Along the mountain front there are small patches of curlleaf mountain mahogany (Cercocarpus ledifolius) and juniper (Juniperus spp.). Grasses constitute about two-thirds of the forage used by livestock. This type presents varied degrees of plant vigor, composition and erosion conditions. It is unquestionably the heaviest and most extensive silt producer in the basin when compared with all vegetative types. It is best adapted for winter grazing by either cattle or sheep and receives its greater use during this period. Some of the type is used as year-long range, principally by cattle, while much of the type which lies adjacent to summer range of the mountains is used as spring-fall range. It is estimated that nearly one-half of all public domain in the basin is characterized by this type of vegetation.

The short-grass type is the most extensive vegetative type in the basin. It occupies nearly one-half of the range area and extends to elevations of about 6,500 feet. The principal specie are blue grama, niggerwool, blue stem wheatgrass, June grass (Koleria cristata), needle and thread grass (Stipa comata). Other important specie are blue grass (Poa secunda), salt grass (Distichlis stricta), blue bunch wheat grass (Agropyron spicatum), cheat grass (Bromus tectorum), black sage, brown sage, silver sage, phlox (Phlox hoodii), lambsquarter (Chenopodium alba), plantain (Plantago purshii), Russian thistle (Salsola postifer) and cactus (Opuntia spp.). Shrubs usually constitute only a small part of the forage composition. The wheat grasses have become extensively established throughout the area and are by far the most vigorous and dominant in this type. This type is best adapted to summer and spring-fall grazing, although year-long grazing is extensively practiced by cattle operators. The foothills range adjacent to the Big Horn Mountains is used mainly for spring, fall and winter sheep range in connection with irrigated ranch headquarters. An estimated one-third of the public domain is found in this type.

ECONOMIC AND CULTURAL DEVELOPMENT

Population

Total population in the Powder River basin in 1940 was approximately 17,000 people, about 12,000 of which were rural-farm and approximately 5,000 living in communities and villages ranging in size from 10 to 2,800. The total population in 1930 was 21,000, a net decrease during the decade of 21 percent. This downward trend was accelerated by the prolonged drought period of the 1930's. The rural-farm populations decreased during this time, whereas the communities and villages increased. The 1940 population of the basin comprised about eight percent of the entire population of the Yellowstone River basin (212,260). In 1940, the average number of inhabitants per square mile in the Wyoming portion of the basin was 1.5, while in Montana it was 0.8. Powder River basin included eight percent of the total land area and only five percent of the total population of Wyoming; while that portion in Montana comprised three percent of the total land area and less than one percent of the total population.

Buffalo, Wyoming, the county seat of Johnson County, is the largest town in the Powder River basin, with an estimated 2,800 residents, which is about 16 percent of the total population of the basin. It is situated at the foot of the Big Horn Mountains at an elevation of 4,635 feet and serves as an important marketing and shipping center for a large livestock and agricultural region in Wyoming. The Wyoming Railway, a small independent line, connects Buffalo with the C. B. and Q. Railroad at Clearmont in Sheridan County. Buffalo enjoys all the advantages of natural beauty in its mountain setting and is fast becoming an important summer resort center. A lumber mill was established at Buffalo in 1944 and has already become an important part of the economic life of the community, cutting more than four million board feet of lumber annually. Mining is done on a small scale with two coal mines near Buffalo furnishing about 6,000 tons of coal annually for local use.

Midwest, Wyoming, an oil town with a population of about 1,000 inhabitants and the second largest town in the basin, is located in the Salt Creek Oil Field in northeastern Natrona County.

Broadus, Montana, third largest town, with a population of about 240 residents, is the county seat of Powder River County.

There are several rural schools in the area and consolidated high schools are located at Buffalo, Midwest, Clearmont and Broadus within the area and at the nearby towns of Casper, Sheridan, Gillette and Miles City. Plans are being made by the state officials for the opening of the University of Wyoming School of Agriculture at Sheridan, Wyoming, as a branch of the State University.

Markets and Transportation

The C. B. and Q. Railroad crosses the central part of the basin, entering on the east near Gillette, Wyoming, crossing Powder River at Arvada and continuing by way of Clearmont and Ulm to Sheridan, Wyoming, and Billings, Montana. An independent line, the Wyoming Railroad, terminating at Buffalo, Wyoming.

connects with the C. B. and Q. at Clearmont, Wyoming, 25 miles to the north. The principal shipping centers for this area are Gillette, Arvada, Clearmont, Buffalo and Sheridan, Wyoming. The Northern Pacific and Milwaukee railways traverse Yellowstone River Valley and provide outlets for the northern portion of the basin at Miles City and Terry, Montana.

The C. B. and Q. and the Chicago-Northwestern railways provide convenient outlets for farm products and livestock in the southern portion of the basin. Both lines traverse the basin on common trackage entering at Powder River, Wyoming on the east side and leaving the basin on the west at Arminto, Wyoming. The principal shipping centers for this area are Casper, Bucknum, Powder River and Arminto, Wyoming.

There are no railways traversing the basin in a north and south direction, but an oiled highway, U. S. No. 87 provides for excellent highway transportation from Casper to Sheridan. Oiled highways for east and west travel across the basin are U.S. No. 12, U.S. No. 14, U.S. No. 16 and U.S. No. 20. U.S. No. 212 connecting Belle Fourche, South Dakota and Miles City, Montana, crosses Powder River near Broadus. This all-weather highway provides the principal farm-to-market outlet for the greater part of the basin in Montana.

A network of State highways and County roads provides good farm-to-market routes. All of the Federal highways are maintained for year-round travel. The county roads are for the most part improved dirt roads, many of which in the remote areas are closed during the winter. Many secondary roads become virtually impassable for short periods during wet weather.

Industries

Farming and livestock raising are the principal industries of the basin engaging a large portion of the total working population. The estimated value of crops and livestock sold in 1945 was $11,000,000. Petroleum products in the same year had an estimated total value of $5,500,000. Small scale lumbering exceeded $150,000 in value and coal mined and sold commercially had a value of about $50,000 in 1945. Other industries of importance are tourism, construction, service trades and rail and truck transportation.

LAND OWNERSHIP AND TENURE

The land ownership and tenure picture is of great importance in working out and securing a sound and efficient land management program. Of the approximately 8,443,000 acres in the basin, about 70 percent lies in Wyoming and the remaining 30 percent in Montana. Two Taylor grazing Districts encompass 30 percent of the gross area and National Forests comprise about 3½ percent of the total watershed. The complexity of land ownership is best illustrated by the fact that there are 13 classes of land ownership. Federal, State and County lands comprise 35.3 percent of the basin and privately owned and railroad lands make up the remaining 64.7 percent.

A total of 1,830,953 acres, or about 22 percent of all lands in the basin are under the custody of the Bureau of Land Management, of which approximately 471,888 acres are in grazing district. (See Table 4.) The greatest

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SEE FULL TABLE ATTACHED

Table 4 - Land Ownership by State and County
Above and Below Moorhead Reservoir, 1949
Powder River Basin

MOORHEAD RESERVOIR							BELOW MOORHEAD RESERVOIR							
					Total Montana and Wyoming		Wyoming			Montana				Total Montana and Wyoming
MING trona County Acres	Sheridan County Acres	Washakie County Acres	Wyoming Total Acres	Montana Powder River County Acres	Acres	Percent	Campbell County Acres	Crook County Acres	Wyoming Total Acres	Powder River County Acres	Carter County Acres	Custer County Acres	Prairie County Acres	Montana Total Acres	Acres
34,596	35,420	4,250	1,134,219	13,267	1,147,486	13.6	80,141	1,535	81,676	238,781	104,420	109,779	5,471	458,451	540,127
- - -	- - - -	(130)	(130)	(13,267)	(13,397)	(1.1)	- - - -	- - - -	- - - -	(238,781)	(104,420)	(109,779)	(5,471)	(458,451)	(458,451)
34,596)	(35,420)	(4,120)	(1,134,089)	- - - -	(1,134,089)	(12.5)	(80,141)	(1,535)	(81,676)	- - - -	- - - -	- - - -	- - - -	- - - -	(81,676)
0,320	1,740	10,040	142,800	- - - -	142,800	1.7	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
160	120	40	440	40	480	- -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
60	- - - -	- - - -	60	- - - -	60	- -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
- - -	3,680	- - - -	273,864	- - - -	273,864	3.2	- - - -	- - - -	- - - -	5,777	3,388	- - - -	- - - -	9,165	9,165
9,320	- - - -	- - - -	9,320	- - - -	9,320	0.1	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
7,562	33,461	5,080	466,485	4,176	470,661	5.6	60,416	70	60,486	113,623	47,051	49,242	3,590	213,506	273,992
9,172	257,599	26,600	2,978,392	20,369	2,998,761	35.5	694,083	11,255	705,338	903,314	169,579	573,538	15,127	1,661,558	2,366,896
- - -	- - - -	- - - -	- - - -	- - - -	- - - -	- -	- - - -	- - - -	- - - -	30,229	11,963	28,725	22,884	93,801	93,801
- - -	- - - -	- - - -	- - - -	- - - -	- - - -	- -	37,420	- - - -	37,420	- - - -	- - - -	35,601	17,881	53,482	90,902
- - -	- - - -	- - - -	- - - -	- - - -	- - - -	- -	- - - -	- - - -	- - - -	4,281	11,497	8,864	- - - -	24,642	24,642
- - -	- - - -	- - - -	- - - -	- - - -	- - - -	- -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	308	308	308

concentrations of public domain lands occur in the southern portion of the basin in Wyoming (See map appendix). Lands administered by the Bureau of Land Management dominate all other classes of land ownership in the entire area drained by the North, Middle and South Forks of Powder River and Salt Creek in Natrona and southern Johnson Counties. In a large part of this area, it comprises more than 70 percent of the total land area. This pattern persists in the breaks along the main stem of the Powder River in Wyoming; but the public lands become progressively more widely scattered as the Montana State Line is approached. In Montana, the public domain is relatively compact in the breaks of Powder River, although small tracts are promiscuously scattered throughout the basin. The watershed east of Powder River in Carter and Powder River Counties contains heavy concentrations of public domain. A comparatively regular checkerboard pattern of public domain exists in Custer County, due primarily to alternate sections of railroad land, much of which has now passed to private ownership.

In some parts of the basin, public domain lands are a minor part of the land setup. In such areas, the public domain consists of scattered and isolated remnants, the "leftovers" of an era of land settlement which had its greatest impetus following the enlarged Homestead Act of 1916. In central and northwestern Johnson County, specifically in the drainage basins of Crazy Woman and Clear Creeks, there is an area of more than a million acres, of which less than three percent is public domain. The same condition exists in the Clear Creek watershed in Sheridan County. In these localities and only in rough areas along Powder River are there found any relatively compact blocks of public domain. Public domain in Campbell County consists for the most part of relatively scattered tracts. About one-half of the total area in this county contains an average of less than three percent Federally owned lands, while in the remaining area, the public lands lie in relatively compact blocks. In Montana, the public domain is of minor significance in about one-third of the basin, chiefly in northwestern Powder River County and in the extreme southern part of Custer County. Detailed studies are needed to classify such isolated tracts and to determine their most efficient and practical method of disposition or management.

WATER RESOURCES

Water resources of Powder River Basin are now used chiefly for irrigation with important but less extensive use for municipal water supply and stock water. Power generation is limited at present to one small plant at Buffalo, Wyoming. Power is imported from other basins. The average annual discharge at the mouth of the Powder River, during the ten-year period from 1931 to 1940, was 310,000 acre feet, approximately five percent of the average annual discharge (6,870,000 acre feet) of the entire Yellowstone River Basin. (See Table 5.)

Table 5 - Surface Water Resources
Powder River
Sources of Run-off (1)

Stream	Location	Drainage Area Square Miles	Average Annual Run-off in Acre Feet - 1931-1940	
Piney Creek	Kearney, Wyoming	106	63,770	(2)
Clear Creek	Near Arvada, Wyoming	1,110	153,600	(2)
Crazy Woman Creek	Near Arvada, Wyoming	948	37,180	(2)
North Fork Powder	Mayoworth, Wyoming	69		(3)
Middle Fork Powder	Kaycee, Wyoming	980	106,200	(2)
Powder River	Arvada, Wyoming	6,050	187,600	
Powder River	Moorhead, Montana	7,880	277,600	
Little Powder	Biddle, Montana	1,450 (App.)	17,470	(2)
Powder River	Mouth of River, Montana	13,193	310,000	(2)

(1) Source: U. S. Geological Survey.
(2) Water year 1941-42 only.
(3) Insufficient data.

In general, the streams which emerge from the Big Horn Mountains run for several miles in an easterly direction, then turn northeastward toward Powder River. It is along these valley streams and their tributaries that most of the irrigated crop and hay lands are to be found, and where the most diversified and profitable agricultural areas are located. During the irrigating season, all normal flow is diverted and a water shortage sometimes occurs during some seasons on part of the irrigated lands. Additional lands are topographically suitable for irrigation, but in such areas the present supply of water is insufficient. Ordinarily, the streams emerging from the forest areas of the Big Horn Mountains are clear, fed by numerous springs and lakes. They become muddy and silt-laden only in periods of heavy run-off. On the other hand, streams rising from some of the more impoverished soil areas, such as are found on South Fork and Salt Creek watersheds, are invariably heavily laden with silt.

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The potential opportunities for ground water recovery within the basin vary considerably because of the dissimilarity of geologic materials and structural conditions. The quality of ground water is good in most cases and becomes better as the mountainous west boundary is approached. No areas are known to exist where underground water occurs in sufficient quantity for irrigation to encourage additional well developments. However, according to reports of the U. S. Geological Survey, artesian flows occur irregularly along the Powder River. Thousands of small stock-watering-reservoirs have been constructed primarily due to the lack of subsurface water supplies. In many of the lower elevation range areas, the reservoirs are the only source of water for livestock.

Irrigation began in the late 1880's, near Buffalo, chiefly for production of livestock feed. Dependable but fairly limited water supplies were available along the base of the Big Horns, and it was only natural that such areas were first developed for irrigation. Rapid expansion took place from 1900 to 1920, during which period nearly all the existing projects were developed.

Existing water facilities consist of stock water reservoirs, wells, direct flow irrigation systems, storage reservoirs, several individual irrigation pumping plants, flood water diversions and springs. Small lakes are abundant in the Big Horn Mountains at elevations in excess of 8,000 feet. Lake DeSmet, the largest body of water in the basin, has an area of 2.7 square miles, and is located eight miles north of Buffalo, Wyoming. Its present storage capacity is about 35,200 acre-feet, and plans of the Bureau of Reclamation call for an increase of 44,000 acre-feet in its capacity. Water is diverted from Piney Creek into this reservoir to augment the comparatively small flow obtained from Shell Creek. An annual interstream diversion of 9,000 acre-feet of water is taken from Piney Creek, a tributary of Clear Creek, for use on irrigated lands in the Tongue River Basin, Wyoming.

Present irrigation developments utilize practically all the available surface water supply, and any further increase in irrigation developments will be dependent upon supplemental storage above existing developments. According to Bureau of Reclamation estimates, there are approximately 42,600 acres of additional land suitable for irrigation below Moorhead Reservoir and 44,360 acres above. Substantially, all such proposed irrigation development would be on private lands. Table 6 depicts the plan of reservoir developments in Powder River Basin as presented in Senate Document No. 191, "Missouri River Basin".

An additional reservoir known as the Camp Comfort project, which was not included in Senate Document No. 191, is being studied by the Bureau of Reclamation as a possible irrigation storage and power site. Situated in the Big Horn Mountains, six of the proposed reservoirs will provide not only additional storage facilities, but will aid in the control of run-off during periods of high water and will greatly reduce the silt flow down the Powder River.

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Table 6 - Reservoirs Proposed by Bureau of Reclamation Powder River Basin

Reservoir	Stream	Unit Served	Total Capacity Acre Feet	Purpose
Wyoming				
Willow Park	South Fork Piney Creek	Piney	9,700	Irrigation
Triangle Park	South Fork Rock Creek	Buffalo	4,000	Irrigation
Bull Creek	Clear Creek	Buffalo	14,000	Irrigation and Flood Control
Lake DeSmet	Piney Creek	Ucross (1)	44,000	Irrigation
Smith	North Fork Powder River	Crazy Woman, Mayoworth and North Fork	30,000	Irrigation and Flood Control
Middle Fork	Middle Fork Powder River	Kaycee	50,000	Irrigation, Flood Control and Silt Control
Montana				
Moorhead	Powder River	Moorhead (2)	700,000	Irrigation, Flood Control and Silt Control
			851,700	

(1) Increase in present capacity of 35,200 acre-feet.
(2) Principally regulatory for flood and silt control; approximately 390,000 acre-feet for irrigation purposes in Montana.

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Livestock Production

The production of range beef cattle and sheep is the predominating agricultural enterprise in Powder River Basin. More than ninety-five percent of the area is devoted to livestock ranching and farming, and it is unlikely that much of the area will ever be put to much more intensive use until additional reclamation projects are developed.

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Sheep predominate in the southern part of the basin. The majority of them are grazed in the summer on the Big Horn Mountains and on the plains and foothills region for the remainder of the year. Some cattle are handled in much the same manner, many of them being summer grazed on the Big Horn National Forest for a period of 3 to 3½ months. For the most part, however, cattle ranches are located in areas of year-long operations, including winter range and sufficient supplemental feed to carry over during the winter feeding season. The dominant use of the winter range area is made by sheep operators who are dependent upon seasonal migration to round out their year-long livestock operations.

The estimated number of livestock within Powder River basin for the year 1945 was 641,700, consisting of approximately 192,600 cattle, 433,500 sheep and 15,600 horses. This number of livestock is equivalent to 294,900 animal units, calculated on the basis that five sheep are equivalent to one horse or one cow. Cattle, therefore, comprise 65 percent, sheep 30 percent and horses 5 percent of the livestock population in the basin. Almost 75 percent of the total livestock population are found on Wyoming ranches and the remainder are in Montana. About two-thirds of the total animal units are found above the proposed Moorhead reservoir.

The health of livestock in the basin is generally good, and they are relatively free from disease.

Severe winter and spring storms are a constant threat to the stability of sheep operations. Sheep losses, for example, in Natrona County alone were estimated at $125,000 in the wake of a snowstorm which blanketed the area on June 20-21, 1947. Severe winter storms of 1948-49 caused much distress and heavy loss among livestock.

Predator losses are diminishing each year as a result of the active control programs of Federal, state and county agencies and various livestock associations.

0798

Crop Production

Three percent of the land in the basin is devoted to crop production, about two-thirds of which is dry farmed. (See Table 7.) Crop production under irrigation, dry land farming and flood irrigation prevail under widely diverse conditions. The crops grown may be divided into three groups; grain crops, hay and forage crops and miscellaneous crops. For the year 1945, the hay and forage crops comprised about 61 percent of the total cropland acreage, grain crops made up about 26 percent, miscellaneous crops about 5 percent, idle or fallow land 7 percent, and crop failure constitutes the remaining one percent of the cropland acreage. These proportions vary from year to year, but hay and forage crops will very likely always be in the majority because of their close relationship to the livestock industry in the basin and to climatic limitations.

Alfalfa and other tame hay were grown on about 88,000 acres, yielding approximately 104,000 tons. Native hay was cropped from about 68,000 acres, with a total yield of approximately 55,000 tons. Winter and spring wheat, the principal crops grown for sale, comprised approximately 53 percent of the harvested acreage of small grains for the year 1944; oats 31 percent and barley

16 percent. The latter two crops are grown chiefly for feed. The sugar beet acreage, at the present time is confined exclusively to Clear Creek and Piney Creek in Johnson and Sheridan Counties; totalled nearly 1,000 harvested acres in 1944, and yielded slightly more than 10 tons per acre. The sugar beets are shipped to the sugar factory at Sheridan for refining. Statistical data pertaining to the value of crops and livestock in Powder River Basin are shown in Table 8.

Table 8 - Value of Principal Crops and Livestock and Number of Farms in Powder River Basin by Counties - 1945 (1)

County	Value of Crops Harvested (Dollars)	Value of Crops Sold (Dollars)	Total Value of Livestock (Dollars)	Value of Livestock and Livestock Products Sold (Dollars)	Number of Farms
Wyoming					
Campbell	860,000	200,000	3,970,000	2,000,000	330
Crook			40,000	20,000	3
Johnson	1,166,410	163,200	5,050,000	2,850,000	386
Natrona	17,000		1,640,000	1,040,000	90
Sheridan	518,000	174,000	1,110,000	940,000	140
Washakie			30,000	20,000	8
Total Wyoming	2,561,410	537,200	11,840,000	6,870,000	957
Montana					
Carter	64,000	10,000	480,000	290,000	45
Custer	442,000	200,000	1,270,000	790,000	115
Powder River	1,500,000	540,000	3,530,000	1,670,000	399
Prairie	50,000	20,000	82,000	50,000	15
Total Montana	2,056,000	770,000	5,362,000	2,800,000	574
Total	4,617,410	1,307,200	17,202,000	9,670,000	1,531

(1) Based on U. S. Census 1945, with adjustments.

Approximately 100,000 acres, including irrigated hayland and pasture, or about one percent of the basin is devoted to production of crops by irrigation. Irrigated land is confined mainly to the valleys of the carrier streams, Clear Creek, Piney, Crazy Woman Creeks and Powder River and lesser tributaries having their source in the Big Horn Mountains. Piney Creek waters are stored in Lake DeSmet. The water is generally ample for the land being irrigated, although in dry years, shortages occur. The most important crops grown are winter and spring wheat, oats, barley, alfalfa and sugar beets. Many of the ranches are of the so-called "shoestring" irrigation variety along the smaller streams. These ranches are operated on the basis of an adequate range forage supply nearby to support livestock six to nine months of the year. Extensive

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irrigated farm developments are found along Clear Creek and Piney Creek in Sheridan and Johnson Counties and it is along these two streams where the greatest diversity in crop production is found.

The tributary streams rising in the Big Horn Range have the most reliable, though limited, flow and carry little silt. The waters are used extensively for irrigation which is carried on by means of individual or cooperative ditches. Little additional land can be irrigated until additional storage facilities are provided.

Comparatively little land above the proposed Moorhead reservoir is irrigated from Powder River, although the Bureau of Reclamation estimates that there are approximately 28,000 acres adjacent to the river which are suitable for farming by irrigation. The uncertainty of flow during the summer months, and the great amount of silt carried during high water makes Powder River unsuited for additional extensive irrigation at the present time. According to the Bureau of Reclamation, the construction of water storage facilities above Kaycee, however, will permit additional irrigation development on Powder River north of Sussex and will provide supplemental water to approximately 6,400 acres of existing cropland in the vicinity of Kaycee and Sussex. Originally developed as a Carey Act Project, 3,729 acres of the irrigated croplands lying adjacent to the river between Kaycee and Sussex are now supplied with water diverted from the Middle Fork west of Kaycee.

Approximately 154,000 acres, about 60 percent of the total cropland of the basin, are in dry farms. In Montana, nearly two-thirds of the dry farmland acreage occurs in Powder River County with scattered acreages in Custer, Carter and Prairie Counties. Most of the dry farms in Wyoming are confined to Campbell, Sheridan and northern Johnson Counties with limited areas in central Johnson and northern Natrona Counties.

Crop production by means of flood irrigation is the least common type, comprising only 24,131 acres. Most of the flood irrigated land lies adjacent to Powder River in Montana. Hay is the principal crop.

The livestock industry held undisputed control over most of the lands in the basin from about the time the Indians were placed on reservations in 1877 until about 1910 when homesteaders began settlement in the more productive areas. This influx was caused to a great extent by the passage of the 320 and 640 acre Homestead Acts. The expansion in dry farming was later stimulated by the introduction of the tractor, the combine, the one-way Wheatland disk plow and the furrow drill. As a result of successive drought years in the thirties, many dry farms and homesteads were abandoned. One of the most outstanding examples of such abandonment occurred in an area locally known as the "Nine-Mile District" in central Johnson County. Approximately one hundred families resided in this area in the twenties and early thirties as compared to about fifteen families at the present time.

The experiences of the last two decades are convincing proof of the erratic and wide variability in crop yields, crop failures and qualities of dryland farms in Powder River basin. This is illustrated by data for Campbell

County which is fairly typical of most of the dryland farms in the basin. These data show that in 1929, a relatively good crop year, 169,260 acres were seeded, of which 11,714 acres were a crop failure. In 1934, one of the drought years, 127,262 acres were seeded, of which 82,237 acres were a crop failure. Thus it is seen that within this short period, crop failures varied from seven percent in 1929 to sixty-five percent in 1934. In 1939 and 1944, generally considered to be excellent crop years, crop failures were about twelve percent and one percent respectively. There was a continual decrease in total cropland seeded, despite the stimuli provided by wartime demand and high prices during the last decade. Submarginal dry farm lands are constantly being retired from cultivation where experience has proven that they are more valuable and suitable for sustained livestock grazing use.

Forage Production

Range livestock numbers cannot be materially increased in Powder River basin without injury to the range resources until additional and supplemental development of irrigation and range management projects takes place. Present plans of the Bureau of Reclamation call for supplemental water supplies for approximately 44,000 acres of land in Wyoming above the proposed Moorhead reservoir. In Montana, it is estimated that 42,000 acres of land in Powder River basin can be provided with water below the projected Moorhead reservoir. Most of this additional irrigated acreage will likely complement the present livestock economy of the area by producing additional forage and feed. This should go far toward relieving or shortening the period of use on range lands which at present are being used too heavily. An increase in forage yields can be effected by such facilities as range reseeding, water spreading, fencing, water developments and by other rehabilitation practices.

Many ranchers have built up feed reserves for use during one or more subnormal seasons, not to provide feed for additional livestock, but to assure maintenance of the livestock in adverse years. Many others, however, are not so fortunately situated and are dependent almost wholly upon the range resources and supplemental feed purchases. A decrease in the supply of native forage as the result of too many grazing animals or drought necessitates the increased use of supplemental feeds or reduction in numbers of livestock. In either event, the net result is reduction in income.

Supplemental feed provides not only reserves for seasons of subnormal range forage production, but makes deferred grazing possible on areas where the vegetative cover is injured by early spring grazing. It also supplements native range and pastures during normal seasons and thereby promotes the well-being of the livestock.

MINERALS

Mineral production of the basin includes oil, natural gas, coal and bentonite; and in 1945 had an estimated value of approximately $6,000,000. Small gold placer deposits have been worked in the past along Kelly Creek, Johnson County, Wyoming, but these are relatively unimportant.

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Petroleum

There are a number of oil and gas fields in the basin, the largest of which is the Salt Creek oil and gas field in Natrona County, Wyoming. The output of this field is piped to Casper, Wyoming, for refining. (See Table 9.) Nearly all of the towns in central Wyoming as well as those in the basin are supplied with natural gas piped from this field, with one line extending into Nebraska.

Naval Petroleum Reserve No. 3, more commonly known as "Teapot Dome", is located adjacent to the Salt Creek field. This reservation embraces 9,320 acres and has not been in production since 1928.

Seismograph field studies and wildcat drilling were very active during the past three years in a large part of the Powder River basin. A wildcat well, drilled by a major oil company, added impetus to oil land leasing in Powder River basin when a good show of oil was reported in October, 1947. This wildcat, known as the "Adon Well" lies in the Little Powder River drainage about 15 miles north of Gillette, Campbell County, Wyoming. Its location was based on seismic work accomplished during the previous two years. Unitization of its Adon Block has been completed, and it is now reported to have about 40,000 acres included in the unit area. Virtually all lands in this vicinity and extending into Powder River County, Montana, have now been leased to oil operators and increased exploratory activity is expected. It is estimated that more than a million acres of land in the Powder River basin, much of which is public domain, was leased following discovery of the Adon Well. The west side of the basin flanking the Big Horn Range in Johnson County, Wyoming, is receiving considerable attention at the present time, and drilling is planned on several wildcat blocks in this area. Extensive areas of public domain are likewise to be found in this area.

Bentonite

The production of bentonite in the basin is very limited at the present time, the chief obstacle being the long distance to markets. Commerical quantities occur, however, in several areas, and increased activity and interest are being taken in development of this resource. While insufficiently prospected as yet, the bulk of the known deposits of bentonite appears to occur in areas where public lands are dominant.

Coal (1)

Coal of lignite and sub-bituminous grade is widely distributed throughout the basin and is being produced in commercial quantities near Buffalo, where output varies from 6,000 to 10,000 tons annually. Sub-bituminous coal resources in the basin are practically undeveloped, limited to small amounts taken by ranchers for their own use and with some commercial production for

(1) The compiled data were obtained from several U. S. Geological Survey publications, the principal source being U. S. Geological Survey Professional Paper No. 100 A 1922, "Coal Fields of the United States" by Marius Campbell.

0802

Table 9 - Production Record of Oil Fields in Powder River Basin, Wyoming (1)

Field	County	Discovery Year	Proven Area (Acres)	Product	All lands Total Cumulative Production through 1945	All lands Total Production 1945	Public Lands Production 1945	Government Royalty Production 1945	Royalty Value 1945 (Dollars)
Shannon	Natrona	1889	55	Oil (Bbls.)	53,441	------	------	------	------
				Gas (Cu. ft.)	------	------	------	------	1,715
				Gasoline and Butane (Gals.)	------	------	23,496,930	838,051	250,703
Salt Creek No. 2	Natrona	1906 and 1929	21,450	Oil (Bbls.)	314,771,071	4,151,115	------	466,755	592,742
				Gas (Cu. ft.)	386,250,000	2,792,000	320,551	34,299	------
				Gasoline and Butane (Gals.)	------	------	1,545,412	65,174	2,672
Salt Creek No. 1	Natrona	1930	1,000	Oil (Bbls.)	2,614,679	499,499	------	22,563	30,958
				Gas (Cu. ft.)	------	------	------	------	------
				Gasoline and Butane (Gals.)	------	------	------	------	------
East Teapot) West Teapot)	Natrona	1922	40	Oil (Bbls.)	139,106	4,724	------	237	355
				Gas (Cu. ft.)	------	------	------	------	------
				Gasoline and Butane (Gals.)	------	------	------	------	------
Notches Dome	Natrona	1923	420	Oil (Bbls.)	569,830	123,169	------	6,158	3,883
				Gas (Cu. ft.)	------	------	------	------	------
				Gasoline and Butane (Gals.)	------	------	------	------	------
Boone Dome	Natrona	1923	400	Oil (Bbls.)	1,257,000	12,000	------	------	------
				Gas (Cu. ft.)	------	9,898	9,898	495	30
				Gasoline and Butane (Gals.)	------	------	------	------	------
Powder River	Natrona	1923	300	Oil (Bbls.)	41,000	2,000	------	------	------
				Gas (Cu. ft.)	------	1,792	1,792	90	4
				Gasoline and Butane (Gals.)	------	------	------	------	------
Billy Creek	Johnson	1923	710	Oil (Bbls.)	------	------	------	------	------
				Gas (Cu. ft.)	3,182,000	------	------	------	------
				Gasoline and Butane (Gals.)	------	------	------	------	------
Total				Oil (Bbls.)	319,446,127	4,792,507	------	495,713	627,938
				Gas (Cu. ft.)	389,432,000	2,803,690	332,241	34,389	1,749
				Gasoline and Butane (Gals.)	------	------	25,042,342	903,225	253,375
Naval Petroleum Reserve No. 3 (2)	Natrona	1922	3,000	Oil (Bbls.)	3,543,282	------	------	484,329	787,284
				Gas (Cu. ft.)	5,162,869	------	------	838,124	52,719
				Gasoline and Butane (Gals.)	------	------	2,483,896	82,796	8,945

(1) Progress Report 1945, U. S. Geological Survey, Conservation Branch, Oil and Gas Leasing Division.
(2) Production from 1922 to 1928 inclusive.

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local consumption in the vicinity of Buffalo, Clearmont, Arvada and Gillette, Wyoming, and Broadus, Montana. The abundance of workable coal seams in the proximity of railroad transportation facilities in Sheridan and Campbell Counties, Wyoming, should make this undeveloped coal region one of future economic importance. The physical and chemical properties of this coal are very similar to those of the Sheridan field, where considerable development has taken place.

RECREATION

The Big Horn National Forest has a variety of resources, including timber, water, forage and wildlife. In addition, it is a beautiful country of mountains, lakes, meadows and streams which lures tourists in ever increasing numbers. It provides many types of recreation, including camping, picnicking, fishing, hunting, winter sports and pack trips into the wilderness country. Thousands of visitors enjoy this vacation land each year. For the convenience of these people, six camp grounds and one picnic ground have been developed in the Powder River watershed. Six resorts and dude ranches operating on the forest under permit, furnish accomodations to the public and provide pack trips into the high country. Civic, fraternal and religious organizations have permanent camps and numerous summer homes and dude ranches are found adjacent to and within the forest. The town of Story, in Sheridan County, Wyoming, is becoming an increasingly popular summer resort in its natural mountain setting.

The Cloud Peak Wilderness Area is located in the most rugged portion of the forest and was set aside in 1932 to preserve unique natural values of wilderness and scenic charm for future generations to enjoy. The entire area lies at high elevations, ranging from 8,500 to 13,165 feet and includes approximately 50,000 acres of the Powder River watershed. Uses are made of the area for recreation, livestock grazing, wildlife and water storage. Cabins and resourts are not permitted in this remote wilderness area, and trail systems and other facilities are held to a minimum.

"Hell's Half Acre", one of the outstanding examples of geologic erosion, is located adjacent to U. S. Highway No. 20, about forty miles west of Casper. This area of precipitious crags and needles was once feared by the Indians as boding ill omens and bad luck. Thousands of tourists traveling to and from Yellowstone National Park photograph and view this sight of nature. Title to the area was conveyed from the U. S. Government to Natrona County in 1924 for park purposes.

FISH AND WILDLIFE

The many tributaries of the upper reaches of Powder River are supplied with clear cold water rising from the melting of snow in the humid mountain areas. It has been estimated that there are more than 500 miles of well-stocked trout streams in the Big Horn Range. These streams carry little or no silt or mud, and thus provide an ideal environment for trout. Upon reaching the lower semi-arid plains area, the streams become suitable for

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only coarse fish such as suckers, because of silt-laden waters. The creation of numerous additional storage reservoirs, which reduce floods and collect silt, will aid in the clarification of waters and improvement of the fish habitat.

A fish hatchery located at Story, Sheridan County, Wyoming, is operated by the Wyoming Fish and Game Commission.

Hunting is an important sport throughout the basin. In Wyoming, for the year 1946, the big-game kill, within the basin, exceeded 3,500 animals, 1,600 antelope, 1,600 mule deer and 395 elk. According to official records of the Wyoming Fish and Game Commission for the year 1946, 6,000 hunters were attracted to the Big Horn area, 2,600 of whom were non-residents. Total license fees paid in 1946 were in excess of $100,000, one-sixth of that for the entire state. Non-residents alone spent an estimated $20,000 during the 1946 hunting season in Powder River basin.

Powder River basin constitutes a favorable habitat for numerous and varied wildlife groups. In the high mountain country within the humid coniferous forests are found bear, deer, elk, moose, beaver and numerous other small game, and an abundance of mountain inhabiting birds. Migratory water fowl and shore birds visit the mountain lakes in large numbers during seasonal migration and breeding periods. In the woodland areas bordering the mountains and in northern Campbell and Sheridan Counties, are found deer and American prong-horn antelope. The extensive areas of grasslands and sagebrush are inhabited principally by antelope.

In Montana, the heaviest concentrations of antelope are found east of Powder River in Powder River County and Carter County, although they are distributed quite generally throughout the entire Powder River Basin. The estimated antelope population in Montana is 3,000. In Wyoming, an estimated 5,000 antelope range in the plains areas along Powder River. In general, it may be said that the antelope range is coextensive with areas where public domain is most prevalent.

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White-tailed deer are found only in a limited area in the Mizpah Creek drainage in Montana. The mule deer range is confined for the most part to southern Powder River County and the major part of Custer County, Montana, where there are an estimated 3,200 animals. In Wyoming, the Big Horn Range and Powder River breaks provide an ideal habitat for an estimated 8,000 mule deer.

The higher elevations of the Big Horn River support an estimated 1,200 elk. An estimated one-tenth of the total annual Wyoming state elk kill is made on the Big Horn National Forest.

Sharp-tailed grouse, often erroneously called prairie chicken or pintail grouse, have increased greatly and are now relatively abundant throughout Powder River County. This county is an ideal habitat because the area is remote from settled areas. The most abundant populations occur where only small areas are dry farmed, the remainder supporting native vegetation of grassland and more or less extensive areas of shrub cover such as sage.

Sage grouse or sage hen are likewise relatively abundant in Powder River, Custer and Carter Counties, Montana, and in Campbell County, Wyoming. They are most commonly observed in abandoned fields where stubble and weeds are most common, and are not necessarily confined to areas dominated by sage. Their range is much more closely restricted to the proximity of water than is the sharp-tail.

Hungarian partridge, while not abundant, are peculiarly adapted to intensively cultivated wheat-growing areas such as Ash Creek, Coalwood-Mizpah and Chalk Buttes areas.

The relatively few Chinese pheasants are confined principally to the bottomlands of Powder River and Little Powder in Montana and in Clear Creek and Crazy Woman Creek in Wyoming.

LAND MANAGEMENT PROGRAMS

Powder River basin presents a picture of diverse land management programs. Parts of six organized soil conservation districts lie within the basin, four of which are located in Wyoming and two in Montana, and comprise a gross area of approximately 950,000 acres, or about 11 percent of the entire basin. These soil conservation districts offer farmers and ranchers an effective means of self-help in meeting conservation problems. Through cooperative agreements with the Soil Conservation Service and other agencies, united group action and organization assures more efficient and more productive use of the land and water resources. The importance of the development of complete farm and ranch plans is stressed. The best use of the range and pasture lands is planned as an integral part of the entire operating unit, which includes crop and hay-lands. The extension of the district programs to reach a greater number of operators is desirable.

The Big Horn National Forest in Wyoming and two divisions of the Custer National Forest in Montana are partially within the Powder River watershed. They comprise an area of approximately 283,000 acres, equivalent to about four percent of the entire basin. About 50,000 acres of this area are included in the Cloud Peak Wilderness Area of the Big Horn National Forest.

The Naval Petroleum Reserve No. 3, more commonly known as "Teapot Dome" is administered by the Navy Department. Located in Natrona County, Wyoming, this reserve embraces a total area of 9,320 acres, the exterior boundary of which is completely fenced. Production of oil and gas in this reserve was discontinued in 1927. Four livestock operators have permits for winter grazing in this area which is administered locally by the Navy Department.

A very small portion of Tensleep Grazing District No. 1, in Washakie County, Wyoming, is included in the Powder River basin. The gross area consists of 2,480 acres, only 130 acres of which are public domain. This area is used for summer range.

With the exception of the two divisions of the Custer National Forest in Powder River County and Carter County, all of the Powder River watershed

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in Montana is within Montana Grazing District No. 3. The gross area comprises 2,543,600 acres, of which 471,718 acres are public domain and 40 acres are withdrawn for Public Water Reserve.

The agricultural and conservation program of the Production and Marketing Administration, commonly known as the A.A.A. program, has met with widespread approval and participation by the farmers and ranchers within all counties in the basin. All soil conservation practices are designed to prevent erosion and are all based on the premise that grass is the best conserver of the soil. The provisions of the program are developed and administered through County and community committeemen elected by the local ranchers and farmers. Range practices completed since the inception of the program have been largely those tending toward better distribution of livestock and more uniform utilization of the range. On the basis of annual reports of the P.M.A., it is estimated that approximately 7,000 range livestock water reservoirs have been constructed, 900 springs have been developed, and about 700 wells have been drilled in the basin. Many ranches are still engaged in developing additional water supplies under this program.

Spring Creek Land Utilization Project Area

A relatively new part of the public land picture in the basin arises from land purchased by the Federal government. The Spring Creek Land Utilization Project Area in northeastern Campbell County is part of several similar enterprises in which the Soil Conservation Service is cooperating with Federal, State and local agencies and ranchers. Under Title III of the Bankhead-Jones Farm Tenant Act of July 22, 1937, the Secretary of Agriculture is authorized and directed "To develop a program of land conservation and land utilization, including the retirement of lands which are submarginal or not primarily suitable for cultivation, in order thereby to correct maladjustments in land use, and thus assist in controlling soil erosion, reforestation, preserving natural resources, mitigating floods, and to effectuate the program he is authorized to acquire by purchase, gift or devise, or by transfer from any agency of the United States, submarginal land and land not primarily suitable for cultivation, to protect, improve, develop and administer any property so acquired".

The Spring Creek Purchase Area comprises an area of approximately 100,000 acres, the greatest portion of which lies in the Little Powder River drainage. The remainder is located in the Little Missouri River basin to the east.

The lands acquired by Government purchase were formerly small dry land farms, abandoned homesteads and tracts of range located at strategic points for water development. The total cost of all land purchased amounted to $111,000, each tract having been appraised to determine its fair value. All the lands that were purchased were voluntarily offered for sale by the owners.

The Government bout out 27 of the 54 operators of the area. For the operators who remained in the area, there was then enough land to permit each to obtain a more economical unit. The average size of operating units in the area was increased from 1,700 acres to 4,760 acres. Land owned by the United States is now leased to individual operators through the Spring Creek Cooperative Livestock Association, formed in 1936 and consisting of 22 members. Either directly, or through its members, the Association controls all lands in the

area. The fees charged the Association by the Government for use of the land for each current year are based on the prevailing prices of livestock and livestock products and on the grazing capacity and general condition of the range. The Association enforces grazing permit regulations, prevents trespass, maintains range developments such as stock water reservoirs, springs and fences, and generally supervises the range operations of its members. Previously subject to many abuses associated with absentee ownership, land misuse, short-term leases and inadequate operating units, the area now provides a far greater stability to the present operators, due to a more satisfactory pattern of land use.

The classes of land ownership for the area within Powder River basin are as follows:

Public Domain Land	2,320 acres	2 percent
Title III Purchased Land	37,420 acres	48 percent
State Land	3,672 acres	5 percent
Privately Owned Land	35,088 acres	45 percent
Total Area	78,500 acres	100 percent

East Custer Cooperative State Grazing District

Incorporated under the laws of the State of Montana, the East Custer Cooperative State Grazing District entered into a 10-year cooperative agreement with the Bureau of Land Management in 1942 for the purpose of bringing about a better coordination of the use of all classes of land used for grazing within the district boundary. By virtue of this agreement, the Bureau of Land Management issues to the State district an annual license or term permit for the grazing privilege that may be utilized on the Federal range in the district by its licensees or permittees and, subject to review, permits the State District to refuse to issue grazing licenses or permits to applicants who fail or refuse to pay grazing fees or assessments due or who fail or refuse to abide by rules and regulations of the State District. The State Grazing District lies in east Custer County and within Montana Grazing District No. 3, established under the Taylor Grazing Act. It comprises a gross area of approximately 175,000 acres, about 80 percent of which lies in Powder River basin. The district includes 36,000 acres of submarginal lands which were purchased by the United States following the drought years of the thirties. Public domain comprises about 8,500 acres, and state, county, railroad and private lands make up the remainder, or about 75 percent of the total area. Under the cooperative agreement, the public domain is rated as having an average carrying capacity of 4.15 surface acres per animal unit month, while Government purchased lands are rated at 3.02 acres per animal unit month. A grazing permit is issued to each livestock operator, which specifies conditions under which the range is to be used and the number of livestock the user is entitled to run. Each member is charged a fee based upon the number of livestock grazed on the district lands.

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Prairie County Cooperative State Grazing District

The Prairie County Cooperative State Grazing District is similar in authorization, purpose, function and operation to the East Custer Cooperative State Grazing District. Only a small portion of this State Grazing District is contained in the Powder River watershed. The gross area within the basin comprises 65,261 acres, or about four percent of the district. Classes of land ownership, acreage, and average carrying capacity are as follows:

Public Domain Land	5,471 acres	5.71 acres per animal unit month
Title III Purchased Land (Administered by the Soil Conservation Service)	17,881 acres	3.71 acres per animal unit month
State Land	3,590 acres	3.51 acres per animal unit month
Private Land	15,127 acres	- - -
Railroad Land	22,884 acres	3.65 acres per animal unit month
Indian Allotment Land	308 acres	- - -
Total Acres	65,261 acres	

Mizpah Pumpkin Creek Grazing District

The Mizpah Pumpkin Creek Grazing District, located partly in the Powder River basin in Custer County, Montana, is unique in that it was not only the first cooperative grazing district formed in the United States, but it was also the first one authorized by special Act of Congress. The preamble to the bill which made possible this area states that it is an Act authorizing the Secretary of the Interior to enter into a cooperative agreement or agreements with the State of Montana and private owners of land within the State of Montana for grazing and range development, and for other purposes. The Mizpah Pumpkin Creek Grazing Association was organized under state law in 1928, and comprised about 15 members who lived in or adjacent to the district. About 43 percent (46,000 acres) of the district lies in the portion of the Powder River watershed drained by Mizpah Creek. About 13,000 acres are public domain, 2,000 acres are owned by the Northern Pacific Railway Company, 2,500 acres belong to the State of Montana, and 28,500 acres are privately owned.

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PROBLEMS RELATING TO THE PUBLIC DOMAIN

A reconnaissance survey and a cursory analysis of published reports and public records has revealed many problems relating to the management, protection, development and utilization of the public domain lands and their resources under the comprehensive program for the development and utilization of the resources in the Missouri River Basin. These studies have not been of sufficient detail to determine their scope and seriousness, nor to prescribe detailed corrective measures. Further investigations will be necessary and, no doubt, additional problems to those listed below will be discovered in the more detailed studies. As previously stated, the purpose of this preliminary survey and report is to determine and describe in general terms the role of the public lands in the development program and to point up the principal problems confronting the Bureau of Land Management in providing for the maximum contribution and service of this public land to the comprehensive program. The following problems appear pertinent at this time.

Problem A: Watershed breakdown and consequent siltation of stream courses and impoundments.

This probably is the biggest single problem pertaining to the public domain lands in the Powder River basin. This problem is not, however, peculiar to the public domain land only, but no doubt is more critical there than elsewhere, due to their poorer soil, vegetative cover and topographic characteristics. As previously explained, the public domain now occupies the lands of lowest productivity with respect to surficial resources. They are inherently the greatest contributors per unit area to siltation from geologic erosion. Many years of unregulated use prior to 1934 has no doubt contributed to the deterioration and depletion of the vegetative cover which has in turn resulted in the acceleration of the erosional processes.

Reconnaissance examination of the drainage area tributary to the Moorhead reservoir site indicates that large quantities of silt are carried by Powder River in the wake of each heavy storm as well as during the period of heavy spring run-off. A large part of the silt-load is probably a result of bank sloughing along the stream channels during such high-water flows. However, the more insidious though less spectacular form of silt contribution results from sheet erosion on disturbed and unstable soils which lack an adequate vegetative cover for their protection. Excessive run-off, while influenced by intensity and duration of rainfall and other factors, is greatly affected by the amount of vegetation. Soil losses and accelerated erosion are greatest in the extensive areas of heavy shales. Salt Creek and the South Fork and Middle Fork of Powder River are considered to be the major sediment contributors per unit drainage area, but available data are inconclusive and do not permit the reliable determination of the amounts of sediment produced by these major tributaries and their numerous ephemeral water courses. Until sufficient reliable data are made available to

determine the true origin and volume of the sediments produced in Powder River basin above the proposed Moorhead reservoir, a wholly reliable and comprehensive plan to obtain the optimum of soil erosion and sediment control cannot be presented.

The only sediment sampling station which exists at the present time on Powder River is at Arvada, Wyoming in southeast Sheridan County. The Water Resources Branch of the U. S. Geological Survey established this station in April 1946, and has been operating since. Records to date are inconclusive as to average condition; however, trends are indicated. For the period April 4, 1946 to September 30, 1947, the total discharge of silt from the 6,050 square mile drainage area above the station was over 9 million tons. Discharges were greatest during May and June, with over one and a half million tons per month and accounting for more than half of the total annual discharge. Discharges were least during the fall and winter months.

In order to establish adequate basic sedimentation data as to amounts, origin and movement of silt, it is believed that additional stations should be installed at or near the mouths of major silt contributing tributaries or at existing stream gauging stations in Powder River basin. In the drainage basins of South Fork and Salt Creek, where the bulk of public lands are situated, the amounts, origin and movements of sediment should be determined in order to facilitate a comprehensive program of public land rehabilitation, development and proper utilization. The installation of coordinated erosion measurement and vegetation plots in representative areas of high silt production and in areas where public lands are predominant will also go far in providing much needed erosion and sedimentation data.

The solution of the silt problem is dependent upon two physical accomplishments. First, where ever possible, soil must be held in place. The maintenance of an adequate vegetative cover is the only practicable means by which this can be accomplished over large areas. Second, where topography, geology, soils, climate and other natural conditions preclude the maintenance of an adequate vegetative cover, that is where normal or geologic erosion results in any considerable movement of soil, the resulting silt must be trapped, if reasonably possible, before it reaches the main channels. The sagebrush type, occupying areas of characteristically heavy soils, is probably the heaviest silt producer in Powder River basin. Accelerated erosion continues to be active in very rough parts of the watershed occupied by this type of vegetation. In the vicinity of the heavily overgrazed stock driveways, deep-cut gullies are frequent, and areas surrounding stock water facilities are too often in a very deteriorated condition. In the grass-land type, on the other hand, there is very little evidence of accelerated erosion except in localized areas.

With the exception of sediment records for Powder River at Arvada, Wyoming, no actual records are available to determine the

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relative silt contributions from the principal tributary streams above Moorhead reservoir site. Such data are needed as a guide to future action. However, on the basis of existing information obtained from various local sources, it is believed to be the consensus that the greatest silt contributions are derived principally from: (1) the upland plains watersheds of South and Middle Forks of Powder River; (2) Salt Creek; (3) the locally dissected "badlands" bordering the main stem of Powder River north of Sussex, and (4) possibly to a lesser extent, Wild Horse Creek near Arvada. This comprises an area of about 5,000 square miles. Portions of the lower elevations of North Fork of Powder River watershed may also have some influence upon silt production. Clear Creek and Crazy Woman Creek appear to be of comparatively little significance insofar as silt contribution is concerned, although it is interesting to note that these two streams are the principal sustaining water carriers in the basin.

The probability that the above-named streams are the source of major portions of silt derived from the basin is of great concern to the Bureau of Land Management because the amounts of public domain in these areas are relatively high. Public lands constitute about 30 to 35 percent of all classes of land ownership in these areas of high silt production.

A detailed survey of the soil erosion situation and vegetative cover of the public domain land and a determination of feasible corrections or control measures is necessary. This should also be accomplished for lands under other classes of ownership, particularly state and private, as the problem must be tackled on a watershed basis.

Problem B: Maladjustments in public land use.

As most of the land in the basin is range land, range management has a most important bearing on the economy of the area. A reconnaissance survey reveals that much range depletion and deterioriation has taken place during the past. Many of the more desirable range plants are being or have been replaced locally by inferior specie. The grazing capacity has consequently diminished. Arrested depletion and sustained yield of the forage resources can be attained only if the range is properly stocked. Attempts to restore the range resource through changes in seasonal use and methods of handling, fencing, reseeding, water developments and other devices will fail unless the intensity of grazing use is brought within the safe long-time grazing capacity limits of the range lands.

In establishing a livestock economy, the range users have made some adjustments in the utilization of the range resources, although the methods of adjustment in all instances do not yet measure up to a well established economy. This is perhaps best illustrated by the existing problems of seasonal misuse of forage resources.

Range rehabilitation through proper management has not kept pace with the improvements in grades of livestock, better husbandry methods, or increased marketing outlets. Forage removed in excessive amounts continues to contribute to the progressive destruction of the range resources, a practice which sooner or later will place such users at an economic disadvantage with more conservative range users. Improvements probably must involve modification of confirmed habits in livestock operations.

One of the most promising outlooks for obtaining proper range use in the basin is found in the growing realization on the part of stockmen that conservative stocking is to their own financial advantage, as well as to the social advantage of the community in protecting land resources.

The problem connected with public land administration also includes the provision for proper management facilities, such as fences, wells, stock water reservoirs, and such rehabilitation measures as flood irrigation, water spreading and range reseeding. Considering the magnitude and significance of the public domain with respect to the problem of siltation alone makes it imperative that a rehabilitation program in the most critical areas be started without delay.

The amount of range rehabilitation work that has been completed is insignificant in relation to the magnitude of the needs. Range developments and facilities which have heretofore been constructed on public lands have been mainly of the type which have facilitated livestock operations and livestock movement. A total of approximately 145 range development projects have been constructed on public lands in the Powder River basin by the Bureau of Land Management. The total expenditure for the construction and maintenance of these improvements was approximately $125,000, of which $27,000 was contributed by Wyoming livestock operators. Government expenditures in the Wyoming portion of the basin amounted to about $59,000 through fiscal year 1947, and about $39,000 was expended in Montana through the same period. In addition to these public land range improvement projects, ranchers have constructed under permit in Montana Grazing District No. 3 about 105 miles of fence, 21 stock water reservoirs, 3 wells and one shearing pen, at a total cost of about $22,000. No estimates are available with regard to the value of range improvements placed on public domain by lessees in the Wyoming portion of the basin, but it is believed to be a fairly substantial amount.

Problem C: Complex land ownership and operating patterns.

The public domain map (index) shows the scattered location and extent of the public domain land and the various Federal land management programs in operation in the Powder River basin. Federal land disposition and acquisition programs have both been operative within the past 15 years. A lack of sound policy as to Federal land

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programs is complicating long-range planning for this as well as other areas in the Missouri Basin. Superficial analysis of the land capabilities and land use economics indicate that much of the "public domain", principally the isolated and widely scattered tracts, could be most effectively managed and utilized under private ownership. Further detailed study of each tract of public domain land and a comprehensive analysis of the entire land use economy of the area is necessary to develop a sound policy and approach to more effective land administration and resource utilization. The many and varied uses of lands and their relationship to public interests and public problems must be fully considered.

Problem D: Stock driveway situation.

A fourth problem so far encountered involves all of the three previously mentioned. It is the problem arising from and indigenous to the stock driveway situation in the upper portion of the Powder River basin. Concurrent with the passage of the stock raising homestead act of 1916, many public domain lands were withdrawn for the alleged purpose of stock driveways to provide access for movements of livestock from range and ranch to market and between-season range areas. Since 1916, the methods of livestock operations have changed and so has the land use economy in the area. Most of the stock driveway withdrawals remain intact, some are used in one way or another to excess, with the result that both the forage and soil resources have seriously deteriorated. It is believed that the resource condition on the stock driveways is more critical than on any other type of land in this area. This condition may be attributable in part to the fact that there has been no administrative authority charged with the responsibility of regulation, management and administration of stock driveway lands outside of Federal Grazing Districts.

There are five principal stock driveways or trail systems in the Powder River basin in Wyoming. These five trails include a total of some 123,000 acres of withdrawn public domain land. In addition, there are many small disconnected driveway withdrawals scattered throughout the upper portion of the basin which include about 20,000 additional acres of public land.

In cooperation with counties and livestock associations, stock driveway committees have been formed in each of Natrona and Johnson Counties. These committees have "assumed" the function of regulating the use of these driveways but, having no administrative authority nor no law with penalty provisions, they have been helpless in trying to eliminate or materially reduce the many abuses, such as trespass, that have been occurring.

In some cases, the driveways are inadequate to provide orderly and proper access between seasonal ranges and between

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ranches and markets. On the other hand, many of the withdrawn lands are no longer needed and many, no doubt, were never needed for stock driveway purposes. It appears that many adjustments such as are possible through land exchange, could be worked out to relieve some of the driveway problems. Other problems concerning the stock driveway situation and requiring attention include:

1. The need for improvements and facilities such as stock water, fences and boundary markers, to promote orderly use.

2. The need for soil and water conservation measures to rehabilitate the deteriorated and depleted resources.

Further detailed study to develop factual data for the solution of these and other problems relating to the stock driveway situation is urgently needed.

Problem E: Integration of land uses.

This problem also is overlapping in scope. It must be considered in connection with all of the others.

As explained earlier in this report, the predominant land use economy in the Powder River basin is built around the range livestock industry. The development of additional forage crop producing farm land through irrigation will no doubt increase the demand for range land use. Through effective integration of such crop land use with range land use, many of the present hazards to the year-round grazing operation could be alleviated, and many of the improper seasonal use grazing practices could be eliminated.

According to statistics of the Production and Marketing Administration, during the past few years the greatest part of the crop land is used for the production of hay, and on many ranches no other crop is grown. Hay was produced on over 156,000 acres, or on 61 percent of the crop land. Small grains were harvested on approximately 66,000 acres, or 26 percent of the crop land. Other miscellaneous crops were produced on about 11,000 acres, or 4 percent. Idle, fallow or pastured crop land comprised almost 18,000 acres, or 7 percent, while slightly less than one percent of planted crop land was reported crop failure.

About 68 percent of the total forage required for livestock is produced on native range lands, while forage production on hay lands furnishes slightly more than 23 percent of the required feed. Small grains, while principally a cash crop, furnish 5 percent of feed. Thus, for the area as a whole, it may be said that about 96 percent of the required forage is produced in the basin, while the remaining four percent of the required feed is brought in from other areas, the greater part in the form of concentrates.

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An analysis of the feed production and requirements, when broken down by states, however, reveals a considerably different condition than that for the basin as a whole. In Montana, for instance, under present practices a slight surplus of feed over requirements is revealed, despite the fact that over 80 percent of the required feed comes from range lands. Numerous stacks of hay are held in reserve, many of which are carried over a period of several years as insurance against less bountiful future days or for anticipated emergency feeding periods. The feed situation in the Montana portion of the basin, therefore, is a healthy one, one in which the livestock operators are in a better position to cope with acute adverse conditions than they have been in the past. The dependency of the livestock operators upon range resources for the bulk of their feed should nevertheless be borne in mind. One or a series of unfavorable years in range resource conditions can again cause considerable distress in livestock practice. The expansion of additional irrigation facilities such as are planned along Powder River will go far toward relieving this situation.

The need for such additional facilities becomes even more apparent in the Wyoming portion of the basin, where under present practices, a deficiency of 10 to 15 percent in feed requirements is indicated. Of the total estimated forage required in the Wyoming portion of the basin, about 65 percent is produced on range lands, about 20 percent on hay lands and 5 percent is obtained from feed grains, stubble and straw. The apparent deficiency of approximately 10 percent comprises purchased feeds, most of which is brought in in the form of feed concentrates.

The deficiency in feed requirements is generally greatest, where dependency upon range resources is greatest, and a further corollary to this fact is that the deficiency apparently becomes most acute in areas where public lands make up significantly high percentages of all classes of land ownership. Furthermore, the deficiency appears to be greatest in areas where sheep production predominates and where seasonal migration is a common phase of livestock operation. Lack of spring-fall range and recurrent seasonal misuse is symptomatic of such deficient areas.

The almost complete dependency of some operators upon range forage in southern Johnson County and in Natrona County accentuates the need for supplemental and additional irrigation developments in this portion of the basin. A recurrence of the range conditions which prevailed during the drought of the 1930's will almost certainly result in greater distress among such operators than those more favorably situated near irrigation developments along Powder River and its tributaries.

The need for further studies of the public lands and their relationship to proposed irrigation developments is of particular

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importance in the Wyoming portion of Powder River basin, because the future economy of much of the area hinges heavily upon the proper use of the public range lands.

With increased development will come increased population and increased demands for recreational uses including fishing, hunting, camping and just plain scenic driving. The public lands now contribute to all of these and other recreational uses. They will no doubt be called upon to contribute more. Hell's Half Acre in the upper portion of the basin and along U. S. Highway No. 20 attracts many tourists. This tract is uniquely situated and well-named, but there are many more acres in a "Helluva" shape that may be of interest at some future time. Incidentally, Hell's Half Acre (320 acres) was deeded to Natrona County by the U. S. Government for recreational uses in 1924. The county has given only token administration to the site.

Problem F: Rodent and insect infestation.

These problems are recurrent, and no doubt we will just have to learn to live with them. Rodent infestations can be and have been important contributing factors to forage depletion and resulting vegetation and soil deterioration. Effects are generally quite localized, and recent developments in control measures are proving very effective.

Grasshopper and cricket infestations remain a serious menace over broad areas. Control measures have so far been sadly inadequate. These are problems concerning the biologist and entomologist, and no doubt will be ably and promptly dealt with.

Problem G: Poison plant problems.

This is a minor problem in the Powder River basin according to reports studied and reconnaissance surveys made. It is also one which can ordinarily be solved through proper land use. It is not expected that much trouble in this connection will be encountered. The vegetation inventory will include the existence, abundance and location of poisonous plants.

Further land classification studies are necessary to obtain the basic data necessary to the solution of the problems here enumerated and to discover other problems not mentioned and plan for their solution. A remedial program should be preceeded by a detailed inventory and classification of the resources of the public domain lands, their capabilities, suitability and condition. A comprehensive analysis of the total land use economy of the basin should be made in cooperation with other land managing agencies and interests.

Such detailed studies should include a qualitative and quantitative appraisal of the many complex multiple land use relationships, with

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emphasis on their watershed significance. With the development of large impoundments on the main tributaries and main stem of the Missouri River, the proper management and protection of the upper watershed area assumes greater importance.

Charged with the responsibility of properly administering and managing nearly one-fourth of the total land area in the Powder River basin, the Bureau of Land Management is directly concerned with the pervasive problem of achieving a balanced land use economy that recognizes all interests. Progress toward this objective will be conditioned in large measure by the extent to which complementary action is effected by the coordinated efforts of all interested agencies, organizations, groups and individuals.

Detailed studies necessary to the solution of these problems will be carried forward by the Bureau of Land Management in the following four sub-areas or problem areas in the order mentioned:

1. Upper Powder River, which will include the drainages of North, Middle and South Forks of Powder River and Salt Creek in Converse, Johnson, Natrona and Washakie Counties.

2. Powder River breaks, which will include the main stem of Powder River tributary to the proposed Moorhead reservoir, but will exclude Crazy Woman and Clear Creek drainages.

3. Moorhead-Powderville sub-area in Montana, which will include all of the watershed in Carter County and all of Powder River County except the Mizpah Creek watershed.

4. The remainder of the watershed or basin.

Sub-areas 1, 2 and 3 have been delineated principally on the basis of the amount and concentration of the public domain lands in the area. Sub-area 4 includes the portion of the basin which contains relatively little public domain, and what remains consists principally of small isolated parcels. Further study of those tracts is necessary to determine the management or disposition (from Federal ownership) which should be carried out.

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Report submitted February, 1949.

Approved:

R. D. Nielson

R. D. Nielson, Land Economist in Charge of Missouri Basin Studies.

Date:

March 1, 1949

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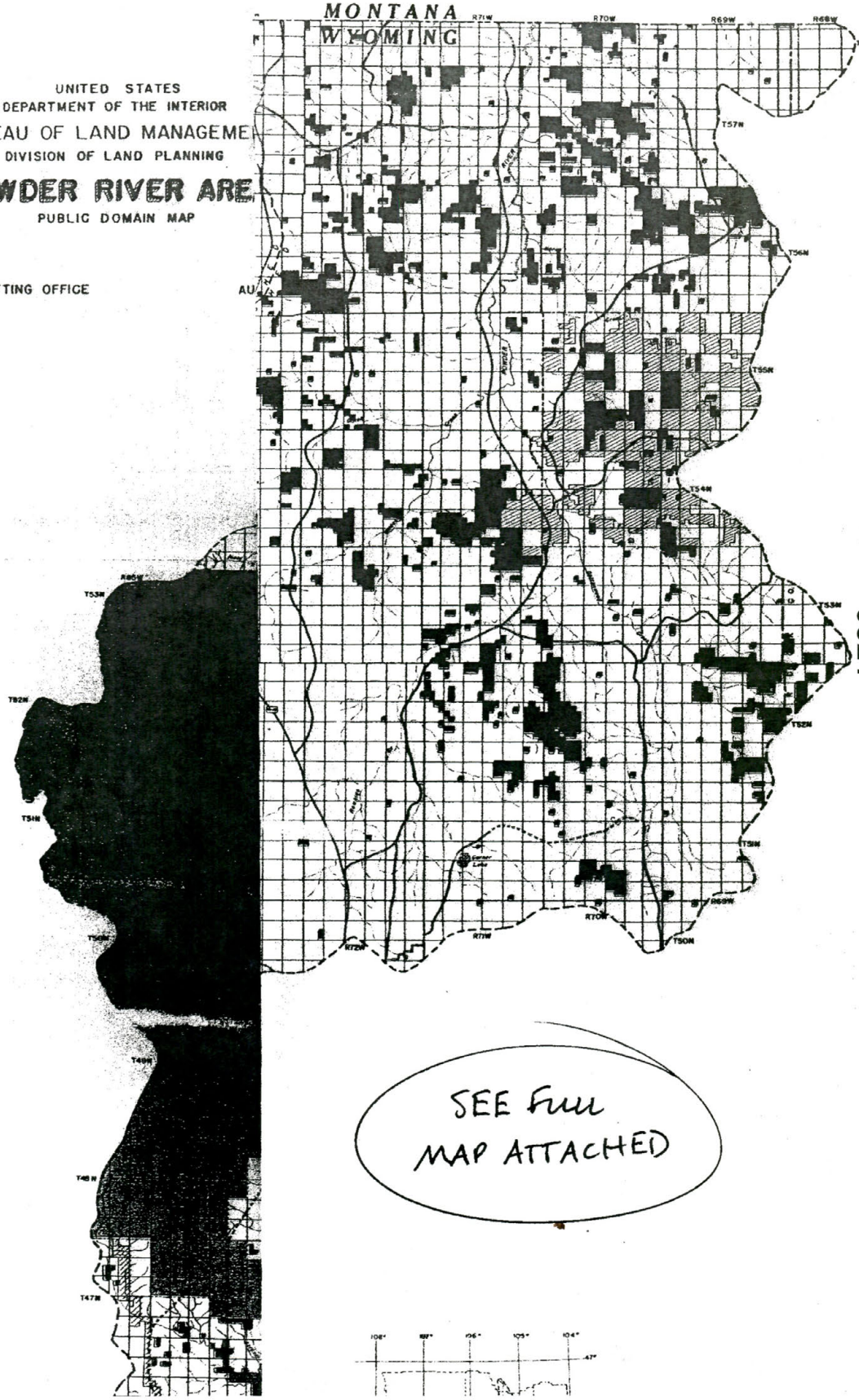
MISSOURI RIVER BASIN INVESTIGATION
BILLINGS, MONTANA

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEME
DIVISION OF LAND PLANNING

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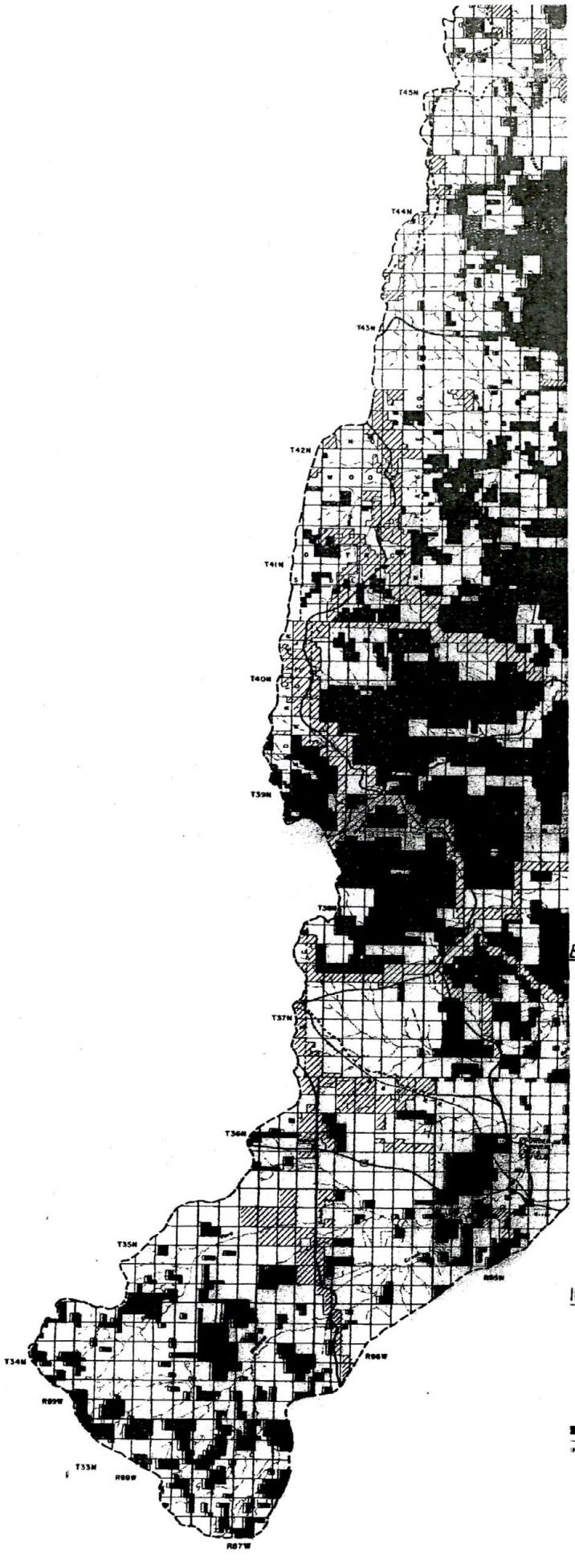
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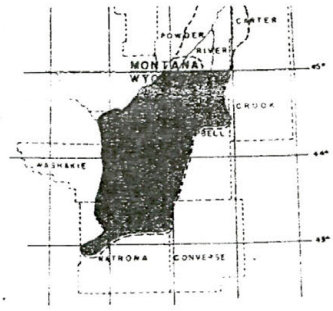
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SEE FULL MAP ATTACHED

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MAP SHOWING LOCATION OF POWDER RIVER AREA

SEE FULL MAP ATTACHED

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EGEND

TOPOGRAPHY

- RIVERS
- PERMANENT STREAMS
- INTERMITTENT STREAMS
- LAKES

WORKS AND STRUCTURES

- RAILROAD
- HARD SURFACED ROAD
- GRAVELED ROAD
- IMPROVED DIRT ROAD
- UNIMPROVED DIRT ROAD
- AIR NAVIGATION AID

IDARIES

- FOREST
- LAND UTILIZATION AREA
- SOIL CONSERVATION DISTRICT
- KNOWN GEOLOGICAL STRUCTURE

2 4 6 8
IN MILES

SEE FULL MAP ATTACHED

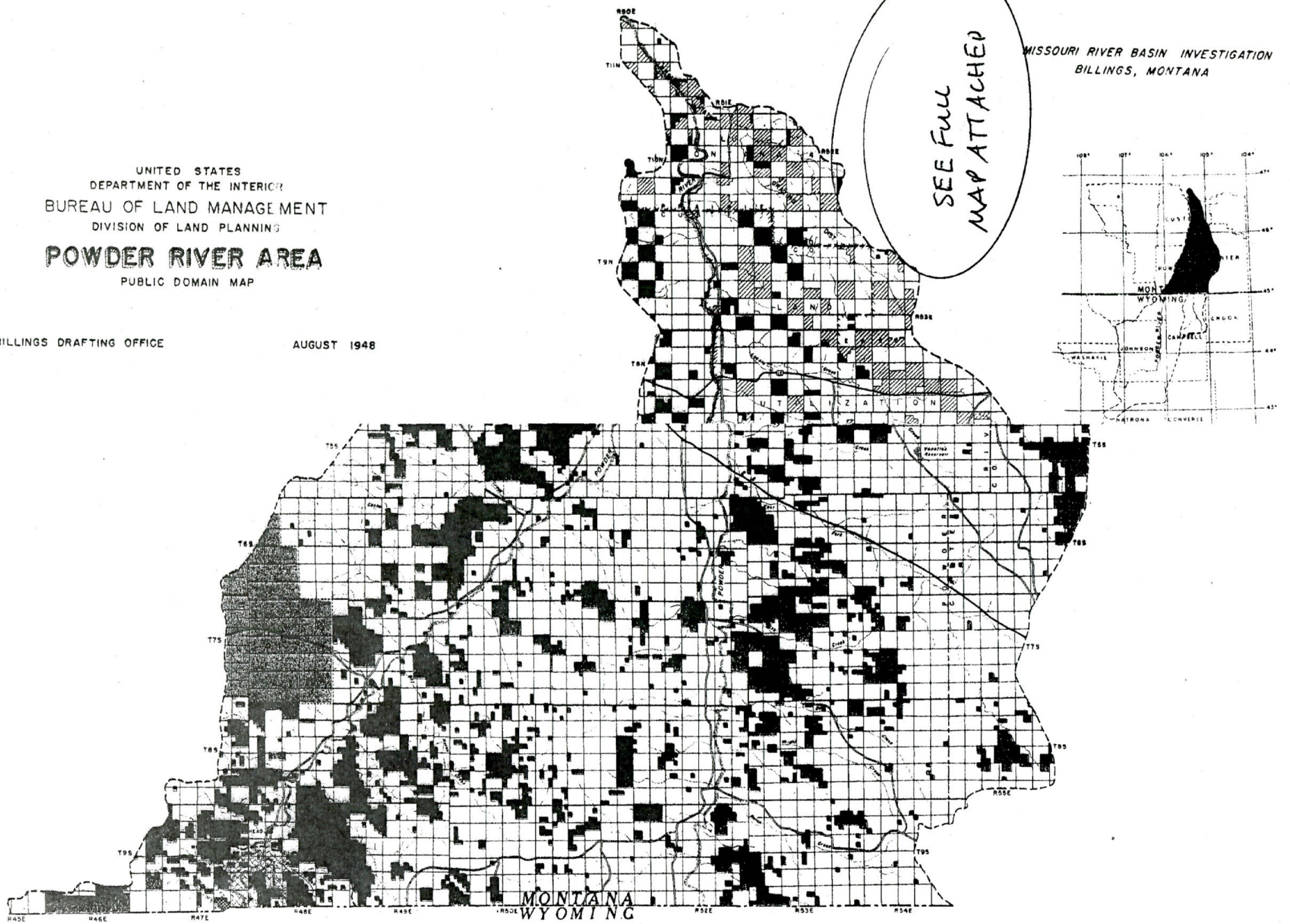
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BILLINGS, MONTANA

UNITED STATES
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DIVISION OF LAND PLANNING

POWDER RIVER AREA

PUBLIC DOMAIN MAP

BILLINGS DRAFTING OFFICE AUGUST 1948



Yellowstone River Compact Tentative Agreements, Feb. 2, 1950

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YELLOWSTONE RIVER COMPACT

Tentative Agreements Reached February 2, 1950

at Billings, Montana.

POWDER RIVER

1. All existing rights to the beneficial use of the waters of the Powder River in the States of Montana valid under the laws of these States as of January 1, 1950, are hereby recognized and shall be and remain unimpaired by this Compact.

2. The total unused or unappropriated divertible flow of the Powder River Basin is divided:

50% to Montana
42½ to Wyoming

3. Same agreement for stock reservoirs as in the 1944 Compact.

TONGUE RIVER

1. Appropriative rights to the beneficial uses of the water of the Tongue River system existing in each signatory State as of January 1, 1950, shall continue to be enjoyed in accordance with the laws governing the acquisition and use of water under the doctrine of appropriation.

2. Wyoming and Montana agree that the unappropriated waters of the Tongue River system subsequent to January 1, 1950, shall be allocated to each state as follows;

60% to Montana
40% to Wyoming

BIG HORN RIVER

1. Subject to existing Indian Treaty Rights, all existing rights to the beneficial use of the waters of the Big Horn River Basin in the States of Montana and Wyoming, valid under the laws of these states as of January 1, 1950, are hereby recognized and shall be and remain unimpaired by this Compact; provided, that at times when insufficient water is available to supply all existing rights in both states the water that is available will be apportioned to rights in the two states on the basis of priority of rights in the two states.

2. The total unused or unapportioned divertible flow of the Big Horn River Basin is divided:

____ to Montana
____ to Wyoming

(The percentages are to be based on potential irrigable areas in the two states as determined by the Engineering Committee and approved by the Compact Commissioners.)

3. Some agreement for stock water diversions as in the 1944 Compact.

CLARKS FORK RIVER

1. All existing rights to the beneficial use of the waters of the Clarks Fork Basin in the States of Montana and Wyoming valid under the laws of these States as of

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January 1, 1950, are hereby recognized and shall be and remain unimpaired by this Compact.

2. The total unused or unappropriated divertible flow of the Clarks Fork River Basin is divided:

40% to Montana
60% to Wyoming

3. Same provision for stock reservoirs as in the 1944 Compact.

1. Unused or Unappropriated Divertible Flow
(Formula Suggested by Wyoming)

The total unused or unappropriated divertible water allocated by the Compact shall be determined on an annual water-year basis measured from October 1 of any year through September 30 of the succeeding year. The quantity to which the percentage factor shall be applied through a given date in any year shall be, in acre-feet, equal to the algebraic sum of:

1. The total diversion for lands in Wyoming and Montana with a priority date later than January 1, 1950.

2. The net change in the storage in acre-feet in all reservoirs completed in Wyoming and Montana subsequent to January 1, 1950, except stock water reservoirs.

3. The quantity of water passing the designated point of measurement on the stream.

These points shall be the lowest point of diversion in Montana on the Powder River (Arvada, Montana), the Tongue River below Yellowstone - Tongue Irrigation District diversion,

The lowest diversion in Montana on the Big Horn River,

and the lowest diversion above Rock Creek on the Clarks Fork River.

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Draft Report by Dan Ashenberg, 1983

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DRAFT REPORT

A COOPERATIVE PLAN TO ADMINISTER THE YELLOWSTONE RIVER COMPACT

by

Dan Ashenberg
Water Resources Division
Department of Natural Resources and Conservation

November, 1983

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MT v. WY/M.T.D. App.
365 (WY)

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I. INTRODUCTION

(A) Analysis of the Compact

On October 30, 1951, the Yellowstone River Compact was approved by the states of Wyoming, Montana, and North Dakota. The intent of the Compact is to establish the process for apportioning water in the four tributaries of the Yellowstone River. Analysis of the Compact would lead one to believe that drafters of this document intended that flow during periods of high runoff would someday be stored and then apportioned on a percentage basis for later use. Therefore, the real purpose of the Compact is to divide excess spring flow.

The Yellowstone River Compact recognizes all water rights existing as of January 1, 1950. The result is that the Compact does not address the division of water during extremely low flow periods because the majority of appropriations in the Yellowstone Basin have a priority date earlier than 1950. If there is insufficient water to satisfy all pre-1950 uses in both states, Wyoming water users would first satisfy their pre-1950 demands. Montana users could then appropriate the remainder, including the accumulated return flow generated in Wyoming. Because agricultural and industrial development since 1950 has been minimal, the need to regulate post-1950 appropriations in Wyoming for the purpose of satisfying pre-1950 appropriations in Montana would also be minimal.

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Along with providing for water allocation, the Yellowstone Compact constitutes an important deterent to the out-of-basin transfer of water. Article X of the Compact states that no water may be transferred out of the basin without consent of all three signatory states. The intent of this Article is to protect existing appropriators in both states who depend almost entirely upon the reuse of return flow. The issue of reusing return flows is important to both states because Article V apportions flow based on diversions, not on depletions. Therefore, if return flows are not available for reuse, downstream appropriators could be harmed. As an example, a pre-1950 agricultural diversion right to 500 acre-feet which is changed to an industrial use and exported out of the basin could potentially impact an additional 375 acre-feet of downstream agricultural diversions. Article X protects these downstream users.

Section C(4) of Article V of the Compact suggests that water which flows past the point of measurement provided by the Compact and leaves the system "from October 1 to any given date" is allocable flow. The analysis of the historic flow at this point of measurement would be useful in calculating the historic apportionment, for sizing new reservoirs, or for analyzing potential development in the basin. However, in terms of real-time administration of the Yellowstone Compact, the division of water as it leaves the system does not make sense because it is physically unavailable for upstream use. For

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example, if 150,000 acre-feet pass the point of measurement from October through April, it would be defined as "allocable flow" by Article V. While this flow is "allocable" in a historic sense, it certainly is no longer available for use during the May through September irrigation season. Therefore, for purposes of real-time compact administration, this 150,000 acre-feet should probably shift from an "allocable" account to an "unused and presently unavailable" account.

(B) Need for Compact Administration

Since 1951, the consensus of the Yellowstone River Compact Commission has been that the level of water resources development in the basin has not warranted administration of the Compact. Recently, however, the demand for Compact administration and irrigation water management in the Yellowstone Basin has been growing. There are a number of reasons for this. First, Wyoming and Montana would like to develop their share of unused and unappropriated post-1950 Compact water. In Montana, a number of storage projects have been planned and the state is proceeding with steps to place reserved water to use. Both Montana and Wyoming either have or are looking to establish in-stream flow requirements for fish and wildlife. In addition, the State of Montana has taken the position that the development of water in the Missouri River Basin should be an integral part of any strategy whose purpose is to protect the water development interests of Upper Basin states from downstream demands.

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Second, there is the potential for appropriating large quantities of water for industrial purposes and for water marketing. As an example, the Yellowstone River Pipeline Company recently filed an application for a permit to appropriate 345 cubic feet per second from the Yellowstone River mainstem. This flow would be considered part of Wyoming's entitlement under the Yellowstone Compact. If Montana granted this permit, or if water was sold from storage for industrial purposes, a mechanism to administer the Yellowstone River Compact should be in place.

Third, reports published by the State of Wyoming have discussed exchanges of Compact water between tributaries in the Yellowstone Basin. In order for an exchange to take place, an administrative process would be needed that could quantify and account for the exchange.

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(C) Scope of this Report

The objective of this report is to provide the State of Montana with a plan to administer the Yellowstone River Compact. Administration of the Compact will most likely prove to be a costly and time consuming endeavor. For this reason, the proposed plan prioritizes activities based on their financial and political feasibility, and then organizes them into five distinct project phases. It is assumed in this plan that all five project phases cannot be implemented

simultaneously, and that the rate of progress from one phase to the next will depend on the level of available funding and the perceived need for water resources management and Compact administration.

This management plan stresses the importance of measuring and keeping accurate records of water use. Without this data the Yellowstone River Compact cannot be administered. Therefore, the question of determining actual water use may be the single, most critical issue to be resolved by water managers in the Yellowstone River Basin today.

II. PURPOSE

The underlying goals of the proposed management plan are:

1. To identify and prioritize certain tasks that need to be accomplished in both Wyoming and Montana in order to administer the Yellowstone River Compact.

2. To suggest a preferred course of action and outline the strategy necessary to accomplish each task.

3. To analyze the preferred course of action for potential problems or areas of conflict.

Implementation of this plan should result in the following:

1. Develop documentation of actual diversions and water use. These records are essential for Compact administration and can also serve as evidence for intrastate or interstate water rights litigation.

2. Allow the quantification of allocable flow on a weekly interval, or at other intervals to be determined by the Compact Commission.

3. Provide assurance that the State of Montana and Wyoming would receive their share of allocable flow.

4. Enable the generation of forecasts for the actual flow expected at streamgages in the basin headwaters and at the state line. These forecasts would be necessary to determine inflow to the river system. A knowledge of inflow would be useful in helping water commissioners regulate reservoirs and headgates, and would be used as input for hydrologic modeling.

5. Promote efficient irrigation water management practices that would increase agricultural production and decrease soil erosion in Wyoming and Montana.

III. METHODOLOGY

(A) Description of the Plan

In order to accomplish the objectives listed in Section II, this plan suggests a five phase process which relates directly to the organization of water rights data, water-use measurement, and to the development of a computer program which can be used to predict divertable flow and also calculate the Compact apportionment. The five suggested phases are:

Phase I - Water Appropriations Data Organization
Phase II - Streamflow Forecast Development
Phase III - Determination of Irrigation Water Use
Phase IV - Intrastate Admeasurement and Interstate Communication
Phase V - Compact Administration

Due to limitations in funding and political feasibility, each phase would be implemented in a step-wise manner. The short-term goal would be to lay as much groundwork as possible in the Yellowstone Basin before Compact administration is absolutely necessary. The advantage to this approach is that the requisite data base would be compiled, and the necessary equipment would be in place and calibrated when the decision to administer the Yellowstone Compact is made.

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Before discussing each of these five phases in detail, the mathematical basis for administration of the Yellowstone Compact is introduced along with a number of simple algebraic equations based on the provisions of Article V. That article defines the quantity of water to be allocated to each state and is equal to a percentage of the sum of the following terms:

1. Total post-1950 diversions in each state.
2. The net change in storage in post-1950 reservoirs in each state.
3. The net change in storage in pre-1950 reservoirs existing prior to 1950 which is used for irrigation, municipal, or industrial purposes that developed after 1950.
4. The flow past the point of measurement specified by the Compact.

A detailed summary of Article V is presented in Appendix A.

(B) Mathematical Basis and Equations for Administration of the Yellowstone Compact

It is proposed that the Compact be administered on a weekly basis using the following algebraic equations to apportion water on each tributary:

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Equation 1

$$Q\ (\text{accumWY}) = \sum_{1}^{N} D(\text{WY}) + \Delta S(\text{WYpost50}) + \Delta S(\text{WYpre50})$$

(This equation states that the accumulation of water used in Wyoming from "October 1 to any given date" subject to the percentage allocation is equal to the sum of the accumulated diversions from day 1 through the N-th accounting period, plus the net change in storage in Wyoming's post-1950 reservoirs, plus the net change in storage from Wyoming's pre-1950 reservoirs used for purposes developed after 1950.)

Equation 2

$$Q\ (\text{accumMT}) = \sum_{1}^{N} D(\text{MT}) + \Delta S(\text{MTpost50}) + \Delta S(\text{MTpre50})$$

(This equation is the same as Equation 1, except the calculation is for Montana.)

Equation 3

$$Q\ (\text{accum}) = Q\ (\text{accumWY}) + Q\ (\text{accumMT}) + \sum_{1}^{N} Q\ (\text{compact gage})$$

(This equation states that the total accumulated flow to which the percentage allocations should apply is equal to the

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sum of the accumulated water use in Montana and Wyoming, plus the flow past the point of measurement specified by the Compact.)

Equation 4

$$Q\ (allocWY) = Q\ (accum) \times w$$

(This equation states that Wyoming's Compact entitlement equals the total volume of water to which the percentage allocation applies, times the specific percentage allocation for any particular tributary.)

Equation 5

$$Q\ (allocMT) = Q\ (accum) \times m$$

(Same as equation 4, except the calculation is for Montana.)

Where, the terms in these five equations are defined as follows:

Q (accumWY) - The accumulation of Wyoming diversions and storage changes since October 1.

Q (accumMT) - The accumulation of Montana diversions and storge changes since October 1.

D(WY), D(MT) - Diversions for post-1950 uses in Wyoming and Montana, respectively.

/\S(WYpost50) - Net change in storage in post-1950
/\S(MTpost50) reservoirs in Wyoming and Montana, respectively.

/\S(WYpre50) - Net change in storage in pre-1950
/\S(MTpre50) reservoirs used for post-1950 water rights in Wyoming and Montana, respectively (storage changes used for pre-1950 rights are ignored).

Q (compact gage) - The flow passing the point of measurement specified in the Compact.

Q (accum) - The total water from October 1 to the calculation date to which the allocation percentages will be applied.

Q (allocWY), - The calculated quantity of water
Q (allocMT) allocated to Wyoming and Montana, respectively, since October 1.

w, m - The percent of Q(accum) that Wyoming and Montana, respectively, are assigned by the Compact, such that w + m = 100%

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N - The N-th accounting period where N cycles from 1 to the last accounting period.

(C) Practical Application of Compact Equations

The key to practical application of the equations presented in the above section would be in the regulation of headgates and the admeasurement of irrigation water. Regulation of D(WY) and D(MT) must force Q(accumWY) in equation 1 to be less than or equal to Q(allocWY) in equation 4, and also force Q(accumMT) in equation 2 to be less than or equal to Q(allocMT) in equation 5. At the same time Q(compact gage) must be minimized, since any extra flow at this point would indicate that either D(WY) or D(MT) is too small.

D(WY) and D(MT) would need to be regulated on a daily or weekly basis to maintain an equilibrium between inflow, diversions, return flow, and allocable flow. Two methods with which to obtain equilibrium are introduced below. They are the "Trial and Error" method, and the "Forecast" method.

"Trial and Error" Method

In order to maintain equilibrium with the "Trial and Error" method, the following procedure would be followed:

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1. Measure the inflow above diversions.

2. Estimate the level of use that could be satisfied with this inflow [D(WY) and D(MT)].

3. Regulate headgates to obtain this level of use.

4. Measure water-use as well as any flow at the point of measurement specified by the Compact.

5. Calculate Q(accum).

6. Compare Q(accumWY) with Q(allocWY).

7. Compare Q(accumMT) with Q(allocMT)

8. IF: Q(allocWY) is greater than Q(accumWY)

   THEN: Wyoming diversions could increase, if the demand exists.

   OR

   IF: Q(allocWY) is less than Q(accumWY)

   THEN: Wyoming diversions should decrease.

   NOTE: The same comparison would hold for Q(accumMT) and Q(allocMT).

9. If needed, adjustments in accounting could be made during the following accounting period to correct for errors in regulating D(WY) and D(MT).

10. Repeat steps 1 through 9 at the beginning of each accounting period in order to maintain equilibrium.

The "Trial and Error" method could be significantly improved if the system was calibrated based on past experience and if the available water supply for the next accounting period could be forecasted. These two improvements form the basis of the "Forecast" method described in the next section.

"Forecast" Method

The "Forecast" method consists of the following steps:

1. Forecast inflow above diversions for the next accounting period. This includes the mainstem and any major tributaries in either state.

2. Compare this inflow with historic inflows.

3. Consult a river calibration curve to identify the historic divertable flow at this level of inflow.

NOTE: The calibration curve would plot the average rate of inflow above diversions for the accounting period on the Y-axis, and the "divertable flow" that could be allocated to each state on a specified percentage basis on the X-axis. An example calibration curve and the accompanying explanatory discussion are contained in Appendix B.

4. With the use of a computer model project the divertable flow and Compact apportionment for the next accounting period.

5. Continue with step 3 of the "Trial and Error" method. If the divertable flow forecast was sufficiently accurate, plot this new data point on the calibration curve.

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The "Forecast" method is more desirable than the "Trial and Error" method because:

1. It provides a guide to water commissioners on how headgates could be set at the beginning of each Compact accounting period.

2. It minimizes error and the need for "adjustments" in allocable flow. In-field water rights administration should be less expensive because less time would be needed in regulating headgates.

3. Minimal error and fewer headgate adjustments would increase project credibility among those appropriators who are being regulated.

4. It provides a method to continually update the calibration through time. The curve becomes more accurate and fine-tuned as additional data points are added.

5. The calibration curve would be combined with a simple computer program which could administer the Article V apportionment on a real-time basis.

The remainder of the Methodology section presents a detailed description of each phase of this plan. For each phase, the principle objectives are listed along with a preferred course of action to accomplish these objections. The preferred course of action has been organized into a list of activities which have been prioritized, and analyzed for potential problems or conflicts.

Phase I - Water Appropriations Data Organization

Objectives

The objective of the first phase would be to distinguish the difference between water rights claims and actual water appropriations, and then organize the water appropriations according to location of headgate, priority date, and flow rate. Water appropriations need to be tabulated in this fashion in order to facilitate headgate regulation, and to determine the quantity of pre-1950, post-1950, and supplemental flow that can legally be diverted.

Preferred Course of Action - Phase I

Activity A

Field check all claims and permits for location of headgate and canals, priority date, and flow rate. Establish the ditch capacity at the headgate. The Department should then file objections on all speculative or abandoned claims affecting state projects. All other speculative or abandoned claims should be informally noted and filed for future reference.

Activity B

Overlay verified water rights data on a mosaic of aerial photographs and U.S.G.S. topographic maps in order to gain an understanding of the spatial distribution of diversions and expected return flows. This information would be necessary for the development of accurate computer models, and would also be a valuable reference for water commissioners and hydrographers.

Activity C

Organize verified water appropriations on a master "Ditch List" according to headgate location. Priority dates and flow rates for each ditch would also be punched onto a metal tag and permanently mounted near the headgate. Water commissioners would find these tags extremely useful in regulating headgates, and their presense would help decrease the frequency of disputes among water users.

Appendix C presents a comparison on how similar water rights in Wyoming and Montana would be organized. Exhibit 1 of Appendix C presents a sketch and short history of water use for "Rod's A-1 Canal". (A fictitious example based on fact.) Exhibit 2 compares Wyoming and Montana water rights filings on Rod's A-1 Canal. Exhibit 3 is an example of the respective ditch lists. Exhibit 4 presents an example of the tag that would be mounted on the headgate.

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Potential Problems - Phase I

There are three areas of conflict that have been identified in accomplishing the activities listed in Phase I.

1. Water rights claims in Montana, and decreed rights outside of the Powder River Basin do not necessarily reflect actual water use. At the present time, one finds an inconsistency in the manner in which enlargements and supplemental irrigation are treated in individual claims. This inconsistency results in duplicate counting of irrigated acres and flow rates. Therefore, a computer program that simply totals the information found in these claims gives inflated results.

2. Because of the limitations which have been imposed on the Department by the Water Courts and the legislature, the present adjudication effort will only provide the State with a tabulation of historic claims. A change in legislative goals and directions, as well as additional funding would increase the robustness of the adjudication process in the following ways:

   a) Water rights claims could be verified in the field. This would be more accurate than the present method of office verification via

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aerial photographs, and would be necessary for a reliable adjudication.

b) Cases involving, speculation, abandonment or incremental development could be sufficiently analyzed. The Department would then have complete and accurate data with which to file objections.

c) The actual volumes and flow rates for each appropriation would be more accurate because they would be measured.

d) Legal land descriptions could be assigned to each place of use.

e) There could be an in-depth analysis of land ownership.

3. The State of Wyoming applies a legal standard to the amount of water that can be diverted to irrigate a certain number of acres. This standard is equal to 2 cfs per 70 acres for water rights with a priority earlier than 1945, and 1 cfs per 70 acres for water rights with a priority later than 1945.

Montana, on the other hand has no consistant legal standard and the present system of water rights adjudication uses a "capping standard" based on flow rate, climatic area, and crop consumptive uses to identify and reduce unjustifiably large claims.

The result is that a ditch company may own very different water rights depending on whether it is located in Wyoming or Montana. Although legal, this inconsistency and bias may become a politically sensitive issue when water rights are regulated on an interstate basis.

Conclusion - Phase I

Administration of the Yellowstone River Compact depends on the availability of accurate and up-to-date water appropriation information including actual irrigated acres, flow rates, and priority dates. At the present time, this information is not available, and subsequently, the basin's water resources are not truly managed. Water management requires an intensive adjudication such as the one in the Powder River Basin. Originally, it was assumed that the statewide adjudication would proceed according to the methodologies developed for the Powder River Basin. Recently, however, the Water Courts have interpreted the intent of the legislature to favor the expeditious adjudication of a "general water rights list" where

specific features are stated but are unverified or loosely verified. This list will probably be subject to future modification through judicial argument and possibly by administrative approval. The DNRC therefore has two options which it could pursue in order to fulfill the objectives of Phase I. These options include:

1. Clarify the intent of the legislature and redefine the goals and objectives of the statewide adjudication to more closely resemble the adjudication in the Powder River Basin. Obtain legislature support for these activities as well as an adequate level of funding.

2. Object vigorously to every decree.

Phase II is presented in the next section. This phase suggests that the State of Montana enter into a cooperative agreement with Wyoming and the Soil Conservation Service to purchase, install, and maintain stream gages and certain telemetry equipment in order to generate streamflow forecasts for each tributary in the Yellowstone Basin.

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Phase II - Streamflow Forecast Development

Objectives

The objectives of Phase II include the purchase and installation of SNOTEL-related equipment and the development of computer software that could forecast streamflow based on snowmelt and other meteorological parameters. Forecasts of streamflow would be necessary for the following reasons:

1. In order to admeasure water, water commissioners and hydrographers would need to know the inflow above diversions at key points on any particular stream. A streamflow forecast for the compact accounting period would give the range of inflows expected during that time period. Based on this information, water commissioners could select ~~an average~~ the proper headgate setting for the accounting period and eliminate the need for daily adjustments.

2. Valid application of the computer model and calibration curve is predicated on an accurate forecast of inflow.

3. Streamflow forecasts would help facilitate basin wide water management because water users could schedule irrigation based on projected supply.

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It is suggested that the U.S. Department of Agriculture, Soil Conservation Service (SCS) be responsible for the development of streamflow forecasts because that agency has considerable experience and expertise in the area of forecasting. Furthermore, the SCS is in a position to act as an independent third party, and could issue credible and unbiased forecasts on each tributary affected by the Compact.

Preferred Course of Action - Phase II

Activity A

Retrofit existing SNOTEL sites with micro-circuit boards that would integrate air temperature at 15-minute intervals. This data would be necessary in order to more accurately forecast snowmelt.

Activity B

Identify basins that do not have a streamflow gage located above major diversions in the basin headwaters. Formulate a cooperative arrangement between Wyoming, Montana, and the United States Geological Survey (USGS) to finance and install these new gages. Each gage would need telemetry capability because real-time data from these gages would be used for the calibration and operation of streamflow forecasts.

Activity C

Identify basins that do not have a sufficient number of weather stations. Finance and install these new weather stations. Climatological data would be most important in basins where streamflow is more dependent on local precipitation than on high mountain snowmelt (i.e.-Powder River Basin).

Activity D

Identify USGS stream gages which are located at the state line or at the compact measurement points that do not have telemetry capability and telemeterize such gages. Real-time flow data from a system of telemetered gages would be necessary to guide water commissioners, administer the compact, and verify that Montana's allocation actually crosses the state line.

Activity E

Compile historic snow-pillow, stream gage, and weather data for each basin. Enter this information into a computerized data base for use in the development of the snowmelt-streamflow forecasts.

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Activity F

Develop the software and statistics to analyze the parameters listed in Activity E and construct a computer model for each basin that predicts streamflow from snowmelt.

The Soil Conservation Service has indicated a willingness to cooperate with the States of Wyoming and Montana in the development of forecasts that would mutually benefit both states and help administer the Yellowstone Compact. The SCS has identified the Clarks Fork Basin as a high priority watershed for fiscal year 1983, and in the near future, intends to draft a cooperative agreement to develop forecasts in the remaining basins.

It is suggested that any costs related to the collection of streamgage data continue to be divided: 25% Wyoming, 25% Montana, 50% USGS. Other costs should be divided equally between both states.

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Potential Problems - Phase II

No problems are expected since the aquisition of hydrologic data and the development of forecasts are activities that could benefit both Wyoming and Montana.

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Conclusion - Phase II

The capability of forecasting inflow to a river would significantly improve the manner in which individual water rights, as well as the Yellowstone Compact could be administered. Basin-wide water management and irrigation scheduling are dependent on accurate and timely forecasts of available water supply.

After a system of forecasting inflow has been developed, the next step in the administration of water rights involves the actual physical measurement of the quantity of water being appropriated. This activity is discussed in the following section.

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Phase III - Determination of Irrigation Water Use

Objectives

The objectives of Phase III would be to educate water users concerning the importance of irrigation water measurement, to install proper headgates, measuring devices, and recorders on all major ditches and canals (The most common varieties of water measuring devices include weirs, flumes, and vane type flow meters. Examples of a number of different types of water measuring devices and the advantages and disadvantages of each are listed in Appendix D.), and to institute a centralized system of uniform record keeping. There is an urgent need to measure diversions and keep accurate records of water use for the following reasons:

1. The apportionment formula in Article V of the Yellowstone River Compact specifically requires these data [See 85-20-101, 105, 106 of Montana Code Annotated]. The measurement of irrigation water is a prerequisite to real-time Compact administration.

2. Adequate headgates and water measuring devices are needed to administer intrastate water rights and to admeasure water.

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3. Water use data are required in order to accurately determine each state's historic share of allocable flow under the terms of the Yellowstone River Compact.

4. The protection of existing irrigation is important to both states. Therefore, this use needs to be accurately identified, measured, and recorded.

5. Water measurement is an integral component of irrigation scheduling and irrigation water management. From an agricultural and economic standpoint, irrigation scheduling and water measurement should provide many benefits to farmers and ranchers. It has been shown that seed germination and plant growth are negatively affected by over-watering. In addition, the erosion of the water-holding organic layer of soil contributes to decreased yields and increased sediment loads to streams. Water users, therefore, need to be aware that there is a financial incentive to managing and measuring the amount of water going to their fields.

A review of Compact Law, as well as Montana and Wyoming state law regarding the authority to measure water use may be found in Appendix E.

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A Strategy for Determining Water Use in Montana

There are two basic strategies the State of Montana could use to promote irrigation water measurement:

Strategy A

Amend state statutes, or have the Board of Natural Resources adopt rules, that facilitate the enforcement of laws requiring water measurement and record keeping. (see 85-2-113-sub 2b, MCA).

Advantages:

1. This method produces quick results.
2. Data could be collected from every water user.
3. The new law, or adopted rule would apply statewide.

Disadvantages:

1. Government regulation is not popular.
2. The political feasibility of amending state law to enforce irrigation water mesurement is questionable.
3. Measurement is costly.

Strategy B

Initiate a program through the Cooperative Extension Service to educate water users concerning the benefits of irrigation water measurement. The purpose of this program would be to explain how water-users can protect themselves under the terms of the Compact and thereby instill a grassroots demand for water measurement.

Advantages:

1. There would be a higher degree of community acceptance in measuring water use.
2. The educational process would most likely incorporate principles of irrigation water management and irrigation scheduling.
3. This method could result in increased agricultural productivity and decreased soil erosion.
4. Users would be documenting their use and protecting their rights through record keeping.

Disadvantages:

1. The process of education is expensive and slow.
2. Compliance is not mandatory.

3. The data resulting from this method would be incomplete.

Preferred Course of Action - Phase III

Analysis of the advantages and disadvantages of strategies A and B suggest that neither strategy would be sufficient by itself. Therefore, the preferred course of action should combine government regulation and public education in a manner that achieves the required results. The following activities are suggested:

Activity A

Develop and promote programs with the Coopertive Extension Service or other interested agencies to educate irrigators concerning Yellowstone Compact issues as well as the importance of irrigation water management and scheduling. The objective of these programs would be to increase community acceptance of measuring diversions and recording water use.

Activity B

After community acceptance has increased, develop rules to be adopted by the Board of Natural Resoruces which would require irrigation water measurement and record keeping.

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Activity C

Assign the DNRC Water Rights Field Offices the responsibility of assisting ditch owners in sizing and installing proper headgates and measuring devices.

Activity D

Introduce legislation that would move the jurisdiction over water rights from the District courts to the DNRC Water Rights Bureau. The District courts would continue to have the power of judicial review, and handle any cases appealed to them.

Activity E

The Water Rights Bureau would set up a data file on diversions, and work directly with water commissioners and the Yellowstone River Compact Commission.

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Potential Problems - Phase III

There are two areas of conflict that the State of Montana should be concerned with:

a. The prevailing attitude concerning the measurement of diversions in the State of Montana.

b. The political feasibility of moving the jurisdiction over decreed water rights administration from the district courts to the DNRC.

Conclusion - Phase III

Irrigation water measurement is one of the most critical issues to be resolved in the Yellowstone River Basin. Without the measurements and record keeping of actual water use in both states, the Yellowstone Compact will probably not be administered. In addition, because water rights administration is tied directly to measurement and adequate record keeping, this issue also has implications outside the Yellowstone Basin.

Two methods of implementing a system of water measurement have been suggested: government regulation and public education. Each has its inherent advantages and disadvantages, and for this reason a combination of education and legal action may prove to be the most effective strategy.

The general public needs to be made aware of the benefits of measuring their water use and a grassroots demand for this activity should be cultivated statewide. In addition, the education process should be subtle and procede in a manner that paves the way for unified state administration. Such administrative activity would then provide a procedural framework and uniformity in rule making that could apply statewide.

Phases I, II, and III are concerned with water rights data organization, streamflow forecast development, and water measurement. The next step would be the formulation of a procedure that could be used by water commissioners to administer water rights on a real-time basis. This is the principle activity of Phase IV and will be addressed in the following section.

Phase IV - Intrastate Admeasurement and Interstate Communication

Objectives

The objectives of the fourth phase of this plan include the creation of an institutional and procedural framework with which to admeasure irrigation water in each state, transfer and store water use data between agencies in a particular state, and communicate this information between states. It is assumed that before water commissioners could admeasure water, the following criteria would have been satisfied:

a. Water rights in each basin would be field-checked, verified, mapped, and then organized according to the headgate from which they originate.

b. Functional headgates and accurate measuring devices would be installed in each ditch.

c. Water rights data (ditch name, priority dates, flows) would be punched on metal tags and permanently fixed to each headgate.

d. Streamflow forecasts would be developed for each basin.

e. Each streamflow gage at the basin headwaters, state line, and compact point of measurement would have telemetry capability.

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The actual need to proceed with Phases IV and V would be predicated on a demand to manage and regulate diversions in the Yellowstone Basin. This demand could come from any one of the following sources:

a. Water users in either Wyoming or Montana might demand regulation due to a severe drought.

b. Water users in Montana might demand interstate regulation in response to a water shortage induced by overdevelopment in Wyoming.

c. Agencies of both state governments might require basin-wide water management if Wyoming began construction on large storage projects.

d. Agencies of both state governments might require regulation if there was a bilateral exchange of water between tributaries in the Yellowstone Basin.

e. The State of Montana would require regulation if permits were granted to Wyoming users for the appropriation of large quantities of water from the Yellowstone River mainstem.

The ability to admeasure water in Montana would depend on a number of factors; the most important of which would be the status of the current statewide adjudication process. For example:

a. If a final decree has been issued on each tributary in the Yellowstone Basin and current state law concerning water rights regulation does not change, then 15% of the owners of the water rights, or the DNRC, could petition the district court(s) to appoint a water commissioner. In this case, the responsibility for the administration of intrastate water rights, as well as for the coordination of water rights related to interstate compact activities, would fall within Montana District Court jurisdiction.

b. If a final decree has not been issued and current state law concerning water rights regulation does not change, there would be some question regarding the water commissioner's ability to effectively regulate non-adjudicated rights. In this case there is a high probability that the Yellowstone Compact could not be administered.

c. If a final decree has been issued and the legislature transfers the court responsibility for administering

pre-1973 water rights to the DNRC, then all Compact and water rights related activities could be coordinated through this agency.

Preferred Course of Action - Phase IV

Activity A

Develop an organizational infrastructure that could administer and regulate water use on both an intrastate and interstate basis. If the Montana District Courts continue to have jurisdiction over water rights administration, there would be a need to define the limits of their responsibilities, and exactly how their acitvities would be coordinated with the Wyoming State Engineer's Office, the DNRC's Water Rights Bureau, and the Yellowstone River Compact Commission.

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Activity B

There is a need for the administrative entities in charge of water use regulation in Montana and Wyoming to meet with the Yellowstone River Compact Commission for the purposes of:

1. Establishing a formal line of communications for in-field administration of the Compact.

2. Developing a procedure to compile and present water use data in a timely, systematic, and uniform manner.
3. Adopting any rules and regulations that would be used as a guide for in-field administration of water rights between states.

Activity C

Introduce legislation that would transfer the responsibility for administration of pre-1973 water rights from the Montana District Courts to the DNRC Water Rights Bureau. The ability to appeal a DNRC decision to judicial review would still be available. This change is suggested for the following reasons:

1. The Water Rights Bureau has experience in processing and verifying water rights claims and should therefore have a comprehensive understanding of water use in the Yellowstone Basin.
2. Water Rights Bureau personnel have worked with water users on an individual basis and have already established credibility and trust.
3. Administration of water rights via the Water Rights Bureau would not depend on legal actions or court proceedings. The total cost to initiate regulation would be less.

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4. Water Rights Bureau Field Offices have already been established. Water rights data, and some of the equipment to access and analyze these data is in place and operational. Water commissioners and hydrographers would be able to work out of these offices.

Activity D

Introduce legislation that would give greater administrative control to Montana water commissioners for the regulation of reservoir storage. All requests for releases from storage should be coordinated with the water commissioner because:

1. The water commissioner would have to quantify inflow above diversions, as well as flows released from storage in order to properly regulate water rights that would be satisfied from natural flow, and rights that would be satisfied with stored water.

2. The water commissioner would be responsible for the quantification of $\Delta S(WYpre50)$ and $\Delta S(MTpre50)$ in the Compact allocation formula. (Equations #1 and #2). These terms represent the net change in storage in pre-1950 reservoirs used for post-1950 development in Wyoming and Montana.

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Activity E

Once an organizational infrastructure is in place, the following rules and regulation would need to be adopted by the Compact Commission in order to administer water rights on an interstate basis:

1. At the beginning of the irrigation season, irrigators in both states would open their own headgates, set flows to the desired level, and measure diversions.
2. There would be no need to administer water rights on an interstate basis until a Montana irrigator on the mainstem of a stream which physically crosses the state line becomes short of water.
3. At this point, Q(allocWY) and Q(allocMT) would be quantified. These terms represent the quantity of water allocated to Wyoming and Montana, respectively, since October 1.
4. If the total accumulated flow in Wyoming Q(accumWY) is greater than the total allocable flow, Wyoming water use must be regulated to conform with the compact equation and satisfy as much of the Montana demand as possible. If not, the Montana irrigator would be regulated according to priority of right within the State of Montana, only.
5. Once the system is in equilibrium, the inflow and the divertable flow would be plotted on the river calibration curve. (See example and methodology in Appendix B).

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Potential Problems - Phase IV

Water rights administration on a full time basis requires a large capital investment. For example, commissioners and hydrographers need transportation and communications equipment. Each office needs to have a copy of all relevant water rights data, aerial photographs and maps. In addition each office should be capable of referencing the central water rights computer file in Helena. Additional staff and such office equipment as typewriters, copy machines, etc. would be needed.

A potential conflict with Montana state law exists on how this equipment and its maintenance would be paid for. Montana Code Annotated (85-5-201 through 206) requires the water commissioner to keep a record related to only the following expenses:

1. "... reasonable expenses incurred by a water commissioner in telephoning to the judge for instructions in cases of emergency."

2. "... any expenses necessarily incurred by the water commissioner in the discharge of his duties in the employment of extra labor for the repair of dams, headgates, ditches, or flumes when immediate action is necessary...."

The law also requires the water commissioner to file a letter with the clerk of court concerning his expenses. This letter would be sent to all appropriators with an opportunity for their objections, a public hearing, and motions to retax. After the objection period, the court would fix and apportion these fees and expenses.

Conclusion - Phase IV

The sections of law pertaining to water commissioners, and their salaries and expenses are inadequate. In addition, the anticipated costs of water rights administration would preclude user taxation as a method of financing. Legislation should therefore be introduced that addresses these issues.

Phase IV has outlined a strategy to provide Montana with an organizational infrastructure to regulate water use on an intrastate basis. After both states are able to administer water rights on an intrastate basis, the final step would be administration of the Compact. Developing the Compact accounting computer model and resolving issues related to administration of the Yellowstone Compact are the principle activities of Phase V.

Phase V - Compact Administration

Objectives

The principle objective of Phase V is the development of a computer program (Compact Accounting Program) that could periodically evaluate the Compact apportionment and maintain such statistics as streamflow, diversions, reservoir operations, evaporation and water transfers. The Compact Accounting Program would be based on the equations that were introduced in Section III B of this report and would use initial input values of divertable flow obtained from the river calibration curves found in Appendix B. An example which ties together the ideas and methodology of Phases I through V is presented in Appendix G.

Preferred Course of Action - Phase V

Activity A

Decisions need to be made by the Yellowstone Compact Commission regarding what person(s) in which agency(ies) would be responsible for:

1. Coordinating activities related to the use and updating of the river calibration curve.
2. Developing computer software and documentation for the Compact Accounting Program.

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3. Developing a user's manual for the Compact Accounting Program.

Activity B

The Compact Commission would need to decide:

1. In which state, and on what computer, the Compact Accounting Program would be stored and how the development of this program would be financed.
2. What person in which state would run and maintain the accounting program.
3. How this person's salary, computer processing, and related expenses would be financed.

Activity C

The Compact Commission would need to adopt rules and regulations that would formalize communications and procedures relating to the coordination of the following activities:

1. Generation of streamflow forecasts.
2. Construction of the river calibration curve.
3. Prediction of divertable flow.
4. Petitioning Montana district courts to regulate diversions.

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5. Regulation of headgates.

6. Reservoir operations.

7. Organization and storage of data.

8. Running the Compact Accounting Model.

Potential Problems - Phase V

There are a number of Compact-related issues that need to be resolved in order to administer the Yellowstone Compact on a real-time basis. These issues include:

a. Allocation of Non-Irrigation Season Flow and Excess Spring Flow (Assuming No Reservoir Storage)

For purposes of this report, flows during the non-irrigation season and excess spring flows shall be defined as that excess flow which passes the compact point of measurement from October 1st to the first day during the irrigation season when water is admeasured on an interstate basis. This flow is physically unavailable during the irrigation season; it is not in the stream, it has not been stored, and it therefore cannot be "allocable flow". For administrative purposes, this water could be moved to an "unused and presently unavailable" account. Statistics from this account would be useful for sizing new reservoir projects and determining firm yields.

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The adjustment described above would have the effect of zeroing out the term Q (compact gage) in Equation 3 until there was a demand on the system to regulate water rights on an interstate basis. Return flows generated below the last diversion in Montana and above the point of measurement would also be subtracted from the Q (compact gage) flow, since this flow is physically unavailable upstream.

An example explaining why this adjustment would be important on streams which have no reservoir storage, and how this adjustment would work can be found in Appendix F.

b. Indian Reserved Water Rights

Would an interpretation of Article VI of the Compact imply that Indian reserved water rights are to be subtracted from the total allocable volume, or are they chargeable to the state in which the use occurs?

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c. Supplemental Water

The Compact Commission would need to adopt a regulation defining "supplemental water". It is suggested that a version of the following definition be adopted:

"Supplemental water, for purposes of administering the Yellowstone River Compact, shall be defined as that

quantity of water having a post-1950 priority which is appropriated for the purpose of bringing a full supply to land already irrigated with water having a pre-1950 priority." Definition of the term "full supply" should be standardized in both Wyoming and Montana.

d. Operation and Administration of Water from Interstate Reservoirs.

Reservoirs located on the state line present special problems in the determination of /\S(WY pre50) and /\S(MT pre50). For example, how would evaporation be charged? The Bureau of Reclamation operates Yellowtail Reservoir to optimize hydroelectric power production. How does this fit into the Article V apportionment?

e. Apportionment of Non-Compacted Return Flows

Return flows via wasteways from non-compacted streams (i.e., Rock Creek in the Clarks Fork Basin) empty into compacted streams (i.e. Clarks Fork River mainstem). Presently, this flow would be considered "allocable" because it would either be diverted or it would flow past the point of measurement. How will cases like this be handled administratively?

f. Protection of Instream Flows

Minimum flow standards for the protection of aquatic habitat in the Yellowstone River Basin have already been adopted by the State of Montana. It is likely that Wyoming may soon adopt similar standards. Instream uses of water present special problems for administration of the Yellowstone Compact because Article V apportions all water flowing past the point of measurement. It is suggested that as soon as Wyoming adopts instream flow standards in the Yellowstone Basin, all instream flows be protected from apportionment under the terms of the Compact. To do this, the Compact Commission might adopt rules or regulations that would have the effect of subtracting the appropriate instream flow from the flow at the point of measurement and then transfering it to an "unused and presently unavailable" account. Another example of how the Compact Commission could protect instream flows is presented in Appendix H.

Conclusion - Phase V

Phase V emphasizes the importance of developing a Compact Accounting program as well as resolving a number of issues affecting the Yellowstone Compact apportionment. It is suggested that a timetable be developed by the Compact Commission to resolve these issues through negotiation rather than through litigation.

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IV. CONCLUSION

Records of actual water use are necessary in order to administer the Yellowstone River Compact, to make a determination of Montana's historic share of allocable flow, and to protect existing irrigation in the Yellowstone Basin. Therefore, the management plan presented herein stresses the importance of providing the State of Montana with an institutional framework to promote water measurement and accurate record keeping.

Suggestions have been presented which would affect Montana state law regarding jurisdiction and procedures pertaining to water rights administration, admeasurement, and regulation. In addition, a method is proposed whose purpose is to forecast inflow and total divertable flow, and to assist water commissioners in the day-to-day administration of water rights on an intrastate and interstate basis.

It is now up to the Wyoming and Montana legislatures, and the Yellowstone River Compact Commission to decide if the Compact needs to be administered and when a system of water measurement should be implemented.

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APPENDIX A - SUMMARY OF ARTICLE V OF THE YELLOWSTONE RIVER COMPACT

A. The Compact does not affect the enjoyment of appropriative rights existing in each state as of January 1, 1950.

B. Of the unused and unappropriated waters as of January 1, 1950, each State is allowed supplemental water for the rights existing as of January 1, 1950. The remaining unused and unappropriated waters are allocated to each State:

1. Clarks Fork - 60% WY, 40% MT;
2. Bighorn River (Exclusive of Little Bighorn River) - 80% WY, 20% MT;
3. Tongue Rier - 40% WY, 60% MT; and
4. Powder River (Including the Little Powder River) - 42% WY, 58% MT.

C. The quantity of water to be allocated by the percentages is on an October 1 - September 30 water year basis. The quantity, in acre-feet, is the algebraic sum of:

1. Total diversions for irrigation, municipal, and industrial uses in Wyoming and Montana developed after January 1, 1950 from October 1 to calculation date.

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2. Net change in storage in all reservoirs in Wyoming and Montana completed after January 1, 1950 from October 1 to the calculation date.
3. Net change in storage in existing reservoirs (as of January 1, 1950) used for irrigation, municipal, and industrial purposes developed after January 1, 1950 from October 1 to the calculation date.
4. The quantity of water that passed the point of measurement in the stream from October 1 to the calculation date.

D. (Addresses Montana - North Dakota allocations)

E. Excludes:

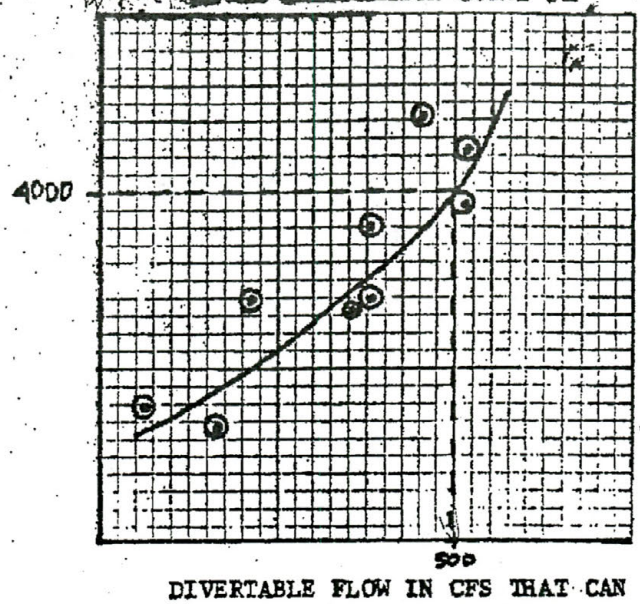
1. Domestic and stockwater uses, provided that the capacity of an excluded stockwater reservoir does not exceed 20 acre-feet.
2. "Devices and facilities for the control and regulation of surface waters."

F. (Allows modifications of allocations under certain conditions.)

0884

APPENDIX B - SAMPLE CALIBRATION CURVES AND EXPLANATIONS

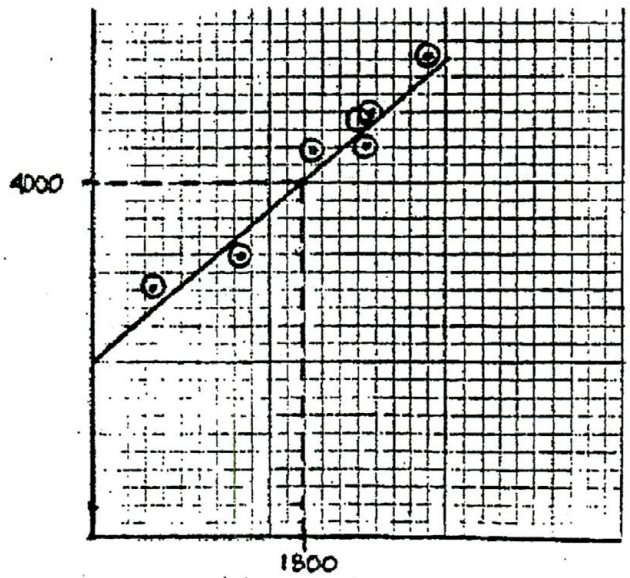
[redacted] CALIBRATION CURVE #1



AVERAGE RATE OF INLFOW ABOVE DIVERSIONS FOR THE ACCOUNTING PERIOD IN CFS

DIVERTABLE FLOW IN CFS THAT CAN BE ALLOCATED ON A PERCENTAGE BASIS

RIVER CALIBRATION CURVE #2



AVERAGE RATE OF INFLOW ABOVE DIVERSIONS FOR THE ACCOUNTING PERIOD IN CFS

AVERAGE STATE LINE FLOW [redacted] ACCOUNTING PERIOD IN CFS

0885

Explanation of Calibration Curve #1

Abscissa - The total post-1950 divertable flow to be allocated on a percentage basis between Wyoming and Montana.

Ordinate - The average inflow to the river system in cubic feet per second for the accounting period (7 days). Inflow is measured above diversions on the mainstem, and on all major tributaries.

Example - Clarks Fork Basin

At the beginning of day 1 of the compact accounting period, the measured inflow above diversions was 3500 cfs. By the end of the accounting period, the measured inflow is 4500 cfs. Assuming a constant rate of increase, the average inflow for this period is 4000 cfs.

Next, assume that pre-1950 users in both Wyoming and Montana can be satisfied and that, after regulation of post-1950 uses, there is approximately 500 cfs of divertable flow recorded. In the Clarks Fork Basin, the split is 60% (Wyoming) - 40% (Montana). Therefore, for this accounting period, headgates are regulated so that there is only 300 cfs of diversions in Wyoming and 200 cfs of diversions in Montana.

0880

Calibration curve #1 serves two functions. First, data derived from actual system operation at the end of the accounting period is plotted. The curve is calibrated with actual measured inflow and actual diversion data. Second, the curve can be used as a predictive tool. Forecasted inflow can predict projected level of use for the upcoming accounting period. The projected level of divertable flow would be used as input for the initial run of the Compact Accounting Program to determine the apportionment.

How to Use Curve #1

(Assume accounting period is from day N to day N + 7)

1. On day N-3, the average inflow above diversions for day N through day N+7 would be predicted.

2. Enter curve #1 with this value and read off divertable flow for post-1950 uses.

3. Apply compact percentage, and calculate divertable flow for each state. "Divertable flow" in each state would translate to a specific priority date or level of use for which water would be regulated. The values for inflow, divertable flow, and return flows could be tested in the Compact Accounting Program at the beginning of each accounting period.

0887

4. Use these values of divertable flow in the initial run of the Compact Accounting Program to determine whether the values chosen conform with the terms of the apportionment. If not, rerun with new values of divertble flow.

5. Water Commissioners in each state would then set headgates on day N to correspond to this level of use.

6. If there is any excess flow at the point of measurement which could be used upstream, headgates would be readjusted accordingly.

7. At the end of the accounting period the Compact Accounting Program would be rerun with actual values for diversions, and actual inflow versus actual divertable flow would then be plotted on calibration curve #1.

8. Steps 1 through 7 would be repeated for each accounting period.

Note: Calibration curves do not take into account water released from reservoirs. This is considered to be a separate issue. Also, the temporal distribution of return flow may indicate that a distinct calibration curve may be needed for each month.

Explanation of Calibration Curve #2

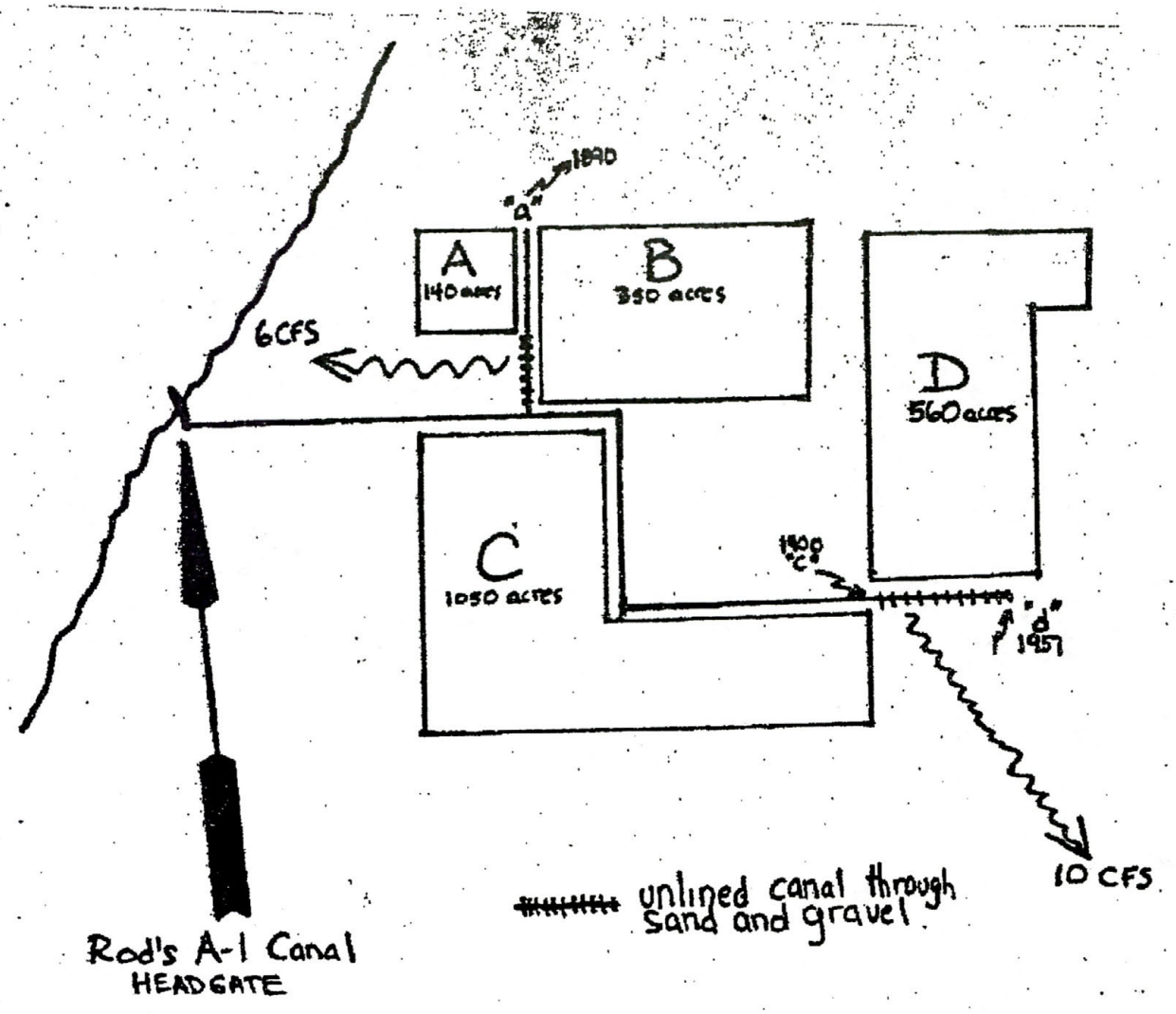
Abscissa - average streamflow at the state line for the accounting period needed to satisfy all pre-1950 users plus any post-1950 uses indicated by calibration curve #1.

Ordinate - average rate of inflow above diversions for the accounting period.

Calibration curve #2 is an extension of curve #1. For the example presented, 4000 cubic feet per second is the measured inflow above diversions. All pre-1950 appropriators are satisfied and there is a total of 500 cubic feet per second of diversions for post-1950 uses. There is little excess flow at the point of measurement. Calibration curve #2 indicates that under these conditions, 800 cubic feet per second should cross the state line. Calibration curve #2 and streamgage telemetry are necessary to insure that Montana receives its share of Compact water at the state line. This flow would probably be monitored on a daily basis during critical low flow periods.

APPENDIX C - WATER RIGHTS EXAMPLE

Exhibit 1: Sketch of Rod's A-1 Canal Company



0690

History of Actual Use During Years of Surplus Water
(Canal located in Wyoming or Montana)

Year	Ditch Capacity	Ditch Completed to Point	Lands Irrigated	Actual Use
1890	15 cfs	a	A	10 cfs diverted 6 cfs lost through leaky canal 4 cfs applied to field A
1910	35 cfs	c	A,B,C	35 cfs diverted 6 cfs lost through leaky canal 4 cfs applied to field A 10 cfs applied to field B - full supply 15 cfs applied to field C - 1/2 supply
1951	80 cfs	d	A,B,C,D	76 cfs diverted 6 cfs lost to system 4 cfs applied to field A 10 cfs applied to field B 30 cfs applied to field C 10 cfs lost to system 16 cfs applied to field D

0891

APPENDIX C - Exhibit 2

Example of Water Rights Filings for Rod's A-1 Canal Company

Wyoming Filings

Note: The water rights have been adjudicated by the Wyoming Board of Control and are listed in a document entitled Tabulation of Existing Water Rights of the State of Wyoming. During a water shortage, water used by Rod's A-1 Canal Company is regulated by a water commissioner according to these rights.

Permit No.	Priority	Flow (C.F.S.)	Acres
1000	1890	4.0	140
Enlargement 1	1910	10.0 (full supply) + 15.0 (half supply) 25.0	350 + 1050 1400
Enlargement 2	1951	10.0 (supplemental for C) + 8.0* 18.0	--- 560
TOTAL		47.0 cfs	2100 acres

*Note: Priorities earlier than 1945 get 2 cfs/70 acres
Priorities later than 1945 get 1 cfs/70 acres

Montana's Filings

Claim #	Priority Date Claimed	(C.F.S.) Flow Rate Claimed	Acres Claimed	Type of Right
1000	1890	15	140	Decreed
1001	1910	25	1400	Use
1002	1951	40	1610	Filed
TOTAL		80	3150	

0892

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APPENDIX C - Exhibit 3

Examples of Master Ditch Lists

Wyoming

Ditch No. 001
Name: Rod's A-1 Canal Co.
Headgate location:
Ditch Capacity: 80 cfs
Acres Served: 2100

Water Rights: Permit 1000
Enlargement 1
Enlargement 2

Type	Priority	Flow
A	1890	4.0 cfs
A	1910	25.0 cfs
A,S	1951	10.0 cfs
B	1951	8.0 cfs

TOTAL PRE-1950: 39 cfs
TOTAL POST-1950: 8 cfs

Montana

Ditch No. 001
Name: Rod's A-1 Canal Co.
Headgate location:
Ditch Capacity: 80 cfs
Acres Served: 2100

Water Rights: Claim 1000
Claim 1001
Claim 1002

Type	Priority	Flow
A	1890	15 cfs
A	1910	25 cfs
A,S	1951	15 cfs
B	1951	25 cfs

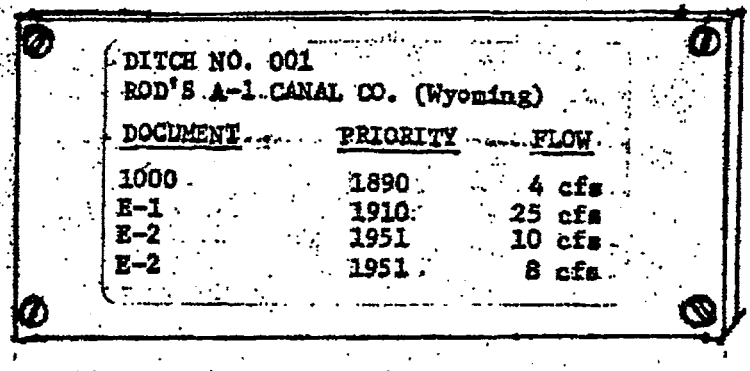
TOTAL PRE-1950: 55 cfs
TOTAL POST-1950: 25 cfs

Key

A = Pre-1950
B = Post-1950
S = Supplemental (defined as that water needed to bring land irrigated prior to 1950 up to a full supply)

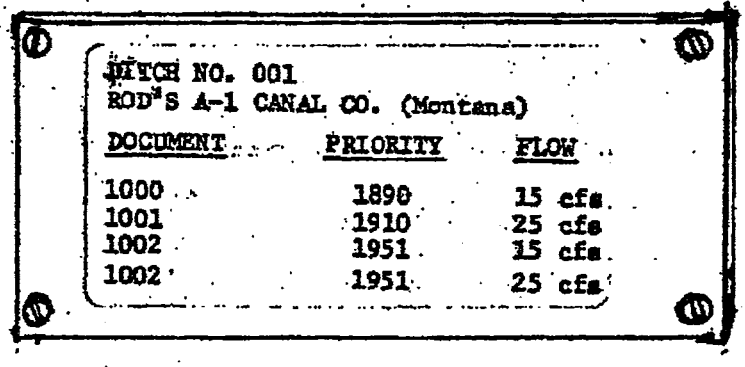
APPENDIX C - Exhibit 4

Example Headgate Tags for Rod's A-1 Canal Company



DITCH NO. 001
ROD'S A-1 CANAL CO. (Wyoming)

DOCUMENT	PRIORITY	FLOW
1000	1890	4 cfs
E-1	1910	25 cfs
E-2	1951	10 cfs
E-2	1951	8 cfs



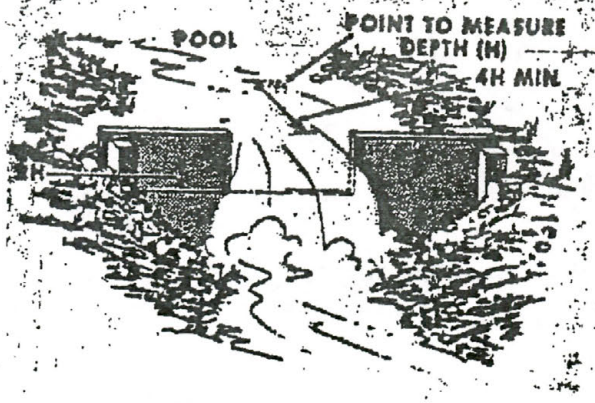
DITCH NO. 001
ROD'S A-1 CANAL CO. (Montana)

DOCUMENT	PRIORITY	FLOW
1000	1890	15 cfs
1001	1910	25 cfs
1002	1951	15 cfs
1002	1951	25 cfs

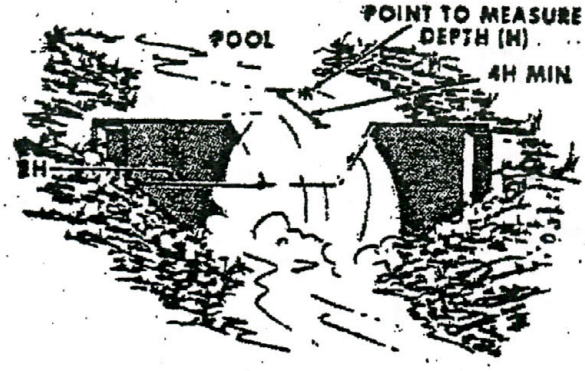
0894

APPENDIX D - EXAMPLES OF WATER MEASURING DEVICES

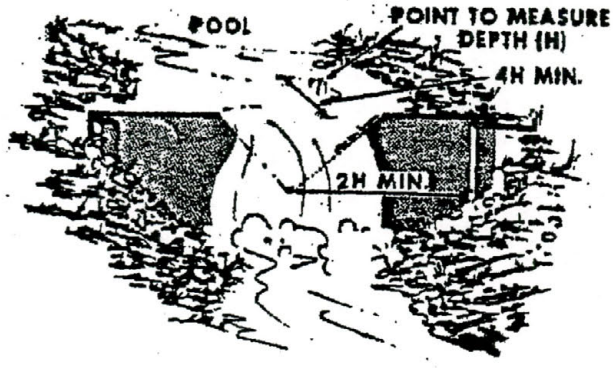
Drawings adapted from Irrigation Water Measurement, Agricultural Extension Service, UW-Laramie



RECTANGULAR WEIR



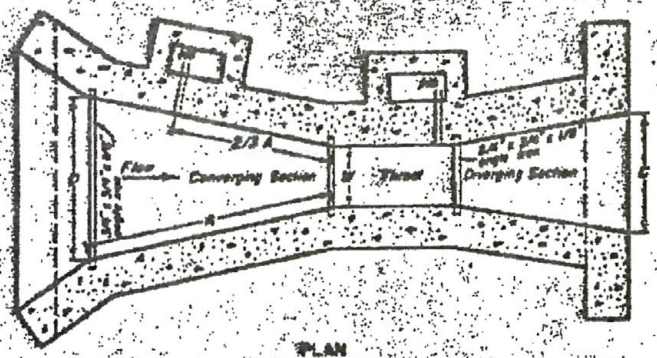
TRAPEZOIDAL WEIR



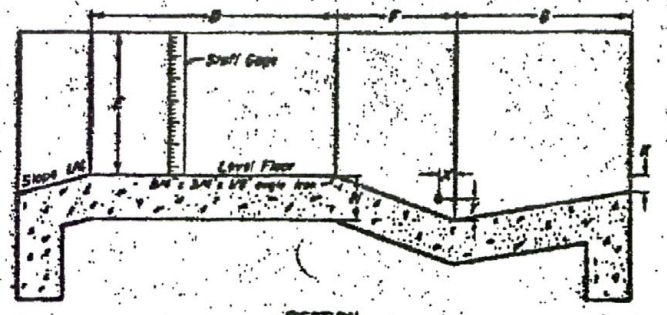
V-NOTCH WEIR

0895

MT v. WY/M.T.D. App.
431 (WY)

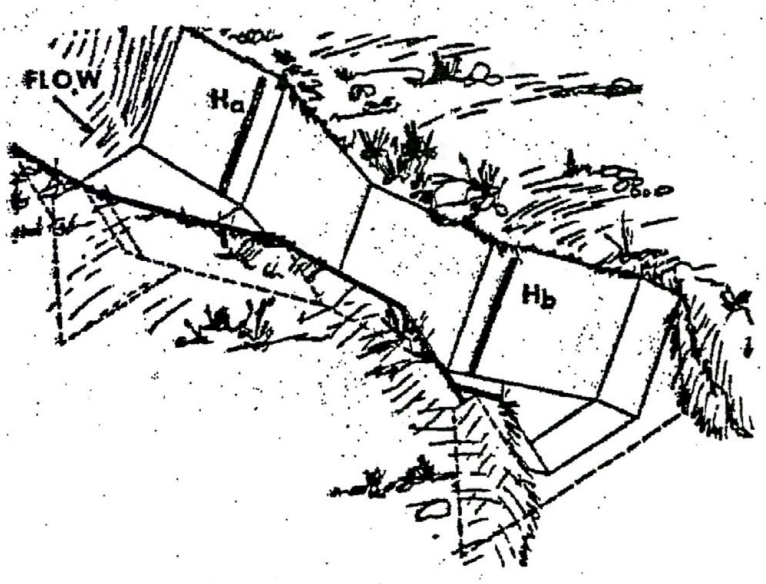


PLAN



SECTION

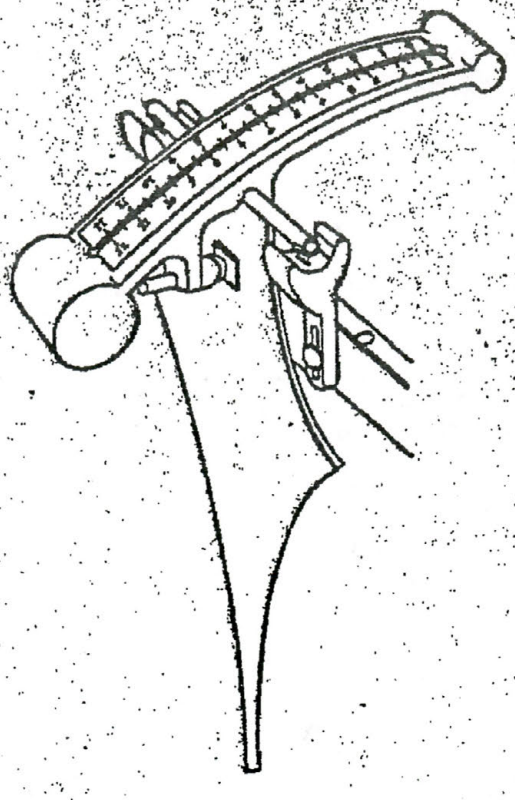
PARSHALL FLUME



TRAPEZOIDAL FLUME

9680

MT v. WY/M.T.D. App.
432 (WY)





VANE-TYPE FLOW METER

MT v. WY/M.T.D. App.
433 (WY)

0897

(A) Weirs - (rectangular, Cipolletti, V-notch)

Advantages:

1. Weirs are simple to construct.
2. Weirs are convenient to use.

Disadvantages:

1. Weirs are not accurate unless they are properly installed and maintained. (the pool of water behind a weir often fills up with sand and silt).
2. Weirs require a considerable drop between the upstream and downstream water surfaces. This may not be possible where ditches are on a nearly level grade.
3. Weirs are not easily combined with turnout structures.

(B) Flumes (Parshall, Trapezoidal)

(Parshall Flume)

Advantages:

1. Parshall flumes are durable and require little maintenance.
2. Parshall flumes are very accurate.
3. Sand and silt in the irrigation water do not affect the performance of a Parshall flume.
4. Parshall flumes do not require a large change in head between the upstream and downstream water surfaces.
5. The rate of flow through the Parshall flume does not affect its accuracy.
6. The Parshall flume has a wide range of flow capacity.
7. Pre-fabricated Parshall flumes are available commercially.

Disadvantages:

1. Parshall flumes are more costly than weirs.
2. Parshall flumes are more difficult to install.

(Trapizoidal flumes)

8680

Advantages:

1. Trapizoidal flumes are easy to construct and install.
2. Trapizoidal flumes do not require a large change in head.
3. The trapizoidal flume can handle a large range of flow.

Disadvantages:

1. Trapizoidal flumes are not as accurate as Parshall flumes because a very small change in head results in a very large change in flow.

(C) Vane type flow meters

Advantages:

1. Vane flow meters are portable and can be used to measure flow on a number of canals.
2. Vane flow meters are easy to install.
3. Vane flow meters give direct readings in cfs.

Disadvantages:

1. Wind affects the accuracy of vane flow meters.
2. Vane flow meters are not inexpensive.

6680

APPENDIX E - LAWS REGARDING THE DETERMINATION OF IRRIGATION WATER USE

Status of Water Measurement - Compact Law

The issue of irrigation water measurement is addressed in Article I, paragraph B, of the "Rules and Regulations for Administration of the Yellowstone Compact". This paragraph states that "Records of total annual diversion in acre-feet above the points of measurement designated in the Compact for irrigation, municipal, and industrial uses developed after January 1, 1950, shall be furnished by the members of their respective States, at such time as the commission deems necessary for interstate administration as provided by the terms of the Compact." In addition, both the Yellowstone Compact and administrative rules state that the "appropriative rights to the beneficial uses of water ... existing in each signatory state as of January 1, 1950, shall continue to be enjoyed...."

It would therefore be reasonable to infer the following:

1. The Yellowstone Compact and administrative rules require that diversions with a priority date later than January 1, 1950 must be measured.

0060

2. For record keeping and accounting purposes, diversions with a priority date earlier than January 1, 1950, should be measured.

Status of Water Measurement - Wyoming Law

The Wyoming State Engineer and the superintendents of the four water districts constitute the Wyoming Board of Control. The Board has the power to regulate water use, and can supervise the diversion, distribution, and appropriation of water from all streams. A water commissioner appointed by the Governor has the responsiblility of dividing water and regulating reservoir storage on all streams in his division.

Wyoming state law requires the owner of any canal or ditch to install and maintain a headgate at the point of diversion which is of such construction that it may be locked and kept closed by a water commissioner. Metal, screw-type headgates set in concrete are recommended.

At the request of the Division Superintendent, owners of canals or ditches must install and maintain flumes and other measuring devices to assist the commissioner in determining the amount of water being diverted. Any person who neglects to construct or maintain headgates, flumes, or measuring devices may be denied water until the required works are constructed.

0901

Any person opening, closing, or changing any headgate or water box without proper authority, or who uses water which has been denied to him by a water commissioner can be arrested and fined.

Admeasurement of water in the State of Wyoming proceeds according to the following sequence of events:

1. At the beginning of each irrigation season, irrigators open their own headgates, and water use on the stream is unrestricted.

2. Water use is unrestricted until the water commissioner receives a call that an appropriator is not receiving his legal entitlement.

3. At that point, hydrographers measure inflow to the stream and then regulate headgates along its entirety according to priority of right. Headgates are set and locked in position.

4. Wyoming state law provides that priorities earlier than 1945 may receive two cubic feet per second (cfs) per seventy acres irrigated. Priorities later than 1945 receive one cfs per seventy acres.

5. If after regulation of headgates along the entire stream the water commissioner finds there is an excess water, this water is presently divided among Wyoming irrigators according to priority of use without regard to the terms of the Yellowstone Compact.

6. Inflow to the river system is measured throughout the irrigation season, and headgates along the entire stream and all tributaries are continually regulated.

Status of Water Measurement - Montana Law

Except for some permits issued after 1973, the State of Montana does not require the owners of canals and ditches to maintain measuring devices or keep records of diversions. However, a water commissioner may be appointed by a district court to admeasure and distribute water when one of the following conditions arise:

1. The owners of at least 15% of the water rights affected by a decree, petition the court to administer the decreed rights.

2. The DNRC requests the court to administer rights on a stream for which a final decree has been issued under Chapter 2, Title 85. (i.e. the Powder River).

There are a number of practical problems with the present system of adjudication and the measurement of irrigation water in Montana. Some of these include:

1. Many court decrees require that the owners of canals and ditches maintain water measuring devices and keep accurate records of diversions, yet these requirements are usually not enforced.

2. Only specific reaches are covered by any particular court decree and often there have been many decrees issued on one "decreed" stream. In spite of this, the majority of water users on a stream do not have an adjudicated right and will have to wait until the statewide adjudication process is complete.

3. Water commissioners have no jurisdiction to regulate pre-1973 water rights which have not been adjudicated. Therefore, there are cases where downstream senior water rights may be denied water because upstream junior rights cannot be regulated.

4. Any particular river basin may be under the jurisdiction of a number of district courts. For example, five district courts have jurisdiction in the Clarks Fork basin. Therefore, coordination of a uniform system of measurement, record keeping, and headgate regulation would be difficult.

APPENDIX F - ALLOCATION FORMULA EXAMPLE - NO RESERVOIR STORAGE

Figure 1 presents an example of the Yellowstone Compact Apportionment based on the equations presented on pages 10 and 11 assuming no reservoir storage is available (e.g. Clarks Fork Basin). In this example, allocable flow is calculated for Wyoming and Montana using two methods. "Method 1" does not adjust for the "unused and presently unavailable" flow passing the Compact point of measurement during the non-irrigation season. "Method 2" makes this adjustment.

In calculating historic allocable flow for both states, the adjustment is not necessary because one would be trying to quantify the flow that could have been used by each state. On the other hand, once that Yellowstone Compact is administerd on a real time basis, flow that passes the compact point of measurement (and leaves the system) is no longer available for use at a later point in time. This flow should not be considered "allocable" because it is really "unused and presently unavailable." In this case, the adjustment would be necessary.

Exhibit 1 presents both versions of calculating allocable flow. There are twelve rows, each summarizing one month of data, and there are fourteen columns:

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0905

Column 1: The present month.

Column 2: Inflow, in 1000 acre-feet above all diversions.

Column 3: The flow, in 1000 acre-feet passing the Compact point of measurement for that particular month.

Column 4: The Compact gage "adjustment" in 1000 acre-feet needed to account for water that is "unused and unavailable" during real-time Compact administration.

Column 5: The accumulated flow in 1000 acre-feet that passes the Compact point of measurement from October 1 to the last day of the present month. This is the last term in Equation #3.

Column 6: The adjusted accumulated flow in 1000 acre-feet that passes the Compact point of measurement from October 1 to the last day of the present month. This value would be substituted in the last term of Equation #3 to calculate the adjusted allocable flow for each state.

Column 7: The total diversions in 1000 acre-feet in Wyoming for the present month.

Column 8: Equivilant to the left-hand-side of Equation #1.

Column 9: The total diversions in 1000 acre-feet in Montana for the present month.

Column 10: Equivilant to the left-hand-side of Equation #2.

Column 11: Equivilant to the left-hand-side of Equation #4.

Column 12: The adjusted allocable flow in 1000 acre-feet for Wyoming.

9060

Column 13: Equivilant to the left-hand-side of Equation #5.

Column 14: The adjusted allocable flow in 1000 acre-feet for Montana.

The example presented in exhibit 1 assumes the following:

a. Flow is apportioned 60% to Wyoming and 40% to Montana.
b. There is no reservoir storage in the basin.
c. All pre-1950 uses for irrigation are satisfied May through August.
d. For the period of May through August there are 100,000 acre-feet of post-1950 demands in each state each month. One-half is for agriculture, the other half is for industrial off-stream storage. Each state tries to satisfy as much of this demand as possible.
e. The example presented is a typical "dry year." While all pre-1950 uses can be satisfied, Wyoming post-1950 demands can not be met after June 1, and Montana post-1950 demands can never be fully met.

The following conlcusions can be drawn from this example:

1. The unused inflow from October 1 to April 30 is 116,000 acre-feet. If this flow is reflected in the Article V apportionment formula, the total allocable flow for May is too high. It is also unfair, because in May, Montana is receiving only 20% of the total divertable flow.

0907

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2. If the 116,000 acre-feet of inflow is moved to an "unused and presently unavailable" account, and the accumulated flow at the point of measurement is adjusted to reflect this, the adjusted allocation makes much more sense. Each state receives a reasonable allocation in May. In this example, Wyoming's post-1950 diversions in May were too high and therefore should have been regulated.
3. The "unused and presently unavailable" adjustment is needed in the Yellowstone Compact allocation formula, at least for real-time administration, because the State of Wyoming would benefit unfairly from water that was "stored on paper" and not stored in a reservoir.

FIGURE 1

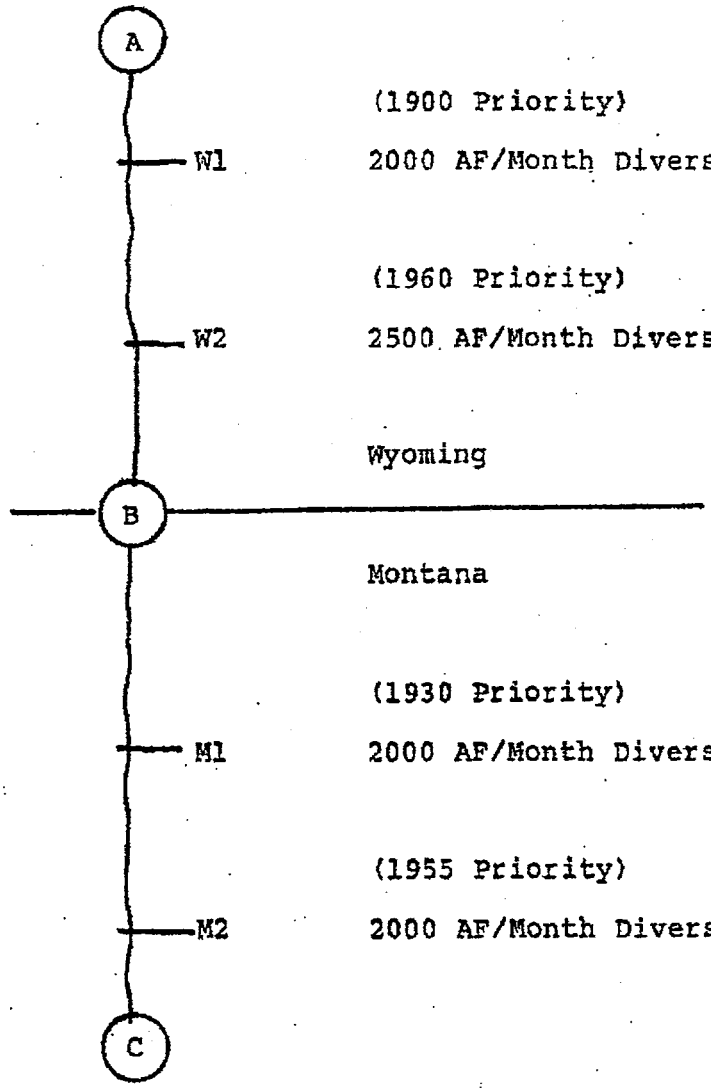
YELLOWSTONE RIVER COMPACT APPORTIONMENT
(Assuming no Reservoir Storage)

All Values in 1000 Acre-Feet

Month	Inflow Per Month	Q (compact gage) per month	ADJUSTMENT (unused and presently unavailable)	$\sum Q$ (compact gage) unadjusted	$\sum Q$ (compact gage) ADJUSTED	D (WY)	$\sum Q$ (accum WY)	D (MT)	$\sum Q$ (accum MT)	Method 1 Q (alloc WY)	Method 2 Q (alloc WY) ADJUSTED	Method 1 Q (alloc MT)	Method 2 Q (alloc MT) ADJUSTED
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
OCT	18	18	-18	18	0					10.8	0	7.2	0
NOV	18	18	-18	36	0					21.6	0	14.4	0
DEC	15	15	-15	51	0					30.6	0	20.4	0
JAN	14	14	-14	65	0					39.0	0	26.0	0
FEB	13	13	-13	78	0					46.8	0	31.2	0
MAR	13	13	-13	91	0					54.6	0	36.4	0
APR	25	25	-25	116	0					69.6	0	46.4	0
MAY	75	0		116	0	100	100	20	20	141.6	72	94.4	48
JUN	50	0		116	0	75	175	15	35	195.6	126	130.4	84
JUL	25	0		116	0	20	195	0		207.6	138	138.4	92
AUG	20	0		116	0	0	↓	↓	↓	207.6	138	138.4	92
SEP	18	18	-18	134	0	↓				218.4	138	145.6	92

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445 (WY)

APPENDIX G - COMPACT ADMINISTRATION EXAMPLE



A = inflow above diversions

B = state line flow

C = flow at point of measurement

W1, W2, M1, M2 are Wyoming and Montana diversions.

0910

Assumptions

1. There is no reservoir storage in the basin.

2. No water flows past the point of measurement and no water is consumptively used for the period October 1 to April 30.

3. The diversion requirement for W1, W2, M1, and M2 are constant for the period May 1 to September 30.

4. Exactly 1/2 of the quantity diverted returns to the stream as return flow. 100% of this flow returns the same month it is diverted.

5. Return flow from M2 comes in below the point of measurement.

6. All pre-1950 priorities in Montana must be satisfied prior to any post-1950 priorities in Wyoming.

7. The Compact apportionment is calculated on a monthly basis and all calculations are in acre-feet/month.

8. For the period May 1 to September 30, the inflow above diversions is equal to:

May	-	6000 acre-feet
June	-	4000 acre-feet
July	-	3200 acre-feet
August	-	2000 acre-feet
September	-	100 acre-feet

9. Montana receives 40% of the allocable flow
   Wyoming receives 60% of the allocable flow

10. Assume both states appropriate water according to the rules of higher priority: "1st in time, 1st in right".

Explanation

The following activities summarize a suggested methodology for administering the Yellowstone Compact for the period May 1 to July 31.

1. Month of May

Activity A

The inflow above diversions is forecasted for the month of May and is equal to 6000 acre-feet per month.

Activity B

The river calibration curve (not shown) indicates that when the inflow above diversion is equal to 6000 acre-feet, all pre-1950 and post-1950 appropriations in both states can be satisfied. Prior to the first day in May, use an accounting model to solve the compact apportionment with the following input (exhibit 1):

inflow = 6000 AF
W1 = 2000 AF
W2 = 2500 AF
M1 = 2000 AF
M2 = 2000 AF

Results of the accounting model first iteration suggest the apportionment can be satisfied for the month of May without the need for regulation.

Activity C

Headgates are opened May 1st on all pre- and post-1950 diversions in both states. Water use is measured and recorded.

Activity D

At the end of the month of May, rerun the compact accounting model with input equal to actual water use. Plot new points on the calibration curve.

2. Month of June

Activity A

The inflow above diversions is forecasted for the month of June and is equal to 4000 acre-feet per month.

Activity B

The calibration curve indicates that when the inflow above diversions is equal to 4000 acre-feet, approximately 7000 acre-feet of diversions can be satisfied. Prior to June 1, run the accounting model with the following input (exhibit 2):

inflow = 4000 AF
W1 = 2000 AF
W2 = 2000 AF
M1 = 2000 AF
M2 = 1000 AF

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450 (WY)

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Results of the Compact accounting model suggest the apportionment can be satisfied when W2 and M2 are regulated as indicated above.

Activity C

Water commissioners in both states regulate water use according to the results of the water model.

Activity D

At the end of the month of June, rerun the compact accounting model with input equal to actual water use. Plot these new points on the calibration curve.

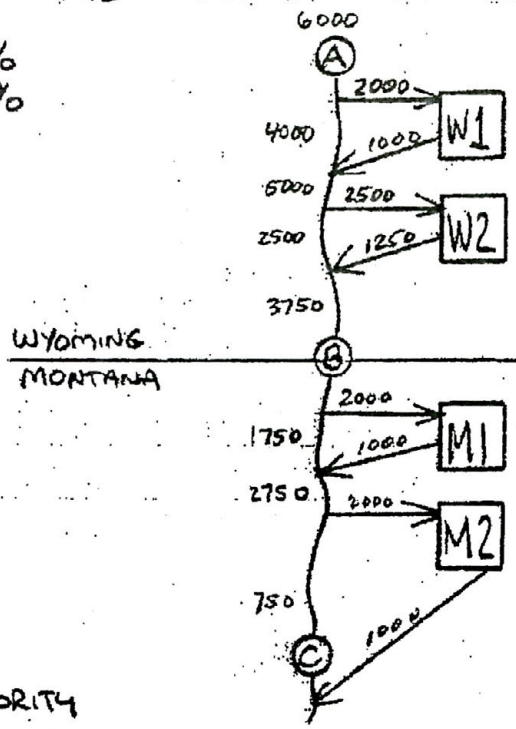
3. Month of July

The same methodology presented for the months of May and June apply in July. Note that even though Q(accumWY) < Q(allocWY) and Q(accumMT) > Q(allocMT), post-1950 water use in Wyoming must be regulated to satisfy pre-1950 water rights in Montana. In the example presented in exhibit 3, a minimum of 2000 acre-feet per month must cross the state line before post-1950 appropriators in Wyoming can divert water.

EXHIBIT 1

YELLOWSTONE COMPACT ALLOCATION FOR THE MONTH OF MAY

MONTANA = 40%
WYOMING = 60%



*= POST-1950 PRIORITY

STREAMFLOW FORECAST = 6000 AF
W1 = 2000 AF
*W2 = 2500 AF
M1 = 2000 AF
*M2 = 2000 AF

SUM FROM PREVIOUS MONTHS		TERM	ΣD(WY) / ΣD(MT)	ΔS(WY POST-50) / ΔS(MT POST-50)	ΔS(WY PRE-50) / ΔS(MT PRE-50)	
0	+	Q(accumWY) + 2500	+ 0	+ 0		= 2500
0	+	Q(accumMT) + 2000	+ 0	+ 0		= 2000

Q(accum) = 2500 + 2000 = 4500

Q(allocWY) = 4500 × (.60) = 2700

Q(allocMT) = 4500 × (.40) = 1800

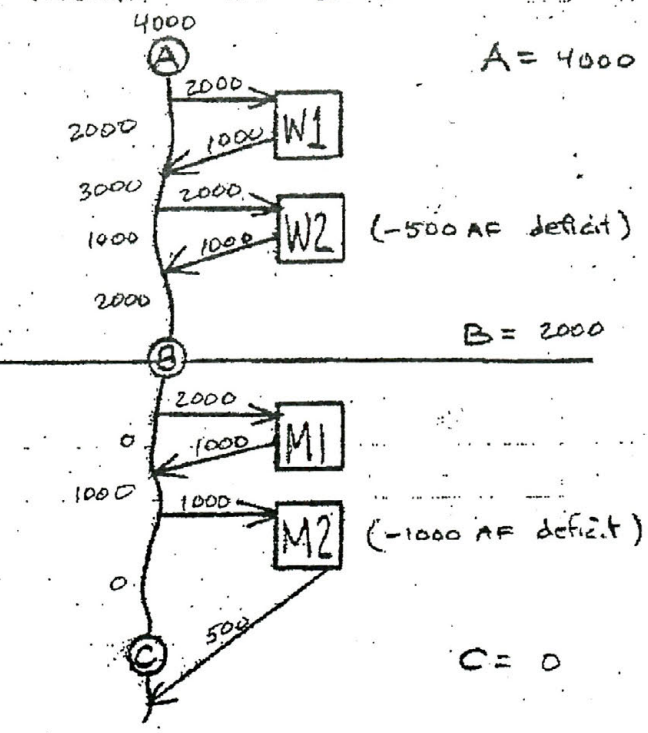
note: There is sufficient water in both states so that no regulation is required and the 750 AF at "C" is moved to an "unused and unavailable" account.

0916

EXHIBIT 2

YELLOWSTONE COMPACT ALLOCATION FOR THE MONTH OF JUNE

MONTANA = 40%
WYOMING = 60%



* = POST-1950 PRIORITY

STREAMFLOW FORECAST = 4000 AF
W1 = 2000 AF
*W2 = 2000 AF
M1 = 2000 AF
*M2 = 1000 AF

SUM FROM PREVIOUS MONTHS		TERM	ΣD(WY) / ΣD(MT)	ΔS(WY POST-50) / ΔS(MT POST-50)	ΔS(WY PRE-50) / ΔS(MT PRE-50)	
2500	+	Q(accum WY) +	2000 +	0 +	0	= 4500
2000	+	Q(accum MT) +	1000 +	0 +	0	= 3000

Q(accum) = 4500 + 3000 = 7500

Q(alloc WY) = 7500 × (.60) = 4500

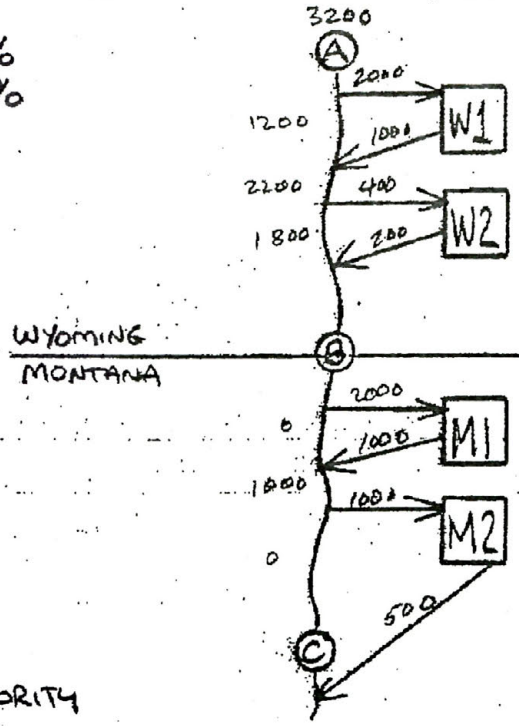
Q(alloc MT) = 7500 × (.40) = 3000

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EXHIBIT 3

YELLOWSTONE COMPACT ALLOCATION FOR THE MONTH OF JULY

MONTANA = 40%
WYOMING = 60%



*= POST-1950 PRIORITY

STREAMFLOW FORECAST = 3200 AF
W1 = 2000 AF
*W2 = 400 AF
M1 = 2000 AF
*M2 = 1000 AF

SUM FROM PREVIOUS MONTHS		TERM	ΣD(WY) / ΣD(MT)	ΔS(WY POST-50) / ΔS(MT POST-50)	ΔS(WY PRE-50) / ΔS(MT PRE-50)	
4500	+	Q(accum WY) +	400 +	0 +	0	= 4900
3000	+	Q(accum MT) +	1000 +	0 +	0	= 4000

Q(accum) = 4900 + 4000 = 8900 AF

Q(alloc WY) = 8900 × (.60) = 5340

Q(alloc MT) = 8900 × (.40) = 3560

note: Even though Q(accum MT) > Q(alloc MT) and Q(accum WY) < Q(alloc WY), post-1950 appropriators in Wyoming must be regulated to allow 2000 AF to cross the state line to satisfy Montana's pre-1950 uses.

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APPENDIX H - RESERVOIR EXAMPLE

It is suggested that the constraints found in this appendix be included in the Compact accounting model for cases where there is significant reservoir storage. These constraints are necessary because a strict interpretation of Article V would result in the division of stored water on a percentage basis that should not necessarily be divided. For example, if Wyoming stores their 60% share, and Montana's 40% share flow past the point of measurement, Article V still attempts to divide Wyoming storage on a 60/40 basis. Therefore, the purpose of the proposed constraints are:

1. To allow each state to store and use their share of Compact water.

2. To protect Montana if Wyoming oversizes their storage projects and stores more than their share of Compact water.

3. To provide a mechanism to equitability handle the problem of instream uses of water for the protection of aquatic habitats in both states.

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Constraints

Define a "storage limit" for each state which is based on Article V:

$$SL_{WY} = (.60) \times [\triangle S(WYpost50) + \triangle S(MTpost50) + \sum_{day=1}^{n} Q(compact\ gage) - (instream\ flows)]$$

$$SL_{MT} = (.40) \times [\triangle S(WYpost50) + \triangle S(:MTpost50) + \sum_{day=1}^{n} Q(compact\ gage) - (instream\ flows)]$$

Where, SL_{WY} and SL_{MT} are Wyoming's and Montana's storage limits for excess spring flow. The storage limits are to be quantified only once per year, and generally at the end of the reservoir(s) filling cycle.

For purposes of compact accounting and model building, it is suggested the storage limits be used as follows:

1. If $Q(accumWY) > Q(allocWY)$;
   and, $Q(accumMT) < Q(allocMT)$;
   and, $\triangle S(WYpost50) > SL_{WY}$
   and, Montana appropriators need water;

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THEN

regulate post-1950 uses in Wyoming (or drawdown the excess storage) until either:

a. Montana appropriators are satisfied

or b. $\Delta S(WYpost50) = SL_{WY}$

whichever comes first.

2. In the Compact accounting model, the change in storage which gets accumulated in the term Q(accumWY) is equal to the quantity $[\Delta S(WYpost50) - SL_{WY}]$ and is added in only when $\Delta S(WYpost50) > SL_{WY}$.

These same constraints hold true for calculations with Montana's storage limits.

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Draft "Yellowstone River Compact" by DNRC, Water Management Bureau, Nov. 29, 1989

0922

DRAFT November 29, 1999

YELLOWSTONE RIVER COMPACT

by
Water Management Bureau
Water Resource Division
DNRC

INTRODUCTION

The Yellowstone River Compact, ratified in 1950 by the United States Congress, divides the unappropriated waters of the four major interstate tributaries of the Yellowstone River between Montana and Wyoming. The compact divides the mainstem of the Yellowstone River below Intake Mt. between Montana and North Dakota. The intent of the compact is to provide for the development of storage in the Basin. The objectives of this report is to provide the Yellowstone River Compact Commission and interested parties with background information that should facilitate discussions and further research regarding compact development and past administration activities, and the identification of differences between the states on its interpretation. Hopefully, these discussions will lead to meaningful results. The report includes: a historical accounting on the development of the compact; an interpretation of the Articles in the Compact; activities of the Yellowstone River Compact Commission since 1950; and issues and concerns that have evolved since 1950 that need resolution before the compact can be effectively administered.

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HISTORY OF THE YELLOWSTONE RIVER COMPACT

Before 1930, Montana was concerned that the Tongue and Powder rivers were fully appropriated during the irrigation season. During drought situations, there was not enough water to satisfy all existing uses in Montana. It has been stated that there were approximately 45,000 acres of irrigation in Wyoming in the interstate tributaries before the first irrigation was developed in Montana which was 1889. Montanans were concerned that they could not protect their existing uses during low flow periods and that there would be no water available for future developments. Montana, therefore, convinced Wyoming in the early 1930's that the two states should develop a compact that divides the waters of the interstate tributaries between the two states. Woming also felt that a compact might enhance both states efforts to have the federal government build multiple use storage projects on the interstate tributaries. The major point of contention in the drafting of a compact was administration ---

this issue is the primary focus in the following discussion.

The first attempt to formulate an agreement began in 1932, when the two states requested and obtained formal approval from the United States Congress to negotiate a compact. Congress authorized four years to complete this task (1932-1936). Wyoming drafted the first compact. Two provisions in the compact became troublesome for the federal government. One would have allowed Wyoming to construct and operate a reservoir on Yellowstone Lake in Yellowstone National Park. The second provision declared the waters of the Yellowstone River and its tributaries as non-navigable waters and therefore properties of the states which they flowed and not that of the federal government. The United States Secretary of Interior Ickes strongly opposed the development of a reservoir system in Yellowstone National Park and the provision that stated the waters were non-navigable. Because of this strong federal opposition, the compact was not developed further and both states sought an extension of time to continue negotiations. Future negotiations would exclude waters from Yellowstone National Park from consideration. The U.S. Congress granted an extension to 1939.

In 1939, the two state negotiation commission drafted a report which contained the following recommendations regarding further negotiations.

1. There was an inadequate data base for developing a compact (Montana lacked most of the data for developing a compact).
2. Large storage projects were needed on the major tributaries for regulating flows.
3. Indian water rights had to be quantified.
4. North Dakota will need to be a party to the compact because the mainstem of the Yellowstone River flows through part of North Dakota.
5. The states needed to ask U.S. Congress for an additional extension until 1943.

A second compact was drafted in 1943. In its attempt to protect existing uses, Montana demanded that a provision be included that would allow water rights to be administered based on priority date regardless of the interstate boundary. The Wyoming legislature could not agree to this provision because it would have an adverse impact on existing uses in the Powder and Tongue rivers in Wyoming during low flow periods. Wyoming was not willing to protect existing uses in Montana to the potential detriment of existing uses and future developments in Wyoming. Because of this, the Wyoming legislature deleted those portions of the compact dealing with the allocation of waters in the Tongue and Powder River basins. With the exclusion of these two basins from the compact the Montana legislature would not ratify the proposed compact.

In 1948, the third attempt for a compact resulted in a similar fate as the 1943 version. A provision was included allowed for an adjudication of the entire river system regardless of the state boundary. For example, Wyoming would receive 72% and Montana 28% of the first 2,200 acre-feet of water of the Tongue River during the irrigation season. Of the next 1200 acre-feet, Montana would receive 57% and Wyoming 43%. This compact was ratified by the legislatures of Wyoming, Montana, and North Dakota. Governor Hunt of Wyoming, however, vetoed the bill. In a letter to Governor Bonner of Montana, Governor Hunt felt the compact was unacceptable because of strong opposition by Tongue River irrigators in Wyoming. These irrigators believed that if the compact was passed in its existing form, Wyoming could not satisfy water demands for 7,000 existing irrigated acres during low flows if required to satisfy Montana's early priority water rights.

The fourth and final attempt at drafting a compact began in November, 1949 and was concluded in December, 1950. Membership included official representatives of the three states and a number of federal agencies representatives (Bureau of Reclamation, Bureau of Indian Affairs, U.S. Geological Survey, Bureau of Land Management, Corps of Engineers and Soil Conservation Services). The group agreed to use the last version of the compact as a basis to begin negotiations. In addition, the group agreed to set up an engineering committee consisting of the three state engineers, Bureau of Reclamation, and Bureau of Indian Affairs to update the technical data necessary to develop a compact and to suggest possible articles for inclusion into a compact, specifically the one dealing with the apportionment of the flows on the interstate tributaries. In addition, each basin had its own technical committee to address issues specific to that basin. The negotiation commission met four times during a one year time span.

Montana again strived to include a provision that allowed for a basinwide adjudication of the four major interstate tributaries. The primary actor in Montana was Mr. Leonard, an attorney from Miles City and a Montana member of the negotiation team for the previous six years. He insisted that no state had the right to divert all the water on interstate tributaries regardless of any injury to a lower state. He held that the rights and interest of each state must be respected by the other and therefore, pushed the doctrine of appropriation as was used in the second and third compacts. According to Mr. Leonard, the U.S. Supreme Court decision in the New Jersey vs. New York case 283 vs. 336 held that interstate streams which provided the necessity of life, must be rationed among those states who have power over them. In this case, he felt that both states have real and substantial interests which must be reconciled. In a letter to Governor Bonner of Montana, Mr. Leonard contended that Wyoming was making unrestricted and unlimited use of the

interstate streams between that state and Montana without regard to the rights of Montana and only wasted water or water which could not used to her advantage was allowed to enter Montana. Leonard stated in one of his letters to Governor Bonner the following:

> " It is concluded that in both states the dependable natural flow of the river and its tributaries during the irrigation season has long been over-appropriated in both Montana and Wyoming. It is only when a shortage of water exists that a conflict exists. Hence, if Montana would recognize all existing rights (1950) in Wyoming in times of shortage, there would be nothing left for Montana".

The Wyoming quarterback was Mr. McNally, a lawyer from Sheridan, Wyoming He claimed that the doctrine of "priority" on long river systems had been repudiated. He referred to the language of Justice Douglas in reference to the case of Nebraska vs. Wyoming which indicated that there is evidence that a river-wide priority system would disturb and disrupt long established uses; and that "equitable apportionment" is the correct rule. He further emphasized the case of Colorado vs. Wyoming where junior rights in Colorado were recognized as having priority over senior rights in the lower state because to do otherwise would have disrupted the economy in Colorado which was built upon junior rights. To support Wyoming's case, Mr. McNally emphasized that 28% of the lands in Sheridan County, or over 7,000 acres, would not be supplied with water if existing rights in Montana were recognized.

The stage was more or less set for the third meeting of the commission on October 24-25, 1950 in Billings, Montana. To reiterate, Mr. Leonard and a number of Montana Commissioners wanted administration of both post and pre-1950 rights based on the doctrine of appropriation. Conversely, most of Wyoming commissioners wanted no administration of existing pre-1950 rights based on the doctrine of equitable apportionment. The engineering committee more or less agreed with Wyoming and, were not in favor of setting up a procedure for administering pre-1950 rights, but were willing to leave the option up to members of the commission.

The engineering committee had considerable influence over the negotiations. At the third meeting, the negotiation commission had lengthly debates over the 20 principles developed by the engineering committee. They are identified below because they shed light on the thinking of the negotiation commission at that point in the negotiations.

1. "It is generally accepted fact that irrigation development in the Yellowstone River Basin, particularly on the interstate tributaries, has very nearly reached its maximum practicable limit without the provision of

additional new storage capacity." Motion passed.
2. "The committee feels that clearing the way for the storage should be one of the underlying objectives of any interstate compact." Motion passed.
3. "From an interstate standpoint, the situation in the Yellowstone River Basin is extremely favorable since on three of the four interstate tributaries there is a reservoir site at or near the state line which can provide adequate control of residual flows from the upper state for continued development in the lower state." Motion passed.
4. "The fourth tributary, Clarks Fork, is not likely to experience water shortages." Motion passed.
5. "The reservoir on Tongue River has already been constructed, and those on the Big Horn River and the Powder River are authorized by Congress for construction by the Bureau of Reclamation." Motion passed.
6. "When these reservoirs are in operation they will have the practical effect of permitting full development in the upper states without affecting the progress of development in the lower states. That fact should be borne in mind." Motion denied based on the objection of Montana.
7. "Concerning treatment of existing developments in the Compact, the committee is of the opinion that there is little to be gained from a water supply standpoint by regulating and administering existing diversions under a compact." Principle passed over---no agreement reached.
8. "It is, of course, entirely up to the Commission whether or not exisitng rights are to be administered under the compact, but from an engineering standpoint, the committee feels that the expense and difficulties of such an administration would be in no way be justified by the benefits that might be obtained." Montana objected therefore, motion denied.
9. "There are insufficient data upon which to base this type of administration due principally to differences in the water laws of the states involved." Montana objected therefore, motion denied.
10. " It would be a major research project to place existing rights in all states on an equivalent basis." Montana objected, therefore, motion denied.
11. "Such procedure undoubtedly would involve interstate adjudication proceedings." Montana objected, therefore, motion denied. It should be noted that items 7,8,9,10, and 11 were debated as a group and that most of the Montana delegation tried to table these items. However, these items were debated with no resolution. Nevertheless, the commission agreed that the following quote is acceptable for inclusion into the compact at this meeting; "both states wanted existing rights recognized in the compact".
12. "There are two principles upon which a satisfactory allocation of the unused waters of the Yellowstone River could be based, One is the so-called divertable flow

priciple, which has been used in previous Yellowstone River Compact attempts. The other is the depletion princip used inthe Upper Colorado River Basin Compact." (note item 14)

13. "The committee feels, that since the divertible flow priciple has been previously used as a basis for a compact, it should be retained, but modified to make the apportionment operative on other than a daily basis so that allocation could be in terms of cummulative volumes of water through an entire year, or portion thereof rather than by daily stream flow. This is because substantially all new development will be based on storage rather than divert flow." (note item 14).

14. "A suggested draft of an apportionment article is attached, together with the supporting definition." The group voted and approved the use of divertible flow methodology based on the acceptance of item 13..

15. "Whatever priciple is used in allocating the water under the compact, it is necessary to select some index upon which to base apportionment, either directly in acre-feet or by percentage." The committee agreed to use irrigable land in the two states as the bases for the apportionment.

16. "The irrigable land in the states are tabulated in the report and the addendum, dated September 24, 1950 of the engineering committee." Committee noted above principle.

17. "The committee feels the irrigable lands as shown by this report and addendum except as to the Bighorn River are a reasonable measure of the new development that is likely to take place in the basin for a long time to come." Motion passed but the addition of " except as to the Bighorn River" was needed for motion to carry.

18. "If the Commission feels that the available data are insufficient on any of the interstate tributaries (Clarks Fork, Big Horn, Tongue, or Powder Rivers) to allocate all of the unused waters of the tributary, it could apportion a first block of water sufficient to take care of the presently indicated potential development." This item was passed over.

19. "Some consideration must be given to supplemental water supply and since such water is for use on existing projects, it is felt that such alloction should be made under the category of existing irrigation work rather than potential." Motion passed.

20. "The committee definitely feels that there is enough information available at the present upon which to base a workable and realistic compact, and that nothing would be gained but much might be lost if a compact were postponed until all the development possibilities in the basin are completely and thoroughly studied. This will take a long time and cost a great deal of money, and if a compact is delayed until it is completed, the basin may well be deprived of the use and benefit of many worth-while

projects which otherwise could be constructed." This item was read as a statement and therefore, no vote was taken.

At the fourth and final meeting of the commission, they finally adopted the engineering draft of Article V of which paragraph A was the point of contention. That paragraph stated "Appropriative rights to the beneficial uses of the water of the Yellowstone River system existing in each signatory state as of January 1, 1950 shall continue to be enjoyed in accordance with the laws governing the actual use of water under the doctrine of appropriation" The Leonard draft went even further. It had the above quoted section but also..." and on the basis of priorities thereunder as single streams and regardless of state lines as such water rights existed as of January 1, 1950, and in the event of a shortage of water to supply all water rights available in any stream shall be divided and apportioned on the basis of priority of rights." This section, however, was deleted from the final compact. The major issue of contention during the last meeting was the issue of article VI and the ramifications of indian reserved water rights on each states allocated share specifically on Montana (note discussion of indian reserved water rights on page __).

The compact was ratified by the three state legislatures and the U.S. Congress and became effective in 1951.

WHAT THE COMPACT DOES

The Yellowstone River Compact contains 18 articles. Each Article is described below.

ARTICLE I

This article states that all water users in the Yellowstone River system in the respective signatory states are subject to the terms of this compact.

ARTICLE II

This article defines the important terms used in the compact. It is noted that all lands and waters within Yellowstone National Park are specifically excluded from the terms of this compact.

ARTICLE 111

Article III describes the administration of the compact. No administrative body divides the water of the Yellowstone River mainstem between Montana and North Dakota. A three member commission divides the flows between Montana and Wyoming and

administers the provisions of this compact. The commission generally consists of the State Engineer from Wyoming, the [illegible] Resource Administrator from Montana and a chairman appointed by the Director of the United States Geological Survey.

The commission has certain definable responsibilities. They are required to administer the compact which includes the collection of data, maintenance of gaging records, and any other pertinent information necessary for the administration of the compact. The commission also has the authority to formulate rules and regulations for compact administration. The two commissioners from Montana and Wyoming are the voting members. If the two states cannot agree, then the federal representative has the authority to break a tie voted ..."on matters necessary to the proper administration of this compact".

ARTICLE IV

Article IV provides the necessary gaging program to administer the Yellowstone River Compact. The gaging program is the responsibility of the U.S. Geological Survey, Montana, and Wyoming. The program is cost-shared with the USGS paying one-half and each state paying a quarter.

ARTICLE V

Article V apportions the flows of the four major interstate tributaries between Wyoming and Montana and includes a number of important statements regarding the division of water. First, all water rights in existence before January 1,1950 shall be protected and used in accordance with respective state law under the doctrine of appropriation. Second, of the unappropriated water as of 1950, there is enough supplemental water allocated to each state to satisfy pre-1950 water rights. Most of the supplemental water use has occurred in Wyoming. Third, the article divides the unused and unappropriated between Montana and Wyoming on a percentage bases as of January 1,1950. Water may be used for direct diversion and storage for beneficial purposes on new lands or for other purposes. The following percentages were determined based on irrigable acreage in the respective basins in both states;

Clarks Fork , Yellowstone River	
Wyoming	60%
Montana	40%
Big Horn River(exclusive of Little Bighorn)	
Wyoming	80%
Montana	20%
Tongue River	

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Wyoming	40%
Montana	60%
Powder River	
Wyoming	42%
Montana	58%

The quantity of water subject to the percentage allocation is based on the period from October 1 through September 30 of each year. The allocation to each state can be determined for any given time by adding the algebraic total of the following four volumes (acre-feet) starting on October 1 to that given date;

1. the total diversions in acre-feet for all uses developed after January 1, 1950,
2. the net change in storage in all new reservoirs completed after January 1, 1950,
3. the net change in storage in existing reservoirs where the use is developed after January 12, 1950, and
4. the quantity of water that passed the point of measurement in the stream during the period. The point of measurement in the four tributaries is generally close to the confluence of the Yellowstone River and that tributary.

Fourth, the article recognizes and protects all existing uses in Montana and North Dakota below Intake, Montana as of January 1, 1950. The remaining unappropriated flows of the Yellowstone River mainstem below Intake, Montana are divided between North Dakota and Montana for the period between May 1 to September 30 of each year based on a percentage of the number of irrigated acres. Fifth, all existing and future domestic, and stock water uses are exempt from provisions of this compact provided that stock water ponds are less than 20 acre-feet. Lastly, the commission has the authority to re-examine the allocation and based on unanimous agreement may recommend modifications. The re-examination shall consider priorities of water rights, acreage irrigated, acreage irrigable under existing works, and potentially irrigable lands.

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ARTICLE VI

This short article states that nothing in this compact shall adversely affect any rights to the use of waters of the Yellowstone River and its tributaries owned by or for indians, indian tribes, and their reservations.

ARTICLE VII

Article VII provides a mechanism to allow either state to apply for and use water within the other state that has not been specifically allocated by or appropriated to that state.

ARTICLE VIII

Article VIII allows either state to acquire through purchase or eminent domain such lands, easements, and right-of-ways for construction, operation, and maintenance of storage reservoirs and other types of water structures.

ARTICLE IX

If a project is constructed in the other state, this provision provides a mechanism to allow the state with the project to construct, operate, repair, and replace facilities subject to the law of the state in which the project is located.

ARTICLE X

No water shall be diverted from the Yellowstone River basin without the unanimous consent of all signatory states. Approval is from the legislatures of Montana and Wyoming and the Water Commission in North Dakota. Both Montana and Wyoming have passed legislation to address this issue in more detail (Appendix 2).

ARTICLE XI

This compact is to remain in full force until amended in the same manner as the initial ratification which is by the respective legislatures and Congress.

ARTICLE XII

The compact can only be terminated with unanimous consent of both states (Montana and Wyoming), but all rights established under the compact shall continue unimpaired.

ARTICLE XIII

This article allows either state to pursue legal remedies in either federal court or the U.S. Supreme Court for the protection of any right under this compact or the enforcement of any of its provisions.

ARTICLE XIV

Article XIV states that this compact cannot set a precedent or any general principle with respect to other interstate streams.

ARTICLE XV

The compact will become operative when approved by the legislatures in the three states and the U.S. Congress.

ARTICLE XVI

This article states that nothing in this compact can impair or affect the United States with regard to jurisdiction, sovereignty, taxation, and state law.

ARTICLE XVII

If any provision of this compact are unconstitutional under state or federal law, then all other provisions remain in full force and effect.

ARTICLE XVIII

No sentence, phrase or clause in this compact can divest any of the three states and its officials from the jurisdiction of the water of each state as apportioned in this compact.

ACTIVITIES OF THE YELLOWSTONE RIVER COMPACT COMMISSION SINCE 1950

Activities and inactivities of the compact commission are identified for each year since its ratification based on the minutes of the annual meetings and other relevant information. Only the most important motions, actions, and activities of the commission are summarized in the following section.

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July 15-16, 1952. No need to administer compact. Major problem is a lack of data on water rights and quantities of water diverted. Commission decided to understand compact better before developing rules and regulations.

November 25, 1952. The first annual meeting of the Yellowstone River Compact Commission. Mr. Buck and Mr. Bishop were the commissioners from Montana and Wyoming, respectively. Mr. Stermitz of the USGS in Helena, Mt. was chairman. The commission felt only new users or appropriators after 1950 would be required to supply data and information to the commission. The commission passed a motion that would require all new water users to install headgates and measuring devices so that accurate records can be kept for the eventually administration of the compact. Another motion was passed to identify the points of measurements on the four tributaries. The last significant motion was that the Commission's annual report be submitted to North Dakota.

November 17, 1953. A motion was made and passed that the rules and regulations for administrating the compact be adopted

as revised (appendix 3). Mr. Bishop presented a listing of water use applications in Wyoming between the period 1950 and [illegible]. Mr. Buck indicated that legislation passed in 1953 will require all pertinent filing information of water rights to be submitted to the State Engineer, but so far, none have been submitted to his office. Both commissions are of the opinion that use during the water year ending September 30, 1953 did not approach the percentages allotted to both state.

November 23, 1954. The commissioners noted that no questions of water use under the terms of the compact have come to their attention. Both commissioners agreed to update water use in their respective states after 1950. The commission noted that average streamflows were generally less than that of the previous year and much below the average on the four tributaries. If trends continue, the commission felt it might hasten..."the need for detailed information on the use of waters allocated by the compact".

November 19, 1955. The commissioners reported that no problems regarding administration of the compact had come to their attention since the last annual meeting. Mr Buck presented information on water right filings from 1950 to about 1955 except for three counties in Montana. Mr. Bishop indicated that he had not compiled a list of permits issued since his last submittal of a year ago. Both commissioners noted on record that water right filings or permits did not necessarily constitute use. Furthermore, the filings or permits may be for supplemental irrigation not within the purview of the compact. Mr. Clinton, Regional Director of the Bureau of Reclamation in Billings reported on the status of Yellowtail Dam and acreage planned for irrigation from water stored behind the Moorhead or Powder River project. Although average streamflows were higher than the previous year in the Bighorn and Tongue Rivers, they were still below average. Mr. Stermitz noted that return flows from irrigation waters diverted from Rock Creek appeared to exceed diversion from the Clarks Fork between Edgar and mouth of Rock Creek.

November 20, 1956. The Commission found no need to administer the compact based on the previous year experience. The commissioner also ..."felt that allocable use did not exceed the pro rata shares in either Montana or Wyoming." The commission opined that there was little to be gained by collecting discharge data on allocable diversion or use until the aggregate of such uses approached each states' percentage allocations. The expense to the states and commission would be large and the results would be primarily of historical value until critical conditions developed.

November 26, 1957. Mr. Paul Richard replaced L.C. Bishop as the Wyoming Commissioner. The chairman informed the commissioners of their responsibility to provided current data on diversions since January 1, 1950 which are chargeable against the states allocated shares. Mr. Richards indicated that the lists of permits in the basin were available for Wyoming. Mr. Buck stated that he had received but few reports on new water right filings in the basin from county offices. He felt there were many unreported filings which he would try to collect. Both commissioners believed that the available information on water rights should not be considered diversionary data, but still good enough to estimate allocable flows. Both commissioners felt that there was no need for collecting detailed information on diversions. The U.S. Steel Corporation requested approval from the commission to transfer water from Popo Agie River in Wyoming into the North Platte River Basin for processing iron ore. The commission passed the following motion;

> "Insofar as the commission authority extends the commission agrees that it will not oppose the diversion of 5.03 cfs having priority earlier than January 1, 1950, as proposed by the Columbia-Geneva Steel Division of the United States Steel Company. This action shall not establish any precedent."

November 14, 1958. Mr. Earl Lloyd replaced Mr. Richards as the Wyoming representative on the Commission. Flows of the Clarks Fork and Bighorn rivers were near the long-term average and those of the Tongue and Powder rivers were 30 to 40% below average. Each commissioner reported that "no matter of compact allocations came to their attention during the year". Mr. Buck presented the Commission a list of water rights filings in Montana since January 1, 1950 which were pertinent to the compact allocations. It was the first detailed list furnished by Montana. Mr. Lloyd noted that the last list furnished by Wyoming covered the period between January, 1, 1950 and December 31, 1957.

November 16, 1959. The meeting was held by conference call. Again, the commission reported that no questions regarding allocation of waters under this compact had come to their attention since the last annual meeting. Based on stream flow records, the commission felt that uses had not increased materially. Article III A of the rules and regulations of the compact commission were revised and approved by the commission The flows of the Clarks Fork and Tongue rivers were approximately average and the Bighorn River was about 75% of average. Flows of the Powder River were greater than the previous year.

November 10, 1960. ~~Nothing happened.~~ The commissioners reported that no questions of allocation of waters under this compact had come to their attention during the year. Flows, however, ranged from 74% to 31% of the long term average.

November 21, 1961. Meeting was held by conference call. As at most meetings, a large percentage of the time was spent discussing installation or modification of gages for measuring flows for compact administration. Flows of the Clarks Fork was 74% of average, Bighorn River was 44% of average, The Tongue, 16% of average, and the Powder River 13% of average. Commissions members felt there was no need for allocating tributary flows in accordance with the compact since the last annual meeting. Furthermore, the commission made no attempt to determine the amount and extent of usage of water in the two states. The effort and cost of such determinations was not considered to be justified at the present level of water resource development. Both commissioners provided updated list of filings or permits of new water uses in the basin.

November 28, 1962. Flows in 1962 were considerable higher than the previous year. Mr. Ross, an attorney from Fromberg and Bridger, Mt met with the commission and stated..."his purpose was to draw the attention of members of the commission and state officials to the need for prompt remedial actions should water supply again be critical." [he was referring to 1961]. The two commissioners, however, agreed that the flows in 1962 were in excess of that provided under the terms of the compact.

November 19, 1963. Earl Lloyd was succeeded by Floyd Bishop as the Wyoming commissioner and Evertt Darlington succeeded Fred Buck as the Montana member on the commission. In general, runoff was slightly less than in 1962, but substantially greater than in 1961 and greater than the average of record. The commission discussed the proposed Cyclone Bar irrigation development in Wyoming on the Clarks Fork of the Yellowstone. The project would primarily furnish supplemental irrigation supply to lands in Wyoming and could also be used in the extreme southern part of Montana. Montana, however had elected not to participate, as concern was expressed over the greater water use that might then occur in Wyoming. Both states updated water permits and filings in their respective states. Commissioners agreed that there was no need to determine respective state allocable shares of the streams involved because of the recent high flows.

November 24, 1964. Streamflows on the four interstate tributaries were 101 to 127% above average. No matters of

concern were noted by either commissioner. Mr. Darlinton indicated that the water resource survey of Carbon County would be updated in 1965 (Clarks Fork is wholly within Carbon County). The first publication of the water survey was in 1946.

November, 23, 1965. Mr. Alex McDermott became the Montana representative, replacing Darlinton as the state commissioner. Noting above average stream flows and reservoir contents, the two states representatives felt that Compact allocations had not been exceeded in the upstream state. Mr Stermitz noted that he was retiring and expressed the opinion that it might be preferable to have a federal representative on the commission that is not a resident of either Wyoming or Montana because of the possibility of bias toward the state or residence of their federal representative. However, the state commissioners agreed that it is more desirable to have a federal representative who is familiar with the Yellowstone River regardless of whether he resides in either Montana or Wyoming.

November 22, 1966. Mr. Stermitz retired and the Director of the USGS appointed Mr. Erskine to serve as the federal representative. George Pike replaced Mr. Stermitz as the District Chief of the Montana office of the USGS.
The flows of the Yellowstone tributaries were below normal, but still higher than in 1961. End of the year content in reservoirs were 27% to 81% above a year ago. Both state commissioners felt that records of stream flow, reservoir storage, and water uses were within the Compact allocation. Mr. McDermott reported that industrial developments will require considerable amounts of water from the Tongue River in Montana and he needed to determine Montana's allocated share. A discussion ensued regarding the availability of data and cost for collecting the information. Mr Bishop opined that the filings for water use permits in the Tongue River basin in Wyoming from 1950 to date would give reasonably accurate information on usage. Mr. McDermott presented a report containing a compilation of all water right filings in the four tributary basins of Montana from January 1, 1950 to October, 1966.

December 19, 1967. Mr. Darlinton replaced Alex McDermott as Montana's representative on the commission. Stream flows and reservoir storage was above average and no shortages were reported. Both commissioners agreed that the high flows suggested that both states were within their compact allocation. Mr. Darlinton reported that with increased interest in the Tongue River for industrial purposes, the Montana Water Resources Board contracted with the Bechtel Corporation to study the quantity of unused and unappropriated water available to Montana for used within the Tongue River Project in Montana. It was

noted that in the study, Montana would use 28% of the diversion as the return flow value. Mr. Harlan of Bechtel Corporation stated that" under the assumed conditions, during the 21-year period there were 11 years when the flows would have been inadequate, and the average annual flow for the entire period would not have been adequate to supply all needs". Mr. Judah of the Bureau of Reclamation (BR) recently executed options contracts with 5 different companies for a total of 203,000 AF/Y of Bighorn water. Mr Judah noted that the state in which 128,000 AF of this total would be used is not specified in the options. Based on preliminary appraisals, the BR feels that Montana may be close to its full allocation under the compact in the Bighorn Basin. However, the BR noted the complexity of the situation because of the indian reservations within the basin. BR estimated that there is about 187,000 AF available to Montana and 1,100,000AF to Wyoming. The study was based on the critically low period of 1959-1962. It was reported that interest was brewing regarding the construction of the Moorehead reservoir site for industrial purposed. Because of this increase interest in industrial water, the commission expressed concern regarding the adequacy of the existing stream flow data collection program to meet the needs when allocating flows will become a necessity. A motion was passed to have the USGS study the issue and report back to the commission.

November 15, 1968. Streamsflows and end of the year storage content were well above the long-term average in all basins. Both commissioners felt there was ample water for both states and well within the Compact allocations. No new option contracts were issued by the BR since last years annual meeting. Mr. Darlinton reported on the findings of the Bechtel report regarding the enlargement of the Tongue River reservoir. He explained that the Tongue River reservoir could supply 100,000 AF/Y of firm supply, of which 60,000 AF would be for industrial use and 40,000 AF for agriculture. Mr Bishop noted that Wyoming did not plan to take a formal position on the report and that the commission should not take formal action regarding its content. Both commissioners felt that the development and use of water associated with indian reserved water rights could initiate litigation in the basin because of interference with existing water uses. Mr. Erskine reported that the Directors of both Water Resource Institutes responded favorably to conduct research to evaluate consumptive use and return flows in the basin. Research on return flows were initiated on an irrigtion project in a mountain meadow in Wyoming and on a cultivated land project with limited water supply in Montana. For more specifi information of the research, refer to the Commission meeting minutes.

December 2, 1969. Governor Anderson appointed Doug Smith as

Montana's new member of the commission replacing Darlinton. Streamflows were about average and well within the compact allocation. Mr. Judah of the BR noted that his agency was surveying the design and cost for moving Bighorn water into the Montana and Wyoming coal fields and future use by energy companies. No new option contracts were finalized with the BR, but there still appeared to be much interest. The Commissioners felt that indian tribes were becoming more aggressive to assert their reserved water rights and litigation will eventually be required to settle the question of the extent of the indian rights. Neither study proposals initiated the previous year received approval at the national level. Mr Bishop noted that the BR is studying the Moorhead site on the Powder River for a potential storage project.

November 9, 1970. Mr Williams became the new federal representative on the commission replacing Mr. Erskine. Flows were near or above the long-term average. A slight shortage did occur, however, in an isolated section of the east flank of the Bighorn Mountains near Buffalo, Wyoming. The BR presented information on its study of possible routes to move water into the coal fields of Montana and Wyoming. Five principal pipeline routes were being surveyed to transport about 1 million AF/Y of water. The Rules and Regulations were modified slightly with respect to the location and name of the gaging site on the Clarks Fork and that the Prarie Dog Creek gage be identified on the map. Also, that the annual meeting shall be held in November rather than on the the third Tuesday of November.

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November 11, 1971. Since Montana's representative could not attend, the Chairman and Wyoming's commissioners agreed that all motions would be seconded by Montana at a later date either by phone or letter. A stenographer was at the meeting to take minutes. Flows were above average for the interstate tributaries. Two meetings were held in June and July to discuss; diversions from the Yellowstone River Basin, who needs to approve out-of-state diversions for each state, the need for changes in Montana water laws to agree with terms of the compact, and the status of the BR aqueduct study. BR officials indicated that about 85 energy companies were now interested in obtaining water for industrial purposes within the basin. The BR reported that it now had 1.7 million AF/Y of option contracts for industrial water. The BR official also felt that were was about 951,300 AF/Y for export at Hardin, Mt. from the Bighorn drainage basin. BR also emphasized the need for the states to agree on their allotments under the Compact. The Chairman opined that the Commission should begin to develop a system for administering the compact and submitted an outline of a computational procedure (appendix 4). Messrs. Pike and Cushman of the USGS reviewed

their report regarding the collection of additional data and administrative procedures for allocating water under the term the compact. Mr. Bishop felt "that evaporation losses in reservoirs with post-1950 storage rights should be charged against the state in which the use of the stored water is being made, whereas evaporation losses from reservoirs with rights prior to 1950 should not be charged to either state. He further stated " that channel losses and return flows need not be considered since water is measured for compact purposes at the points of diversion." Montana reaffirmed its interest in building the Moorhead project, whereas Wyoming had apprehension because it was so far downstream and would have little benefit for it's irrigators.

November 21, 1972. Grant Buswell represented Montana on the Commission replacing Darlinton. The Governors of Montana and Wyoming meet on the issue of transbasin diversions from the Yellowstone River Basin. No decision was reached for obtaining unanimous consent for taking water outside of the basin. North Dakota officials could not see any benefits to North Dakota for consenting to out-of-basin diversions. Mr. Bishop and the BR emphasized the need for settling the diversions issue so that orderly development of the coal resource within the basin can occur. Mr. Williams of Wyoming summed up the discussion on interbasin transfer by saying " there is basic disagreement on the transbasin diversion question and the question needs to be resolved because development of the coal deposits in the three states is going to take place one way or another, and the technical consideration should be taken into account as well as the political ones." A motion was passed requesting the three Governors to appoint legal representatives from each state to define procedures for obtaining consent. A number of studies and activities were discussed including; Missouri River Basin Commission, Northern Great Plains Resource Program, Resource and Land Information Program, State Water Planning in the Bighorn Basin of Wyoming, and North Central Power Study. Both Commissioners felt flows were adequate and that there was no impact on compact allocation. Wyoming noted that it was keeping records on major diversions and on small ones where there was a need to administer and regulate flows, whereas Montana was not. Mr. Buswell indicated that legislation is being drafted which will centralize water right records in the Department of Natural Resources and Conservation (DNRC).

Novmber 1973. The year was very exciting for the commissioners. A special meeting was held in July on a number of issues therefore, the annual meeting was held by conference call presumably in November since the meeting minutes did not identify a date. As in previous reports, no incidents during the year required administration of water in accordance with compact

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provisions. Stream flows were slightly above average in all drainages except for the Clarks Fork which was slightly below average. Most of the discussion revolved around article X of the compact because of the increase interest in coal development and transportation of water within and outside the basin. The legal representatives appointed by the Governors of the three signatory states determined three ways in which permission could be granted under article X. They included: a bill resolving the issue presented to each legislature; resolutions by the three legislatures; and to amend the compact Article X which requires Congressional approval.

Intake Water Company, a Delaware Corporation and a wholly owned subsidiary of Tenneco, Inc., has applied for an appropriation of water to be diverted from the Yellowstone River in the vicinity of Intake in Dawson County, Montana for use in the Little Missouri River basin of Montana and North Dakota. Intake also filed a lawsuit against the Commission and its members in Federal District Court in Billings, Montana on June 29, 1973. The suit challenged three areas: The Attorney General of Montana be enjoined from enforcing Section 89-846 of the Montana State Statues, which forbids such out-of-state diversion without the consent of the Montana Legislature; the Yellowstone River Compact commission and its members be enjoined from enforcing Article X of the Compact and that article X be declared unconstitutional as an unwarranted burden on interstate commmerce; and the commission be enjoined from enforcing article X and article X be declared unconstitutional as a violation of the equal protection clause of the 14th Amendment of the Federal Constitution. Another interesting event was the application by Utah International Corporation to divert water from the Powder River and from a storage reservoir on Fence Creek, a Powder River tributary in Wyoming. The company plans to pump water from the reservoir by a 48-inch pipleline to the project site in Montana. The application pertains to the diversion in Wyoming of presently unused and unappropirated water of the Powder River allocated to Montana for beneficial use in that state pursuant to Article V, B.4a of the Compact.

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November 26, 1974. Walter Scott became the new federal representative and chairman replacing Robert Williams and Orrin Ferris became the Montana commissioner replacing Grant Buswell who retired. Streamflow and storage was above average and no problems existed. Ted Doney, attorney for the Montana DNRC summarized the Intake Water Company lawsuit against the Compact Commission, Attorney General of Montana, and each commission member. Intake Water Company, which is a wholly owned subsidiary of Tennaco claimed that Article X of the Compact is unconstitutional because it impedes interstate commerce and that Montana's ban on out-of-state diversions is unconstitutional.

Mr. Bishop emphasized the need for joint water development programs between the two states and felt that water had to be transferred outside the basin. Mr. Ferris indicated that Montana was definitely interested in a joint water development study , only if Wyoming's motivation was not interbasin transfer. Mr Bishop felt that water has to be diverted out of the basin and that each state has the right to divert their allocated share. Regarding the documentation of post-1950 uses, Mr. Bishop noted that Wyoming has a good handle on water rights because of its ongoing adjudication. Orrin Ferris reported that a new water law passed in Montana that will allow the documentation of existing water rights and that this adjudication is proceeding in the Powder River basin and the next basins to be adjudicated will be the Tongue River and Rosebud and Armells Creek. Both Commissioners disagreed with the BR allocation study. Orrin Ferris noted that the Bechtel Study on the Tongue River resulted in different allocation numbers. Furthermore, studies completed by Wyoming also showed differences with the BR study. A motion passed that requested each state to identify manpower and objectives of a study to determined a mechanism to administer the Compact. The study would address return flows, evaporation and potential for joint developmental programs.

November 13, 1975. George Christopulos replaced Floyd Bishop as Wyoming's representative on the commission. There were no incidents during the year that required administration of the Compact. Again, the commission emphasized the need to begin developing procedures for administering the compact because of the increase in demand for Yellowstone River water. Documentation of per-1950 rights have been completed in Wyoming. Based on the new 1973 water codes in Montana, the DNRC is beginning to document existing water rights. Ted Doney reported on the status of the Intake Lawsuit against the Commission regarding Article X and the two new lawsuits filed by the Crow and Northern Cheyenne against the state regarding whether the state or federal court has jurisdiction to adjudicated indian reserved water rights. Orrin Ferris noted that the adjudication of the Yellowstone River basin will probably take 15 to 25 years. Mr. Ferris also emphasized the need to start issuing principles that would help define guidelines for administering the Compact. One such statement might be related to supplemental water. Mr. Shore of the Missouri River Basin Commission discussed its proposed objectives for a Level B study of the Yellowstone River Basin.

November 1976. Little happened at this meeting. Commissioners reported that there was no reason to administer the compact. Flows were near average in the four tributaries. Discussions took placed regarding the need to develop an administrative procedure to eventually administer the compact,

the status of the Intake Water Company Lawsuit, and the potential for large scale development of water and coal in the basin.

November 9, 1977. Streamflows were considerably below average, but there was no incident that required administration of the compact. A special Compact Administration Subcommittee meeting was held to begin resolving differences in interpretation of the compact. The commission again indicated that the compact will eventually need to be administered and waters allocated between the two states. Orrin Ferris presented preliminary information on Montana's water use. Because of the potential for large-scale use of water associated with coal development, the commissioners requested the Subcommittee to meet again to do what was necessary to develop an administration procedure and joint development and allocation studies. Frank Trelease presented Wyoming's subcommittee report. He indicated that half of the 13,000 AF/Y of water rights filed since 1950 have been adjudicated, but did not know whether the water is being used for full service or supplemental water supply. He stated that the water right system is not geared to meet Compact requirements and feels that administering the compact will be quite a problem. Both commissioners thought that having the federal representative from North Dakota was better than someone from the regional office of the USGS in Denver. Both commissioners agreed that a proposal should be drafted for obtaining financing to develop an administrative model to allocate the flows of the interstate tributaries. An attorney from Intake Water Company petitioned the Commission for diverting water from the basin (from the Yellowstone River at Intake Mt. to the Little Missouri Basin) for the purpose of constructing a synthetic natural gas plant. A motion was passed by the Commission; to accept the petition, to develop a legal position regarding consent, and to get back to Intake Water Company on its findings. Status of the Intake Water Company lawsuit was presented. The DNRC argued that Intake Water Company had a post-1973 water right and the Company argued that it was pre 1973. Ted Doney noted that the lawsuit regarding the priority date of Intake's water right was appealed by the state to the State Supreme Court and the Court ruled in favor of Intake Water Company.

November 9, 1978. A severe winter storm prevented the commission from meeting and therefore, the meeting was held by conference call. Two special meetings were held in January and May, 1978 to continue discussions of water-right procedures in both states, definition of terms in the Compact, and to respond to Intake Water Company's petition to the Commission requesting permission to divert water out of the Yellowstone River Basin. The legal opinion on what state entity has the authority to approve interbasin transfers concluded that the Montana and North Dakota legislatures and the North Dakota State Water Commission

were the appropriate entities. In response for seeking legislative authority for the Commissioners to act for the signatory States, the Governor of Montana determined that he was not willing to sponsor such legislation and the Governor of Wyoming indicated that he would not oppose such legislation, but that it would be difficult to get it passed. The commission felt that no incident occurred during the year that required administration of the flows in accordance with the Compact. The commission, however, is still focusing attention on the need to define detailed procedures for implementing and enforcing Compact provisions. Because of this, the Subcommittee has been requested to continue its investigations. It was noted that interest in Yellowstone River water for coal development is still increasing. Documentation of pre-1950 water rights have been completed in Wyoming. Montana is working on it, but has a long ways to go. The commission noted that a major concern with allocating the flows of the four interstate tributaries is the unquantified indian and non-indian reserved water rights.

November 14, 1979. Gary Fritz replaced Orrin Ferris as the Montana Commissioner. Two meetings of the subcommittee were held in July and September of 1979. The purpose of these meetings was to continue developing an understanding of the compact and potential ways that it might be administered. The commission felt there were no incidents that would require administration of the compact, however, as in previous annual reports, the commission felt that compact administration will be necessary in the future. The minutes are almost a verbatim transcript of the previous year.

November 21, 1980. Grady Moore replaced Walter Scott as the Chairman and federal representative to the commission. A special meeting was held in April to discuss compact administration and interpretation. No discussion of joint water development activities occurred at this meeting. The commission felt that there was a need to administer the compact, but again they did not feel they were in a position to do so. Even though the report says the interest in coal development and peripheral needs are continuing, in reality the interest in coal is beginning to decline. The commission drafted a proposal for improving the administration of the Yellowstone River Compact. Objectives of the proposal were to: obtain a better understanding of the compact; determine the quantity of water that is available to Montana and Wyoming under the terms of the Compact, determine whether the apportionment formula in Article V is still applicable, and equitable for dividing and apportioning the waters with respect to present and future demands; and develop an accounting system which will allow the commission to administer the compact on a regular basis and to predict future water needs. The proposal is to be sent to the Old West Regional

Commission.

December 21, 1981. The compact was not administered. Streamflows were below average for the year on all four tributaries. The Old West Regional Commission thought the Compact Commission's proposal was acceptable for funding, but with the demise of the Old West Regional Commission, all hopes for funding disappeared. This being the case, both states assigned individuals to develop a proposal for administering the compact, with the Tongue River being the initial basin of study. A number of important issues were discussed at the meeting. The potential development of the Little Bighorn by the Sheridan-Little Horn Water Group and potential impacts to Montana became an issue. This company is proposing to build a series of 3 storage reservoirs and sell up to 32,000AF/Y for industrial purposes. The Commission agreed that the issue of interstate ditches, where the diversion is in one state and the use in the other, must to be resolved. The commission began thinking of appropriate rules and procedures for resolving this issue. The Commission discussed the Jan Paul Application. This is where the Yellowstone Pipeline Company filed an application with Montana to divert 348 cfs or 251,952 AF/Y near the confluence of the Powder and Yellowstone rivers for use in Wyoming and the company would use part of Wyoming's allocated share. An update of the Intake Water Company's lawsuit was presented by Montana. The Company is challenging article X on the bases that it is a burden on interstate commerce and therefore unconstitutional. Montana described S.B. 243 which delegates authority to the Montana DNRC to authorize diversions from the Yellowstone River Basin. The last significant issue discussed was the lawsuit between Utah International and Intake Water Co. regarding which company' water right had the earlier priority date for a storage project on the Powder River.

November 10, 1982. An April 26 special meeting was held to formulate approaches to study the Little Bighorn and Tongue rivers. A technical committee was appointed to study the Little Bighorn River, and to provide background information for negotiating a compact between the two states and between Montana and the Crow Tribe. Another technical committee was formed to determine and agree on the storable inflows to an enlarged Tongue River Dam that Montana is entitled to under the compact. Montana voiced concerns that Wyoming will need to regulate its post-1950 flows more carefully so that it does not use Montana's pre-1950 water. A condition developed in 1981 where Montana was almost unable to fill the Tongue River reservoir which has a pre-1950 right.

At the annual meeting, the commission noted that the compact has never not administered, but hopes the results from

the Tongue River studies will provide information to assist in the development of an administrative procedure for article V of the Compact. The issue of how the enlargement of the Tongue River Reservoir might effect article V was discussed with no resolution. The Little Bighorn Technical Committee reported that a base accounting model had been developed by Montana for the river. The model was sent to Wyoming for review. Wyoming indicated that Governor Hershler will appoint a team to negotiate the flows of the Little Bighorn and a legal firm to develop a negotiation strategy. The Tongue River water model has been developed by Montana and the two states are discussing refinements. The commission discussed the U.S. Supreme Court finding that upheld the Montana Supreme Court decision in Utah International vs. Intake Water Company. The Court ruled that the DNRC acted properly when it assigned Utah International the earlier priority date on its water right application than that of Intake Water Company. The commission began to identify interstate ditches that the commission needs to resolve and began to develop rules. The last issue discussed revolved around the relationship between the compact and the brewing conflict in the Missouri River basin between the upper and lower basin states. The Commission voiced the opinion that the Yellowstone River and tributaries should be excluded from a Missouri River Compact because it is already compacted by the U.S. Congress.

January 4, 1983. On April 27, 1983, a special meeting of the commission was held to address a number of issues. The first issue discussed was interstate ditches. Both states provided an update of the number of ditches and available data on them as well as reviewed the draft rules for resolving this issue. Regarding the Clarks Fork Basin, Montana described HB(914) which gave the Montana representative the authority to work with Wyoming on developing a potential joint storage project in the basin. Wyoming identified its assessment of potential projects for consideration. Wyoming updated the commission on the status of the Wind River adjudication and concerns that Wyoming has with quantification of indian and non-indian reserved water rights. A brief discussion occurred on the programmatic EIS being prepared by the BR on water for marketing out of Yellowtail and Boysen Reservoirs. The commission spent considerable time discussing the Little Bighorn River issues related to the proposed developments by the Sheridan-Little Horn Water Group. Specifically, issues included the status of the model development and results by the technical committee, status of negotiations with the Crow Tribes and Wyoming legislation affecting the Little Bighorn negotiations. Montana proposed that a joint study be initiated by Montana and Wyoming to evaluate the potential for a joint project on the Powder River and to develop a basin management plan that satisfies the needs of both states. Wyoming is presently evaluating a number of potential storage sites for develpment in this basin with the Middle Fork Project being the most desirable site. Considerable time was devoted to discussing

the Tongue River. Discussions revolved around the water model, supplemental water supplies, Montana direct flow rights, status of negotiation with the Northern Cheyenne Tribes, and Wyoming's water development activities within the basin. Montana presented a draft proposal for review by the commission regarding the administration of the compact and allocation of water under Article V (Appendix 5). Wyoming wanted the opportunity to study the proposal in more detail. Both states reported on legislation that would allow them to evaluate proposals to transfer water outside the Yellowstone River Basin that would meet the requirements of Sporhase vs Nebraska.

The regular meeting was held in January. The commission spent considerable time discussing interstate ditches. Montana presented a proposal for resolving the issue and Mr Christopulos had concerns with Montana's proposal because of a number of legal issues that must first be resolved. He plans to get back to the commission by May, 1984. Wyoming presented further detail of its study of potential storage sites in the Clarks Fork River Basin. Montana presented a report of the continuing saga of repairing and enlarging of the Tongue River Reservoir. Wyoming noted that three storage sites are being evaluated in the Tongue River Basin. Wyoming discussed the Little Bighorn negotiations. Last issues of discussion included the status of ongoing litigation specifically, the Intake Water Company's challenge of Article X and Jan Paul application.

November 20, 1984. A special meeting was held in April to address two topics--interstate ditches and administration of Article V of the Compact. The Commission developed administrative rules for processing of claims for use of water from interstate ditches. Draft rules and procedures for advertising the rules were developed. A mailing list of all interstate ditch water users were compiled for notification. Dan Ashenberg of Montana presented a method with assumptions for administrating the compact and presented a simple example. Wyoming wanted Montana to use a more complex example and suggested the Tongue River Drainage Basin. Montana agreed and will present the information at the next annual meeting. The Commissioners agreed that there was no incidents that required the administration of the Yellowstone River Compact. Stream flows were above average on all tributaries. Interstate Ditches were a major issue of discussion. Rules were adopted early in the year by the Commission and mailed to all interested parties on October 2, 1984 with a December 31, 1984 deadline for submitting claims. As of the time of the meeting , no claims have been submitted to the commission. The issue of salt loading from Salt Creek into the Powder River was discussed. It appears that discharges from oil well treaters in the Salt Creek drainage may be the source of increased salinity in the Powder River. George Pike of the USGS presented preliminary data that

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suggested chloride increased 5 fold since 1950 and that the increase can be attributed to one of two sources; secondary oil well treaters or geothermal activity; there is no geothermal activity in the basin. The USGS requested that a joint study be initiated that would allow a better documentation of sources of contaminants into the Powder River. The Commission approved the study. The Commission also received a status report of the joint Wyoming-Montana SCS study designed to forecast streamflow in the Clarks Fork Basin. The model is being developed by the SCS's West National Technical Center in Portland, Oregon. A January meeting was proposed to discuss the Ashenberg administrative model.

November 26, 1985. A special January meeting was held to described the Ashenberg approach for administering the compact. Wyoming agreed to evaluate the methodology and assumptions and to get back to the commission.

At the annual meeting, the first issue addressed was a letter sent by the Montana representative to the Wyoming and federal members of the Commission which asked the commission to determine the applicability of Articles V and X of the Compact to the Middle Fork Powder River water development project. The issue is whether the 1940 Wyoming water right permit for storage at the Middle Fork project falls under the jurisdiction of the compact. The representatives of the two states disagree. Mr. Fritz requested the Commission to take the issue under advisement and establish a hearing date and procedure. A conference call was set up in December to discuss the letter in more detail because neither the Wyoming representative nor federal chairman had an opportunity to study letter since they just received it. Streamflows for the year averaged between 47-70% of the long-term average. Wyoming indicated that the SCS report on forecasting of flows in the Clarks Fork basin will be completed this winter. The SCS plans to provide a weekly forecast for the Clarks Fork River at Belfry, Mt. during the April through September period. Wyoming reported that the Wyoming Water Development Commission is considering whether to seek legislation to proceed with the environmental impact statement and permitting process on the Middle Fork project. The Water Development Commission is also studying storage projects in the Clarks Fork. Adjudication of claim on the interstate ditches were received by the commission and are being processed. Further efforts are planned to work on an administrative model to apportion flows of the interstate tributaries. Montana indicated that the water accounting model for the Little Bighorn is finalized and two reports are available from the Mt. DNRC.

[Since the minutes for 1986, 1987, and 1988 annual meetings of the Compact Commission are very detailed and accurate, they are not included here. Please refer to the minutes for

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information.]

SYNOPSIS OF COMPACT COMMISSION ACTIVITIES

Based on a review of the minutes a number of conclusions can be drawn regarding the compact.

1. The compact has never been administered. Key terms of the compact remain ambiguous.

2. The issue involving interstate ditches where the point of diversion is in one state and use in the other has been resolved through the compact.

3. During the 39 years the Compact has been in existence, the states have experienced severe droughts and the compact has not been administered as initially contemplated by its negotiators.

4. The technical data base on pre-1950 and post-1950 water rights and actual water use is not accurately known in both states for compact administrations nor have the states attempted to keep the information up to date in accordance with compact provisions. It should be noted, however, the data base in Wyoming is better than that in Montana.

5. Neither state knows whether Montana is being adversely affected during periods of below average flow nor whether water used in Wyoming is contrary to the terms of the compact.

6. It is to Wyoming's advantage not to administer the compact and to Montana's advantage to administer it.

. The only article that has been administered is article X and the feeling of the states is probably that the article is a hindrance on water development activities within the individual states.

8. There are many issues that Montana and Wyoming disagree on regarding the interpretation of the compact. These issues have to be resolved before the compact can be administered.

ISSUES

1. INDIAN RESERVED WATER RIGHTS.

ISSUE: Article VI of the Compact clearly states "nothing contained in this compact shall be so construed or interpreted

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as to affect adversely any rights to the use of the waters of Yellowstone River and its tributaries owned by or for Indians, Indian tribes, and their reservations."

WYOMING POSITION: Wyoming believes the founders of the compact determined allocable waters on interstate tributaries based on percentage of irrigable acreage in the basin including lands on and off indian reservations. Therefore, reserved water rights in Wyoming would come out of Wyoming share and reserved water rights in Montana would come out of Montana share. The minutes of the final negotiation meeting held in December, 1950 appears to substantiate this position.

MONTANA POSITION: Montana believes that the tribal water rights pre-date or are senior to the Yellowstone River Compact and that Article V-A also applies to tribal reserved water rights. That Article states that all appropriative rights to the beneficial uses of water within the Yellowstone River system existing in each state as of 1950 shall be enjoyed in accordance with the laws governing the acquisition and use of water under the doctrine of appropriation. Therefore, tribal rights must be satisfied first and what water is still unappropriated is to be divided by both states. If Wyoming's position prevails then Montana could conceivable lose existing rights and its total allocable share in the Bighorn River Basin to the Crow Tribe. Moreover, in 1950 a number of the negotiators felt correctly that indian reserved water rights might not be limited to "presently projected use as estimated by the engineering committee, but might become relatively unlimited". The negotiators in 1950 could not have guessed the outcome of the U.S. Supreme Court decision in Arizona vs. California in 1963 that based the quantification of indian reserved water rights on practicable irrigable acreage. Also the negotiators questioned the accuracy of the irrigable acreage identified in the Bighorn River Basin and before the engineering committee's principle on this issue would pass the negotiation committee, the Bighorn Basin had to be exempt from the principle (refer to page ___).

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2. JURISDICTION OF THE COMMISSION CHAIRMAN.

ISSUE: The issue is under what situations does the chairman have the authority to break a tie vote when the two states disagree. This issue arose when Montana attempted to have the commission determine whether pre-1950 permits or unperfected rights developed after 1950 fall under the jurisdiction of the Compact and are included in the apportionment.

WYOMING POSITION: According to Wyoming, the federal chairman can only break a tie vote when it involves the administration of the compact and not its interpretation. Article IV-F states that if

the representatives of the two states cannot agree "on a manner necessary for the proper administration of this compact", then the chairman breaks the tie vote.

MONTANA POSITION: Montana believes Article VI-F clearly allows the chairman to break a tie on any issue involving the interpretation of the Compact. To the extent that many issues regarding specifics of compact administration were left unresolved or non-explicit in the final compact, interpretation plays a key role in administration. For without an agreement on the meaning and intent of the Compact, the Compact cannot be administered.

3. SUPPLEMENTAL WATER

ISSUE: The Compact has a provision that allocates to each state enough unuse and unappropriated water as of 1950 for use as supplemental water supplies for water rights in existence before January 1, 1950. The issue is two fold: not knowing the amount of unappropriated flows allocated to each state because of the continual use of supplemental water and the question of due diligence or time allotted to develop full service irrigation on pre-1950 water rights.

WYOMING POSITION: The major use of water in Wyoming is the development of supplemental water supplies after 1950 and it is a very important provision in the compact.

MONTANA POSITION: Since the compact has been in existence for 39 year, Montana feels that there has been more than enough time for perfection of pre-1950 uses with the use of supplemental water in both states. The concept of supplemental water also makes it extremely difficult to determine what percentage of water each state is entitled to in any given year. Development of supplemental water will decrease each states allocated shares under the compact. Moreover, if unappropriated and unused water is divided between the two states and developed after 1950, a pre-1950 water user can develop supplemental water supplies for a pre-1950 water right and cause a post-1950 water user to lose its water supply.

4. ADMINISTRATION OF PRE-1950 WATER RIGHTS

ISSUE: Article 5 states that the appropriative rights to the beneficial use of Yellowstone River system water in existence as of January 1, 1950 in each signatory state shall continue to be enjoyed in accordance with the laws governing the acquisition and use of waters under the doctrine of appropriation. The question is---does the compact commission have jurisdiction to administer pre-1950 water rights?

WYOMING POSITION: Wyoming believes the commission has no jurisdiction to administer pre-1950 water rights and that the way the compact has been managed historically still applies. That is, Wyoming satisfies its pre-1950 water rights first, then Montana satisfies its pre-1950 rights and whatever is left over is divided on a percentage bases between Montana and Wyoming on the interstate tributaries.

MONTANA POSITION: Montana does not believe the issue is that simple. Throughout the twenty years of negotiating a compact the major stumbling block was the administration of pre-1950 water rights. A number of Montana negotiators continually argued for a provision that would allow the compact to administer pre-1950 water rights. However, at the eleventh hour of negotiations a provision to allow for administration of pre-1959 rights was rejected because it was the final hurdle before a compact could be agreed upon. Further, Montana believes that since the negotiators could not agree on this issue it was left out of the compact and therefore, not addressed. Montana believes that Wyoming's interpretation of article V for allocating flows on the interstate tributaries is not an equitable apportionment.

5. WATER QUALITY

ISSUE: Article V-A states that pre-1950 rights in both states shall continue to be enjoyed in accordance with the laws governing the acquisition and use of water under the doctrine of appropriation. The question is; does the Compact have jurisdiction over activities in one state that change water quality to the detriment of existing pre-1950 water rights in the other state?

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WYOMING POSITION: Wyoming believes that water quality is not a compact issue since it is not specifically mentioned in the compact.

MONTANA POSITION: If existing pre-1950 uses in either state are adversely affected by detrimental changes in water quality caused within the other state, then the Commission has jurisdiction to do what ever is necessary to protect the pre-1950 water rights. This would include requiring the other state to clean up any activity that caused the degradation to water quality.

6. THE APPORTIONMENT PERIOD.

ISSUE: Paragraph C of Article V indicates that the quantity of water subject to the percentage allocation shall be determined on an annual water year basis measured from October 1 of any given

year through September 30th of the succeeding year. The quantity of water to be divided at any given time is the sum total of those quantities identified in Article V-C since October 1. The issue is that many of the negotiators of the compact contemplated the construction of large storage projects on the interstate tributaries in Montana that would provide Montana's allocation. No new storage projects, except Yellowtail Reservoir has been built since 1950 and the likelihood of additional large storage projects being built on the interstate tributaries is very remote.

WYOMING POSITION: Wyoming believes the apportionment formula should be strictly adhered to as defined in Article V. (Refer to the memo by Lou Allen to George Christopulos regarding compact administration).

MONTANA POSITION: Since federal storage projects will not be built on the Powder, Tongue, and Clarks Forks Rivers in the foreseeable future, the apportionment formula as presently interpreted does not work pratically or equitably. For example, if the total of the flow to be divided on one of the four interstate tributaries in August is 100,000AF (the sum of the four quantities in Article V-C from October 1 to August 1) and the actual flow in August is less than 5,000 AF, Wyoming would be entitled to 42,000AF or the entire flow and Montana would be entitled to nothing if strict adherence to the apportionment formula is maintained. Montana takes the position that the compact should actually apportions the flows on a weekly to monthly period beginning in October 1 and once the flows are apportioned they cannot be reapportioned. In August, the 5,000AF would be apportioned between the two states in an equitable manner based on the percentages. Montana also believes that the hydrology and distinct water supply/demand characteristics of the rising and falling limbs of the hydrograph are responsible for a timing problems which dictate that each limb of the hydrograph be apportioned separately according to Article V. If each limb is not apportioned separately, the article V calculation would have the effect of dividing flow at the downstream gate for use upstream at a later date, This is a physical impossibility. Secondly, the rising and falling limbs should be apportioned separately so that each state may quantify that portion of the rising limb which can be put in storage and used to supplement irrigation after the given date. Flow apportioned during the rising limb and that water which has been stored will not be re-apportioned after the given date. Likewise, post-1950 diversions satisfied from water apportioned before the given date, are not included in the apportionment after this date.

8. LITTLE BIGHORN.

ISSUE: The issue is whether the Little Bighorn is included into

the Yellowstone River Compact.

WYOMING POSITION: Wyoming believes the Little Bighorn is excluded from the Yellowstone River Compact and is specifically excluded in Article V under the apportionment of the Bighorn River and in Article II under the definition of interstate tributaries.

MONTANA POSITION: Even though Article V specifically excludes the Little Bighorn, Montana believes that the definition of the Yellowstone River Basin and Yellowstone River system clearly includes the Little Bighorn with regard to all articles of the compact except article V. The reason the Little Bighorn was excluded from article V is because there were little to no water uses in Wyoming as of 1950 and 90% of the basin is in Montana and on the Crow Indian Reservation. At that time, the compact negotiators were uncomfortable addressing indian reserved water rights.

9. DIVERSION VERSUS DEPLETION.

ISSUE: The apportionment formula in Article V is based on diversions and not depletions. When agriculture is the predominate use, diversions is a reasonable basis for determining the apportionment. Since the initiation of the 1970's and the increase in industrial use with little or no return flows, the use of diversions may not be the most appropriate measurement to use. Moreover, the apportionment mixes two types of water (divertable and diversionary flows) that makes it impossible to balance water apportioned to the two states.

WYOMING POSITION: Wyoming sees no problem with the use of the four measurements as defined in Article V as the basis for apportionment.

MONTANA POSITION: Montana believes that it is possible to prepare a water budget based on the two types of flows used in the apportionment. The only way the apportionment formula can work properly would be to use similar units. All units should be converted to their divertable flow equivalents. Conversely, divertable flow equivalents could be converted back to depletable flows when it is necessary to calculate the quantity of water to be released from storage.

10. DIVERTING WATER FROM ONE STATE INTO ANOTHER; ISSUE OF PRIORITY DATE.

ISSUE: If one state wants to divert water allocated to it from

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the other state, there appears to be a question regarding the priority date of the water right and which state has jurisdiction over the priority date.

WYOMING POSITION: Wyoming contends that the original intention of Article VII of the compact is to allow Wyoming to divert water from Montana where the water comes from Wyoming allocated share and has a priority date established under Wyoming law. This issue evolved with the filing of the Jan Paul application for use of Wyoming's allocated share of water, but diverted within Montana.

MONTANA'S POSITION: Montana argues that Article VII states that Wyoming would have to abide by Montana's water laws including the establishment of a priority date. For example, Article VII-C states that " Appropriations may hereafter be adjudicated in the state in which water is diverted..." and further states, "Each adjudication is to conform with the laws of the state where the water is diverted and shall be recorded in the county and state where the water is used."

11. ADMINISTRATION OF NON-PERFECTED PRE-1950 WATER RIGHTS UNDER THE COMPACT.

ISSUE: The issue is whether undeveloped pre-1950 water rights in either state are to be allocated under article V of the compact.

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WYOMING POSITION: Wyoming feels that unperfected water permits in existence before 1950 are not to be administered by the compact. For example, the 1940 permits for water use in the Powder River Basin can be developed today and not become apart of Wyoming allocated share for this basin.

MONTANA POSITION: Montana believes Article V-C clearly states that all water associated with the development of reservoirs after January 1, 1950 or new uses in pre-1950 reservoirs shall be allocated between the two states. Montana also questions the issue of due diligence on permits that have been in existence for over 40 years and still un-perfected.

12. POINT OF MEASUREMENT.

ISSUE: The point of measurement is generally near the confluence of the tributary and Yellowstone mainstem. The issue is---should the flows be allocated at the interstate boundary?

WYOMING POSITON: Wyoming notes that the reason the point of measurement is the confluence with the mainstem is that Wyoming

negotiators in 1950 insisted that the entire flows of the interstate tributaries be divided and not just the flows orginating in Wyoming. It should be noted that the negotiation commission in 1950 concurred with Wyoming's position.

MONTANA POSITION: Montana agrees that the point of measurement is the confluence of the tributaries with the mainstem, but feel that this makes it very difficult to actually apportion the flows between Montana and Wyoming. Montana believes the flows must be divided at the interstate line and that some type of real-time forecasting is important for accurate apportionment.

CONCLUSIONS

1. The compact has not been administered for 39 years. Specifically, flows have not been apportioned between the two states. The basic reasons for developing a compact have not been met.

2. Data necessary to apportion the flows based on article V would be very difficult and expensive to collect. Article V would also be very cumbersome and expensive to administer.

3. Because less than two years were available to draft and finalize the 1950 version of the compact, many of the disagreements between the two states were not resolved and therefore, the compact is ambigious in these areas. This is probably the basis for so many disagreements between the two states at the present time.

4. The apportionment formula was based on large federal storage projects being built in the major basins. It was contemplated that Montana would be able to store its allocated flow in these projects and release it in times of need. Major projects, however, have not been constructed in the Tongue and Powder River basins. At that time, the compact drafters felt there would be no significant issues on the Clarks Fork that would require administration. Today, a literal interpretation of Article V of the apportionment formula may hurt Montana because the situation in the basin is so different than contempleted in the 1950's.

5. In 1950, no one realized the magnitude of indian and nonindian federal reserved water rights in the basin. Because of U.S. Supreme Court decisions in the 1960's and 1970's, the percentages in the apportionment formula may not reflect the extent of indian reserved water rights.

6. Article V-F states that "From time to time the commission shall reexamine the allocations herein made and upon unanimous agreement may recommend modifications therein as are fair, just, and equitable,[emphasis added] giving consideration among other

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factors to: priorities of water rights; acreage irrigated; acreage irrigable under existing works and potentially irrigable lands". This provision may provide the commission with the option to consider appropriate changes to reflect present-day conditions in the basin. However, if "recommend" means to obtain Congressional ratification than Montana and Wyoming may not wish to seek such approval because the lower Missouri River basin states may attempt to abolish the compact in order to obtain a portion of the flows. Conversely, if appropriate changes can be included in the regulations and rules to the compact then the states may wish to consider this possibility.